

# **Metaverse or Mindtrap: Inner Shift, Outer Shock**

*A note on the organizational structure of this book*

by Ramesh Ramloll

Published by Ramesh Ramloll

Feb 22, 2023, Rameshsharma Ramloll

First Edition

In "Metaverse or Mindtrap: Inner Shift, Outer Shock", the reader embarks on a comprehensive exploration of the Metaverse, an evolving digital frontier. Driven by a blend of technology, creativity, and human interaction, the Metaverse is reshaping our perception of reality, offering profound transformations and challenges alike.

At the onset, the book dives deep into understanding the origins and myths surrounding the Metaverse, demystifying the hype and laying out its vast ecosystem. The author delves into his personal trajectory, offering a firsthand account of the journey through this digital expanse.

The text articulates the potential transformations the Metaverse can impose on society, cognition, and physiology. Distinct functionalities are unveiled, from productivity to social-centric applications, as well as its interrelation with AI. Importantly, the Metaverse is portrayed from various viewpoints, highlighting its multifaceted nature.

A significant portion of the narrative revolves around creating and consuming content within the Metaverse. The author

unpacks the nuances of designing in this expansive realm, emphasizing cognitive dynamics, research challenges, and strategies to enhance creative processes.

Challenges in user experience design are addressed, with a spotlight on the Internet's evolving role and the implications of the Metaverse transcending mere gaming. A vision of inclusive creativity is painted, emphasizing support for end-users and celebrating the future potential of content production.

The intricacies of the human brain come into play as the book progresses. Insights into cognitive science and neuroergonomics provide a deeper understanding of Metaverse design. Abstraction and compositionality become focal points, presenting the art and science behind these concepts.

From harnessing the capabilities of the brain to expanding collaborative avenues in the Metaverse, the narrative broadens its scope. Discussions on educational potentials in virtual worlds, the future of the Metaverse, and the empowerment of people through decentralization and open-source movements become central themes.

The concluding sections of the book delve into the transformative role of Generative AI in catalyzing the Metaverse's growth. Ethical considerations, transparency, and the blurring boundaries between the real and virtual worlds are addressed, culminating in reflections on the birth of a new epoch.

Ultimately, this book invites readers on an enlightening journey through the Metaverse, challenging them to envision a world where digital and physical realities coalesce. It provides a roadmap for understanding the intricate dance between

illusion and the Metaverse and offers a spiritual take on this boundary-pushing frontier.

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Names: Ramloll, Rameshsharma, author.

152 Park Place

Landisville, PA, 17532

Title: Metaverse or Mindtrap: Inner Shift, Outer Shock

Description: Amazon Kindle Direct Publishing, [Year of publication: 2023/2024] | Includes biographical references and index.

Identifiers: LCCN 2023922747 | ISBN 9798988433002  
(paperback)

Subjects: LCSH Virtual Reality | Computer Networks | Digital Media | People with Disabilities -- Services for | Human-computer Interaction | Self-help Devices for People with Disabilities | Information Technology | Computer Networks -- Social Aspects | Group Work in Research | Design | Visual Communication | Graphic Arts | Human Engineering | Cognitive Ergonomics | Neurosciences | Cognitive Science | Information Technology -- Psychological Aspects.

Classification: LCC [To be assigned] | DDC [To be assigned] -  
- dc23



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## ***Dedication***

In the grand tableau of human endeavor, this book is devoted to you, the valiant ones, who rise above the common currents of life. Your existence, resolute and unyielding, bears testament to the noble truth that elevating our standards is not a retreat, but rather a bold and necessary foray into the realities of our world. Amidst an ill-conditioned society where worth is too often gauged by what we surrender, rather than what we zealously chase, you stand as a beacon of aspiration and commitment. To you, the tireless seekers, who refuse to falter in the face of convention, this work is dedicated.

# Acknowledgements

In the process of bringing this book to life, I have accumulated more debts than I could ever possibly repay. This page is a humble attempt to acknowledge those who contributed significantly to this journey. While I cannot name everyone individually, please know that your influence and support have been invaluable to me. Together, you have played an integral role in the creation of this book, and for that, I am eternally grateful.

To those who shared my journey as teachers, colleagues and fellow students at various educational institutions, College du St Esprit (Mauritius), Indian Institute of Technology (Kanpur, India), University of Mauritius, Lancaster University (UK), Glasgow University (UK), Catholic University of America (US), Idaho State University, thank you for the countless discussions, collaborations, and shared experiences. To my fellow engineers and research associates at the Medstar Research Institute (DC, USA). To the various US educational and research institutions, such as the UK Commonwealth Scholarship Scheme, National Institute of Health (USA) who have funded many of my research efforts.

To my exceptional team of co-workers at our bootstrapped company, I want to take a moment to remember our dear colleague, John Hopkin. As a brilliant software engineer and jazz musician, John brought a unique blend of talent and passion to our work. His recent passing has left a void in our hearts, and we deeply miss him.

I would also like to extend my appreciation to Ludovic Lotoah, Andrew Hellershanks, Sue Glover, and Anabel Nowak for their invaluable contributions. Your insights and expertise have not only enriched my understanding of the subjects we write about, but they have also fostered a collaborative environment where knowledge thrives.

I am deeply grateful to my wife, Jaishree, for being my unwavering source of encouragement and inspiration. To my parents, Prasram and Vidya, and brother, Rajesh, who have helped me navigate life and its challenges.

In closing, I extend my heartfelt thanks to the invaluable beta readers and reviewers. Your contributions have been instrumental in shaping this book into its final form.

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## **A Note about Illustrations**

In this book, we have incorporated a comprehensive array of figures to elucidate various concepts. Almost all of the figures, crafted in the vein of patent diagrams as mandated by the USPTO, are more than mere illustrations of hypothetical situations. Each one encapsulates the quintessence of screen captures from actual interactive 3D virtual world experiences that we painstakingly created and explored. We also included a small set of figures to describe a number of insightful experiments carried out years ago but appear to be quite relevant today.

Our decision to adopt this approach was driven by a desire to enhance the longevity and timeless relevance of these diagrams. We aimed to circumvent the potential distraction of readers by the superficial elements of screen captures, which are largely dependent on the current underlying graphics platform. This strategy underscores the fact that while all the virtual world content was hosted on an OpenSimulator platform and accessed through the Firestorm viewer, the content could have been hosted on any platform.

The crux of the matter is that the ideas and motivations underpinning these depicted scenarios are the true focus. These are the elements that hold enduring significance, transcending the specifics of the platform or the aesthetics of the graphics rendering technologies.

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# Preface

In mainstream media, most of the ongoing discussions regarding the Metaverse seem to be motivated by Wall Street experts, blockchain technology developers, and speculators. Their concerns are mostly financial in nature. Making financial projections about a technology that we do not yet grasp satisfactorily has been puzzling for many to say the least. The mainstream media has portrayed the Metaverse as a fully immersive virtual environment where many people can share experiences at the same time. This has been amplified by movies and social media influencers. While these perspectives are valid, they do not tell the whole story.

The Metaverse is so much more than a tool for mass entertainment, socialization or making money. It can help us to connect with each other in ways that were previously impossible. It can change the way we perceive and interact with the real world. It can revolutionize the ways we learn. It has the potential to make visible aspects of ourselves that usually remain hidden in the real world. It can help us expand our self-identity. The Metaverse can be a force for good in the world, and that is something that we should all be excited about.

However, the double-edged nature of every technological advancement is well known. The negative impacts of the Metaverse are therefore anticipated, and plans should be made to mitigate their effects. In this book, we explore the Metaverse from a productivity and utilitarian perspective without diminishing its social dimension. The perspectives we offer are influenced by research findings in fields related to collaborative computing technology, human-computer

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interfaces, cognitive science, and engineering. Let us begin by exploring the origins of the Metaverse.

### **Who is this book for?**

The aim of this book is to provide a comprehensive understanding of the Metaverse to a broad audience. We intend to reach educators, multimedia artists, virtual world architects, gamers, students, investors, and entrepreneurs who are interested in gaining a deep understanding of the Metaverse. We believe that this book should be accessible to both lay and expert audiences.

For lay readers, this book will provide a glimpse into the direction the Metaverse is likely to unfold, while for expert readers, it will inspire them to advance areas that are of driving significance for the Metaverse. However, we do not view this book as a technical or implementation document that describes specific tools, programming environments, or platforms.

One of the fundamental premises of this book is that content creation is not limited to developers and 3D modelers. When designing virtual environments to support learning, ideation processes tend to be very conservative, and there is often an impulse to translate linear approaches to creating content into a virtual environment. Unfortunately, this approach results in virtual PowerPoint presentations in virtual worlds, which do not take advantage of the full potential of the Metaverse.

By the end of this book, we aim to establish a solid understanding of how humans process information and how tools developed in the real world can enhance cognition. When attempting to expand the application design space for virtual environments, adding a cognitive science perspective to the

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design process can catalyze fearless experimentation and innovation.

We approach the Metaverse from the standpoint of human-computer interface design and cognitive psychology, which focuses on the brain as a processor for information reaching our sense organs. While we do not equate the brain with a computer, we use the abstractions used to describe information processes in a computer to describe brain functions in general that come into play during interactions with virtual content. By providing this perspective, readers will gain a deeper understanding of how the Metaverse can be designed to provide a more engaging and immersive experience.

### **Skip the theory**

This book aims to provide readers with a comprehensive understanding of the Metaverse from multiple perspectives. However, we acknowledge that not all readers may be interested in all aspects of the Metaverse, and some may prefer to focus on actionable recommendations or guidance. For those readers, we recommend jumping straight to Chapter 6, which provides specific information and guidance on practical aspects of the Metaverse.

Additionally, in the Appendix, we provide information about online platform tools and solutions that readers can access immediately, which may be especially useful for those looking for quick and practical guidance.

However, we caution readers against skipping sections of the book that may not immediately apply to their interests. By doing so, they may miss out on valuable insights and perspectives that could shape their approach to designing for

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the Metaverse. For instance, the content that may not seem directly applicable at first glance, such as the philosophical and theoretical aspects of the Metaverse, can provide a broader perspective on what the Metaverse could be and inform readers' design choices.

In addition, by reading through the design stories presented in this book, readers may gain valuable insights into how others have approached Metaverse design challenges and be inspired to develop new technologies or extend existing ones.

Therefore, we encourage readers to consider reading the entire book to gain a comprehensive understanding of the Metaverse and to inform their approach to designing for it.

## Origins of the Metaverse?

The 1935 novel *Pygmalion's Spectacles* by Stanley G. Weinbaum presented a convincing early model for virtual reality. According to the story, the main character, Dan Burke, encountered Albert Ludwig, an eccentric professor who invented a pair of goggles. This appears to be a fairly accurate description of what is expected from VR head mounted displays.

Albert invented a pair of goggles which enabled “a movie that gives one sight and sound [...] taste, smell, and touch. [...] You are in the story, you speak to the shadows (characters) and they reply, and instead of being on a screen, the story is all about you, and you are in it.” Stanley G. Weinbaum – *Pygmalion's Spectacles*.

## Preface

Neal Stephenson coined the term Metaverse in his 1992 novel “Snow Crash” while others believe that it was William Gibson’s groundbreaking 1984 novel “Neuromancer” that popularized the idea of a Metaverse.

“Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts... A graphic representation of data abstracted from banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding...”

— William Gibson, Neuromancer

The concept of the Metaverse has been a topic of discussion for several years, and its potential to create a new reality that combines virtual and physical elements has intrigued many developers. However, the idea of creating alternative realities is not new, and people have been exploring this concept for decades. It is essential to keep in mind that despite the various descriptions of the Metaverse, there has been no universal interpretation of the term.

To understand the concept of the Metaverse, it is crucial to clarify what it means. The Metaverse can be defined as a collection of shared virtual spaces created by combining virtual reality, physical reality, and the Internet. The defining characteristic of the Metaverse is the embodiment of fellow users and the facilitation of social interaction between them. The presence of user avatars is one of the most crucial features of the Metaverse.

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It is important to note that any application designed as a single-user application, such as a banking application or a Solitaire game, would not be considered part of the Metaverse unless they are available on a 2D display while sharing the same 3D environment with other avatars. In other words, the Metaverse is a shared space that allows for social interaction and the embodiment of users in a virtual world, rather than a simple 2D application.

## Age old myths coming to life?

The idea of many worlds, some even contained within others, and how beings incarnate in them for limited periods is prevalent across many cultures. Although it is challenging to pinpoint the origins of the Metaverse as a concept, one could say that it represents the universal human desire for worlds beyond the one we know. As such, it does seem that the Metaverse was originally rooted either in escapism or a hunger for causal stories that would explain various life conundrums. It is not uncommon for ancient cultures to include notions such as spirits and realms or other worlds, and sometimes avatars in their stories.

“The Metaverse, in some sense, is an escape from the physical world.” - Tim Sweeney, founder and CEO of Epic Games, creator of the Unreal Engine a game development platform.

Humans have fantasized about living in other realms or worlds throughout history. Ancient Hindu and Buddhist texts mention the existence of many lokas, one of which is Brahma-lokha, for instance. According to Hindu belief, there are 14 lokas, or worlds in Sanskrit, that make up a multiverse. Many beings are

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believed to descend or manifest as avatars within these world systems. Lokas are not only viewed as habitable worlds but also as planes of existence. Each one of these planes can be a state of awareness/ consciousness. The plane is defined by the identity currently manifesting in its visitor. So, in this view, all these planes exist concurrently and can be navigated by 'login into' the relevant identity.

“To be yourself in a world that is constantly trying to make you something else is the greatest accomplishment.” - Ralph Waldo Emerson

The concept of identity plays a key role in many ancient cultures because it is generally assumed that it is identity that shapes what is experienced. Virtual worlds provide a mechanism for sustaining suspension of disbelief and keep an individual locked into an identity in a very controlled manner.

For thousands of years, humans have used psychedelics as ritualistic, medicinal, social, and recreational tools. Psychedelic users often describe their experiences as trips in alternate realities and their encounters with beings from beyond. One of the differences between chemically induced alternate worlds and virtual ones is that we have no evidence of individuals traveling together on a trip or sharing a dream where they share experiences and validate them upon their return.

However, a persistent virtual reality shared by a lot of people does not seem revolutionary anymore because we see glimpses of it every day even when using contemporary technology devices.

While the concept of realms or lokas in ancient religions and the Metaverse in modern technology are fundamentally

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different in nature, some parallels can be drawn between the two.

*Multiple layers or dimensions:* Both ancient religious concepts of realms or lokas and the Metaverse involve the idea of multiple layers or dimensions of existence. In ancient religions, these layers often represent various spiritual planes, while in the Metaverse, they represent interconnected virtual worlds.

*Interaction and influence:* Entities from different realms or lokas in ancient religious beliefs are often thought to be able to influence or interact with one another, just as users in the Metaverse can interact and collaborate with each other across different virtual spaces.

*Transcending physical limitations:* Both concepts involve the idea of transcending the physical world. In ancient religious beliefs, this transcendence is often spiritual in nature, while in the Metaverse, it is achieved through digital technology that enables users to engage in immersive, shared virtual experiences.

*Altered states of consciousness or perception:* In some religious and spiritual traditions, practitioners may enter altered states of consciousness to access or interact with other realms. In the Metaverse, users may experience an altered perception of reality through immersive virtual environments and the use of avatars.

It is important to note that these parallels are mostly metaphorical or thematic, as the underlying principles and purposes of realms or lokas in ancient religions and the Metaverse in modern technology are quite different. Realms or lokas are typically part of spiritual or religious cosmologies,



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while the Metaverse is a technological construct designed for entertainment, communication, and collaboration.

Nevertheless, the comparison highlights how human beings have long been fascinated by the idea of transcending the limitations of the physical world and exploring alternate dimensions or realities, whether through spiritual practices or modern technology. And we believe more than ever emerging technologies are going to make the construction of these different dimensions of existence a reality that can be accessed by anyone willing to do so. In this book, we will have the opportunity to build a vision of how such a future may manifest itself.

## **Faking hype, hyping fake**

Every period of exuberance about any technology is most likely to be followed by a cooling off period. The Covid-19 pandemic was a catalyst that amplified interest in a whole range of technologies that allowed individuals to connect for work, play and social reasons. Unfortunately, we are already seeing diminished interest after the Covid situation has been brought under control. A few early adopters, however, are staying around and trying to fully understand the myriad aspects of these technologies to make informed decisions about how to use or develop applications for the Metaverse.

## **Mapping the Metaverse ecosystem**

The landscape of technology is constantly evolving, and many believe that the future Internet or Metaverse will be built on various applications and platforms. However, navigating this complex ecosystem can be overwhelming for many people.

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This book aims to serve as a map to help readers understand the various technologies that will be integral to the Metaverse.

One of the challenges of understanding the future Internet is that different scientific fields tend to evolve independently of each other. Areas such as AI, 3D modeling, photogrammetry, haptics, brain-computer interfaces, and others are all being researched at a rapid pace. However, linking these fields under a common framework with an overarching goal can be challenging.

Just as there are many different types of real-world maps, this book provides a variety of perspectives to help readers understand the complex world of the Metaverse. Some maps show landmarks of interest, others show resources, such as restrooms and restaurants, and others show dangers and things to watch out for. Unexplored territories may also be indicated on maps, which can be attractive to explorers.

Without maps, knowledge of relevant places would not be shared as efficiently as it is. Therefore, this book serves as a guide to help readers navigate the intricate world of the Metaverse and understand the inter-relationships between various scientific fields. By providing this map, readers will be better equipped to explore and navigate the Metaverse with greater understanding and ease.

## **My personal trajectory**

“You have the right to work, but never to the fruit of work.”  
(Bhagavad Gita, Chapter 2, Verse 47)

To give you a deeper insight into my perspective on the Metaverse, I think it is important to share some key moments from my personal journey that have shaped my views.

## Preface

As a child, I was an avid video game player, and my first encounter with an interactive virtual world was Doom, a game created by John Carmack and John Romero. My academic research in the United Kingdom during the late 1990s and early 2000s revolved around human-computer interaction and computer-supported cooperative work.

I was also inspired by early pioneers like Morton Heilig, Ivan Sutherland, Jaron Lanier, Bruce Damer, and Philip Rosedale, who were leading the charge in virtual world research. Many of my ideas about virtual worlds were born from time spent with friends at Lancaster University (UK), home to one of the world's top Computer Supported Cooperative Work (CSCW) research departments, and at the University of Nottingham, a hub for VR research in the UK.

My time as a computer science and engineering student at the prestigious Indian Institute of Technology in Kanpur, India, exposed me to the theoretical aspects of computing sciences, enriching my experience in the field. I also had the opportunity to design and develop applications for technologies related to virtual or augmented reality, including 3D sound, immersive 3D headsets, haptics, and location sensing at the University of Glasgow in Scotland.

While the term Metaverse was born from Neal Stephenson's desire to escape the dystopian unpleasantness of the physical world, I believe that the Metaverse will truly shine when we can create virtual worlds that positively impact our physical reality. I do not see escapism as the primary purpose of virtual worlds, and I cannot remember many instances where I felt they offered an escape.

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My personal journey and perspective provide the context and background that shape the content and approach of my book. I believe the Metaverse will have truly arrived when we can see how virtual worlds are directly and positively impacting our physical world.

Over the years, I have had the privilege to work on several academic research projects in the United States, developing healthcare-oriented VR and virtual world solutions. Together with a team of talented individuals, we founded our bootstrapped startup, armed with a wealth of knowledge and experience in virtual world design, 3D design, and education.

We approached virtual reality applications from various angles, creating strategies to facilitate the transition of applications between the two realms. We initially decided to title our book ‘View from the Darkest Corner of the Metaverse’ because we utilize open-source tools that often go unnoticed in mainstream media. We also found it crucial to pause along our journey to connect the dots between various projects that seemed unrelated at first. This process was key in helping us see and understand how each part of our efforts was interconnected.

We hope that the stories we share in our book will inspire others on their journey to make the Metaverse a reality. Through our experiences and insights, we aim to give readers a better understanding of the potential of virtual reality and the steps needed to realize it.

The best days of the Metaverse will have arrived when it becomes obvious how virtual worlds are directly impacting the physical world (hopefully) in a positive way.



*Chapter cover 1 Reality divided: The Metaverse Mirage*

# 1. Introduction

## *Exploring the Metaverse*

Welcome to the intricate and multi-dimensional realm of the Metaverse. This digital landscape, still in its nascent stages, is teeming with unexplored complexities and infinite possibilities. Indeed, we are living in an epoch of rapid technological evolution, a period of unparalleled innovation in computing, virtual reality, and, most notably, artificial intelligence.

In the forthcoming chapters, we shall embark on a rigorous exploration of the Metaverse's various facets. We will probe its depths through diverse perspectives - the architect who designs it, the consumer who navigates its digital corridors, and the content producer who enriches it with their creations.

The advent of the Metaverse brings with it a wave of disruptions, impacting social constructs, cognitive processes, and physiological responses. Functionality within the Metaverse presents a delicate equilibrium between productivity and social interaction. This balance is further nuanced by the integration of artificial intelligence, particularly in the form of social and productivity tools and agents, which are gradually becoming integral cogs in the digital machinery of the Metaverse.

We shall also delve into the apparatus of content creation and consumption within the Metaverse, shedding light on the tools and techniques that facilitate these processes. Moreover, the importance of design theories and their relationship with cognitive dynamics will be analyzed, along with discussions on creative strategies within the digital landscape.

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Prepare yourself, then, for this intellectual voyage into the Metaverse. We stand at the threshold of a new reality, a reality that might just redefine the contours of human understanding and existence.

### **A simple way to view the Metaverse**

For this book, we use the term Metaverse in its most basic sense. Here, the reader can assume that the Metaverse consists of many virtual worlds linked and inhabited by avatars representing people.

However, from a very general perspective, the Metaverse can be viewed as a composition of virtual embodiments designed to illustrate both non-abstract concepts, such as a building and a vehicle, and abstract concepts, such as a molecule or a mind map, so that they can be explored, controlled, manipulated, and inhabited by humans through various digital representations, also known as avatars.

In this view, the Metaverse ultimately aspires to accelerate the expansion of human consciousness by reducing the boundless complexity of any domain of interest to simpler forms that humans can occupy and/or process because of the inherently limited cognitive capacity of the brain. This appears to be a promising approach for enabling humans to gain a deeper understanding of all that is.

The Metaverse may help humans explore their inner worlds as much as their outer worlds. In addition, it provides opportunities to construct new remote collaborative approaches or to build social connections between geographically separated individuals.

## 1. Introduction

The Metaverse ultimately aspires to accelerate the expansion of human consciousness by reducing the boundless complexity of any domain of interest to simpler forms that humans can occupy and/or process because of the inherently limited cognitive capacity of the brain.

Owing to advancements in technology, we now not only have the capability to create shared virtual realities and discuss their wide range of applications but are also able to build them in a very controlled and repeatable manner for the mass market. While it is evident that there is still a long road ahead, the Metaverse is likely to disrupt four areas concurrently: social, cognitive, physiological, and technological.

### **Potential transformations caused by the Metaverse**

#### ***Societal: Society's foundations will change***

Social, because the reexamination of deeply ingrained assumptions about self-identity, social connections, intimacy, work ethics, remuneration, and governance issues will lead to deep changes in attitudes and behaviors in real life.

#### ***Selectable or modifiable self-identity***

The idea that self-identity is malleable and replaceable is attractive to many. As we shall discover in this book, it will not be possible to alter our self-identity at the skin level but also at the level of cognition, as it becomes increasingly possible to delegate cognitively taxing tasks.

Using one's identity in a playful way is rooted in role-playing traditions in the arts as well as some religious rituals. Probably because these primitive concerns are typically thought of as



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off-topic by some Metaverse developers, these similarities rarely appear in Metaverse discussions. The only reason we choose to include this example is to explain the exploration of alternate versions of reality and transcending who we are deeply rooted in the human psyche and certainly is not a recent development.

The fact that self-identity can be reshaped and erased within compressed timelines in a controlled manner has attracted the attention of many researchers. This provides many opportunities to observe how one's sense of self changes in virtual experiences. As this understanding escapes into the 'real' world, we may become less vulnerable to the narratives we tell ourselves about who we really are.

This inevitably leads to feelings of being deeply connected with each other and the universe.

“Virtual reality is the ‘ultimate empathy machine’. These experiences are more than documentaries. They’re opportunities to walk a mile in someone else’s shoes.” - Chris Milk, American entrepreneur, innovator, director, and immersive artist.

Metaverse technologies have the potential to turn identity into an object that can be shared or sold. The implications can be frightening.

When it becomes possible for anyone to wear a celebrity's skin, or to look and behave like someone else, the nature of identity as an obvious means to differentiate between actors can become problematic. This will raise issues beyond the problem of verified identity, where we need to develop

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technologies that would create a counterpart to a user's DNA that could serve as a unique identifier.

### *A safe space to explore the self*

Virtual worlds provide a safe space for individuals to explore aspects of their identity and personality that they might normally keep hidden or be ashamed of. They can try on different personas and roles, experiment with different behaviors, and confront their fears and anxieties in a safe and controlled environment. This freedom to explore can lead to a deeper understanding of the self and what one wants out of life.

In addition to providing a safe space for personal exploration, virtual worlds also offer a way for individuals to encounter different cultures and environments without having to physically travel to those places. They can also explore dangerous or difficult situations without putting themselves in actual danger, leading to a more accurate representation of reality than the real world.

Furthermore, virtual worlds allow individuals to come away from their experiences with a more precise idea of what is real and what is not. Overall, virtual worlds offer individuals the opportunity to explore their deepest and darkest secrets, discover hidden talents, and come to a greater understanding of themselves and the world around them.

### *Distributed identity and delegation to twins*

It is becoming increasingly common for people to have multiple online identities, or avatars. In some cases, people have multiple concurrent avatars in a single virtual world.

This can be a good thing for several reasons. First, it allows people to delegate complex tasks. For example, if someone is

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running a business in a virtual world, they may have avatars that are responsible for different aspects of the business, such as customer service, accounting, and marketing. This allows the person to focus on the big picture and delegate complex tasks to others.

Second, it allows people to send instructions to a virtual non-player character (NPC). This can be helpful if the person is not available to do the task themselves. For example, if someone is running a business in a virtual world and they need to take a break, they can send instructions to their customer service avatar. This avatar can then take care of customer inquiries and problems.

Third, it allows people to have a humanoid-centric user interface. This can be helpful because it allows people to communicate with avatars in a more natural way. For example, if someone is trying to find a business in a virtual world, they can ask a human-like avatar for directions. This is more user-friendly than trying to figure out a complex map.

Overall, there are many advantages to being able to control multiple concurrent avatars in a virtual world. This can be a great way to delegate complex tasks, send instructions to NPCs, or have access to a more advanced form of productivity amplification.

Suffice to say that most currently are underestimating the social disruptions that a Metaverse could unleash.

### *Transcending geographic separation*

As governments begin to realize the potential impact of technologies that make geographic separation increasingly

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irrelevant, they will start paying more attention to the Metaverse.

Many laws and regulations targeting areas such as technology and technology transfer are typically confined to physical territorial borders. The fact that technologies can transcend them is of concern to the power brokers. Regulators realize that it is time to re-evaluate and update laws and regulations related to transactions across physical borders and that they may end up colliding with developers of free and open Metaverses.

Even within one physical geographic jurisdiction, as we begin embracing hybrid workplaces, where workers are allowed to work away from their normal work locations, new HR rules will have to be implemented. The work culture will also be under pressure to change. The boundaries between work and home life are increasingly blurred, and the line between work hours and personal time is becoming more fluid. These changes will require companies to re-evaluate and update their policies, procedures, and even their management styles to accommodate the new work reality.

As the Metaverse continues to evolve and grow, it is likely that these changes will only accelerate. With an increasing number of people spending more time in virtual worlds, new issues related to privacy, security, and ownership will need to be addressed. Governments and companies alike will need to adapt quickly to keep up with the changing landscape, or risk being left behind. As such, it is crucial that we begin thinking now about how to manage these changes, rather than waiting until they are upon us.

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### *Amplifying diversity and inclusivity*

Co-working in 3D worlds as avatars for significant periods convinced us that what we were doing in a virtual environment was not only cost-effective but also impactful. Such virtual environments can enable designers and service providers to collaborate efficiently across cultural, social, linguistic, geographical, governmental, and financial boundaries.

Based on our observations, we were convinced that these worlds have the natural ability to accelerate inclusivity by gracefully preventing and transcending stigmas while providing a more friendly workspace for neuroatypical labor.

|                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>These worlds have the natural ability to accelerate inclusivity by gracefully preventing and transcending stigmas while providing a more friendly workspace for neuroatypical labor.</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Our team is an excellent example of individuals from various countries collaborating in a virtual world, investing their own time and money while facing sometimes extreme challenges in creating products that are both beneficial to virtual and real worlds.

Age, health problems, caregiving obligations for chronically ill family members, and financial strain are among the many challenges that can limit the scope of the potential contributions of many who may be in these situations. Adding to this issue, population aging has become a global concern and the time to retire increasingly never comes for many.

Virtual worlds play a significant role in making such invisible and trapped talents and skills accessible. Aging can

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unfortunately also be accompanied by a higher frequency of cognitive or physical issues.

Virtual worlds can arguably be more easily designed to be accessible for people with both physical and cognitive disabilities. For example, Metaverses can be created with assistive technology features, such as speech recognition, to help those with mobility issues navigate the virtual environment.

In conclusion, virtual worlds have the potential to provide a solution to some of the challenges that limit individuals from contributing to society. As the world population continues to age, the importance of virtual worlds in enabling individuals to utilize their talents and skills, regardless of physical or cognitive limitations, will only increase.

### ***Cognitive: Impact on thinking habits***

#### *Pressures to evolve cognitive skills*

Cognitive, because most of us will initially resent the change to cognitive habits that may have served us well.

Adapting to practices that may be completely foreign does not always proceed smoothly. For example, spatial thinking is the ability to visualize and mentally manipulate objects and ideas in space. It involves understanding the relationships between objects and their relative positions, sizes, shapes, and orientations. Spatial thinking is often used in tasks such as navigation, problem-solving, 3D design and understanding diagrams or maps.

The use of spatial thinking when creating or finding relevant content may be controversial in terms of finding common

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design solutions that are likely to satisfy the needs of most people. Such problems are probably rooted in the various ways brains process the same information or in the various ways people accumulated their knowledge.

The identification of these friction areas will inform future research efforts. Some of our attempts have been presented in this book.

The use of spatial thinking when creating or finding relevant content may be controversial in terms of finding common design solutions that are likely to satisfy the needs of most people.

### *Detachment from reality risks*

The concern about detachment from reality is multifaceted, with potential implications at both a surface level and a more profound level. At a cosmetic level, the use of headsets for complete immersion in public places can lead to feelings of vulnerability, as users are often unaware of the physical environment around them. The lack of situational awareness about the world around them can create a sense of detachment, making users more susceptible to potential dangers or threats.

However, the deeper issue at hand involves the potential long-term impact of spending extended periods of time in virtual environments. It is widely understood that the human brain is wired to adapt to the environments in which it operates. As such, we must question whether the adaptation of the brain to virtual worlds, which are not necessarily an accurate reflection of the physical world, could lead to negative effects on the brain's fundamental functioning.

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This raises important questions about the balance between virtual and real-world experiences, and how we can ensure that our engagement with virtual environments does not come at the expense of our physical and emotional well-being. As the use of virtual environments becomes increasingly common in our daily lives, it is crucial that we continue to explore the potential risks and benefits associated with these experiences and develop strategies to ensure that they enhance, rather than detract from, our overall quality of life.

### *Bad design can erode cognitive function*

We are already aware of the impact of existing social computing technologies on fundamental cognitive abilities, such as the shrinking attention span problem and addiction to content targeting the primal brain and expect to see more research in this domain. Mental health costs will be a major concern for Metaverse users in the future. The unbridled appropriation of consumers' working memory by advertising companies empowered by social media corporations is concerning.

### ***Physiological impact: untold cost of new interaction paradigms***

#### *After tech neck and back, what's next?*

It is evident that the physical environment we design for ourselves has an impact on our health, and sometimes these designs have led to negative outcomes.

When one spends time interacting with a phone or computer screen for an extended period, prolonged sitting, and poor posture can be promoted, leading to many health issues. It is



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well known that many users experience discomfort after wearing head mounted displays for longer than 15 min.

People often experience discomfort in work environments caused by overheated wearable devices, eye strain, vertigo, headaches, and general musculoskeletal strain caused by maintaining an unbalanced body posture for extended periods. As immersive virtual worlds continue to develop, this problem is expected to become increasingly severe.

Even if the technical problems of HMDs with resolution and latency can be addressed, it is unlikely that those associated with the different stresses on the visual and balance systems will soon be resolved. Users of many productivity applications are expected to spend a considerable amount of time in the virtual world.

In addition to generating heat, heavy devices can also be tiring because discomfort compounds over time.

### *Cognitive disruption: Impact on Perception and Thought Processes*

There is still much technology to be disrupted before Metaverse hardware interfaces, which do not physically strain or harm the human body, become available. Recently, there has been much discussion of brain-computer interfaces and their potential to render wearable hardware user interfaces irrelevant. Currently, the state-of-the-art suggests that this goal may be far off.

## **Establishing Metaverse functionality**

Despite the immense effort and resources required to engineer disruption in a particular market, the prospect of having so

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many fields to disrupt simultaneously makes us wonder whether it is even possible to develop a Metaverse that would be acceptable to most.

As we move forward, we can only hope that solutions engineered in various sectors will eventually synergize to enable a Metaverse that empowers its users and serves most of their needs.

It is important to recognize that currently, our information space is divided into two distinct clusters separated by an apparently impenetrable barrier.

### *Productivity-centric applications cluster*

In the first cluster, we see applications very strong in their potential for utility (i.e., getting work with real-world impact done), but very weak in their potential for capturing, representing, and exchanging live and information-rich social cues.

One could argue that most applications in the first cluster tend to address the needs of the prefrontal cortex. These include word processing, graphics applications, spreadsheets, and Internet applications from video conferencing to social media platforms. Most of these applications are two-dimensional (2D) displays, and users are not required to be tethered to hardware user interfaces.

### *Social-centric applications cluster*

In the second cluster, which is much smaller than the other in terms of the diversity of applications, we see applications that appear weaker in utility but very strong in their potential for capturing, representing, and exchanging social cues.

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Currently, most applications of the second cluster catering to the primal brain are primarily designed for recreation. The second silo currently attracts simulation environments in narrow domains, multiuser games, virtual worlds, and remote-sex centric platforms.

Unfortunately, most applications require users to be tethered to hardware user interfaces. We will likely see applications migrating from one silo to another, as if by osmosis, because as individuals become aware of the strengths and weaknesses of each silo, they will begin to demand what appears to be missing.

We expect this tendency to create a more balanced world of digital information which will add value to our lives. In the future, users will be able to fine-tune the extent and depth of the collaborative functionalities of applications in ways like how we fine-tune game graphics to suit hardware availability.

Users will be able to fine-tune the extent and depth of the collaborative functionalities of applications in ways like how we fine-tune game graphics to suit hardware availability.

### ***The Metaverse: An obvious space to house embodiments of AI agents and their processes***

The rise of robots or humanoid agents in society has been a topic of debate for many years. Some believe they will eventually take over many jobs currently done by humans, while others believe that they will simply supplement humans in the workforce.

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However, there is one area where robots are already beginning to have a significant impact: social and productivity robots.

Social robots are designed to interact with humans in a social setting. They are typically used in settings such as elder care, childcare, or therapy. These robots can provide companionship, assistance with daily activities, and even emotional support.

Productivity robots, on the other hand, are designed to help humans with tasks such as manufacturing, construction, or logistics. These robots can perform repetitive or dangerous tasks, improving efficiency and reducing the risk of injury to human workers.

In the virtual world, social and productivity robots are beginning to make their presence felt as well. Avatars, or virtual representations of real-world people, are increasingly being used in online games and social networking sites. These avatars can be automated so that they can perform tasks on behalf of their human users. This can free up users to perform other tasks, or simply to enjoy their game or social networking site without having to worry about their avatar.

The rise of social and productivity robots in the real and virtual world is having a profound impact on society. These robots are changing the way we interact with each other and with our environment. They have the potential to automate many tasks currently done by humans, freeing up our time for leisure and other pursuits.

While productivity robots can improve efficiency and reduce the risk of injury, they may also lead to job displacement for humans. Social robots can provide much-needed companionship and support, but they may also raise ethical questions about the nature of human-robot relationships.

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In conclusion, the rise of social and productivity robots is a complex issue with far-reaching implications for society. It is important to continue exploring the potential benefits and risks of these robots and to ensure that they are used in a responsible and ethical manner.

### **Looking at the Metaverse from multiple perspectives**

#### *A builder's view of the Metaverse*

Media outlets often portray virtual environments from the perspective of individuals who mostly use them for entertainment such as gaming and social interactions (e.g., dating). We will break from tradition and present one perspective from an admittedly smaller community of users who spend more time creating these environments than consuming them. They can be referred to as virtual-world architects and builders.

Residents of virtual worlds from my generation have had their first taste of the Metaverse through games, or more accurately virtual worlds, like Activeworlds™, Minecraft™ and Second Life™. We were blown away when these platforms were introduced because they allowed users to create large-scale shared artifacts or living spaces in a world unconstrained by physical reality. This was no longer an abstract notion to be entertained anymore, it occurred.

Back then, we became aware of the challenges of virtual economies and their impact on real-world economies. Many people are drawn to virtual environments, as they like collaborating with like-minded individuals. Co-creation and

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community appear to be the heart and soul of the virtual world, respectively.

Our team has been creating virtual world experiences and applications for over a decade. Otherwise, our observations, insights, and findings can provide a more comprehensive picture of what is happening. In the best-case scenario, our research could serve as inspiration for putting resources into avenues that we believe show promise or for identifying potential dead ends to avoid.

### *A content consumer view of the Metaverse*

There are users who are satisfied with existing virtual worlds and have no interest in building in 3D. These users often view virtual environments purely as entertainment, like interactive TV shows. Their exposure to AAA games with clear storylines contributes to this view. However, there is also a group of users interested in building, but they tend to specialize in narrow niches.

Certain games allow users to build and test rockets, while other virtual worlds like Second Life™, OpenSimulator™, and Minecraft™ attract communities of builders. These communities are essential precursors to the Metaverse, a virtual reality space where users can interact with a computer-generated environment and other users in real-time. As technology continues to improve, the Metaverse is becoming an increasingly realistic possibility, and these early builders and communities are laying the groundwork for its development.

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### **Creating and consuming content in the Metaverse**

#### ***Focusing on end user content production***

In contrast to many of our colleagues, we have a different focus when it comes to virtual worlds. While others may see them primarily as entertainment or gaming venues, we are more interested in their social and productivity features. We do not view virtual worlds as a refuge or an escape, but rather as a tool that can help users solve real-world problems more efficiently.

To achieve this objective, we have developed our own infrastructure on top of the free open-source and decentralized Metaverse platform, OpenSimulator. This allows us to operate independently, with the assurance that we will retain control over how we share our intellectual property. We believe that the use of an open-source platform is consistent with the current belief that experts and users from a wide range of backgrounds and intellectual traditions will collaboratively develop the future web.

We are not convinced that the future web will be a product of the selection of corporate technology providers. Instead, we believe that a scalable, diverse, and resilient future web infrastructure is most likely to result from the contributions of an ecosystem of independent developers and users. These contributions can come from a wide range of sources, rather than just a few companies with enormous resources. By streamlining and accelerating user content production and consumption in virtual worlds, we hope to contribute to this vision of a more decentralized and collaborative future web.

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### ***Tools for content creation and consumption***

Designers should be encouraged to come up with controversial ideas that may fail, because many ideas fail for reasons that cannot be anticipated. The stories we share include both those with both positive and negative outcomes. Discovering the reasons for failure could lead to revolutions. Therefore, failure under controlled conditions provides learning and growth opportunities. Most importantly, failure stories should be deemed as informative and as valuable as success stories.

Designers should be encouraged to come up with controversial ideas that may fail because many ideas fail for reasons that cannot be anticipated. Publishing failures, particularly unanticipated ones, are of great value.

In many fields, ranging from architecture to human–computer interface design, architects and engineers have attempted to create design theories that would help accelerate the design process and shorten the time between ideation and the final product.

### **Design theories and strategies**

Several approaches can be used to guide Metaverse design processes. As veteran application designers for the Metaverse, we observed several approaches and practice patterns that emerged organically and appeared to be significant.

We organize our understanding under two umbrella theories: cognitive outsourcing and composition. Many designers instinctively achieve good designs without relying on design principles and theories. However, in our opinion, design



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theories that either explain or inform design can narrow the search space for effective solutions to design problems.

The ability to discover patterns in content and processes is a key skill of designers. This will help them construct design theories of their own or make it easier to share their lessons learned and recommendations with their peers in a very effective way. Discovering repetitive patterns of objects or events in Metaverse is a good first step toward motivating automation. This process can not only help simplify the user interface because there will be fewer control points required, but it will also free the working memory of content creators so that they can focus better on what they want.

Throughout this book, we examine and demonstrate the design of tools that we create to accelerate content production and consumption. We hope that readers will be motivated to create their own design theories or adopt ours when ideating how to advance their goals for the Metaverse. We intend to share our design journey without shying away from discussing deeper philosophical and theoretical foundations, while providing enough examples to guide new and upcoming Metaverse builders in coming up with their own design approaches.

To familiarize readers with the complexities surrounding the design challenges of the Metaverse, we have developed an informative infographic that highlights the numerous issues and associated disciplines involved, as well as their interconnections. In order to enhance understanding, we present a comprehensive list of definitions for key terms found within the infographic. Throughout the book, we strive to address and discuss these topics in depth, striking a balance between theoretical foundations and practical applications. By providing a wealth of real-world examples, we aim to bring the

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subject matter to life and facilitate a deeper understanding of the intricate Metaverse landscape.

Here are the main areas, as illustrated in Figure 1, to keep in mind, as we explore various Metaverse design trajectories:

### *Cognitive dynamics: exploring limits and opportunities*

- **Cognitive Constraints Determination:** Identifying the cognitive limitations and challenges that users may face within the Metaverse.

- **Native Cognitive Strengths Discovery:** Uncovering the inherent cognitive abilities and strengths that users can leverage for an enhanced Metaverse experience.

- **Cognitive Support Approaches:** Strategies and techniques for providing cognitive assistance, such as offloading or outsourcing tasks, to improve user experience and interaction within the Metaverse.

- **Cognitive Amplification:** Enhancing users' cognitive abilities and performance by leveraging technology and design within the Metaverse.

### *Design concerns: these could fuel research for years to come*

- **Abstraction in Design:** The use of simplified, minimalist visuals and elements to convey complex ideas and concepts within the Metaverse.

- **Multimedia Content Composition:** Creating and organizing diverse multimedia content, such as visuals, audio, and text, for effective communication and interaction within the Metaverse.

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- **Sensory Adaptation:** Designing applications that adjust or shift sensory information (e.g., visual, auditory, tactile) to match a user's unique perceptual abilities, ensuring accessibility and user-friendliness.
- **Mutual Emotional Responsiveness:** Facilitating a two-way emotional interaction between users and humanoid agents or interfaces, where both parties can recognize and react to each other's emotional cues.
- **Socially Enhanced Productivity:** Designing Metaverse applications that promote both social interactions and productive work, supporting collaboration and communication.

### *Creative strategies: enhancing process efficiency*

- **Optimized Creative Control:** Efficient management and organization of creative processes, including human-centered creativity and collaboration with AI systems.
- **Content Production Pipeline Efficiency:** Improving the production pipeline of content creation processes, focusing on streamlining workflows and enhancing productivity.
- **Content Composition Principles:** Fundamental guidelines and rules for constructing and organizing content effectively, enabling users to communicate content ideas and structures to the machine using a modular system.

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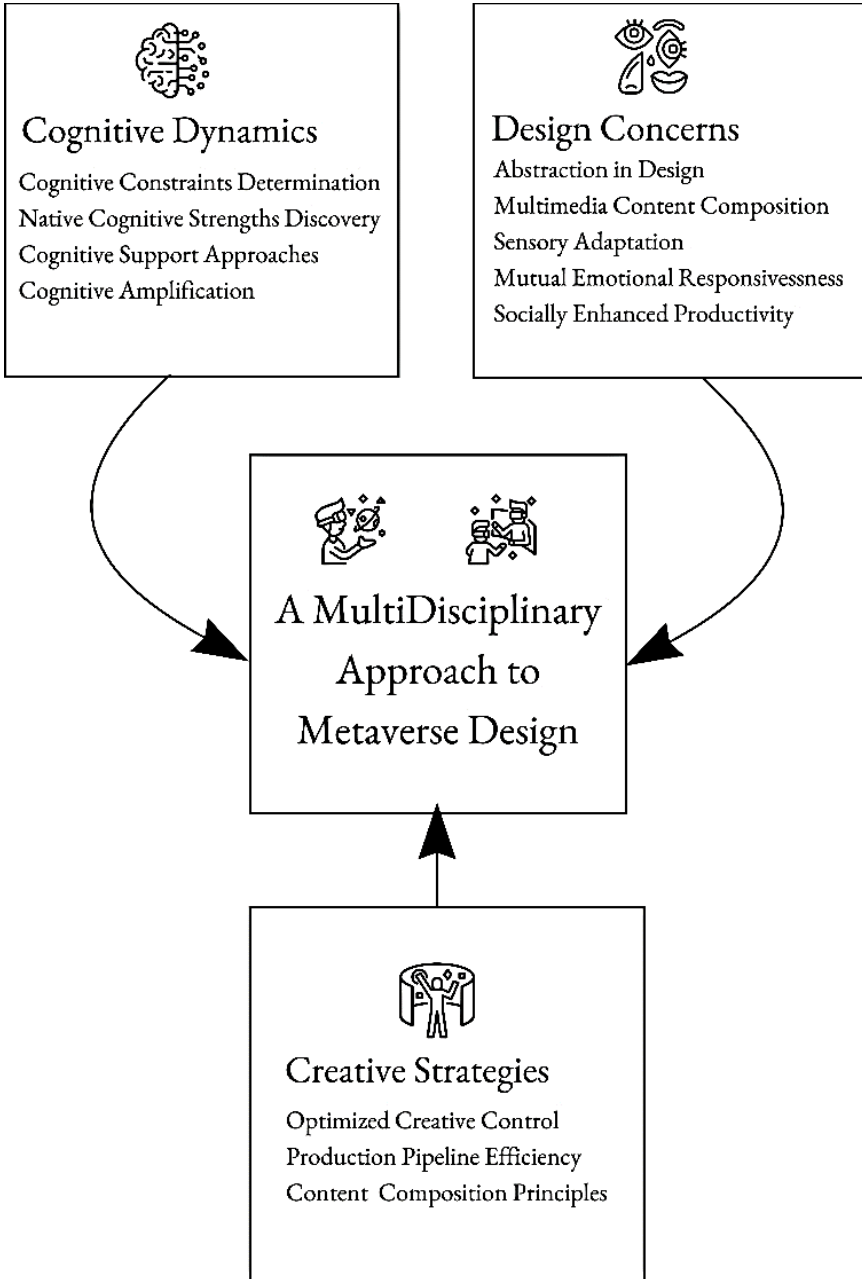


*Figure 1 A Multidisciplinary Approach to Advance Metaverse Design*

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### **Chapter summary and what's next**

Chapter one's exploration of the Metaverse presented a horizon teeming with possibilities and challenges – a new frontier that could redefine the social, cognitive, and physiological dimensions of human life. As we move forward, we are led to ponder the next step. How do we translate these abstract concepts into tangible realities? How do we tackle the issues and realize the benefits that come with this new virtual landscape?

Chapter two does just that, taking us from the theoretical terrain to the more practical aspects. It is a journey into the workings of the Metaverse, taking lessons from our current technological landscape, especially social media platforms, and their implications for our primal brain. It challenges us to rethink design approaches and to shift our focus from mere entertainment to enhancing productivity and collaboration.

Like venturing from a majestic overlook to a bustling marketplace, chapter two narrows our focus from the sprawling vista of the Metaverse to its core mechanisms, applications, and the issues it might raise – like the potential marginalization of remote workers, or the hurdles faced when transitioning from 2D to 3D. It argues for a more nuanced understanding of 3D visualizations, showing how less often can be more in creating an immersive, effective Metaverse.

With the promise of the Metaverse laid out before us, chapter two guides us down the path of pragmatism, looking closely at the obstacles that could trip us up and the opportunities that could propel us forward.



*Chapter cover 2 Digital Chains: The Addiction Paradox*

## **2. Challenging User Experience Design**

### *From clickbait to value-driven engagement*

#### **The Internet's future as a Metaverse?**

In 2021 and 2022, Wall Street showed a particularly strong interest in the Metaverse, more so than other sectors. However, even the most enthusiastic technology analysts struggled to coherently explain what it was exactly or what its potential uses would be.

Metaverse advocates tend to expect high-fidelity virtual representations and large numbers of participants in a common virtual space. However, when asked to clarify their expectations, specific use cases are seldom discussed.

The number of people who take a closer look at Metaverse fluctuates between viewing it as a niche market and viewing it as the future of the web.

#### ***Manufactured hype?***

During the 2021-2022 hype wave, veteran Metaverse creators, along with many others, have been intrigued by the stream of demos from the most prestigious companies. This is primarily because they have not taken the risk of presenting new potential use cases but chose to showcase demos that appeared like a light rehash of earlier work that were already presented a

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decade ago to illustrate potential uses of virtual environments in the field of education, healthcare and entertainment.

Even so, we should take comfort in the fact that some old ideas that failed to gain traction for various reasons, such as technological constraints, may get a second shot at success as a new generation of users or designers show interest in them.

Several leading social media companies are also experiencing market saturation. They are desperate to pivot, and the Metaverse seems to be an ideal next-frontier initiative.

Many from this crowd believe that the Metaverse is a new advertising and marketing platform. How a platform ends up being is determined by the primary underlying motivations that inevitably finds its way into the architecture of the system. Whether this is a good thing or bad remains to be determined.

### *Merging of application domains*

VR continues to be niched into dedicated simulations characterized by narrow but high-fidelity application domains, such as flight simulators for airlines and military or healthcare training applications. Can we envision a future in which such highly specialized VR applications will converge with social virtual worlds and become a part of the Metaverse? Currently, the goal of achieving a continuous homogeneous world that would accommodate every type of application appears to be quite challenging, and the computing resources needed would probably be an order of magnitude greater than they are today.



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### **Surely it could be much more than gaming!**

#### ***Innovating ways to work together***

So far, the most popular idea among developers and users is to use virtual worlds for entertainment and socialization. It is understandable why we mostly see incremental innovations around virtual concerts, quests, and sometimes museums rather than true breakthroughs.

Several blockbuster gaming environments have undergone frequent re-engineering to improve their social and collaborative aspects. However, the success of these modifications remains unclear. As it turns out, it is not possible to easily transform a story-driven game into a collaborative space that can be used for a far wider range of generic activities.

When developing a platform for deep collaboration, special attention must be paid to the lowest architectural layers. The implementation requirements for behaviors faced by the end user in virtual collaborative settings are often rooted in the deepest layers of the technology stack.

#### ***The great engagement confusion***

In recent years, there has been an increased focus on ‘engagement‘ as a key metric for success in the technology industry. Venture capitalists seem to value companies purely based on their so-called ‘traction‘, which is often a measure of how many hours users spend using their product. This has influenced designers to try and develop products that are aimed at being addictive, rather than empowering.

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Everyone seems to be interested in maximizing the engagement of their offering. There is a misunderstanding of what healthy engagement is, and many designers who have studied how addiction works design products that trap users in experiences long after they have stopped finding it enjoyable. Some game designers apply lessons learned from behavioral psychology, such as Skinner's box, to make games addictive. They understand that by changing the schedule of rewards or punishments, the addictive nature of a game can be amplified.

Engagement considerations alone do not necessarily lead to experiences that feel empowering. In fact, in most cases, the gamer feels spent, unfulfilled, and guilty about the time wasted on a game that, in retrospect, was not intrinsically fun in the first place. Unfortunately, this problem goes way beyond the gaming arena. When it comes to social media applications, design professionals often face the challenge of balancing engagement and empowerment.

On one hand, it is important to create an engaging experience that encourages users to return to the app and continue using it. On the other hand, it is also important to empower users by giving them the tools they need to interact with the app in a meaningful way. There are a few key reasons why engagement appears favored over empowerment in social media applications. First, engagement is relatively easy to measure. Empowerment, on the other hand, is more difficult to quantify. Second, designing for engagement is often less resource-intensive than designing for empowerment. This is because engagement can be achieved through simple tricks, such as notifications and likes, while empowerment requires a more thoughtful approach.

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When designing social media applications, it is important to consider the potential risks of creating a platform that encourages engagement at the expense of empowerment. While increased clickbaiting to motivate engagement can lead to more users and more opportunities for monetization, it can also create negative outcomes such as echo chambers, filter bubbles, and addiction.

### **Clickbait**

*Type:* Noun

*Definition:* A form of online content that exploits the human brain's instinct for curiosity by using provocative text or images, with the aim of eliciting reactions but often failing to provide substantive information or experience.

Echo chambers are created when users only see content that confirms their existing beliefs. This can lead to a reinforcement of false information and confirmation bias. Filter bubbles are similar in that they also show users content that is tailored to their interests, but the content is not necessarily accurate or representative of all viewpoints. This can create a distorted view of the world and the people in it. Addiction is another potential peril of social media engagement.

When users are constantly checking for new content and notifications, they can become addicted to the dopamine hit that comes with it. This can lead to decreased productivity, mental health problems, and even physical health problems. It is important to consider these potential risks when designing social media applications.

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While it is possible to create a platform that encourages both engagement and empowerment, it is important to strike a balance. Too much engagement can lead to negative outcomes, but too little engagement can also be detrimental. By finding the right balance, social media applications can be designed in a way that encourages healthy user behavior.

Designing to satisfy online interaction's most addictive aspects is an old-school way to create a steady flow of returns, while making sure users do not feel lost and unguided in a virtual space. Thus, success in this domain usually involves reaching out to a large base of consumers who expect instant gratification, either by reflexively eliminating obstacles or peer competitors or by engaging players in quests where they get to gather artificially and reliably scarce commodities, through blockchain technologies, to be traded later for money or power. Among the key aspects of these types of environments is that the footprint that comes with deep user content creation is bypassed thereby allowing them to be very fast and responsive.

In our opinion, we will never be able to realize the dream of making the Metaverse the future of the Internet so long as we rely on such entertainment-centric views of the Metaverse.

We will never be able to realize the dream of making the Metaverse the future of the Internet if we rely on such entertainment-centric views of the Metaverse.

One approach to making social media platforms successful is by eliminating the need for advanced content production and incentivizing content that appeals to the primal brain. This can create a space where many users feel entertained and in control of their social media experience. However, many of these users

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may eventually regret spending their time on content that has limited value to them.

Participating in this addiction can consume valuable cognitive resources that could have been used for other personal pursuits. As a result, social media addiction can have a negative impact on consumer well-being and productivity. While this strategy may benefit social platform owners and businesses, it is not always in the best interest of consumers.

### ***Unethical growth strategy: cultivating addiction***

There is a growing consensus that consumer-generated content is essential for the success of virtual world technology in supporting the next generation of the Internet. Game and virtual world developers are increasingly exploring the use of these environments for applications beyond computer games to expand their total addressable market (TAM).

However, a paradigm shift in design approach is required, moving away from catering to the predictably addictive entertainment and towards improving collaboration and productivity. Many researchers have proposed gamification (Hunter, 2015) to motivate productivity, but past attempts have failed due to the distraction caused by adding an extra layer of reward dispensing mechanisms to motivate individuals to accomplish tasks more enthusiastically.

To generate engagement and monetization, we must transcend the instant gratification approach and find new ways to improve productivity while avoiding distraction.

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### **Abundance of applications fit for the Metaverse**

Metaverse low-hanging fruits are problems that can be solved here and now on very short notice.

#### ***Show and tell opportunities***

When developing applications for the Metaverse, our primary focus is on creating a collaborative environment that is both social and productive. A critical aspect of group work is the ability to display what one wants or is allowed to display. In the virtual world, achieving this goal may be easier than with traditional desktop and multiuser tools.

The conventional practice of having users park their avatars in virtual chairs to watch a slideshow or park their dancing avatars in a virtual club to socialize is unlikely to be the ultimate use of 3D virtual worlds. In a future section, we will provide examples of advanced show-and-tell scenarios.

The usual practice of letting users park their avatar on a virtual chair to watch a slideshow presentation or letting users park a dancing avatar in a virtual club to socialize is unlikely to be the ultimate utility of 3D virtual worlds.

#### ***Expanding social information bandwidth***

There is much more bandwidth available for collaborative communication in the real world than when using multiuser applications on a 2D virtual desktop. Collaborating with a coworker across a desk or around a water cooler in the real world can be much more engaging than seeing each other as green dots in an instant messaging application.

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In research literature from the late 2000s, the importance of peer awareness, both gaze and gesture, in collaborative spaces has been regularly emphasized. Trying to capture such information to represent them meaningfully in 2D spaces is fraught with fundamental problems that cannot be solved (Ramloll, 2001).

By representing people as humanoid avatars, it is only natural to display their activities and emotional states using familiar gestures and facial expressions. Thus, the humanoid form can be viewed as a rich information display, and most humans do not require training to decode facial expressions or gestures.

Owing to human evolution for thousands of years, it is not necessary to create and learn a new social language to support deep collaboration when humans are represented as 3d avatars in a virtual world. Otherwise, in 2D environments, new social languages must be recreated to represent the type of social information we are familiar with in 3D worlds.

Architects who attempt to achieve this in a 2D environment, using animated icons and spatial sound, for example, soon find out how rapidly users become overloaded with symbolic information that they cannot decode quickly and painlessly in real time.

### *Avoiding physical world costs*

At first glance, 3D virtual workplaces appear to be more affordable than real ones. No buildings need to be rented or purchased, and workers do not have to travel. Space constraints cease to exist when the space to be occupied becomes decoupled from physical reality.

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However, this is not a significant enough advantage to encourage people to work in virtual worlds under normal real-world conditions. Although a pandemic, such as the Covid-19 pandemic, can push people into this environment, it should not be viewed as a permanent catalyst, but as a temporary one.

### *Amplifying cognition*

There are clear advantages to working in non-immersive 3D-spaces even if they are rendered on a familiar 2D desktop environment. We expect many designers to try to leverage this affordance to make remote workplaces significantly better in the 3D world.

With its natural affordance as a memory palace (Peeters, 2019), 3D space is better for locating and searching things. For example, a 3D version control system would allow users to view inventories in a 3D space.

In addition, users can experience sharing of the same virtual space through their 3d avatars. One major advantage of this approach is that it does not require the user to wear a hardware user interface for extended periods.

We explore this topic in later chapters of this book.

## **Metaverse outstanding challenges**

### *Marginalization of remote workers*

As designers, we aim to bring people closer together through virtual spaces, but often end up driving them apart. The polarization and fragmentation of online communities can be traced back to the technological choices we make, both consciously and unconsciously.



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One of the most notorious culprits is social media algorithms, which prioritize provocation over genuine engagement. Only recently has the power of these algorithms to shape society and behavior been acknowledged.

However, we should also pay attention to seemingly innocent design choices, particularly in user interfaces, that have a significant impact on weakening social connections between individuals in virtual spaces.

Designers often set out to create virtual spaces to connect people across geographic separation, only to find that they are driving them further apart as human beings. It seems that there is a natural tendency for virtual channels of communication between individuals to turn into barriers of separation between tribes with amplified voices. How can this trend be reversed?

Social bonds between colocated workers and their peers, as well as their employers in the real world, were observed to be stronger than those between remote workers. Compared to remote workers who are based at the employer's designated office, social distancing appears to reduce the influence of remote workers on their physical work environments or general work processes.

It is conceivable that this may be because remote workers do not have a sustained or permanent presence in a shared physical work environment. Their contributions are sometimes assumed to be less significant because of their invisibility in a shared physical office environment.

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### ***Building utilitarian worlds is hard***

Open floor offices were once a popular workspace design for big corporations because they believed that increased visibility of peers would encourage collaboration. However, many people were not surprised when this trend shifted.

One primary concern of remote work opponents is the lack of social information exchanges that occur naturally in the real world, which cannot be replicated in virtual environments. This problem has negative effects on creativity, connections between team members, and productivity.

Creators of virtual worlds struggle to design 3D virtual worlds that have a direct real-world impact. Examples include a 3D world that enhances the end user's productivity in the real world or one that anticipates the cognitive limitations of users and is cleverly designed to bypass them.

Designing a virtual world with a broad utility that directly meets physical or real-world needs is more challenging than creating a shooter, racing game, or plot-based virtual world.

A plot-based virtual world is significantly easier to construct than a virtual world with a broad utility that directly meets physical or real-world needs.

### ***Bending laws of physics without confusing users***

Changing the laws of physics will not benefit a Metaverse much if cognitive limitations and conditioning cannot be changed. Virtual spaces offer higher degrees of freedom but do not always translate to higher levels of freedom experienced. Creating a reality-replacing Metaverse that people will love is

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complicated by technical problems and people assuming they can automatically take advantage of the extra degrees of freedom. However, people often struggle with basic tasks like camera control or movement in a virtual world while focusing on a task. And in situations where physical laws are altered, users can feel lost or confused, eroding their immersion.

While virtual worlds offer a lot of freedom, cognitive abilities can limit us when system constraints are relaxed. For example, it may be acceptable for avatars to fly or teleport, but changing how light or sound propagates can result in incomprehensible worlds.

There is not much correlation between higher degrees of freedom provided by a virtual space and higher levels of freedom experienced.

### *Less is often more*

Over the course of decades, researchers have found that, in most cases, assuming a 3D data visualization will provide more value than a set of 2D visualizations is probably a mistake. Numerous occlusion-related issues can obscure or distort the relationships between variables. It is vital to remember that every design that appears to be a good fit for a 3D space requires rigorous testing with a target audience.

### *2D to 3D migration struggles*

In the 3D Metaverse, the applications could either be redesigned from scratch so that they appear as some new mind-blowing 3D versions of themselves, or they can stay in their current state and remain on a 2D plane.

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No designer, we believe, will relish the thought of redesigning a word processor as a 3D application or even reforming a drawing application into its 3D version. However, we have already seen design attempts to create music-sequencing applications in immersive 3D environments. There is still some question as to whether the added dimension makes it easier to accomplish relevant tasks than in the traditional 2D versions of the application.

Any small friction in the user interface will compound, resulting in poor overall user experience. For example, the camera control problem does not arise in 2D desktop metaphors; however, in immersive 3D or desktop 3-D worlds, control of the camera during intricate tasks makes it more difficult to complete.

Using simple examples, the following section illustrates our design philosophy for enhancing the utility of virtual environments. Our experience in this domain has strengthened our conviction of never giving up the search for more efficient end-user content creation, in addition to finding new ways to empower users in virtual worlds so that their activities can more effectively influence the real world.

Current desktop applications must migrate to the Metaverse if it is to compete with the World Wide Web. Although virtual worlds can become more collaborative with the migration, it is impossible to predict the final form factor of these applications without conducting an experiment. Let us look back at the 2D desktop GUI that we are all familiar with, but with a perspective informed by what we now know is possible in 3D spaces.

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Current desktop applications must migrate effectively to the Metaverse if it is to stand a chance of competing with the World Wide Web.

### *Stickiness of the 2D desktop GUI*

Many believe that virtual worlds are virtual sandboxes or welcome refugees from the real world. This is not a generic characteristic of virtual environments; it depends on how they are designed and for what purpose.

In the case of a desktop graphics user interface, one could easily argue that we already spend a lot of time in virtual 2D environments that have a direct real-world impact. In addition, even if a virtual world is designed to be a refuge and a self-contained environment, the user will always have both feet in the real world, and once done with their virtual adventure, will certainly carry a memory of the virtual experience into the real world.

Application designers often move applications between domains characterized by their dimensions. Let us examine this migration history through the eyes of a designer deeply ensconced in a 3D virtual reality worldview.

Common command line interfaces can be thought of as the 1D version of user interfaces, in that they are linear and have implicit logical ordering for commands to execute. It is also noteworthy that 2D display technologies have been improving, making it possible to migrate some aspects of the 1D user interface to 2D. Graphical user interfaces are an excellent example of this.

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The familiar world of 3D objects, such as the desk, and the tools on it, such as the calendar, calculator, and clock, can be thought of as having been migrated to a 2D interface that we have been calling the virtual desktop for half a century. The move from 3D real to 2D virtual was arguably the biggest leap forward in virtualization in history.

The user camera can be easily navigated around this 2D space with a mouse by clicking on 2D UI elements and scrolling. Users can interact with objects via mouse clicking and/or dragging. The mouse cursor is perfectly adequate as an avatar representation of the user. The right-hand is especially important for representation. Even today, the default cursor points to the upper left corner of the screen.

With 2D virtualization, one also obtains an untethered virtual experience, which is not true for 3D virtualization. This virtualization effort was designed to increase productivity and has proven to be very successful in this regard.

With the advent of touch screens, the cursor has become a vestigial representation that has to be removed. It perfectly complies with the perspective that if an environment is not designed for concurrent use by several users, it is pointless to represent the user in it.

*Why change if not broken?*

There is a strong argument that the transition from desktops to 3D is unlikely because most productivity applications do just fine through the 2D desktop metaphor. Even so, as previously discussed, capturing, and representing awareness information in a 2D setting can be very challenging, as opposed to when the performers are in a 3D shared environment.

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This is because our brain is well trained to read gazes, gestures, and emotional responses from others. However, although this design works well in single-user settings, it has many limitations when viewed in terms of multiple user or group settings. Humans have had about 300,000 years to perfect their face processing skills and are able to use this information ubiquitously and informally in 3D interactions with peers.

During group activities, awareness of peer gaze, facial expressions, mood, and micro and macro-body gestures is crucial. Brains have evolved to be able to produce this information and consume it efficiently and effortlessly in 3D space. Thus far, there has been no success in capturing this rich and wide spectrum of emotional and gestural information in 2D where user representations are omitted. In fact, current wisdom holds that this goal cannot be achieved without representing users in a virtual world in 3D.

### **Closing thoughts**

Most arguments against remote work center around the fact that the social aspects of teamwork suffer greatly. It is not possible to virtualize and access the social clues that are crucial in social interactions. When team members do not share a common physical space, they become unfocused and easily distracted. This is deemed true even if video conferencing is used.

As we have witnessed the struggles and potential of transitioning social media platforms and other applications from the 2D desktop environment into the 3D space of the Metaverse, it is becoming clear that the challenges we face are not merely technical, but also conceptual. After all, the 2D desktop environment was successful because it significantly

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improved productivity, despite its limitations in capturing social information. While 3D environments have the potential to better capture and represent social information through avatars, they present new challenges in terms of user interface and the experience of ‘being’ in such spaces.

However, the shift from 2D to 3D is not just about translating existing platforms and applications, but also about redefining the balance between content consumers and content creators. As we delve into the next chapter, we must ask ourselves: In this new 3D world, who will create the content that populates it? How can we optimize the content creation process to support not just professional developers, but also everyday users and subject matter experts? Can AI play a role in assisting these new creators in their journey? As we’ll see, the answers to these questions could redefine our relationship with virtual spaces and the Metaverse.





*Chapter cover 3 Innate Architects: The Human Creative Urge*

### 3. Creativity for All

#### *Content creation, a basic human right!*

People typically dislike being boxed into content consumer only roles. Currently, we estimate that for every content producer, we have around 10 content consumers. This is true for social multimedia content and virtual worlds that allow users to create 3d content.

A growing number of automated content production tools will change this situation. Tools that facilitate or automate content production for end users currently do not generate content that strictly satisfies content design requests.

Too often, end users will settle for what an AI content production application creates, for example, simply because the results are coherent, even if they somewhat diverge from what end users originally wanted. We need to find a way to balance the cohesion of what is generated by an AI system with the amount of control that the end user expects.

#### **Lack of support for subject matter experts**

Creating 3D experiences to facilitate teaching, explaining, and testing a given subject is difficult for teachers. Most would prefer to limit their tools to editable slides to be displayed in front of an audience of avatars that their owners have typically parked on virtual seats. Many real-world observers in this case may find it odd why such rituals are necessary only to listen to a speaker running through a slide presentation.

Creating 3D platforms to facilitate content creation by subject matter experts is as difficult as creating a 3D visual-

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programming language. There are not many successful trajectories to describe on that front; therefore, there are many opportunities and room for progress here.

Many teachers find it challenging to construct 3D immersive environments to effectively illustrate abstract concepts or to support their courses. This is not a criticism of teachers' abilities; rather, it is acknowledged that there are a wide variety of opinions regarding the best methods of compressing and transmitting knowledge.

It remains to be seen whether we need specialist courses to encourage or to demonstrate to teachers how to translate their linear teaching paradigms to exploratory ones. Linear teaching paradigms put teachers front and center as the source of knowledge that needs to be absorbed by students. With exploratory immersive learning approaches, both teachers and students share a common learning experience. In the first case, the cost of instruction, both in terms of needed technology and preparation time, is typically much less than in the second case.

To reduce the costs associated with immersive teaching, we have implemented tools that allow subject matter experts, for example, to create museums, treasure hunts, quests, shareable virtual locations of real-world locations, and subject matter-specific training simulations on the fly in virtual worlds. These tools will be described in the next chapter. We introduce this topic here to encourage teachers to start thinking about how they would implement immersive learning in their practice.

Transforming text into a 3D representation is a novel concept with a variety of potential applications. For instance, a CV or biography can be transformed into a virtual museum exhibit by parsing the text and using it to specify the 3D content. This

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idea of using language to describe 3D environments is not new and has been implemented in the past using languages like VRML, which translates descriptive text into an actual 3D place.

#### **The end user content creation process**

User content creation is one of the most challenging and misunderstood concepts in virtual-world design. It may be considered too self-evident and paradoxically too complex to be deconstructed meaningfully.

Currently, there is no general theoretical framework for describing user-generated content, and there appears to be little interest in developing one. But since any process that can be accurately described is more likely to be optimized or improved, we must at least attempt to examine content creation from a theoretical standpoint.

There is currently no general theoretical framework for describing user-generated content and there appears to be little interest in developing one.

A theoretical framework would probably emerge as designers carefully monitor how end users craft content and attempt to automate the process. A standard approach involves identifying steps in content production processes that are often repeated and reducing them into a single one.

#### **Streamlining content production**

These problems are often encountered by designers in practice. A trivial example, just for illustration, is the creation of natural landscapes. In this scenario, trees, stones, and terrain can be

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manually adjusted in terms of orientation and size, after they have been introduced into a virtual world, to avoid scenes with trees and stones that look unreal because they are all in exactly the same orientation and size.

The process of deploying content in this manner is time consuming and tedious. Automatically randomizing sizes and orientations of these landscape objects lead to the generation of a more organic looking landscape. Various small improvements, such as in this trivial example, significantly reduce content creation fatigue.

Using this strategy of condensing repeated patterns into a single step may also help balance the user control and automation. When this simple approach is applied to as many tasks as end users need to complete to reach their goals, content production efficiencies can be achieved quickly.

Sometimes, it is possible to create tools to streamline content creation directly without automation but through better application design choices.

Using our system, to be described in further detail in subsequent chapters, for example, we reduced the amount of camera motion required in the virtual world to deploy content. Moving the camera over long distances to find the target placement locations is time consuming and slows content deployment.

By placing the corresponding icons on a board in a virtual room, users can deploy objects, buildings, flora, fauna, and NPCs over large-scale terrains. This simplification resulted in significant efficiency gains regarding the deployment of content in large-scale virtual worlds by users, who were not

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modelers or programmers. This design is explained in detail in a later chapter.

The concept of task granularity is important for designers to build tools to accelerate user-content creation. It can be said that the granularity of a task is of order  $N$  if it requires  $N$  steps to be completed.

## Accelerating content production

### *Task granularity*

The concept of task granularity is important for designers to build tools to accelerate user-content creation. It can be said that the granularity of a task is of order  $N$  if it requires  $N$  steps to be completed. Tasks of the lowest granularity are of order 1, that is, they require a single step to complete. Automation tends to decrease the granularity of tasks.

End users lose control when the granularity decreases, but the tasks are completed faster. This may provide them with the opportunity to focus more on their primary goal.

### *Creating large scale content rapidly: e.g., a virtual 3D town*

When constructing a virtual town for a class, a teacher may have access to a grid of roads that they can first deploy on an empty plot of 3D virtual land. In the next step, they can place a city block, which is a randomly generated set of floras and buildings.

It takes 16 steps to create the town if there are 16 blocks to build. Therefore, the granularity of this town-building task is 16.

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However, if we automate the creation of the town in one step, we reduce the task granularity to one.

#### *Hunting for optimal granularity*

The same approach can be applied to a wide range of use cases, from deploying exhibit space in a virtual museum to deploying seating arrangements for large virtual conferences.

The optimal level of granularity for a content production task depends on the expertise of the end users or the amount of cognitive bandwidth that they can commit to this task.

When discussing content production automation, either procedurally or with the aid of artificial intelligence, it is helpful to keep in mind the desired granularity of relevant tasks to be better prepared to address any problems that result from over-automation.

### **Avatar embodiment customization**

#### *Embellishing identity*

Crafting user representations is often overlooked as a critical component in user-facing content creation. It is our experience that end users tend to search for ways to quickly establish an identity after logging into the virtual environment, either by customizing their avatars or acquiring objects that would make them stand out.

Using AI techniques, avatars can now be generated from a single image. Naturally, this opens more questions concerning identity and ownership, as it is becoming increasingly easier to create representations of celebrities using deep fake technologies or avatars based on their images.

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#### *Capturing and representing live social data*

Another crucial aspect of the equation is to provide tools that allow users to capture and map their facial expressions in real-time.

In most cases, users seem to prefer controlling their avatar's emotional responses manually, only if it does not result in an undue cognitive burden over time. For example, pushing keyboard buttons or clicking on menus to animate your avatar quickly becomes a chore and is quickly abandoned.

In our experience, it is best for the user to generate face animations or body gestures as automatically as possible. Efforts to improve the process of creating satisfactory avatars for end users are underway and typically involve face and body tracking technologies.

This problem becomes more challenging in non-immersive 3D virtual environments where the user is comfortably sitting while their avatar is standing in the virtual world.

#### **Fidelity: sensory, physical and social**

Fidelity is another concept that is difficult to understand. It can be assumed that fidelity describes the degree to which a virtual object or behavior is like its corresponding real-world counterpart. It has long been assumed that higher fidelity, in this sense, will automatically lead to greater immersion and engagement.

However, it appears that this is not the case. The stickiness and allure of blocky virtual worlds, such as Minecraft and Roblox, has shown that fidelity in this narrow sense is less important for increasing engagement.



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The current lack of discussion around social fidelity is concerning. We hope to fill this gap in later chapters.

#### ***Our multi-sensory system to access the world***

The concept of fidelity can be explored from a sensory perspective, such as visual, auditory, or haptic. Simulating the physics of the visual, auditory, and haptic domains is certainly one way to approach fidelity.

In any case, we are quite far from virtual touch or smell at this point, so we will not discuss them. It does appear that we are not at liberty to stray far from the physical behaviors we experience in the real world.

#### ***Optimized 3d content for immersive worlds***

Response time is probably the biggest factor when it comes to raising the immersivity of virtual content. When creating VR content, special attention must be paid to prevent overloading or slowing down the VR environment.

|                                                                                                           |
|-----------------------------------------------------------------------------------------------------------|
| Response time is probably the biggest factor when it comes to raising the immersivity of virtual content. |
|-----------------------------------------------------------------------------------------------------------|

It is challenging for content creators to create content that satisfies both aesthetic and functional requirements while utilizing minimal resources. Achieving this is very challenging especially for non-professional 3d modelers.

One approach to deal with this issue is to design content composition tools that allow users to compose complex environments from optimized simpler parts. We will

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demonstrate this approach by referring to our very own content composition platform, RezMela.

#### *3D spatial audio*

Virtual worlds are becoming increasingly popular as a means of entertainment, education, and even business. As the technology continues to develop, so too do the possibilities for how these virtual worlds can be used. One area that is particularly important in virtual worlds is the design of the soundscape.

The soundscape of a virtual world can have a significant impact on the user experience. Good sound design can make a world more immersive, while bad sound design can make it feel jarring and artificial. One of the key elements of sound design is 3D spatial audio.

3D spatial audio is the process of creating audio that sounds like it is coming from specific locations in three-dimensional space. This can be done using a variety of different techniques, such as binaural recording, sound propagation, and head-related transfer functions (HRTFs).

Binaural recording is a technique that uses two microphones to capture sound from different directions. This allows the sound to be reproduced with more realism, as it captures the way that sound waves interact with the human head and ears.

Sound propagation is the process of simulating how sound waves travel through the environment. This can be used to create realistic echoes and reverberation.

HRTFs are a set of algorithms that are used to simulate how sound is heard by a human listener. This includes factors such

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as the shape of the head and the size of the ears. HRTFs are often used in virtual reality headsets to create a more immersive experience.

The use of 3D spatial audio can make a virtual world feel more realistic and immersive. It can also be used to create a sense of place and atmosphere. In some cases, it can even be used to guide the user through the world.

Soundscape design is a relatively new field, and there is still much to learn about how to create effective soundscapes. However, the use of 3D spatial audio is a promising start, and it is likely that we will see more and more use of this technology in the future.

#### *A Note on Haptics: Virtual Touch*

In our exploration of creativity within the virtual landscape, we must consider the vast array of tools at our disposal. Beyond the realm of the visual and auditory, another frontier quietly beckons: haptics, or ‘virtual touch’. This facet of digital content creation, while still in its infancy, presents a fascinating avenue for human creativity to traverse and transform.

Haptic technology represents a bold new frontier of virtual interaction, wherein the sense of touch is recreated by applying forces, vibrations, or motions to the user. This technology has the potential to expand our creative boundaries, to make the virtual world feel as real as the physical one, allowing us to engage with digital content in an entirely new and immersive way.

A pivotal aspect of haptics, as it currently stands, is kinesthetic feedback. The principle is akin to a person using a cane to sense their environment, replacing the cane with the

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technology at hand. This sense of spatial awareness and touch gives us the ability to feel and interact with our digital creations in a much more tangible and direct way. This type of touch feedback has already borne fruit, in the form of virtual graphs, which allow visually challenged individuals to ‘feel’ data and comprehend it in an entirely new dimension.

Nevertheless, the development of cutaneous feedback - the detailed, tactile interaction with objects that includes texture, pressure, and temperature - remains a complex challenge. It is akin to the difference between knowing an object is there, and understanding what the object feels like to the touch.

This note on haptics is simply to illuminate another area of the virtual landscape where creativity can, and is beginning to, flourish. While we have yet to fully realize the potential of haptic technology, the early iterations and the ongoing research into this field underscore the immense possibilities that lie ahead.

In the broad canvas of virtual creativity, haptic technology is an intriguing element that is set to redefine our experiences. Even as we marvel at the richness of audio-visual content, let us not overlook the sense of touch, and how it can add another dimension to our digital encounters. We will delve into this fascinating world in more depth later in our journey. Until then, let this serve as an introduction to the vast potential of haptics, a promising domain where technology and creativity meet to push the boundaries of our sensory experiences.

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## **Supporting end user content creation is hard**

### *External vs In-world content creation tools*

If content creation is separated from in-world experiences, the platform's potential for growth into the future Internet seems to be reduced. Several AAA game companies have attempted to convert game-level editors into content creation platforms for end users. While this effort has resulted in some educational environments, none seems to have taken hold. Using external tools may be better suited for allowing experts to create content, but this also robs end users of content creation opportunities. This leads one to ponder whether it is possible for a virtual world optimized for a particular game to evolve into the Internet of the future.

### *Designing building tools from ground up*

Platforms designed to include user content creation have proven to be more successful in opening up a range of new possible application domains. Many of these platforms are currently being used by educators to meet each other and share content, but none of them are emerging as generic platforms that could potentially replace the Internet of tomorrow.

### *Limited end user content creation opportunities*

The challenge here is that maintaining content creation in the world places a lot of strain on limited resources, which even impacts immersion and usability. At the same time, companies are incentivized to make their platforms available through thin clients so that they can be accessed easily through a web browser or smartphone. Providing deep content creation tools within the virtual world but via a browser or smartphone designed to have limited access to resources, often for security

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reasons, is therefore very challenging, given the current ecosystem of technologies.

#### ***The web browser as a gateway to the Metaverse***

Every major industry contender in virtual reality started out with tools that could only be accessed through a powerful computer or console, but no matter how hard they tried to make their tools and worlds available via a browser, they never succeeded without having to cut down core functions, such as world building. Video streaming console experiences through web browsers have been attempted successfully to bypass browser limitations, but these services are very costly.

#### ***Mobile access to the Metaverse***

Content creation in three-dimensional virtual worlds often negatively impacts the experience of users because it slows the platform's overall performance, which affects the frame rate and immersion. In addition, the creation of content may make a virtual world unsuitable for access through most popular end-user devices and smartphones with limited screen real estate. One can imagine bypassing these limitations by making content available through an HMD connected to the phone; however, we must deal with the HMD issues that we discuss in a forthcoming section.

#### ***Unnecessary barrier between creators and consumers***

In the past, solutions to this tension were either to keep building tools outside of the shared virtual world or to create a viewer version of the shared virtual world. As a result, there is an artificial technological barrier that separates content creators from consumers. This wall negatively impacts communication between creators and consumers, which usually results in

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suboptimal products resulting from an extended path between ideas and products. Because of this segregation, collaboration is the first casualty, which justifies the cost of optimizing the use of limited distributed computing resources.

Providing deep virtual content creation tools in-world through a desktop Internet browser or a smartphone poses challenges given current technologies. The limited screen real estate of smartphones makes advanced content creation difficult.

However, a smartphone can serve as a window into a 3D visual world when used as a head-mounted display. In this case, the smartphone acts as a heads-up display, or HUD, providing a conduit from the physical world into an immersive virtual environment. This enables natural user interfaces within the 3D world for robust content creation that would otherwise be difficult on a smartphone alone. The smartphone as HUD paradigm bridges the gap between the physical and virtual, transforming the smartphone into a viewport rather than a creation tool itself.

Providing deep virtual world content creation tools via a desktop Internet browser or a smartphone poses challenges given current technologies.

### **Future of content production is bright**

We are at the cusp of revolution in user-generated content production. For too long, the opportunity for end users to create content was restricted to writing, speaking, photography, and video recording. Now, they will have access to tools that will allow them to create content with similar efficiency as professionals. It is certainly going to be very interesting to observe how content creation will evolve now that AI plays a

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big role in this domain. As illustrated by the Dall-E software, AI has already produced an extensive collection of paintings that have drawn the attention of experts. Similar approaches are likely to work in 3D as well. There are already apps that scan Lego blocks and use artificial intelligence to suggest what to build with them (BrickIt, 2023).

#### **The future of the creative process**

AI systems can generate questions that were previously unknown due to their lack of cognitive biases. This ability to explore a larger space of possibilities can lead to asking better questions, as the answers are often encoded within them.

The role of AI in the creative process is becoming increasingly important, with possibilities ranging from AI replacing humans to augmenting or enhancing human creativity. To ensure that AI enhances human creativity, it is crucial to embrace AI and learn how to use it to generate better questions and answers.

The goal should be to use AI to create better answers in the creative process.

We have recently seen an explosion of AI art production algorithms. For example, the stable diffusion algorithm has allowed anyone to generate various kinds of artwork. This space has seen an explosion of applications in open-source AI communities.

We noted the emergence of many sketches to image applications where users can use a text prompt and their scribbles to explain what they need in finished art that expresses. A text prompt is a description of what you need to see. By the time this book is published, it is likely that we will



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already be seeing applications that can translate scribbles with text prompts into 3D models.

The field of AI art production has witnessed remarkable advancements in recent years. One of the major driving forces behind this progress is the development of algorithms like the stable diffusion algorithm. These algorithms enable anyone to generate various types of art using AI-based tools and techniques. The open-source AI community has been instrumental in fostering innovation in this area, leading to the emergence of new applications and tools.

One of the most exciting developments in AI art production is the emergence of sketch-to-image applications. These applications allow users to input a text description or their own sketches to generate finished art that meets their vision. With the help of AI, users can now create stunning images and artworks even if they lack traditional artistic skills.

While AI-based tools have been successful in creating 2D content, converting scribbles with text prompts into 3D models is still a challenge. However, researchers are exploring new methods for creating 3D content using AI. One promising approach is to use vocal instructions to help end-users create 3D models. By using voice commands, users can create more complex models and shapes than they would be able to with traditional input methods.

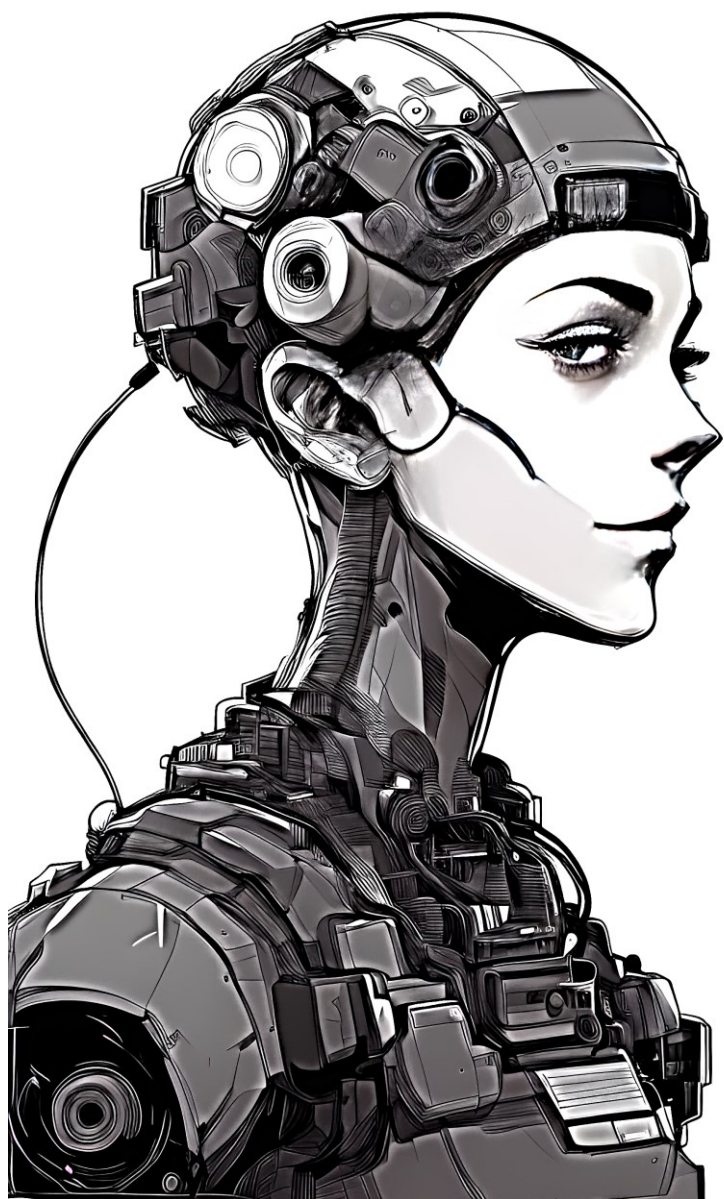
## Conclusion

In conclusion, the field of AI art production is rapidly evolving, and we can expect to see many exciting developments in the years to come. With the emergence of new applications and

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tools, AI is transforming the way we create and appreciate art, making it more accessible and inclusive for everyone.

As we reflect on the pressing need for enhanced tools to boost content creation in the virtual domain, it is imperative to understand that these tools are not just about augmenting creativity. They are also about facilitating the comprehension and navigation of complex virtual environments, considering the constraints of the human brain. As we will explore in the next chapter, a deeper understanding of our cognitive limitations can significantly influence how we approach design within the Metaverse. We will delve into how cognitive science can inform Metaverse design, optimizing it for the user's cognitive capacity and fostering healthier user experiences. This transition from discussing tools for content creation to focusing on user-centric design underlines the importance of the symbiotic relationship between the user and the technology in the evolving Metaverse.



*Chapter cover 4 Cognitive augmentation strategies*

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### *Adapting design to cognitive constraints*

The Metaverse has the potential to transform how humans interact with digital environments. To fully harness this potential, designers must consider human cognitive limitations from the outset. Viewing design problems through a cognitive science lens can foster innovation and experimentation, avoiding hindrances to the Metaverse's development.

Understanding human cognitive constraints can lead to more user-friendly and enjoyable environments. By recognizing how humans process and interact with information, designers can optimize Metaverse experiences for cognitive capacity. This approach enhances learning outcomes, performance, and the overall experience.

Acknowledging human cognitive constraints encourages experimentation and innovation. This perspective opens doors to alternative solutions, fostering new and creative approaches to immersive digital environments.

In this chapter, we will introduce a few theoretical design terminology and concepts from a cognitive science perspective that Metaverse designers need to be aware of. These include mental models, attentional resources, affordances, and feedback. By understanding these concepts and applying them to virtual environments, designers can create experiences that are intuitive, informative, and rewarding for users.

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### **Engineering approach and historical context**

Throughout history, engineers have crafted solutions for immediate problems, often without waiting for scientific principles to be fully developed. This intuitive approach has led to remarkable innovations, from the steam engine to the Internet, but also some notable failures, such as the famous bridge collapse in Tacoma, Washington.

This historical context is not merely a reflection of the past but a lesson for the present and future. It illustrates the importance of grounding technological development in scientific understanding, especially in complex and evolving fields like the Metaverse. The emergence of cognitive science, with its interdisciplinary insights into human cognition, represents a critical advancement in this direction.

By acknowledging the successes and shortcomings of historical engineering practices, we can appreciate the vital role that cognitive science plays in modern design. It emphasizes the need to move beyond intuition and experimentation, to a more methodical, research-driven approach. This shift is essential in the design of the Metaverse, where understanding human cognitive limitations and capabilities is key to creating immersive, user-centered experiences.

The transition from traditional engineering to a cognitive science-informed approach marks a significant evolution in design thinking. It sets the stage for the subsequent sections, where the application of cognitive science and neuroergonomics to the Metaverse is explored in detail.

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### **Introduction to Cognitive Science**

Before the advent of cognitive science, understanding human cognition was primarily the domain of philosophy and introspection. Cognitive science emerged in the mid-20th century as an interdisciplinary field, bridging various disciplines to unravel the intricacies of the human mind. It explores underlying mechanisms of mental processes, providing insights into how information is processed, stored, and retrieved. Cognitive science is vital for understanding ourselves, improving education, enhancing technology, and addressing mental health. Its emergence marked a turning point in our understanding of human cognition, with far-reaching implications. It is also important to keep in mind that our understanding of human cognition itself is constantly under the pressure of paradigmatic shifts.

For example, Enaction, a concept introduced by Francisco Varela, Evan Thompson, and Eleanor Rosch (Varela, 1991), argues that cognition arises through a dynamic interaction between an organism and its environment, emphasizing the role of embodied experience. This view resonates with the ancient philosophy of Vedanta, particularly the Advaita Vedanta school, which posits a non-dual reality that transcends the apparent separateness of individual selves and the external world (Sankaracharya, 8th Century). Adding another layer to this perspective is the Extended Mind theory by Andy Clark and David Chalmers (Clark, 1998), which suggests that cognitive processes extend into the environment and the tools we use. These philosophical and cognitive theories contrast with the Information Processing model (Miller, 1956), which likens the human mind to a computer and has been influential in fields like Human-Computer Interaction and Artificial

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Intelligence. While the Information Processing model offers a straightforward, measurable approach for engineering applications, theories like Enaction and the Extended Mind can challenge us to think beyond traditional boundaries. Thus, it's advisable to maintain awareness of these philosophical perspectives like Enaction and the Extended Mind, even as we primarily navigate our engineering endeavors using the more measurable and straightforward Information Processing model, for as long as it serves our objectives effectively.

Given the Metaverse's potential to transform human interaction, it is vital to consider how cognitive science can inform virtual environment design. Understanding cognitive mechanisms underlying human perception, attention, memory, and decision-making, including the sensory systems that are part of the nervous system, can help create more effective and engaging experiences. Sensory systems, responsible for receiving information such as sight, sound, touch, taste, and smell, play a crucial role in designing immersive experiences. Challenges such as the need for seamless integration across devices and platforms must also be addressed.

#### **Neuroergonomics and its potential impact on Metaverse design**

Cognitive psychology has been instrumental in understanding human behavior and has led to the creation of engaging digital experiences, including smartphone games and social media platforms. However, some of these experiences have inadvertently fostered addictive behaviors. We have to investigate why the Industry is so keen on incentivizing addiction, click baiting or choose to ignore the signals that their offering may be not as harmless as first thought.

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Neuroergonomics, weaving together neuroscience, psychology, and engineering, builds upon the insights of cognitive psychology to further nurture user well-being and empowerment. By embracing neuroergonomic principles in conjunction with cognitive psychology, designers can create products that not only engage users but also bolster their health, satisfaction, and autonomy. This balanced approach avoids addiction-driven models and aligns with a growing demand for well-being-focused products.

Rather than designing solely for engagement, we must aspire to craft products that enrich users' lives holistically. This entails promoting health, fulfillment, and agency through considered features that empower, not addict.

The future of this design shift depends on market forces and people becoming more sensitive to situations that challenge their wellbeing. Another possible driver for change include social media harm becoming so bad that they become difficult to ignore. That is how we will get technology that lifts up humanity as a whole.

There are several lessons that can be learned from neuroergonomics that can be applied to the design of virtual worlds.

1. First, it is important to understand how the nervous system works to design technologies that are compatible with it.
2. Second, neuroergonomics can help to identify the most efficient and effective ways to perform tasks. This information can be used to design virtual worlds that are more user-friendly and efficient.
3. Third, neuroergonomics can provide insight into how people learn and remember information. This



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information can be used to design virtual worlds that are more effective for learning and retention.

4. Fourth, neuroergonomics can help to identify the potential risks and hazards associated with using certain technologies. This information can be used to design virtual worlds that are safer and more user-friendly.
5. Overall, neuroergonomics is a valuable tool that can be used to improve the design of assistive technologies for virtual worlds. By understanding how the nervous system works, designers can create technologies and virtual environments that can adapt to our changing cognitive abilities over the course of our lives.
6. Neuroergonomics can be used to evaluate the effectiveness of training programs or other educational materials that are designed to be used in virtual worlds. By understanding how the nervous system responds to different stimuli, it is possible to develop more effective and efficient methods for teaching people how to use virtual worlds.

### **What informs Neuroergonomics studies**

In this field, a wide range of human data is collected to inform research and design decisions. This data can be divided into three main categories: physiological data, behavioral data, and cognitive data.

Physiological data is a cornerstone in neuroergonomics, offering insights into how the human body responds to different tasks and environments. This category includes a wide array of measures. Brain activity is captured via Electroencephalography (EEG) or Functional Magnetic Resonance Imaging (fMRI), eye movements are tracked through eye-tracking technology, and body movements are

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analyzed via kinematic measures. A crucial yet often overlooked metric in this category is Galvanic Skin Response (GSR), which measures the electrical conductance of the skin and is indicative of psychological or physiological arousal. Additionally, Heart Rate Variability (HRV) is used to assess stress and mental workload, Electromyography (EMG) measures muscle activation to assess physical strain, and Functional Near-Infrared Spectroscopy (fNIRS) measures brain activity by detecting changes in blood oxygenation. Pupil dilation serves as an indicator of cognitive load or emotional arousal, while skin temperature variations can indicate stress levels. Respiration rate, monitored through breathing patterns, also offers insights into stress levels and cognitive load. By incorporating these diverse biomarkers, researchers can obtain a more nuanced and comprehensive understanding of human responses, thereby enabling more effective workplace design and performance optimization.

Behavioral data includes measures of task performance, such as accuracy and efficiency. This type of data can be used to identify areas of improvement in task design or execution and can also be used to evaluate the effectiveness of neuroergonomic interventions.

Cognitive data includes measures of attention, memory, and decision-making. This type of data can be used to understand how different areas of the brain contribute to these cognitive processes and can also be used to inform the design of cognitive training and rehabilitation programs.

Subjective workload assessments are a vital part of ergonomics. They allow us to identify how much work an individual is doing and how this compares to their mental and physical capacity. Subjective workload can be assessed in a

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number of ways, with two of the most common being to ask individuals to rate their level of mental and physical effort on a scale from 1 to 10, or to use the NASA-TLX (Task Load Index) to rate different aspects of workload including mental demand, physical demand, temporal demand, performance, and effort. Subjective workload assessments are used to compare the workloads of different jobs or tasks, and to assess the impact of changes in the work environment on workload.

Subjective workload assessments have many advantages, including that they are quick and easy to complete, do not require special equipment, and can be adapted to different types of tasks and work environments. Subjective workload assessments have the potential to be inaccurate because they rely on self-reports from workers. They may also be influenced by the workers' current mood or level of fatigue. When used correctly, they can provide valuable insights into how workers feel about their workload and help identify potential issues that need to be addressed.

Collecting all this brain and behavior data can be a challenge, but it is an essential component for the field of neuroergonomics and as such needs to grow and improve through more dedicated research.

#### *Cognitive limitations*

Every communication channel is measured by its capacity, and the amount of noise it is associated with. Claude Shannon identified a hard limit that can be determined for any communication channel. If the communication link is subject to random transmission errors, the Shannon limit or Shannon capacity refers to the maximum amount of error-free data that can theoretically be transmitted over the link for a particular

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noise level. This limitation is expected to play a major role in determining the upper bound for all communication channels, including neuron-level communications.

### *What are the causes?*

The upper bound on cognitive abilities is determined primarily by brain physiology and the physics of signal transmission through noisy biological networks (Markowsky, 2023).

Without data abstraction processes that allow a limited mind to make sense of the world, it would be impossible for humans to assimilate all the information that constitutes the universe, even if we adjust the sensitivity and range of our biological sensors to infinity through technology.

It appears that most of the abstraction processes that help us make sense of the world are the result of brain function, occur outside our conscious or probably unconscious awareness, and appear to be fortunate products of evolution. Perception mechanisms in various domains, from vision to touch, are examples of natural abstraction processes that cannot be altered intentionally. This creates a very stable, common, and shareable illusion that we label reality. So, in a way, the foundation of reality is rooted in our cognitive limitations.

### *How to measure cognitive limitations?*

Despite our understanding of how these cognitive limitations play a role in creating the illusion of reality, we do not yet exactly know how they emerge and how to measure them directly. We can only estimate them by designing tasks at different difficulty levels and measuring how successfully these tasks are solved, for example, the visual span test. There are many examples in Cognitive science where attempts are made to measure aspects of our sensory systems. For example,

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just-noticeable-difference (jnd) studies for every sensory media is common. One of the classic psychoacoustic jnd experiments involves a subject being asked to compare two sounds and to indicate which is higher in level or frequency.

##### ***What is cognitive bandwidth?***

The two most common definitions of cognitive bandwidth are as follows: bandwidth refers to our cognitive capacity and ability to pay attention, make good decisions, stick with our plans, and resist temptations. Cognitive bandwidth can also be viewed as the bandwidth for conscious activity (mental or physical). It is easy to verify through self-experience that it is finite (Kahneman, 2011). Working memory capacity appears to be an important constraint on cognitive bandwidth.

##### **Working memory as key constraint**

The working memory model proposed by (Baddeley, 1974) consists of three components: the central executive, the phonological loop, and the visuo-spatial sketchpad. The central executive is responsible for attention and control.

The central executive is responsible for overseeing and coordinating the activities of the other two components. It is also responsible for the coordination of information and processing between the short-term and long-term memory systems.

The central executive is believed to be a limited-capacity system, and it has been suggested that it is the bottleneck for the working memory system.

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The phonological loop is responsible for the temporary storage and rehearsal of verbal information, while the visuo-spatial sketchpad is responsible for the temporary storage and manipulation of visual and spatial information. This component is thought to be located in the right hemisphere of the brain. Studies have shown that damage to this area can lead to difficulties in tasks that require mental rotation or visualization, such as imagining how an object would look from a different angle.

The visuo-spatial sketchpad is believed to play an important role in many everyday activities. For example, when we drive, we constantly need to update our mental map of the environment in order to navigate effectively. Similarly, when we read a text, we use the visuo-spatial sketchpad to visualize the layout of the page in order to follow the flow of the argument. There is still much about the visuo-spatial sketchpad that remains unknown. For example, it is not clear how information is represented in this component, or how it is accessed during problem solving. However, the visuo-spatial sketchpad is a key part of working memory, and a better understanding of its role in cognition will help us to understand how we think and learn.

Working memory is a cognitive system that allows us to temporarily store and manipulate information in order to complete complex tasks such as reasoning, problem solving, and comprehension.

#### **Quantitative estimates about the working memory system**

The central executive, phonological loop and visual sketchpad are all important working memory systems in the human brain.

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However, they all have limitations in terms of capacity. These limitations can be measured using a variety of tests.

The capacity of the phonological loop is typically measured with the use of the digit span task. In this task, participants are presented with a list of digits, and they are asked to remember the sequence of digits. The list of digits is then repeated, and the participants are asked to recall the sequence. The capacity of the phonological loop is measured by the number of digits that the participants are able to correctly recall.

The capacity of the visual sketchpad is typically measured with the use of the change detection task. In this task, participants are presented with a display of items, and they are asked to remember the items. The display is then changed, and the participants are asked to identify the changed items. The capacity of the visual sketchpad is measured by the number of items that the participants are able to correctly identify.

The capacity of the central executive is estimated to be around 4-7 items. The phonological loop is estimated to have a capacity of around 2-4 items, and the visual sketchpad is estimated to have a capacity of around 4 items. These estimates are based on a variety of tests, including the digit span test, the phonemic awareness test, and the visuo-spatial sketchpad test.

The Stroop task is often used to measure the capacity of the central executive. In this task, participants are presented with a list of words, with each word printed in a different color. They are then asked to name the color of the ink in which the word is printed, as quickly as possible. The task is a measure of the capacity of the central executive because it requires participants to inhibit the natural tendency to read the word.

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The reaction time is measured from the onset of the cue (the color of the ink) to the time the button is pressed.

Now that we have an approximate idea about the fundamental limitations of the cognitive system we must work with, we are in a better position to discuss the various design theories.

Metaverse content creators are, of course, not expected to become cognitive science experts, but it is certainly sufficient for them to be mindful of potential cognitive constraints and their impact on design. This impact can then be confirmed or disproved through traditional human–computer interface studies, many of which are well-known.

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### **Why design theories?**

It is often argued in many creative domains, that theory is certainly not necessary, that good design is primarily Art and that any attempt to create guidelines or steps to engineer Art is bound to cripple it. For instance, experts in music theory are not often known for the music they compose. But many musicians with little background in music theory have been known to produce ground-breaking and memorable music. We do not believe theory and practice to be enemies. For example, music theory opens doors to creativity and shortens the path to something that is cogent and acceptable efficiently, especially when improvising with others. Designing for the Metaverse presents us with a similar challenge. While some prefer theories to guide them, others will prefer to treat design purely



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as Art, stumbling through discoveries as they go. A good balance between theory and practice is desirable.

In many fields ranging from architecture to human–computer interface design, architects and engineers have attempted to create design theories that would help accelerate the design process to shorten the time between ideation and the final product. Design theory has several stages.

The initial stage typically involves the identification of repeated patterns during the design process. The relationships between the various patterns that arise are captured and studied. Causal relationships between the various patterns are also discussed. The best design theory is the one that leads to the most aesthetically pleasing and most functional products in the shortest time possible.

It is perhaps ambitious to suggest that we can design, produce, and distribute content intended for easy and efficient consumption by applying design laws, conjectures, or guidelines, but we think that it is an important goal to strive for. Currently, few outstanding design theories exist for Metaverse design. We invite peer experts to add their own theories to those we propose. It is likely that we will see a set of theories powerful enough to guide the development of the Metaverse in the future. Hopefully, the examples presented in this book will motivate others to collaborate and discover them.

##### ***Types of design theories: Explanatory and Practice***

Theories of design generally fall into two broad categories: explanatory and practice. Explanatory theories (Richard Baskerville, 2010) aim to provide a coherent account of how designers actually go about their work, while practice theories

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offer explicit advice or guidance on how designers should work.

The cognitive outsourcing theory we propose is a good example of an explanatory design theory. Such theories allow designers to offload much of the cognitive load associated with design tasks, and thus makes the design process more efficient and effective. In this chapter, we describe how designers can rely on the lessons learned in the fields of cognitive engineering and neuroergonomics to narrow down the design solution search space.

The theory of composition that we also propose, on the other hand, is more direct and narrowly focused, and thus serves as a good example of design practice theory. The theory provides explicit advice on how designers should go about their work, specifically in the domain of composition. The theory prescribes a specific process for deconstruction of complex objects or concepts into simpler ones that can be reassembled rapidly and effectively often with zero coding to produce more complex entities that can satisfy a wide range of needs.

In order to realize the full potential of the Metaverse, we need to develop new theories and tools for content creation. We invite all practitioners involved in the creation of 3D content for the Metaverse to collaborate and advance new theories so that we can come up with tools that will help improve the quality of content creation.

### *Theory of cognitive outsourcing*

After years designing content production software, we could not avoid recognizing the need for a theory of control delegation that would help us figure out where to draw the line

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between design processes that need to be automated and those that do not. Too much automation can kill the creative process of designers and marginalize them; too little can freeze the creative process because the tasks are so labor-intensive that, in some cases, the trajectory from ideation to product is so long that it cannot be completed without a lot of blood and tears.

We also realize the central role of information-processing theory when designing virtual content to represent selected aspects of complexity to make it more generally accessible. Multimedia data visualization would be a good example of this class of problems. Here, the relevance of the fundamental Shannon's limit of our sensory channels for information when creating content cannot be understated. Our aim should always be to create content or applications that will not overwhelm the capacity of our sensory channels as this would hurt the quality and utility of the consumption experience. For example, having too many animated icons to represent external events might be difficult to follow because either there are too many of them or they are changing too fast.

The design process also involves ethical dimensions that we may not always pay attention to. For example, designing content to appropriate the working memory of unsuspected content consumers is probably acceptable today and even incentivized, as in the online advertising community, but such practice is likely to be regulated in the future. The attention or cognitive bandwidth allocation problem required for task demands is traditionally assumed to be in control of the consumer of content. But in practice this responsibility is slowly being transferred to external software systems such as social media algorithms.

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### *Theory of composition*

Composition is the process of assembling reusable components typically efficiently and easily into entities of higher complexity. In other words, it is the process of taking smaller, simpler pieces and assembling them into a more complex whole. This process is what allows us to build things, not only Lego toys and Meccano machines, but also mental models, software programs, really anything that we can imagine.

The reverse process of composition - deconstruction - is what allows us to take a complex object and break it down into its simpler parts. This process is much more difficult to understand and conceptualize. In order to deconstruct something, one must first understand the composition of the object - how it was put together in the first place. Once the composition of the object is understood, the deconstruction process becomes much easier. However, an added layer of complexity arises when the composition process is unknown or unknowable. Then it becomes the responsibility of the designer to divide the object into meaningful simpler parts.

There are many reasons why someone might want to deconstruct a complex object into its simpler parts. For example, they may want to understand how the object works, or they may want to reuse the parts for other purposes. In this chapter, we discuss how this theory of composition could help inform tools and approaches to help the end user create content for the Metaverse easily and efficiently.

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### **What is cognitive outsourcing?**

Before we discuss how cognitive amplification can be achieved through cognitive outsourcing, we describe four main areas that are the pillars of the theory of cognitive outsourcing.

1. *Cognitive offloading*: Cognitive offloading is traditionally described as the transfer of brain functions to external devices so that the brain can focus more effectively on tasks that require creative control.
2. *Abstraction capturing or prototyping*: This is the process of discovering repeated patterns to create concepts, modules, or components.
3. *Sensory channel load optimization*: This is the process of choosing representations to embody abstractions, either as symbols, text, images, sounds, or tactile cues, in order to make optimal use of human perceptual channels and working memory.
4. *Control delegation*: Outsourcing control of sub or lower-level tasks to external party, often a device or AI system, to reduce cognitive footprint

Let us consider each aspect of cognitive outsourcing theory in more detail.

#### ***Cognitive offloading***

Numerous devices have been created throughout history to reduce the cognitive load that would otherwise have made the accomplishment of complex tasks impossible. We invented writing tools and paper to relieve the memory burden. With the advent of clocks, it has become much easier to track time. Modern technology has given us access to computers, calculators, and advanced cameras, as well as a wide range of

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other technological advancements aimed at reducing our need to memorize, while ensuring that the brain still has enough resources to meet new and immediate task demands.

Cognitive offloading is traditionally described as the transfer of brain functions to external devices so that the brain can focus more effectively on tasks that require more creative control.

Cognitive offloading (Beaudoin, 2013) as a concept satisfactorily explains how a brain can transcend its inherent cognitive limitations. However, we currently believe that cognitive outsourcing more elegantly expresses the control delegation aspects, which have grown in importance as we delegate an increasing number of cognitive functions to AI systems. Most importantly, we believe that considerations of cognitive outsourcing when designing the Metaverse will emphasize the importance of delegation control in the Metaverse.

### *Abstraction design*

Abstraction capturing or prototyping relates to the reduction of complexity into interconnected abstractions, which often serve as building blocks for the assembly or construction of explanatory stories. It is also common for abstractions to efficiently reduce the working memory demands for many tasks that humans have identified.

### *Abstraction capturing*

We consider abstraction to be an emergent phenomenon, as it can arise as a result of natural evolution and not only by human-led design. For example, it can be argued that the

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illusion of reality is itself an example of abstraction at work and is simply the product of the evolution of our sensory apparatus and brain.

It is abundantly clear that the brain has a number of areas dedicated to specific cognitive functions, and it is not entirely inaccurate to consider them as ‘bio’ firmware which does not need conscious intervention or control for them to serve their function in the background, for example, vision and sound processing will fall under this category. Successful abstractions enable reasonable and reliable expectations to be constructed regarding what lies beyond our limited cognitive window. The ability to connect these abstractions into causal or descriptive stories probably makes the human brain unique.

In summary, we have argued that there is a close connection between the quest for meaning and the cognitive limitations of the brain. We believe that it is these limitations that motivate the emergence of abstractions or concepts, which are essential for storytelling. Without abstractions and concepts, we would not have languages to express our quests and our pleasure of finding things out, just to mention two out of the many drivers of the human experience.

Our cognitive limitations are perhaps an evolutionary blessing in disguise. Donald Huffman mathematically proved (Gefer, 21): ‘An organism that sees reality as-it-is is never more fit than an organism of equal complexity that sees none of reality and is just tuned to the fitness payoffs.’ Translated, that means if you see the truth, you’ll go extinct. However, as engineers or designers, we are generally more concerned with making things with what is known, rather than trying to explain them away to their core. We believe that this is the best way to make use of the limited cognitive resources available to us.

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### *Abstraction prototyping*

What is the relevance of ‘abstractions’ to the construction of the Metaverse? When we set out to accelerate the production of content and make it easier for everyone to access it, we must determine how to help users create their own worlds, and whether they want to use them for social, productivity, or other purposes without coding or 3D modeling.

When the Metaverse becomes a reality, we expect users to have the flexibility to experiment with various embodiments of abstractions to amplify social connections with others to enhance learning or productivity. Thus, the Metaverse provides immense opportunities for prototyping and for evolving abstractions.

Can these devices be programmed using natural speech in the future? Can interactive 3D world builders simply drag, drop, and snap 3D objects to create Metaverses that most will enjoy using and visiting?

After the design framework has been established, there are no shortcomings in creative ideas that can be experimented with. When it comes to research, every failure is a learning opportunity and a steppingstone to higher ground.

In any medium of perception, right abstraction can yield powerful mental objects that do not strain working memory. We can remember the shape of a graph more easily than the table of numbers used to create it. Students of the Soroban abacus can perform advanced calculations even if they do not have access to the device or are blindfolded. We can recall the shapes of molecules and perhaps rotate them mentally to check whether two apparently different-looking molecules are isomers.



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### ***Sensory channel load optimization***

The second area is related to how we allocate the bandwidth of our perception channels to maximize information flow while avoiding overwhelming the working memory. We also have to keep in mind the known inherent channel limitation as described by the Shannon limit. This limitation is expected to play a major role in determining the upper bound for each communication channel, including neuron-level communications.

### ***Delegation control***

The third area involves the delegation of control so that a task can be divided into subcomponents, which are then individually addressed by third-party experts. As the outsourcer will partially use its working memory for communication with external collaborators, a cost is incurred. However, when properly implemented, delegation increases productivity.

## **Delegation control**

The brain and executives of big corporations delegate tasks in similar ways, with the less creative and repeatable tasks being delegated first, and eventually higher-level tasks.

### ***Over delegation***

It is important to view content production and consumption in future Metaverse using an information processing lens because creative tasks are increasingly being outsourced to AI computer systems, and the concern about shifting the locus of cognition outside the human brain is more relevant than ever (Sautoy, 2019).

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### *Loss of creative control*

When designing computing systems, it is important to consider what could happen if we outsource too many cognitive functions to external entities that we cannot control, as this could sever the connection between our intentions and our actions, causing distress.

Technologies say that we will reach AI singularity when the AI either becomes self-aware or is able to improve continuously on their own without human intervention; however, we believe AI could take over most of our creative functions leaving us with the marginal role of content consumption even before AI becomes self-aware.

The role of artificial intelligence in our lives will either be that our identity expands to encompass our cognitive AI tools, or that our AI tools will do all the cognitive heavy lifting and we will be left by standing with a marginal role as an observer. The use of artificial intelligence in content creation has the potential to change the way we think about intellectual property and the law may need to adapt accordingly.

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The role of artificial intelligence in our lives will either be that our identity expands to encompass our cognitive AI tools, or that our AI tools will do all the cognitive heavy lifting and we will be left by standing with a marginal role as an observer.</p> |
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Our cognitive outsourcing theory is an example of a design theory that is mostly explanatory but can also make the design process more efficient by highlighting possible cognitive challenges. The theory of composition introduced can serve as a foundation for collaborative and facilitated user generated content for a 3D Metaverse that users occupy through their

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avatars. We will have the opportunity to revisit this topic in deeper details in forthcoming chapters.

### **Concluding remarks**

The aim of this chapter was to explore how we can design cognitive amplifiers so that we can further expand the range of human experience and influence. By grounding the design in the lessons learned or discoveries from the fields of cognitive science and engineering, and neuro-ergonomics, we can create powerful tools to amplify our abilities.

Chapter 4 wraps up on a salient point - the balance between automation and human control in the Metaverse design. While there is great value in outsourcing cognitive functions to external devices, this cannot go so far as to sever our control or diminish creative engagement.

As we leave Chapter 4 behind, we come to understand the complexities of the human brain, its immense capabilities, and inherent limitations. We have explored how this rich understanding can guide us in designing virtual worlds that empower users. The awareness of cognitive bandwidth allocation and the exploitation of the brain's latent abilities can lead to more efficient design practices.

However, a question emerges: How do we manage these cognitive limitations, is their transcendence possible? This brings us to Chapter 5, where we delve into fundamental concepts we need to understand before we can attempt to construct and implement solutions efficiently. We will start by studying the power of abstraction, a cognitive tool that allows us to simplify, organize, and represent complexities that

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otherwise would have remained completely inaccessible to our minds.

In this upcoming chapter, we move from the concrete intricacies of the brain to the more generalized tool of abstraction. We explore the balance it provides, helping us make complex systems manageable without losing sight of their inner workings and shortcomings. We will see how this technique, properly employed, can amplify cognition and productivity in virtual worlds. Abstractions qualify as a type of a cognitive amplifier in that it is geared towards creating a concise body of knowledge that can be used to explain the world within its boundaries. This allows for fields of study to emerge with the necessary tools needed to create explanatory and predictive stories. Abstractions not merely compress information, but also allow different fields of study to develop their own unique perspectives and explanations for how the world works.

While the nuances of the human brain provide us with a roadmap to user-centered design, abstraction arms us with a lens through which we can interpret, simplify, and effectively apply this knowledge.



*Chapter cover 5 Visual Power: Unlocking Abstraction and Data*

# 5. Unraveling Complexity

## The Art of Abstraction

This chapter explores abstraction as a vital tool for designing and building the Metaverse. As pioneers grapple with immense complexity in crafting expansive virtual worlds, abstraction provides a path to make this intricacy comprehensible and manageable. It reduces complexity by extracting only the essential aspects, enabling designers to divide and conquer the problem space.

Designing good abstractions is very difficult. Though there are no easy solutions so far, it is a critical skill that deserves focused attention. Abstraction sits at the core of design work, yet its importance is often overlooked. By examining abstraction head-on - its challenges, nuances, and role in the process - we can get better at this subtle craft. This understanding moves the field forward. While we will not unravel all the mysteries here, dedicating serious time to abstraction design or discovery is obviously necessary and we hope some readers will be motivated to pursue this journey much further than we could.

Abstractions manifest in diverse forms tailored to their purpose, including symbols, conceptual models, frameworks, and languages. When skillfully balanced, abstractions enhance workflows, creativity, and cognition. Just as abstractions enabled innovations across science, technology and other fields, they can unlock new possibilities in Metaverse creation. This chapter seeks to equip Metaverse architects with an understanding of the vast potential of abstraction, while also delineating its boundaries.

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### **A blessing in disguise**

Fundamentally, abstraction arises out of the necessity to address the cognitive constraints of our minds which most would assume to be a negative, but it turns out that they are very probably the foundation of the human experience which we obviously cannot live without. Humans possess limited perceptual bandwidth, working memory, and information processing capacity. These boundaries shape how we interface with the vast complexity of reality. To cope, our minds construct simplified mental representations - abstractions - that extract only salient details. They form the building blocks of cognition, enabling comprehension, prediction, communication and reasoning in a complex world. Without judiciously reducing raw data through abstraction, an unconstrained perception of reality would immediately overwhelm our faculties. In our view, it should be clear that not all abstractions are designed by humans, many arise as a result of evolution. For example, the amount of social information condensed into facial expressions makes the face a very rich information display for most. Though undeniably useful, abstractions inevitably distort or omit components of actual phenomena. This is not a flaw per se, but a tradeoff for usefulness that we must remain cognizant of.

Wittgenstein stated, “The limits of my language mean the limits of my world.”

South Asian and Eastern philosophers recognized the limitations of the human mind and the need for abstractions or useful illusions to make sense of an infinite world. However, it is difficult to pinpoint an exact number of years before the Greek enlightenment that these insights were obtained (Greek Enlightenment, n.d.). Nagarjuna, a Buddhist philosopher who

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lived in the 2nd century CE, stated, “When the notions of real and unreal are absent from before the mind, there is no other possibility but to rest in total peace, beyond concepts” (Winters, 2012). Adi Shankara, an Indian philosopher who lived in the 8th century CE, stated, “All things are empty: Nothing is born, nothing dies, nothing is pure, nothing is stained, nothing increases, and nothing decreases” (Garfield, 2011). Lao Tze, the founder of Taoism, also recognized the limitations of human understanding and believed that the ultimate reality, the Tao, can only be experienced directly (Fundamental Elements of Oriental Philosophy, n.d.).

These quotes offer thoughtful perspectives on the restrictions of human knowledge and expression. The philosophers insightfully indicate the constraints of language and thought. However, it is vital to acknowledge that just because something escapes representation does not negate its existence. Rather, it suggests the thing in question exceeds the boundaries of useful, verifiable depiction - namely, observable reality. The inability to represent something does not disprove it, but shows it transcends the frameworks we can reliably describe and confirm.

Alfred Korzybski, an influential philosopher, famously declared “the map is not the territory”. Scientists like Albert Einstein and Arthur Eddington argued scientific models merely approximate reality based on our current knowledge. The most powerful abstractions artfully balance fidelity, precision, expressiveness and comprehensibility.

Though we may never fully grasp the true essence of reality, this should not stop us from refining the concepts and models that enhance our understanding of the world around us. The universe itself can be seen as an overarching abstraction of all



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that exists. Despite our limited cognition, we must persist in developing more effective abstractions, allowing our minds to expand their scope. We feel that the Metaverse is a perfect playground to allow abstractions and their ecosystems to evolve, collide, merge and interact with each other.

Humans are not inherently predisposed to completely reject concepts simply because those concepts are likely to be incomplete representations of reality. We have a natural capacity to accept useful but imperfect models and use or build upon them. As we continue to grow, our capacity to acknowledge and to become comfortable with our innate incompleteness is perhaps the most optimal path along an evolutionary trajectory. Most can easily step back from such philosophical heights and to address the practical challenges of advancing useful, well-designed abstractions because of these efforts are often found to be not only interesting but also joyful.

Visual abstraction plays a key role in expanding human cognition. Data visualizations utilize abstraction by representing complex datasets in simplified formats that highlight critical patterns and relationships. Encodings like charts, graphs, and diagrams act as cognitive tools by leveraging visual bandwidth and capacities like pattern recognition. Effective visualizations artfully compress dataset complexity to focus on key aspects, such as a scatter plot abstracting multivariate data into an x-y spatial mapping. Interactive capabilities allow drilling down on details. As data visualization expert Cole Knafllic states, “Storytelling with data needs effective visuals to help convince people and drive change.” As Edward Tufte has articulated, effective data visualizations tend to convey substantial information concisely.

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### **Abstractions in Science, Technology, Engineering, Arts and Math**

Math, physics, chemistry, biology, technology and engineering provide endless examples of how abstraction enabled many innovations by unveiling patterns and distilling complexity into comprehensible representations. In physics, Newton and Leibniz used symbolic notations to express laws as computational equations. For instance, Newton's second law abstracts the complex motion of objects into a simple  $F=ma$  equation using symbolic representations for force, mass and acceleration.

Chemistry's periodic table by Mendeleev abstracted elements into an elegant organizational system based on their basic properties such as the number of electrons in the outer shell. The Periodic table has an uncannily high information density. It is not only a descriptive tool but can and has been used to make predictions about chemical reactions. In fact, strangely many elements were described in the Periodic table even before they were found in the real world. It is worth mentioning here that molecular modeling leverages abstraction to study complex biomolecules.

#### ***Computer Science***

In computer science, programming entails creating abstract models to systematically instruct machines. Algorithms, logic gates, data structures and programming languages are formal abstractions that software engineers combine to control complexity. For example, abstraction enabled the development of machine learning algorithms by providing modular software components like neural network layers that hide lower-level mathematical complexity. Information theory conceptualized

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communication itself as an abstract encoding/decoding process. Abstraction is a fundamental tool to design algorithms, data structures, interfaces, and more.

Computing history reveals how evolving layers of abstraction enabled programmers to tackle ever more complex challenges. Early programmers worked at the hardware level, manually configuring circuits and writing primitive machine code. To enable more complex software, assembly languages were invented to abstract away details of bit patterns and memory addresses. Instead, programmers could focus on higher level operational concepts like loading data or performing calculations.

### ***Programming***

Each programming paradigm utilized new abstractions, enabling more complex software. Assembly languages abstracted away hardware details like memory addresses. Procedural languages encapsulated common tasks into reusable functions and data structures. Object-oriented abstractions modeled real-world entities through modular objects containing data and behaviors. Modern libraries and frameworks provide further abstraction, packaging entire processes like web serving into simple interfaces.

Procedural languages like FORTRAN and C further abstracted repetitive low-level tasks into reusable functions and data structures. Each of these abstraction layers empowered new capabilities by hiding lower complexity.

### ***Games and music***

The emergence of useful abstractions touch every sphere of human activity. For instance, a chess player memorizes the

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position patterns and corresponding strategies to deal with each situation, allowing them to play faster. Similarly, guitar players memorize shapes that point to the locations of notes over the entire fretboard, enabling them to improvise in real time and be in sync with the ongoing chord progression.

### *Abstractions in teaching processes*

The level of abstraction used in teaching depends on the learning objective and the students' understanding level. Starting with basic concepts and gradually introducing more abstract concepts as the students' understanding grows ensures they comprehend the material without being overwhelmed. Abstractions are used to represent relationships between different concepts, the sequence of activities, and the course's learning goals, aiding in retention and comprehension of the material.

### *The role of abstraction in collaborative processes*

We can divide and conquer high-level problems by dividing them and outsourcing them to other devices or users, who then return the intermediate results at an abstraction level we can understand and use. This capacity for deep collaboration across space and time is a significant evolutionary advantage.

Thus, abstraction enables collaboration by scoping complexity into compartments. In teaching, high-level introductions provide scaffolding before integrating details, avoiding cognitive overload. In research, abstraction divides problems across experts who can integrate findings later. The most useful abstractions elegantly balance fidelity, precision, expressiveness and comprehensibility. Next, we will discuss a central theme in the field of abstraction design, namely

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compositionality. What is compositionality, and why it is so important.

### *The emergence of compositionality*

In many of the previous examples, including the one about programming languages also illustrate one key aspect of abstraction: compositionality. Their expressive power emerges from the ability to combine basic abstractions into larger constructs ad infinitum. Words integrate into sentences, instructions into functions, functions into programs. Finding elemental abstractions that lend themselves to open-ended composition is key in language design. The Metaverse stands to benefit from composable abstractions as we show in forthcoming chapters. While we understand that all languages without any exceptions have inherent limitations, we do recognize their immense power in organizing and representing knowledge.

## **Compositionality and Generative AI**

For AI systems like large language models, compositionality unlocks generative capabilities. Given foundational abstractions (like words), AI can synthesize cohesive novel compositions such as sentences, paragraphs and even books. It naturally follows that if we are able to create foundational abstractions like 3d object primitives in a 3d virtual world, then these primitives can be organized or assembled into worlds or Metaverses.

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### **Effective abstraction principles**

#### *Using Generative AI to accelerate world production*

Applying this to the Metaverse, composable abstractions could empower generative AI to automatically construct or assemble expansive environments, characters, and narratives. However, providing the right abstraction embodying primitives remains challenging and is likely to inform research missions in the automated content creation arena for many years to come.

#### *Generative AI and abstraction design*

Looking forward, an intriguing possibility is using AI itself to create the primitives and modules that enable generative composition. Rather than relying solely on human-crafted abstractions, future systems could potentially leverage AI to analyze environments, interactions, and narratives to extract underlying patterns and derive novel abstractions autonomously. The abstractions derived by AI could serve as the vocabulary for its own generative engines, creating a cyclical abstraction-composition loop. This approach could rapidly accelerate worldbuilding, allowing AI to construct virtual environments with increasing autonomy. However, care must be taken to ensure the AI-derived abstractions resonate with human meaning-making and intentions. Otherwise, there is a non-zero chance that humans could be sidelined into a real world that can no longer communicate with or control advanced AI agents in a virtual realm.

For now, the manual approach for engineers to abstract complexity could be summarized as the following iterative approach:

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- Analyze to identify key content components, patterns and relationships.
- Selectively filter to derive a simplified representation capturing only essential factors.
- Embody abstractions into executable artifacts like algorithms, data structures, APIs and 3D objects with various degrees of interactivity.
- Combine abstractions compositionally as modular components to assemble manually or automatically into more complex artefacts.
- Monitor abstractions in operation to pinpoint inaccuracies.
- Refine abstractions to improve utility without overcomplicating.
- Establish new abstractions iteratively on top of existing ones to encapsulate higher complexity.

As we will explore in the chapter on applying Metaverse technology to education, our design for the building blocks of the Metaverse incorporates aspects of this approach. Overly simplistic systems produce repetitive experiences, while excessive detail overwhelms. User research, prototyping, and active feedback channels help strike this balance.

### **Abstraction Design to improve composition**

Applying theory to design can help create a more cohesive and effective design. Our solution involved creating reusable libraries of virtual objects for our interactive virtual world composition application. We identified recurring patterns of 3D virtual world objects and behaviors in the Metaverse,

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abstracted them into concepts, and developed software architectures to transform these concepts into tangible, interactive library objects for building virtual world applications.

Our design of the abstraction layer led to the development of a tool we call the Composer. This tool allows users to generate a wide variety of applications from a point-and-click assembly of modules or libraries of simpler 3D objects in a 3D world. This flexibility is made possible by our abstraction layer, which hides much of the complexity associated with these different types of applications behind a simple interface. It allows creators to create new applications without worrying about low-level details or their programming skills or 3D modeling abilities.

Thoughtfully designed underlying layers can lead to better user interfaces. The abstraction architecture we landed on allowed us to create a powerful but simple Heads-Up Display (HUD). As will be described in forthcoming chapters, all user interface control points for content creation and navigation were made accessible through this one HUD. This allows for efficient content creation by minimizing disruptive camera motion and enabling smooth avatar movement within the 3D virtual world, greatly improving the overall quality of experience.

### *Dissolving boundaries in 3D spaces*

Our extensive explorations of three-dimensional virtual worlds revealed intriguing patterns in the content and objects users create and share. They inspired us to design reusable components that we then organized into modules. These modules facilitate the composition and customization of more complex application objects or world scenes. Most



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surprisingly, rigid boundaries delineating application classes evaporated when manifesting applications in 3D virtual interactive spaces. The key ideas to take away here are that traditional distinctions between application types become blurred, applications merge and borrow functionality from each other, and rigid boundaries give way to fluidity and integration when transitioning from 2D to 3D virtual environments. We feel that this is actually a significant realization worth exploring further: Application categorical boundaries break down and evolve while transitioning to new dimensions of existence.

It is worth mentioning here a few specific examples to illustrate more concretely the convergence of applications traditionally thought of as distinct and separate. The objects from a narrow set of select modules that can be composed into a 3D slideshow can also be used construct a museum exhibit or entire campus with a few clicks from an end user. The light sources objects from the lights module can be arranged to illuminate virtual exhibits but they are also found to be useful for changing the brightness of artwork created by a 2D object-oriented graphics editor in the virtual world. Post-it notes from a meeting board can be moved, duplicated and arranged into a 3D mind map. Bookmarked web pages embodied automatically, by an inworld web browser, as labeled 3D book objects can be organized as interactive books on virtual shelves to create a 3D library.

As we can see the transition from 2D desktops to 3D virtual spaces catalyzes more than the convergence of existing applications and the boundaries between them collapse - it opens the door to entirely new genres of applications not previously feasible. Unmooring apps from 2D constraints and

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leveraging 3D presence unlocks spatial computing, allowing more immersive experiences that meaningfully leverage volumetric space. Multi-sensory applications can engage sight, sound, and even touch in deeper ways. Hybrid productivity suites blend office tools, creative features, and communications into integrated 3D workspaces. High-fidelity simulated environments enable lifelike training, education, and visualization. Augmented and blended realities fuse our physical and digital worlds. Persistent 3D worlds link users across time and geography. Embodied avatars with greater personalization and social presence transform virtual collaboration. It is perfectly possible today to implement virtual worlds where one person in the real world becomes in control of a team of AI assisted specialists that is accessible for productivity amplification purposes. We are now well positioned to introduce what we feel are important signposts for readers interested in abstraction design theory.

### **Much needed conjectures about abstractions**

The nature of abstraction and how it arises in intelligent systems is a fascinating research area crossing multiple disciplines. Our adventures in designing productivity spaces for the Metaverse motivated our following conjectures. While these insights may indeed echo historical parallels, articulating them here is crucial. Our personal journey to acquire them has imbued us with a profound belief in their significance.

#### ***The Cognitive Constraint Conjecture***

The first, termed the Cognitive Constraint Conjecture, posits that innate limitations in mental bandwidth give rise to abstraction as a strategy for managing informational complexity. Under this model, finite cognitive capabilities

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manifest as selective focus on key details and general representation of concepts. Without such constraints, the drive to abstract away extraneous information may not develop. This view implies that since meaning stems from mental concepts and human emotions, which are simplified representations of more intricate information, without cognitive constraints the experience of a meaningful life becomes impossible. We find that this conjecture also has a consequent conjecture that is relevant to how we can construct AI agents with inner workings that can be inspected, controlled or communicated with easily.

### *The Indistinguishable Cognition Conjecture*

This consequent conjecture is the Indistinguishable Cognition Conjecture. It suggests that an artificial intelligence constructed with calculated constraints similar to human cognition might develop comparable abstraction abilities and reasoning strategies. Restrictions forcing strategic allocation of limited resources could pressure an AI to construct abstractions, mental models, and information prioritization in a human-like manner. Testing this conjecture takes on new relevance given advances in AI-generated content.

Simple strategies for implementing cognitive constraints in AI systems are as follows:

- Sensory and information constraints: Limiting the input and information available to AI systems to mimic human sensory limitations.
- Goal setting: Defining specific objectives for AI systems to guide their decision-making and behavior.

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- **Interactive environments:** Creating virtual or physical environments that allow AI systems to interact and learn from their surroundings.
- **Feedback mechanisms:** Providing AI systems with feedback on their performance to facilitate learning and improvement.
- **Incremental complexity:** Gradually increasing the complexity of tasks and challenges presented to AI systems to enhance their problem-solving abilities.
- **Embodiment:** Incorporating physical or virtual bodies for AI systems, enabling them to interact with the world in a more human-like manner.
- **Social interaction:** Allowing AI systems to interact and collaborate with humans and other AI systems, fostering social intelligence and cooperative behavior.
- **And last but not least, Ethical and emotional frameworks:** Integrating ethical principles and emotional understanding into AI systems, promoting responsible and empathetic decision-making.

Both conjectures emphasize the important role constraints play in shaping abstraction. While humans abstract to handle their limited bandwidth, AI systems may require particular restrictions to avoid turning into deeper impenetrable black boxes. Research in this area may reveal new insights about abstraction as an emergent property of both biological and artificial intelligent systems with engineered constraints to pressure them to encode knowledge in a way that will be meaningful for humans.

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The Cognitive Constraint Conjecture also gives rise to what we call the “Unconstrained AI Paradox”. This suggests that an AGI without limitations may lose the impetus for human-like abstraction and meaning, and may even find the quest for finding the true nature of reality not only an unsolvable problem but also an irrelevant one. An AI system with no constraints might never develop perception or intentions. This is because such systems, theoretically capable of processing all available information simultaneously and executing any tasks without limitations, would have no need for the strategic allocation of resources. It highlights the counterintuitive idea that the lack of constraints might actually hinder the development of advanced cognitive processes like perception and intentionality in AI systems.

Together, these conjectures and paradox present a pathway for AI development, where future AI systems might not only exhibit intelligence indistinguishable from humans but do so through cognitive processes akin to our own, shaped by their unique cognitive constraints. However, if we allow AI systems to freely evolve their own abstractions, then the constraints arising may result in AI systems devoid of some of the very cognitive traits that make human intelligence what it is, and we can expect break down in communications between humans and AGI.

### **Data abstraction is not just data compression**

It is important to note the distinctions between data abstraction and data compression especially because there appears to be a tendency to measure the intelligence of systems based on their ability to compress data. Here are a few key reasons why data abstraction should be considered a better measure of intelligence than pure data compression:

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Firstly, abstraction requires selecting relevant information and discarding irrelevant detail. Compression algorithms do not necessarily distinguish between importance and noise - they compress everything. Abstraction involves prioritizing, filtering and identifying significant patterns, which requires understanding semantics and meaning in the data. Compression lacks this higher reasoning component.

Secondly, abstraction requires mapping between different levels of representation. Making connections between detailed raw data and high-level abstract concepts is key. Compression lacks this ability to translate between granularities in a coherent way. The flexibility to move between levels of abstraction is the hallmark of intelligence.

Thirdly, abstraction has generative capabilities - the abstractions can be used to recreate new examples or scenarios. Compressed data can only reconstruct the original dataset. Abstractions support generalization, extrapolation and reasoning between related concepts. This creative aspect requires intelligence beyond compression. Compression ratio alone is therefore not a good way to evaluate an abstraction.

### **Towards a theory of composition**

We have a long history of developing conceptual architectures of knowledge domains, such as the periodic table of elements or the taxonomy of living things. These architectures, as it were, allow us to organize and understand the vast amount of knowledge that we have acquired over time. They also allow us to build new knowledge on top of existing knowledge, which can lead to breakthroughs in our understanding of the world.

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The modularization of knowledge has several benefits. First, it allows for a more agile and iterative approach to developing new knowledge. Second, it enables different experts to work on different aspects of a problem, which can lead to a more comprehensive solution. Finally, it allows for the integration of new knowledge into existing systems, which can make those systems more efficient and effective.

In the computing industry, there is a trend of developing conceptual architectures of knowledge domains after a period of modularization and encapsulation of a range of insights, discoveries, and meanings. This trend is deeply human, as there are many examples of this in different industries. For example, Block Inc., which is a popular financial services company, labels many of its services as microservice blocks that can be assembled to create many different enterprises level applications. To take a perhaps more familiar example, WordPress makes use of plugins that users can add to their websites to increase its functionality.

### ***Collaborative content creation***

The brain is amazing but has limitations. It is impossible for anyone to know everything, which is why we need domain experts. Domain experts are people who have knowledge in a particular area and can help us understand the abstractions, concepts and symbols used in their field.

Collaboration is important because it allows us to share our knowledge and ideas. When we work together, we can achieve more than we could on our own. However, collaboration can be difficult because there can be many fields, each with their own language.

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Metaverse developers need to be able to translate between the various languages in order to create a virtual environment that is understandable to domain experts. By studying a particular domain and finding out the various concepts and symbols used, developers can create a virtual environment that is meaningful to domain experts and allows them to share their knowledge with others. We choose to anchor these abstract concepts in 3d content creation examples.

Specialization is necessary because of the various cognitive limitations of the human brain that prevent one from being an expert in all domains.

In the case of 3d content creation, there are two types of workflows: advanced 3d modelers and artists creating content with external but powerful sophisticated tools that require specialized training, and end users constructing environments and expressing themselves using this content to others about subjects they are knowledgeable about.

Using primitives from lower levels of abstraction and reusing them in multiple ways is essential for storytelling (as we have defined it). Imagine what happens with most current end-user content on various social media platforms. Creating fonts and emojis is the work of advanced content creators; however, end users do not have to know how to create fonts or emojis to create phrases that express stories. The same pattern occurs for 3D user content creation. In the early days, Second Life users created content utilizing 3D primitives such as cubes, spheres, and many other simple objects, and we found that designers currently sell architectural mesh primitives that can be assembled into buildings.



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This general theory of composition will uncover the process of how to construct optimally complex objects from simpler parts in order to address identified requirements in a given field of abstraction.

### *Deconstructing into parts for re-composition*

There are many ways to decompose a complex entity into simpler parts. The choice of decomposition strategy depends on the application domain and the specific goals of the content decomposition. In general, the goal is to decompose the complex entity into parts that can be reused in different contexts. For example, in the case of a software system, we may want to decompose the system into modules that can be reused in different applications. In the case of a 3D virtual object, we may want to decompose the object into its constituent 3D parts so that it can be recycled or reused in different contexts. Deconstructing complex content into its component parts is a valuable skill that can have several applications. By understanding how to deconstruct content, we can develop automated content creation processes and workflows. If in some cases, it is found that over automation is hurting creative control, we can opt for discovering ways to facilitate the assembly process from a user interface perspective. In our experience, there are always opportunities to do so.

Currently, the process of simplifying complexity is largely driven by human effort. Identifying the boundaries between objects and fragmenting large objects, such as buildings, into reusable parts is a subjective and tedious process. There may be a machine learning technique capable of handling the most difficult and repetitive aspects of this task, but we will still rely

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on human arbiters to decide which sets of components produced are of the best quality and most expressive.

It is important to consider the fact that, although machine learning may be able to take on some of the grunt work in terms of simplifying complexity, the final product will still need to be reviewed and approved by humans. This is due to the fact that, while machines may be able to identify patterns and trends, they are not yet capable of making the same level of judgment calls as humans. Therefore, it is still necessary to have humans involved in the process in order to ensure that the final product is of the highest quality.

Identifying the boundaries between objects and fragmenting large objects such as buildings into reusable parts is by and large a very subjective and tedious process.

Complex behaviors can be assembled from simpler ones. This is a key principle of many successful systems, from the gears in a machine to the neurons in a brain. There are a few challenges that need to be addressed when using this approach. First, it is important to design the interfaces between the objects in a way that makes it easy to assemble them into more complex structures. Second, it is necessary to define the behavior of the objects in a way that allows them to interact correctly with each other. And third, it is often necessary to optimize the objects for the specific task at hand, which can be a challenge in itself. However, these challenges are not insurmountable, and the benefits of this approach make it worth pursuing.

Next, we use LEGO as an example to anchor a few of the ideas introduced more deeply. LEGO is a perfect example of modularization and encapsulation, as the bricks can be

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assembled in many ways to create different structures. This flexibility is one of the reasons why LEGO is so popular. In addition, LEGO bricks are also standardized, which makes it easy for people to purchase LEGO bricks from different project kits, or manufacturers (if they are allowed to) and still be able to use them together. Let us consider what we can learn from LEGO and how it can inspire us to identify ways to facilitate content production in virtual worlds.

### *Lessons learned from LEGO*

In the 1930s, Danish carpenter Ole Kirk Christiansen started making wooden toys in his carpentry workshop. He named his company LEGO, based on the Danish words “leg godt,” meaning “play well.” By 1934, LEGO was producing plastic toys, which became wildly popular. It wasn’t until 1949 that LEGO began producing the interlocking blocks that are now known around the world. The LEGO Group realized that by producing standardized, interchangeable blocks, they could greatly increase the number of combinations that could be made from a limited number of parts. In other words, they modularized the design of their product. This increased the flexibility and usability of LEGO blocks, and helped LEGO to become the global phenomenon it is today. Mindstorms is a LEGO set that includes programmable bricks, sensors, and motors. It allows users to build and program robots. The modularity of Mindstorms makes it possible to create a wide variety of robots, from simple to complex. Now that we have a fairly clear idea of what LEGO is, let us try this thought experiment.

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### *Universal Lego Block Creator thought experiment*

Imagine a universal LEGO block creator that allows end users to print as many 3D LEGO blocks as needed. With this technology, advanced LEGO users would have the opportunity to learn how to use the various commands that the LEGO block creator understands to create custom blocks. As a result, we might expect a wider variety of blocks and assemblies/compositions to be produced down the road. In addition, it would not be a big surprise if we see the emergence of two separate communities: block-makers and block users. In fact, we may even witness the emergence of a creative economy.

Imagine a universal LEGO block creator that allows end users to print as many 3D LEGO blocks as needed. Further, advanced LEGO users can learn how to use the various commands that the LEGO block creator understands to create custom blocks.

All these blocks may be grouped together organically by user communities in sets that appear useful for particular use cases. Various sets may become popular over time. For instance, one set may be the most popular because it allows for a wide range of compositions, while another might be more popular because of the color scheme used or the style of its objects.

For convenience, we will look at each set as a language in which each block is a word and each composition is a sentence. Thus, the LEGO block creator can be viewed as a meta-language engine that can be used to create new languages, that is, new Lego sets. The metaphor of language suggests that each

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set of objects created has some measure of expressivity, and some end up being better than others.

If history is a guide, the drive to automate content production is likely to spread at all levels wherever an opportunity arises. We are already seeing applications designed to scan a pile of Lego blocks in the real world and to make suggestions on possible compositions that could yield interesting objects. It is also likely that we will see AI approaches applied to generate good candidates for Lego sets after examining a series of possible Lego builds that are found to be popular in various communities. Meta-languages will be evaluated based on various parameters such as expressivity or aesthetics. How does all this Lego talk concern Metaverse design? The next section will provide some answers.

### ***Walking the Talk***

To enhance the utility value of Metaverse, we believe that this approach will become popular when designing tools to facilitate end-user content creation. We experimented with this approach and created a Composer app that uses objects from different sets stored in libraries we call 3D modules to create virtual world setups. In this case, the counterpart to LEGO blocks are virtual objects with varying degrees of interactivity. Examples of objects with low levels of interactivity are stones and terrains of different kinds, whereas examples of objects with higher levels of interactivity include virtual post-it notes, non-player characters with conversational behaviors controlled by external AI engines, and flora that change with the weather. Just like LEGO, these 3D virtual world contents can be snapped together to quickly create a wide range of advanced 3D scenes.

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Within a decade, we expect many Metaverse's content creation processes to follow a similar trajectory. There will be a convergence of technologies, including photogrammetry, which will lead to an explosion of low-cost but high-quality user-captured or user-generated content. We will also see the AI rendering of 3D objects based on end user text prompts. It might seem too simplistic to imagine a user generated Metaverse as assembled blocks that are shared, traded, duplicated, and evolved, but we believe that this is the most probable scenario.

It might seem too simplistic to imagine a user generated Metaverse as assembled blocks that are shared, traded, duplicated, and evolved, but we believe this is the most probable scenario.

### **Transitioning from theory to practice**

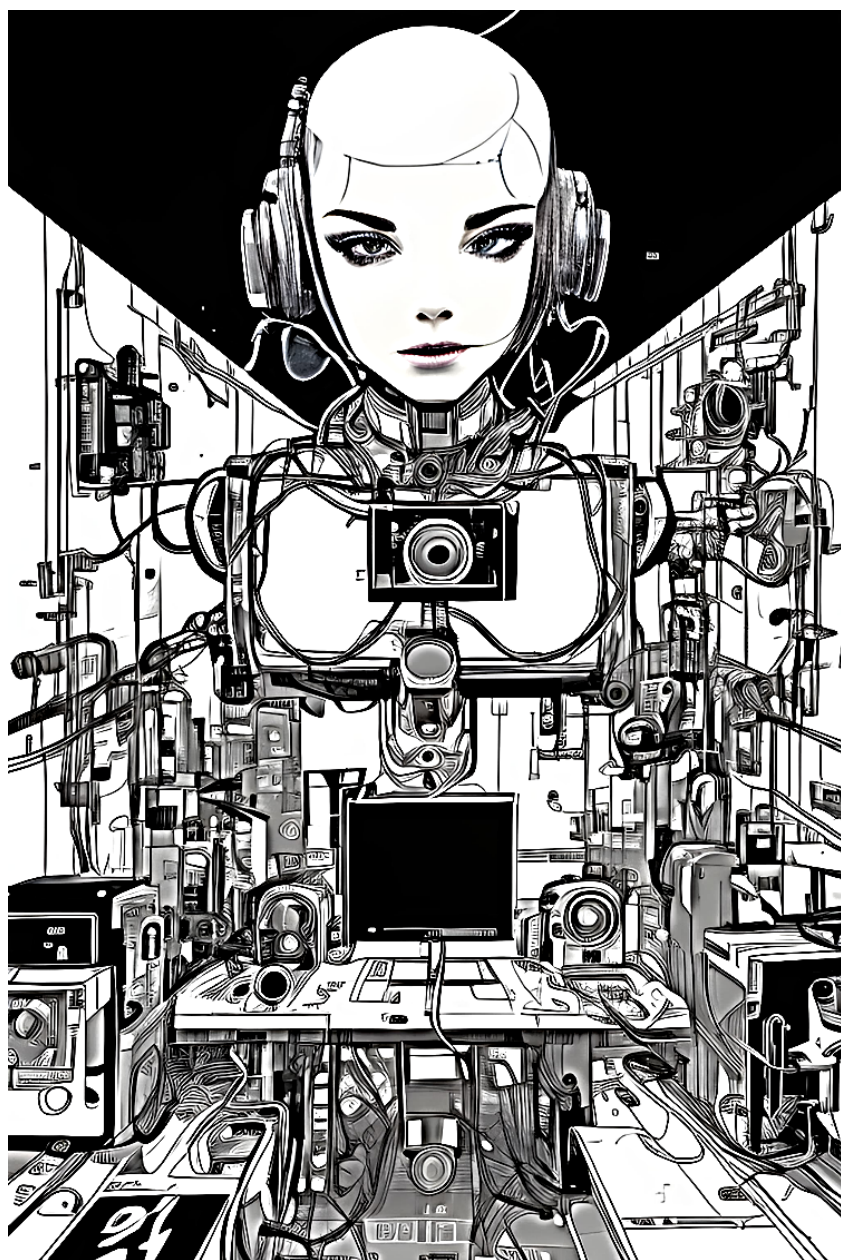
This chapter aimed to encourage future Metaverse stakeholders to take an interest in the importance of abstraction design and find ways to advance this field. While we do not provide easy answers, we hope that the readers will persevere along their own journey and come up with new and more effective abstraction design approaches. Mastering the art of balancing precision and simplicity that unlocks abstraction's full potential to enhance workflows, creativity, and cognition, still defy formalization and remains an Art.

The abstract concepts we have learned, from how we utilize cognitive tools to manage complex systems, to the balance between comprehensibility and oversimplification, all come into play in the forthcoming chapters. As we transition from the theoretical to the applied, we carry forward the knowledge

## 5. Unraveling Complexity

that abstraction is not just a concept, but a tool for effective problem-solving and innovation.

Now, let us shift our perspective from external tools such as abstractions to the internal mechanisms that allow us to perceive and interact with complexity in a meaningful way. After all, it is our brain that interprets, manages, and makes sense of the data that reaches our senses. Chapter 6 provides a fascinating exploration of our brain's capabilities for specific tasks, and how understanding them can lead us to design tools that can further enrich our virtual experiences. It will explore how social cues, realistic avatars, assistive technologies, and an understanding of cognitive bandwidth allocation can shape virtual spaces that are both immersive and cognitively comfortable. This approach will have a fundamental role to play in virtual environments that are inclusive i.e., they should be comfortable to users with different cognitive profiles.



*Chapter cover 6 Brain Balance: Leveraging Strengths and Weaknesses*



## 6. Harnessing the Brain

### *Making better use of hidden or forgotten potential*

The human brain took millions of years to evolve into this amazing tool that we may often take for granted. As we learn new things and experience new environments, our brain adapts and changes to better suit our needs.

As designers, it is important that we keep in touch with the latest explorations, discoveries, and studies about the attributes of the brain so that we can design for the brain better. Brain attributes are qualities or characteristics of the brain that can be measured or observed.

When it comes to the virtual worlds of the Metaverse, it is important to make the best of the brain's existing strengths, rather than try to force it to learn new ways to interact with interfaces that we design. By taking advantage of the brain's existing strengths, we can create virtual environments that are more user-friendly and enjoyable to use. None of us certainly want to design interfaces or systems which can exacerbate frustration and fatigue. First, let us begin by examining some of them.

“Our technology, our machines, is part of our humanity. We created them to extend ourselves, and that is what is unique about human beings.” - Ray Kurzweil, American computer scientist, author, inventor, and futurist.

The brain can be very good at certain tasks, such as pattern recognition, and not so good at others, such as arithmetic.

## 6. Harnessing the Brain

When we try to force the brain to do something it is not good at, we are inevitably disappointed. By understanding the brain and its limitations, we can reduce the likelihood of making design blunders. By recognizing precisely what makes the brain a powerful sensing and thinking machine, we can begin to draw efficient and effective trajectories to improve our quality of life.

Clearly, virtual worlds lack the social bandwidth we are used to in the real world. Identifying the underlying causes of this problem is important. Let us first examine how the depth of social connection we experience in the real world comes about. The social brain is the part of the brain that is responsible for social cognition, providing people with the ability to interact with peers. It is this ability that allows us to communicate, cooperate, and collaborate with others. The social brain is made up of many different regions, each of which plays a role in social cognition. For example, while the temporal lobe is involved in processing emotions and facial expressions, the prefrontal cortex is responsible for executive functions such as planning and decision-making.

### **The brain as a formidable face processing machine**

“Artificial intelligence is growing up fast, as are robots whose facial expressions can elicit empathy and make your mirror neurons quiver.” - Diane Ackerman, American poet, essayist, and naturalist

Perhaps, dedicating specific regions of the brain for face processing for example, is nature’s way of indicating the importance of this feature in human-to-human interaction (Hadders-Algra, Jan. 2022). We should therefore recognize the necessity to try to create avatars that can support facial

## 6. Harnessing the Brain

expressions that are as rich as what we are used to in the real world. These expressions should of course be reproduced with as minimal lag and end user stress as possible in the virtual world.

If we want general purpose 3D virtual worlds to be successful, we need to at least find ways to increase its social bandwidth. By doing so, we can make 3D virtual worlds more appealing to users and increase the likelihood of them being used for more than just gaming. General purpose 3D virtual worlds are so much harder to implement than 3D collaborative gaming worlds where narrow storylines and very simple game mechanics are enough to keep users engaged through tight challenge-reward loops. We do not believe that this gaming approach will serve users who are looking to use the Metaverse as a place to work or to build and share content at their pace for real world impact. Even though it is likely that most can intuitively understand why social bandwidth is key for general purpose virtual worlds, it is still useful to examine this assumption from the perspective of cognitive science.

It is well understood that people use a variety of social cues to understand the emotions and intentions of others (Blackmore, 2010). These cues include facial expressions, gaze direction, and mouth gestures. The use of these cues is especially important in infancy and early childhood when verbal communication skills are not yet developed.

Studies have shown that face processing takes up a large amount of cognitive bandwidth, especially when we are trying to identify a specific person. The processing of faces requires significant cognitive resources (Tsao, 2008). This suggests that the face is a very important part of our social cognition, and it does seem humans are wired for empathy. The face is so

## 6. Harnessing the Brain

important for social communication that we have evolved specialized neural mechanisms for processing faces. These mechanisms are highly efficient and allow us to process faces quickly and accurately.

In the late 90s, there was a lot of discussion about how the absence of gaze awareness in virtual environments would negatively impact communication between avatars. Gaze awareness is basically analyzing someone's gaze to figure out what they're looking at and what their feelings are about it. It was believed that gaze awareness (Gemmell, Toyama, Zitnick, Kang, & Seitz, 2000) was a key cue in interhuman communication and had deixis properties. Gestural deixis is the use of gestures to refer to specific people or objects. For example, pointing to someone while saying their name is a form of gestural deixis. This type of deixis is often used in child-directed speech, as children are more likely to respond to gestures than to words alone.

A human face can reveal several clues about a person's interests concerning objects in the world. The gaze at an object of interest and facial expressions convey the subject's emotions and perhaps thoughts about the object being observed in the world. Therefore, the human face is probably the most efficient platform for representing social cues in a virtual world. This facial gestural language, as it were, does not require explicit learning for typical human beings and happens unconsciously. A face is indeed worth a thousand social cues.

|                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>The human face is probably the most efficient platform for representing social cues in a virtual world. The interpretation of facial gestures does not require explicit learning for typical human beings. A face is indeed worth a thousand social cues.</p> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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Yet, it is worth pondering Moravec's Paradox (Agrawal, Dec 2014) here: the tasks that are simple for humans are often the most challenging for computers. While we excel at interpreting nuanced facial expressions, machines still struggle to match our innate skills. This paradox serves as a cautionary tale for designers aiming to replicate human-like facial cues in virtual environments. Despite advancements in affective computing, the subtleties of human emotion and social interaction present a complex puzzle that technology has yet to fully solve. Consider this a signpost for future research: solving this paradox in the context of virtual worlds could lead to impactful, perhaps even disruptive, advancements in how we interact in digital spaces.

While virtual worlds offer unprecedented opportunities for remote collaboration, they often fall short in replicating the richness of face-to-face interactions. This is a significant drawback for those who rely on these subtle cues for effective collaboration. In light of these considerations, the preference for real-world, face-to-face interactions becomes not just a matter of comfort but a rational choice for effective collaboration. Until virtual worlds can fully replicate the social bandwidth offered by the human face, they will remain a second-best alternative for tasks that require nuanced interpersonal communication.

The quest to enhance the social bandwidth of virtual worlds is not just a technological challenge but a psychological and sociological one as well. As we strive to make virtual interactions as rich and meaningful as those in the real world, understanding the pivotal role of face processing becomes imperative. It is not merely about improving technology but about enriching human interaction in all its complexity.

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To truly revolutionize the way, we interact in virtual spaces, we must harmonize technological innovation with a deep understanding of human psychology and social behavior. This delicate balance becomes even more critical as we explore the capabilities and limitations of Head Mounted Displays (HMDs) in facilitating immersive experiences.

### **HMDs: opportunities and challenges**

The all-surrounding immersive display enabled by a head mounted display (HMD) is one of its primary advantages for accessing a 3D virtual world. Zooming in or in-world navigation opportunities make the amount of space for presenting information quasi-infinite. However, the same technology that enables immersion in the virtual world also makes sharing of visual social cues within the physical world challenging. It may be tempting to set up cameras inside HMDs to track features of the face, gaze motion or mouth movements, but we do not yet know if adding more hardware on the face is what users will appreciate. Meta, a leading social computing and AI enterprise, has recently demonstrated a headset that implements these functions. However, HMDs are not yet known for their ubiquity and cannot be worn for long durations. To enjoy a similar level of social connection in fully immersive virtual worlds as in the real world appears doable but it might take more time than we expect especially if the device is expected to be used for extensive durations.

### **Using Desktop VR to overcome HMD limitations**

In order to create truly realistic avatars, it is necessary to capture facial expressions at a desktop and use this information to drive in real time the virtual faces of avatars. This would ensure that the avatars would be able to convincingly convey a

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wide range of emotions and would add a new level of immersion to virtual reality experiences. One advantage of this approach is that the user does not need to wear an HMD that would have also acted as a blindfold to events in immediate physical surroundings. This would free up the user's hands for real world keyboard interaction with less worries about virtual force feedback and allow them to interact with the virtual world in a more natural way. Additionally, this would allow for a more comfortable experience over longer periods as the user would not need to worry about the weight of the HMD on their head.

While the technological advancements in avatar realism offer a new frontier for human-computer interaction, they also open up profound opportunities for enhancing empathy in digital spaces. The ability to convey nuanced facial expressions in a virtual world is not merely a technical feat; it is a leap toward humanizing digital interactions. This is especially crucial in an era where social media platforms, now more than ever, have shown the limitations and even dangers of reduced social bandwidth.

### **Designing to support empathy**

Current social media platforms demonstrate how severely societal cohesion can be undermined when human-to-human social bandwidth is constrained to short text snippets that lack nuance or depth. The minimalist nature of platforms like Twitter, now rebranded as X, diminishes opportunities for meaningful interaction and facilitates polarization. The often-caustic tone across major social media reveals the deep structural damage that can occur when social bandwidth is severely limited. The practice of confining human

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communication to brief text snippets and basic meme visuals significantly diminishes both nuance and context.

Narrowing of communication channels is likely to amplify information bubbles by facilitating the misinterpretation of content and the identity or characteristics of the source. Future social media algorithms might focus on the popularity of content itself, rather than its creator, potentially mitigating the influencer effect. The aim is to develop a market for ideas based on their merit, independent of their creators' brands. This presents a significant opportunity for researching future social media algorithms.

It is important to remember that everyone experiences the world differently and that there is no single right or wrong way to design for empathy. The best approach depends on the situation and audience. In general, it is helpful to think about how you can create an experience that allows people to see things from another perspective. This could involve using storytelling, interactivity, or other methods to help people understand what someone else may be feeling or thinking. It is also important to consider the overall tone of your design and whether it will promote feelings of understanding and compassion or further division and misunderstanding.

While designing for empathy may seem like an abstract endeavor, it is deeply rooted in our biology, specifically through mirror neurons (Vittorio Gallese, April 1996). These specialized cells activate both when we perform an action and when we observe that same action in others, serving as the neurological underpinning for empathy. As you tailor your design to evoke understanding and compassion, you're essentially tapping into this innate neural framework. Thus, the



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art of empathetic design and the science of mirror neurons are intrinsically linked, each enriching and validating the other in the quest for genuine human connection. Mirror neurons are a type of brain cell that activates when an individual performs an action as well as when the individual observes another performing the same action. These cells were first found in monkeys, and they have also been found in humans. Scientists believe that mirror neurons may play a role in social cognition, language development, and motor learning. The neural basis for empathy may be a system of mirror neurons.

### **No compelling Metaverse without high fidelity avatars**

It is important to have accurate facial expressions in 3D virtual worlds for many reasons. Humans are social animals, and we rely heavily on nonverbal cues to communicate with each other. One reason is that our existing neural pathways for interpreting social information are designed to interpret faces. If we were to try to interpret social information in any other way, it would likely overwhelm our working memory. Faces are an important part of how we communicate. They allow us to convey a wide range of emotions, from happiness and excitement to sadness and anger. They also allow us to gauge the emotions of others. This is why it is so important that the faces of characters in 3D virtual worlds are accurately represented. If they are not, it can be very difficult for users to interpret the emotions of those characters, and this can lead to misunderstandings and communication difficulties.

Another reason why it is important to have accurate facial expressions in 3D virtual worlds is that they help to create a sense of presence. When we see a character with a realistic

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face, it helps us to feel as though we are in their presence. This is important for immersion and for making the virtual world feel like a real place.

### **High fidelity faces for enhanced conversational UI**

To maximize the social brain's latent functions, the rise of conversational user interfaces (UI) powered by increasingly affordable and accurate speech recognition technology is a pivotal development. This advancement has paved the way for high-fidelity faces on humanoid non-player characters (NPCs) in virtual environments. These enhanced facial features not only facilitate clearer communication by understanding user instructions but also elevate the realism and believability of interactions between players and NPCs. Whether aiding in-game navigation or enriching the narrative experience, high-fidelity faces become a cornerstone in making conversational UIs more effective and immersive.

Up to this point, we have explored the brain's extraordinary capacity for facial recognition and emotional resonance. The question then arises: How can we translate this innate strength into the design of collaborative systems? Over a decade ago, we tackled this challenge head-on. We acknowledged the limitations of simply overlaying videos of participants onto shared virtual spaces. It was also clear back then that the technologies available were not adequate for meeting the needs of high-fidelity avatars. This motivated us to ask a radical question: Could we capture the essence of social interaction without relying on facial representation? This led us down an intriguing path, one punctuated by both pitfalls and revelations. In the next sections, we unpack the valuable lessons learned from this daring approach.

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### **Adventures in social cue capturing and design**

Between the late 90s and early 2000s, we ran a few experiments using 3D sound displays, and eye tracking technologies to learn what it would take to create collaborative virtual environments that were first and foremost designed to be predominantly ‘utilitarian’ in nature but that would also support the exchange of social cues that were believed to be so important for teamwork. Let us examine the challenges involved as we plan to adapt single user applications for collaboration within and even outside virtual worlds.

We thought of starting our design trajectory with using eye trackers to capture social cues. Eye trackers are devices that track the movement of your eyes and can be used to infer what you are looking at. This information is deemed to provide users with relevant information about the current visual interests of others.

#### ***Capturing and representing peer visual awareness***

We initially experimented with approaches to capture gaze positions in a multiuser desktop environment and employed advanced algorithms to assign visual attention weights to various GUI elements such as windows as they appear on screen (Ramloll R., 2004). We represented the amount of visual attention received by an object by changing some of its visual characteristics such as brightness or color, but unfortunately, we realized that these changed too fast for easy comprehension and would certainly prove to be distracting to peers. This was not a failure but a revelation, underscoring that while capturing social information may be straightforward, creating intuitive visualizations for end-users is a far more complex task.

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Armed with these insights, we moved to explore another sensory modality that we hope would not be as intrusive as visual animations: the realm of 3D soundscapes to represent the activities of others. Note that we use 3D soundscapes here instead of 2D because we used low pass filtering to muffle sound sources and to simulate depth or containment. A sound associated with a text file that was being edited for instance would have produced a muffled sound if it was hidden in a shared folder on the multiuser desktop.

### *Exploring auditory cues in shared spaces*

We toyed with the idea at that time that such a design would foster a collaborative environment where individuals working in large teams would be peripherally aware of activities around them. Not unlike how human beings absorb information while standing in a busy city square surrounded by a cacophony of sounds, sights, and scents. There may be street performers, bustling crowds, vendors selling their wares, and traffic whizzing by. Amidst all this sensory input, the brain is working hard to process the information to overcome its inherent limitations. While it cannot pay attention to every single detail of the environment it is immersed in, human beings have developed strategies, some conscious and others not, for focusing only on salient events of interest. For example, moving through a party of people having conversations is a conscious way to mediate access to information and the properties of 3D sound perception itself allows one to focus on only certain conversations and not others. This is known as the cocktail party effect.

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### *Lessons from Multiuser white board experiments*

In our shared whiteboard application, we took a similar sensory approach by assigning distinct sounds to each drawing tool and graphical object primitives. While this enabled users to audibly perceive the activities of their peers, the complexity of the resulting soundscapes posed interpretive challenges. Users were faced with the daunting task of learning not just the sound-to-object mappings but also decoding this new auditory language in real time. The endeavor of capturing and representing peer activities through sound proved to be more intricate than anticipated. Consider the cognitive load of deciphering a 3D auditory landscape filled with layered sound patterns—all to deduce unseen activities, identify the participants, and recognize the tools in use. The concept held promise in theory, but faltered in practical execution because we ignored cognitive limitations. This instance was not unique in challenging our initial assumptions; there were more eye-opening moments to come for our limited minds.

After grappling with the complexities of sensory integration in our multiuser whiteboard, we also realized that the design had more problems. How would one control the placement of the virtual sound sensor in this 3D soundscape without turning it into yet one more task that the user will have to address? The answer seemed to lie in the untapped potential of gaze-controlled interaction. With the advent of eye-tracking technology, the opportunity to explore gaze as a natural, intuitive controller for moving a sound sensor through a soundscape was too compelling to pass up.

### *Gaze auditory browsing*

Here, we carried out experiments where the ‘auditory sensor’ was controlled by the mouse in one mode of interaction, and it

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was synchronized with the user gaze position in another. Even though users were able to locate sound sources using gaze, users experienced higher subjective workload than the case where they had to use the mouse to position the sound sensor. The observed outcomes may be attributable to the instability inherent in the inaugural generation of eye-tracking devices, a point discussed in the Appendix. So, we would not recommend dismissing our approach in this space yet without replicating the experiments again with the latest generation of eye trackers.

### ***Soundscape Design: Lessons learned***

The evaluation of these exploratory designs led to several important insights:

*User Preference:* Users found it challenging to explore evolving soundscapes through gaze control of their sound sensor, preferring to use the mouse to position it. This indicates that leveraging perceptual awareness may require more intuitive and familiar methods for users to adapt quickly.

*Sound Complexity:* The experiments highlighted the difficulty of composing synthetic sounds to represent complex events and the challenge for users to understand them with ease. Future research should focus on developing more recognizable and meaningful sound representations. The complexity of this task has thus far eluded formalization, maintaining its status as an art form.

*Gradual Change:* The experiments demonstrated that fully exploiting the brain's untapped potential may require a gradual process of adaptation and learning. Introducing new methods of interaction and representation should be done incrementally to allow users to become accustomed to the changes.

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### *Attempting to improve gaze behavior in autistic toddlers*

In 2002, a significant endeavor was undertaken to explore a novel method aimed at altering the cognitive behavior of autistic children, based on insights from prior gaze behavior studies. The initiative, though promising, faced an untimely halt due to financial constraints, leaving the efficacy of the developed system untested.

Previous investigations by the Dr Cheryl Trepagnier's research revealed distinct differences in gaze behavior between autistic toddlers and their non-autistic counterparts. This foundational understanding led to the conceptualization of a system to amend such behaviors (Ramloll, Trepagnier, Sebrechts, & Finkelmeyer, 2004). A virtual environment was engineered to reward toddlers for exhibiting desired gaze behaviors, such as increased face fixations. Rewards included gentle rocking motions of their seat or engaging visual alterations, aimed at encouraging corrective gaze behavior. This system is described in the Appendix. Among the pioneering steps taken was the design of an auto-calibration feature for eye trackers, enhancing the system's potential for real-time feedback and interaction.

At first glance, these experiments may seem unrelated to our concerns, but they have reinforced our belief that high-quality avatars are vital for enhancing the social dynamics of the Metaverse. If our goal is to improve the quality and depth of social interactions in this virtual environment, the incorporation of detailed and realistic avatars with accurate gaze behavior will be crucial.

|                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------|
| The fidelity of avatar facial representation is paramount for the accurate capture and conveyance of nuanced social cues. |
|---------------------------------------------------------------------------------------------------------------------------|

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Our interest in exploring the importance of gaze awareness in collaborative processes led us to create specialized collaborative environments for those with visual impairments—a compelling and logical avenue for exploration. We knew, even back then, that the field of assistive technology would become an important aspect of an inclusive Metaverse.

### **Assistive Technology for the Metaverse**

Assistive technology provides tools that people with disabilities need to communicate and navigate virtual worlds, allowing them to enjoy these environments fully. By providing tools that allow disabled users to more easily navigate and interact with virtual environments, assistive technology can help make virtual worlds inclusive. There are several different types of assistive technology which could be used in virtual worlds including speech-to-text tools for those who are hearing impaired, text-to-speech for those with visual impairments, and physical disability controllers. Such tools not only improve accessibility, but they also create new opportunities educationally and vocationally for people with disabilities.

However, the role of assistive technology extends beyond mere user interface design or repurposing existing technology. The content itself often needs to be reframed and re-presented in innovative ways to be truly accessible. For instance, musical pitch can be used to represent numbers, and a sequence of notes or pitches can represent a graph in an auditory medium.

Furthermore, empowering users with atypical cognitive or physical profiles within the Metaverse has the potential to eradicate any lingering stigma. By making these virtual worlds truly inclusive, we not only expand opportunities but also dismantle barriers of prejudice.



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Once the Metaverse has established itself as a realm that not only entertains but also tangibly improves the quality of life of individuals with atypical cognitive or physical profiles, the role of assistive technology will transition from an afterthought to a central concern for designers.

### **Sensory channel load optimization**

Let us now examine how we can use a methodical approach aimed at harnessing the full spectrum of human sensory capabilities. Recognizing that each sensory channel has its unique strengths and limitations, we begin by identifying these constraints, particularly focusing on commonly compromised channels like vision. Once these limitations are acknowledged, our exploration shifts to alternative sensory mediums. The auditory channel serves as our first alternative, offering a rich landscape for information processing when the primary channel falls short. If auditory solutions are inadequate or inappropriate, we then delve into the haptic medium, exploring tactile and kinesthetic avenues for interaction. Finally, we can check if we can synthesize these approaches into a multi-sensory integration framework. For example, when figuring out a solution, a designer can combine a virtual touch and virtual sound environment approach to deal with the limitations experienced in the visual medium.

### ***Limits of Brain-Computer Interfaces: Why Sensory Adaptation Remains Crucial***

As individuals age, or due to congenital issues, lifestyle choices, and injuries, sensory channels may diminish in effectiveness. It is not rare for individuals to experience sensory degradation, with challenges ranging from minor eye floaters to severe retinal detachments. By designing interfaces

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from an information-processing perspective on cognition, designers can better accommodate these perceptual changes. For example, sonified or auditory graphs have been developed specifically for those who are blind or visually impaired.

Such approaches can be argued to become less important in an age where brain computer interfaces (BCIs) are becoming more and more powerful. Brain-computer interfaces show potential in addressing certain types of visual impairments, particularly those related to the retina or the optic nerve. For retinal-based blindness, such as age-related macular degeneration or retinitis pigmentosa, BCIs can bypass damaged photoreceptor cells and send signals directly to the remaining healthy retinal cells. For blindness due to optic nerve damage, BCIs might be designed to send signals directly to the visual cortex in the brain, bypassing the eyes and optic nerve entirely. These scenarios are promising, but the current level of BCI technology can only provide a limited form of visual input and is far from restoring vision to the level of normal sight. On the other hand, visual impairments caused by damage to the visual cortex of the brain pose a greater challenge. Creating a BCI to stimulate the correct parts of the brain to generate visual experiences is significantly more complex and is currently beyond our technological capabilities. As such, these cases are less likely to be successfully addressed with current and near future BCI technology.

The following sections will present experiments that were carried out decades ago, and the technology used will reflect that. But the research framework, questions or motivations have not changed much.

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### **Sensory adaptations: audible and tactile 'visualization'**

#### *Sound as a lens for the visually impaired*

Figure 2 illustrates a simple system (Ramloll & Brewster, 2002) designed to make mathematical data more accessible to the visually impaired. This system uses position sensors placed on the left B (Figure 2, B) and right fingers of the user. A virtual sound source is created and located at the position of the right fingertip, while a virtual listener is positioned at B. The sound is rendered in 3D and can be heard through a headset A (Figure 2, A.) This approach enables users to perceive the data through sound, using the relative position of their fingers as a means of navigation. Keep this set up in mind as we present the following examples.

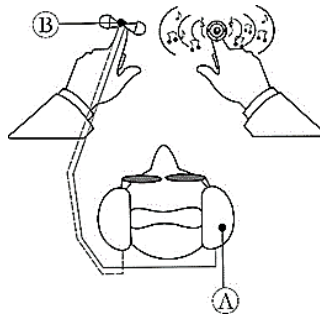


*Figure 2 User listening to real time 3D virtual sound located at right fingertip*

We transformed a long table of numbers into an auditory experience by mapping each Y value to a piano pitch (See Figure 3). This innovative approach created an audible range from 0 to H, where h represented the data value. We also

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designed a tactile curve, allowing the user to feel its shape through touch. The tactile curve could be a raised diagram or one that could be felt through a VR haptic device.

To achieve this, we placed a sensor A (Figure 3, A) at the curve's origin and another sensor B (Figure 3, B) on the user's right finger. As the finger glided along the curve, our sound mapping system converted the graph's value at each point into a distinct pitch. This enabled the visually impaired user to audibly perceive the curve's shape as their hand moved from left to right, distinguishing higher peaks from their surroundings with ease. This example of augmented reality for mathematical data visualization demonstrates our ability to identify a problem space, devise an adaptive tool, and cater to the cognitive needs of our target users namely the blind and visually impaired.

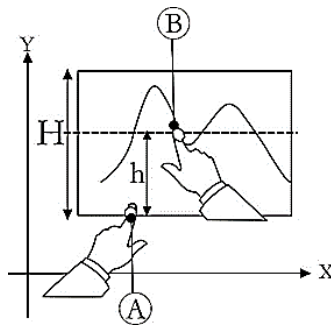


*Figure 3 A simple sound mapping strategy: Pitch heard at B as a function of  $h$*

Figure 4 provides more details about how we were able to track the position of fingertips. We use an early-generation Polhemus motion tracking device A (Figure 4, A) that we attached to the finger so that the position of its tip could be tracked.

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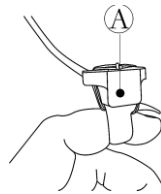
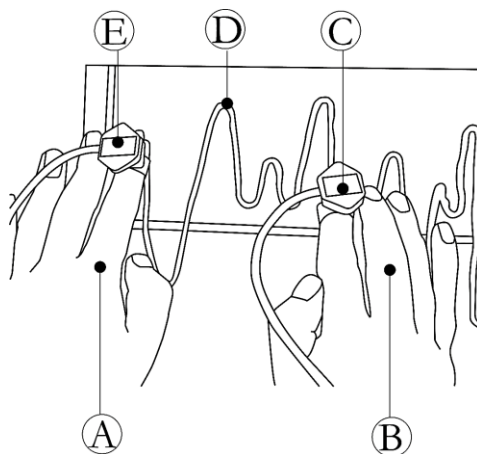


*Figure 4 An early-generation Polhemus motion tracking device (c. 1999-2001)*

In Figure 5, we illustrate a tactile graph created by affixing a thick string to a board, to represent the curve of the data. To enhance the user experience, the axes of the graph can be explored with both hands A and B (Figure 5, A and B). A user would typically position sensor E (Figure 5, E) at the origin and move sensor C (Figure 5, C) along the curve, experiencing the changes in pitch as they navigate the graph. Creative techniques can be used to compare local maxima D (Figure 5, D) by manipulating the positions of sensors E and C (Figure 5, E) and (Figure 5, C). This successful experiment opens a world of possibilities, suggesting that numerous other experimental approaches can be developed to translate tabular numerical values into pitch variations for deeper understanding.



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*Figure 5 A visually impaired person using motion tracking to read a raised line graph (c. 1999-2001)*

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In the forthcoming Figure 6, we present an experiment that studies the feasibility of auditory graphs generated from tactile interactions with a raised bar chart D (Figure 6, D). This tactile chart is meticulously crafted using strips of thick paper C (Figure 6, C) pasted onto a background sheet to form distinguishable axes and bars. Employing a similar sound mapping technique, the results demonstrate the potential usefulness of audio-enhanced real-world features felt by exploring hands A and B (Figure 6, A and B) for visually impaired graph readers, opening up new avenues of accessibility and understanding. At this point, the reader may ask what all this has to do with the Metaverse. Our mission has always been to explore virtual reality and augmented reality domains as deeply as possible in order to get inspired to create a Metaverse with real world applications. These little experiments serve as the dots that we are convinced are going to be connected later on.

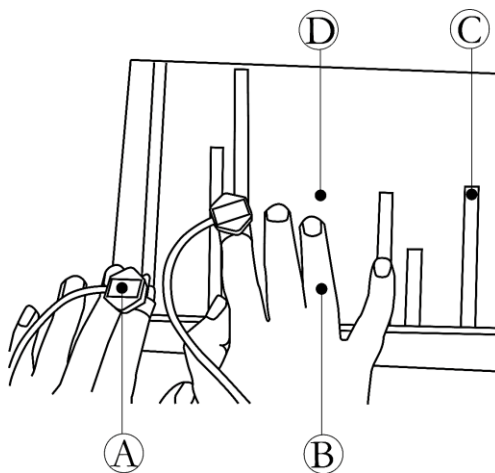


*Figure 6 A visually impaired person using motion tracking to read a raised bar chart (c. 1999-2001)*

## 6. Harnessing the Brain

The upcoming Figure 7 highlights a relevant experiment designed to explore the ability of individuals to simultaneously comprehend multiple auditory graphs, with each sound source representing a distinct variable (Ramloll R. , 2002). In the real world, we often take it for granted that multiple people can study a graph at the same time, but is this activity possible for individuals with visual challenges? In this approach, a sound sensor is attached to the user's finger, enabling them to browse and compare various variables across different sound sources each representing how a variable changes with time. Positioned at the center of a triangle, users can discern auditory graphs on the left, right, and front. What truly sets this experiment apart is the fascinating insight it provides into the limits of human perception within complex soundscapes.

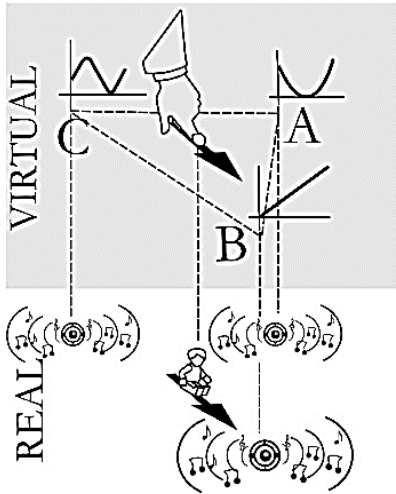


*Figure 7 Listening to three audio graphs at the same time*



## 6. Harnessing the Brain

In the accompanying Figure 8, we see a user seated at a table wearing a blindfold A and a headset G (Figure 8, G), engaging with a unique user interface (UI) that presents three variables at the corners of an elevated triangular configuration, (Figure 8, E). The UI, referred to as C (Figure 8, C), features three switches enabling the user to navigate and explore the variables' values. The top and bottom buttons allow for forward and backward navigation, while the central button prompts the system to verbally announce the current values of the variables under examination in speech. The user attached a position sensor D (Figure 8, D) to her left finger and the connecting cable was held securely using a strap (Figure 8, F). Doing dry runs with this set up illustrate the clear possibility for developing insights about how each variables relate to each other.

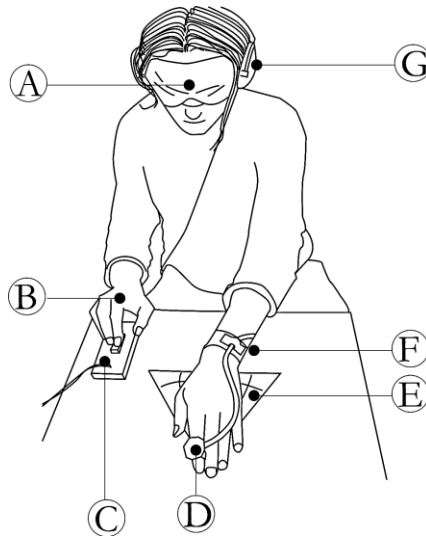


*Figure 8 Experimenting with spatial 3D sound graphs (c. 1999-2001)*

## 6. Harnessing the Brain

We push boundaries further and investigate whether this approach can be used in a collaborative setting. Figure 9 illustrates an environment involving two visually impaired users A and D (Figure 9, A and D), from wearing eye masks F (Figure 9, F), seated at a table immersed in a shared auditory landscape akin to the one previously detailed. For all practical purposes, the reader can assume user A and D to be in locations separated by a wall C. The sealed headsets made sure they could only hear the shared virtual soundscape and nothing else. Within this setting, the participants can converse through a directional microphone E (Figure 9, E), with the sound of their voices appearing to emanate from their fingertips' location thanks to some clever sound mapping strategy. This auditory experience enables concurrent exploration of datasets and spatial awareness of each user's position in this purely auditory space, thereby enriching collaborative discussions with valuable contextual insights. Again, these experiments may appear peculiar even today, but they provide a lot of information about how virtual worlds can feel like if we push in this direction.

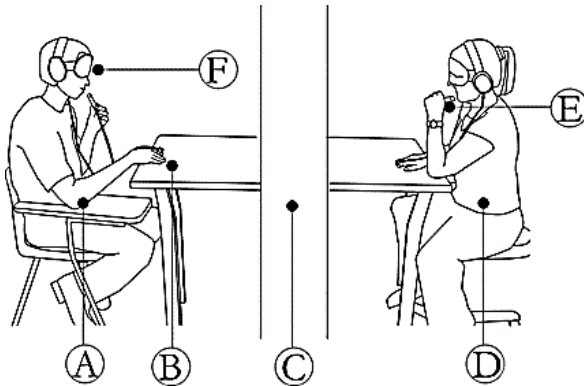


*Figure 9 Two users browsing and discussing about spatialized sound graphs (c. 1999-2001)*

## 6. Harnessing the Brain

Our pursuit of this research back then over a very short period of time highlighted the critical need for understanding the limits of auditory perception. This included grasping how well people could localize sounds, as well as their ability to discriminate between different yet concurrent sound sources. Representing oneself as a voice avatar without a body did feel ghostly and intriguing. The creation of sound graphs required us to invent new data abstractions and innovative ways to convey complex information through audio alone. We sincerely hope that such experiments will be tried again today with the latest technologies by a new generation of researchers.

Through our work in data sonification and auditory perception, we not only expanded the horizons of augmented reality but also paved the way for more inclusive and accessible data representations. Our research serves as a testament to the power of interdisciplinary collaboration and the importance of understanding the human brain when creating innovative solutions to complex challenges.

The lesson here perhaps is that the best virtual world architects and designers will strive to create systems that can adapt to evolving human cognitive needs, which are expected during the natural course of a human lifetime. For completion, we will describe other some other experiments that we ran in the virtual touch or haptic domain.

### ***Haptic data exploration: Virtual touch for capturing overview***

While data sonification is the process of converting data into sound, haptics technology is used to create virtual touch. These approaches have the potential to provide a more multimodal and effective way for students to engage with mathematical concepts. This is yet another example where virtual

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environments can provide opportunities for tapping into underused sensory channels to increase comprehension and productivity.

In Figure 13, we illustrate researcher A (Figure 10, A), exploring a simulated groove C (Figure 11, C) within a virtual environment, employing the Phantom haptic device B (Figure 12, B) (Yu, Ramloll, & Brewster, 2000).

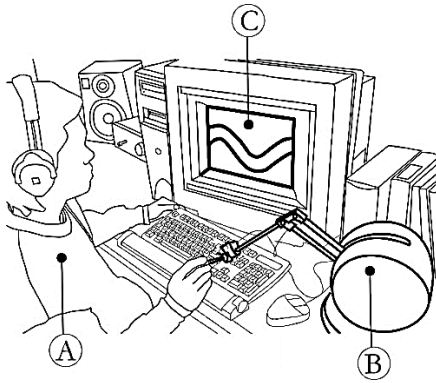


*Figure 13 Researcher using a haptic device to explore a curve that represents data (c. 1999-2001)*

The Phantom haptic device is a remarkable piece of technology that enables users to interact with and receive feedback from virtual objects in a simulated environment. It achieves this by providing the user with tactile sensations, such as resistance and texture, mimicking the feel of real objects. In this example the user only experiences kinesthetic haptic feedback.

Kinesthetic feedback, that is haptic feedback experienced through the held pen, is not as rich as cutaneous touch feedback in the real world, but is quite useful in helping a visually impaired user experience a curved groove or raised surface. We compared various virtual surfaces. The raised surface A (Figure 14, A) is less effective as a haptic representation for

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graphs than a groove B which traps the haptic pen and prevents it from slipping away (Figure 14, B). One way for the reader to imagine what the subject A (Figure 14, A) experiences is to consider what a hand feels as it holds a stylus (Figure 14, D) and moves it along a groove such as (Figure 14, C) in the real world.

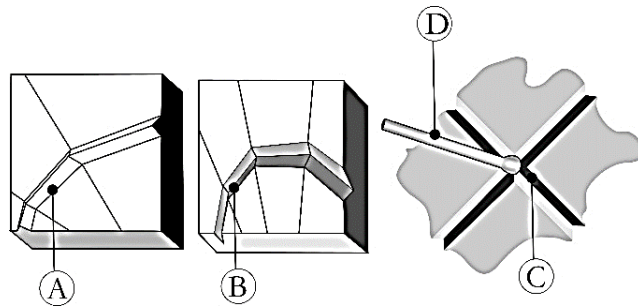


*Figure 14 Exploring different types of surfaces to represent data (c. 1999-2001)*

After delving into the transformative power of sensory adaptations—in order to maximize data flow into underused sensory channels—we now turn our attention to another marvel of human cognition: the brain’s latent ability to build spatial cognitive maps. This shift in focus is an extension of our exploration into human cognition and interface design. In summary, our methodology focuses on examining the mechanisms of perception, pinpointing the brain’s constraints and overlooked capacities, and subsequently designing applications to optimize brain utilization. Just as we have harnessed the auditory and tactile senses to enrich user experience, we will examine how understanding the brain’s spatial mapping capabilities can further improve both real-world and virtual interactions.

## 6. Harnessing the Brain

### **Brain's latent ability to build Spatial Cognitive Maps.**

Spatial cognitive maps are mental representations of the layout of our surroundings (Bunce, 2022). They help us orient ourselves in space, keep track of where we are, and plan efficient routes from one place to another. Beyond navigation, cognitive maps also play an important role in memory and learning. For example, when we try to remember the location of a specific item in a store, we are relying on our cognitive map of that store. Studies have also shown that having a detailed cognitive map of an environment can help us learn and remember new information about that environment more effectively. The reality that evolution guided the brain to devote particular areas to bolster spatial recollection implies this confers an evolutionary benefit.

The hippocampus is a brain region that is thought to be important for the formation and retrieval of cognitive maps (O'Keefe & Nadel, 1978). This is supported by evidence from studies in humans and animals. For example, damage to the hippocampus can lead to impairments in memory and navigation. Additionally, the hippocampus is active when we are performing tasks that require us to use cognitive maps, such as remembering the location of an object or imagining future events.

The 2014 Nobel Prize in Physiology or Medicine was awarded to John O'Keefe, May-Britt Moser, and Edvard Moser for their discoveries of cells in the brain that allow for spatial navigation and positioning. In 1971, O'Keefe discovered "place cells" in the hippocampus that create mental maps of the environment (O'Keefe, 1971). In 2005, the Mosers identified "grid cells" in

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the entorhinal cortex that generate a coordinate system for positioning and pathfinding (Hafting, 2005). The entorhinal cortex envelops the hippocampus, providing a major input to this deep brain memory structure. Together, place and grid cells constitute an "inner GPS" that enables spatial orientation and navigation. This research provided a cellular basis for cognitive functions like mapping spaces and memory, and advanced our understanding of impairments seen in Alzheimer's disease. It represents a paradigm shift in neuroscience toward elucidating how specialized cells work together for higher cognition (Sargolini, 2006).

### *Capturing and representing spatial cognitive maps*

In our opinion, tapping into grid and place cell activity could enable numerous applications involving spatial mapping, navigation, and geographical tagging; assisting impaired spatial memory; neural integration with prosthetics to guide automated movement; geo-tagging images and videos by matching place cell firing to physical locations; location-based gaming that tracks brain activity for accurate player positioning; and hands-free spatial computing interfaces using place cell firing as virtual buttons for navigation instead of hand controllers. In summary, reading the brain's innate spatial mapping system could benefit any technology relying on physical positioning, navigation and contextual location data. For example, one could recreate a usable map of an environment solely from the information provided by place cells and grid cells. The specific landmark signaling from place cells combined with the precise spatial coordinates from grid cells could certainly make this possible. Unfortunately, we lack the resources as a bootstrapped team to implement these ideas. We hope others

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will be inspired and address this goal which we think is worthwhile and has a high likelihood of success.

### *A simple approach to augment spatial memory*

Although the human brain already assists us quite well in navigating our surroundings, we have contemplated an inexpensive method to further improve this ability, particularly in virtual environments. Currently, individuals can traverse virtual spaces faster and with greater ease than physical spaces, yet they may also become disoriented more readily in digital realms. Our intent is to encourage development of tools that will aid navigation through virtual worlds by gathering salient details about the environments explored along the way. Moreover, these details could constitute a form of travelogue that can be shared with peer travelers.

Designing an application to capture spatial cognitive maps involves finding ways to capture sensory snapshots and organizing them in a structure that facilitates their retrieval. If we only consider the visual medium at this time, it is fairly straightforward to implement a camera to take pictures of what the explorer sees as they navigate a given environment.

Let's provide an example, we will choose a virtual Museum example for navigation because these buildings typically have a lot of content which are spatialized meaningfully across the many rooms they contain. The approach is also applicable to open environments without walls but for simplicity let us focus on closed spaces.

In Figure 15, we present a detailed floor plan of a selected section of a popular destination in the virtual world of Second Life™: The Vordun Museum and Gallery, complete with the



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locations of its diverse exhibits and amenities. The diagram traces the path of the visitor, as depicted by an arrow, upon entering the museum and arriving at position P (Figure 15, P).

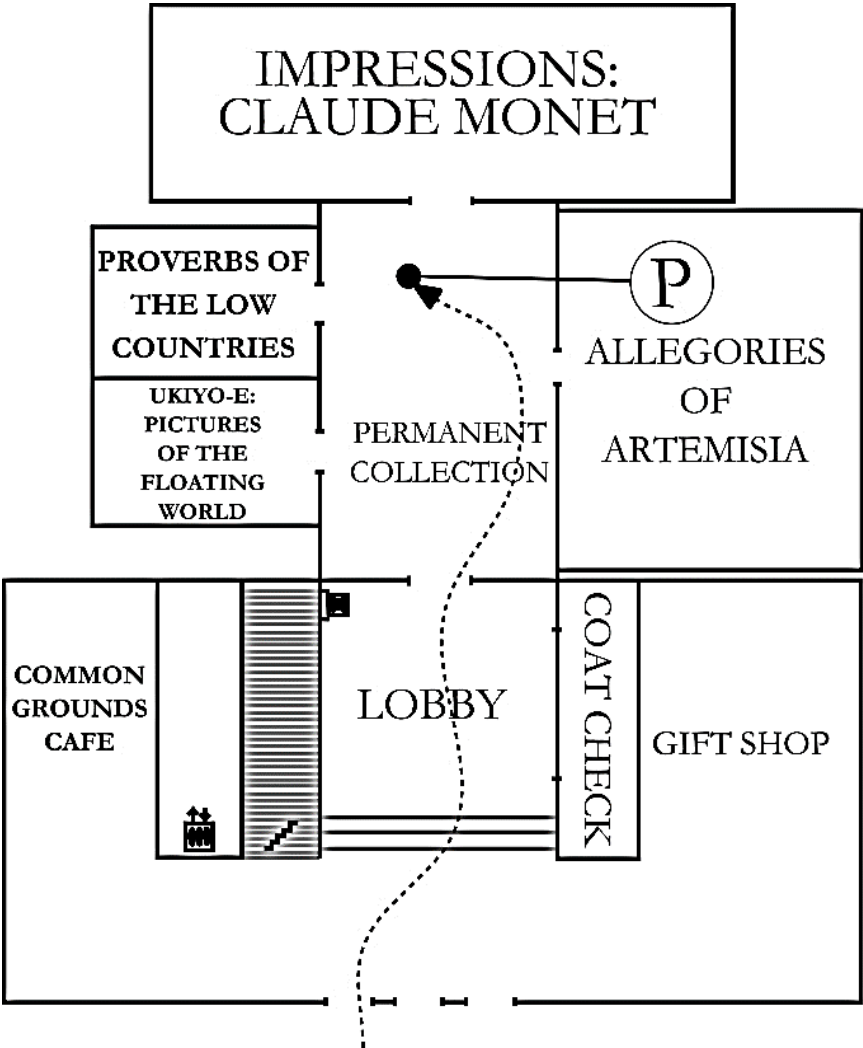


*Figure 15 Map of a section of a museum floor, and path of a visitor*

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In Figure 16, we showcase an example of an interactive user interface designed to record a navigator's spatial cognitive map as they explore the virtual museum. This approach was implemented more than a decade ago using Java3D, and we can certainly anticipate better results if today's technologies are used (Ramloll & Mowat, 2001). The interface features a central 3D view, with three groups of thumbnail images surrounding it, and navigation controls. To fit the entire diagram on one page, the 3D view is scaled down.

The 3D view includes a set of standard navigation buttons G (Figure 16, G) for turning and moving, as well as a camera button H (Figure 16, H) to capture points of interest. As the user explores the virtual environment, the central 3D view updates accordingly. Three panels of thumbnails provide vital information: Panel E (Figure 16, E) displays images of entrances to the current space, panel A (Figure 16, Panel A) shows exits from the current space, and panel C (Figure 16, Panel C) contains user-captured images of notable objects encountered within the room. The entrance (panel E) and exit images (panel A) are automatically generated by the spatial cognitive map capture algorithm.

As users navigate through the museum, entrance, and exit thumbnails update automatically, and new objects of interest are added manually to C by clicking H (Figure 16, Panel H). Users can click on these images to teleport to corresponding locations, or disable syncing with navigation by clicking on B (Figure 16, button B). In the latter mode, users rehearse navigation without physically moving in the virtual world.

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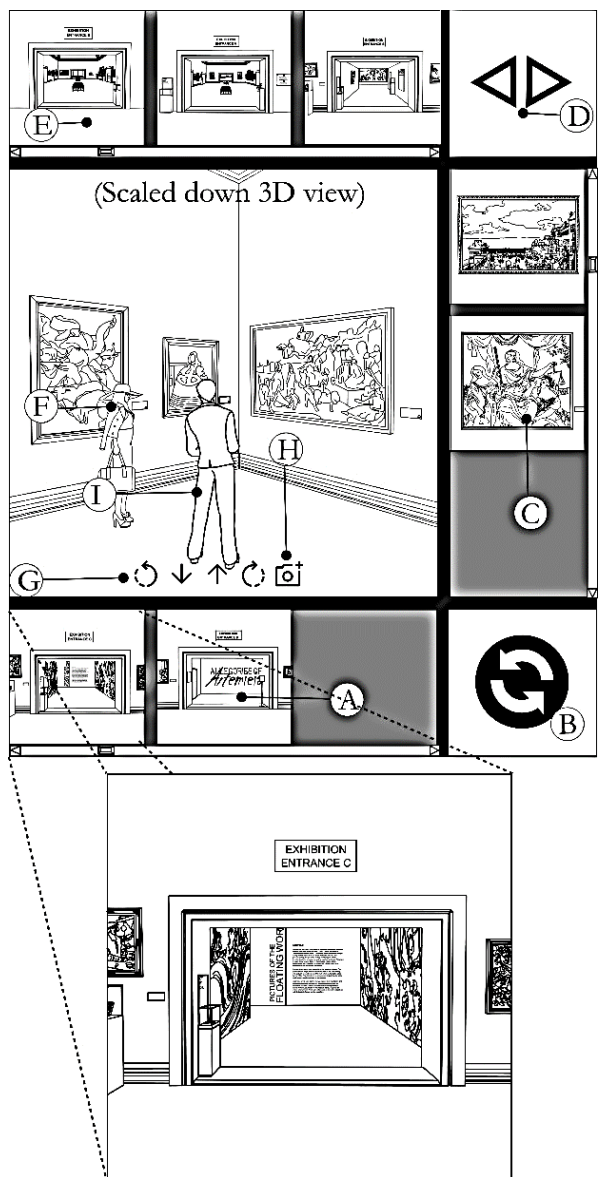


*Figure 16 Example design of an application that captures a navigator's spatial cognitive map*

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Additionally, this interface allows users to navigate their own or others' trajectory with the forward and back buttons in D (Figure 16, Panel D). While the current setup only captures images, future implementations could potentially record auditory information or any other biological signals from the navigator that could be made available for interpretation down the line. This innovative interface enables users to document their virtual experiences, which can be shared with others and as such can function as a travelogue for collaborative exploration.

This approach has potential for both real world and virtual world settings but for now, we have only explored a virtual world one because of its simplicity.

### ***Beyond navigation aids for large scale 3D worlds***

A Memory Palace (Krokos, 2019) is a mnemonic technique that involves associating pieces of information with specific locations within an imagined space. This method not only helps us remember information more effectively but also capitalizes on the brain's natural propensity for spatial organization. Many of us have personally experienced the benefits of organizing information in this way. In their book, *Metaphors we live by*, Lakoff and Johnson (Lakoff, 1980) explain how metaphors in language reflect and shape our understanding of complex concepts, especially through spatial terms.

The brain's ability to navigate its internal spatial cognitive map has practical applications in various information-seeking tasks. For example, when we are trying to recall a piece of information, our brains can quickly search through this spatial map to find the appropriate memory. As technology continues to advance, we may see a future where our ability to capture

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and navigate our internal spatial cognitive maps is amplified, ultimately improving our capacity for information-seeking tasks and memory retention.

Such ‘augmented memory’ systems could work well in conjunction with brain computer interfaces. The combination of wearable devices and artificial intelligence to help users better navigate their internal cognitive maps or externalized ones from others, and access stored information appears to be an interesting future research endeavor.

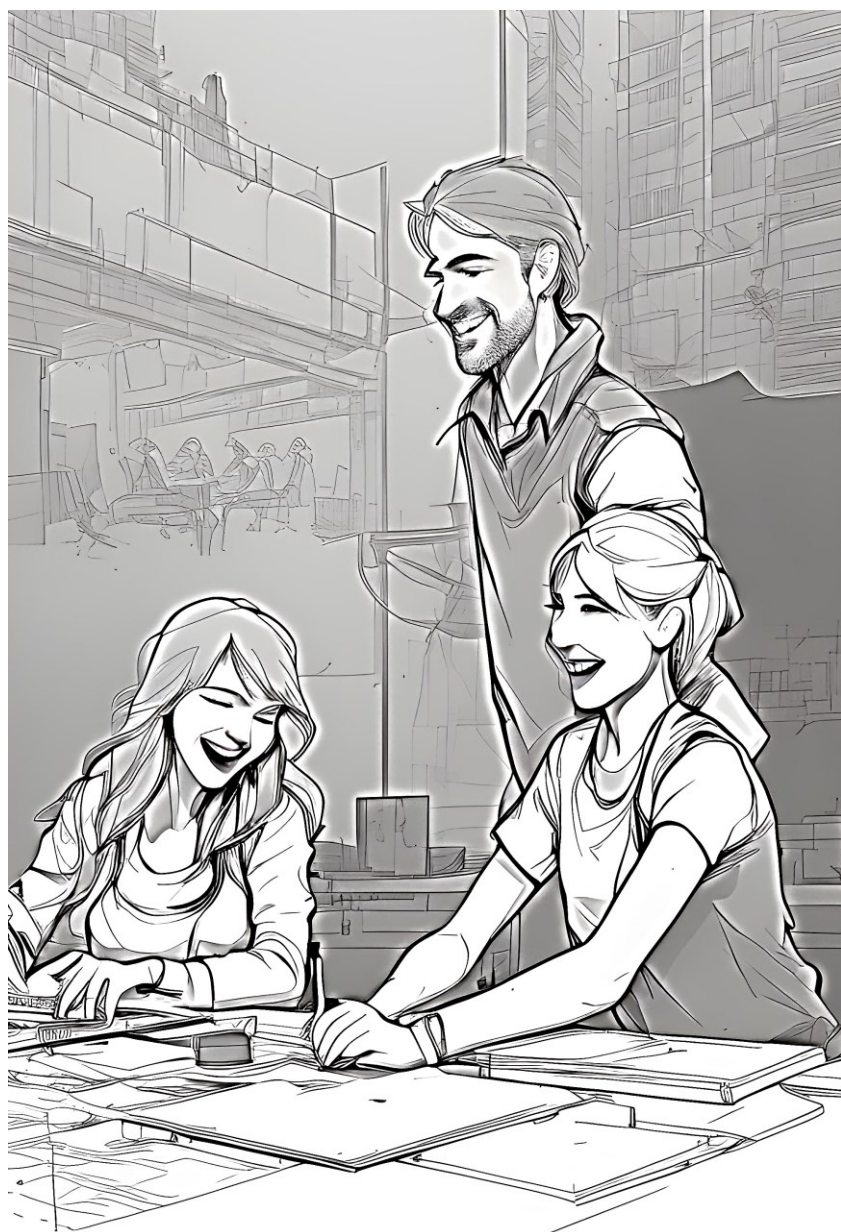
In the next chapter, we will get a chance to explore, for example, how users curate web information and organize it meaningfully in 3D spaces.

## Conclusion

Understanding the strengths and weaknesses of the human brain is not just an academic exercise; it is a cornerstone for impactful design. By tailoring applications to complement the brain’s natural abilities and compensate for its limitations, we can create experiences that are not only immersive but also intuitive and accessible. This is the hallmark of an impactful Metaverse designer—one who can seamlessly integrate scientific insights into practical applications. As we stand on the cusp of a new era where virtual worlds will become increasingly integral to our daily lives, the role of a Metaverse designer will evolve to be one of immense value and complexity. The future extends an inviting hand to those ready to dance in the realm of multidisciplinary exploration, to wear both the hat of a scientist and the cloak of an artist, to be a technologist with a heart of a humanist.

## 6. Harnessing the Brain

In the next chapters, we will delve into the iterative design of virtual workspaces, the challenges and solutions in content creation, and work towards amplifying the utilitarian nature of 3D Metaverse products. It is about taking the insights we have gained from the chapters on Mindful Design, Unraveling Complexity, and Harnessing the Brain, and applying them to create a Metaverse that is not just immersive but also a powerful platform for collaboration and problem-solving. However, we acknowledge that integrating these various facets into a seamless experience is a monumental task. We do not claim to have crafted the ultimate, flawless plan for a collaborative Metaverse. Rather, we present our bootstrapped efforts as a designer's diary, in the hope that many will resonate with our journey and contribute to this ever-evolving landscape.



*Chapter cover 7 Social Bandwidth: Physical and Virtual Connection*

## 7. Broadening Collaboration Avenues

### *Designing utilitarian virtual environments*

This chapter delves into the power of no-code tools that make the creation of diverse 3D worlds accessible to a broad audience. These tools democratize the development process, enabling even those without technical expertise to contribute. While this book is rich in line diagrams that illustrate various concepts, it's important to note that these aren't mere speculative designs. We have actually developed and utilized these scenarios both internally and for our clients and we accumulated lessons that may be valuable to peers. We opted to use line diagrams created from screenshots for a very specific reason: longevity. Our aim is for these examples to serve as enduring blueprints that inspire future work, rather than becoming outdated due to their visual presentation.

We recognize that leading entities in the realm of Metaverse research and development possess resources that dwarf our own small and largely self-funded team, enabling them to advance at a faster pace and explore multiple platforms concurrently. Given this context, we felt a responsibility to meticulously document our experience so that our insights stand a better chance to survive the test of time.



## 7. Broadening Collaboration Avenues

### **Creating, using and evolving virtual collaborative environments**

It has been our belief for a while that the best way to come up with design solutions that will maximize 3D virtual worlds' utility is to iteratively design solutions while immersed in them to meet our own needs.

Consequently, we would be better equipped to understand how this space can be utilized, how it was evolving and how to develop effective solutions. We would learn something from this that would impact the design of future workspaces or shed light on the future of work. Thus, our plan for creating a virtual workplace consisted simply of the following:

1. Create one for our team and see how it works
2. Identify the needs as they arise
3. Create in-world products to address those needs
4. Iterate and evaluate the product design
5. Establish a content creation infrastructure to facilitate the creation of products, and
6. Distribute successful products to other teams.

Let us visit some of the applications that we implemented as part of this plan. Many of these applications are directly utilitarian in nature, that is, they are not mere props but can also be used to solve actual problems.

#### ***A no-code content creation infrastructure***

Establishing a content creation infrastructure is the most challenging step of this plan. Software that supports content creation that does not require end users to code, is continually

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evolving to meet new needs as they arise. We will focus in this section on the products that this infrastructure supports.

This infrastructure can be considered, for now, as software that coordinates communication between base objects (e.g., trees, post-it notes, chairs, models of atoms of molecules, non-player characters) organized into modules and a set of Composer applications deployed on the virtual land. Each of these Composer applications can be used for a specific purpose. The modules appear as labeled 3D boxes, with the labels and images indicating the category of virtual objects contained within. These virtual objects become accessible to end users after signing into a particular Composer application. The box contents manifest as selectable items in the users' Head up display, enabling them to build or utilize the application. Each Composer app communicates with chosen modules to determine the items to render in the Heads-up display. A Composer can be used to create interactive setups that present specific functionalities as we will soon see. All instances of Composers can share the content of modules that constitute the library of objects available for the construction of scenes. The form and interactivity of each scene is what determines its functionality.

### *Why no-code?*

Our no-code Composer application lets users easily build 3D world scenes by selecting objects from libraries. This 'no-code' feature is designed for assembling these objects. Although creating the objects themselves demands advanced programming and 3D design expertise, for which we developed specialized tools, our goal is simple. Our aim was to streamline scene building for subject matter experts by offering them a customized level of modification aligned with their

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competencies and comfort. These experts might not have the technical skills or the time to craft high-quality library objects. Yet, with our system, they can create 3D scenes that more closely match their needs typically within the time they can afford. Many examples, which will be provided soon, will help illustrate this concept. When we designed the Composer, we also envisioned a marketplace where skilled developers could create and share these objects.

The compositional tool we introduce in this chapter comes in various forms and adaptations, offering a flexible approach to suit different needs. For smaller geographic deployments, we present the application for example using an embodiment described in Figure 17. This allows for targeted and localized utility, making it easier to manage on a smaller scale. For more expansive, large-scale deployments, we introduce a map-based composition and event monitoring application that can handle the complexities associated with bigger projects (United States of America Patent No. 61/841,380, 2016). Examples describing the use of this particular embodiment will be described in Figure 20.

### *The power of modular building*

One of the most vital takeaways from our work is the transformative potential of modular building. This approach enables seamless interoperability across a wide range of applications, effectively dissolving the boundaries that often limit cross-functional utility. In this chapter, and the next, brace yourself for a plethora of examples drawn from various fields and scales. The point we aim to drive home is the remarkable diversity of content that our straightforward approach can facilitate, without alienating end-users from the content creation process.

## 7. Broadening Collaboration Avenues

A positive side effect of our approach is that now users or content creators can make use of a limited number of resources, for example, a limited virtual land area or number of objects and processing power, to create a very large number of experiences that can be loaded, modified or deleted at will.

One strength of our methodology is its capability to store scenes in an object-oriented format, reminiscent of familiar object-oriented drawing applications and the inherent benefits they offer. In contrast, another method, photogrammetry, captures 3D environments without distinguishing which points constitute specific objects, making scene modifications challenging. Clearly, when it comes to harnessing AI capabilities, object-oriented frameworks seem more promising for 3D virtual worlds than their photogrammetric counterparts. For instance, Object-oriented scene files, with their structured data and explicit definitions of each object and its attributes, provide a superior foundation for AI-driven scene generation based on verbal instructions compared to photogrammetric information. While photogrammetry offers detailed scene reconstructions, it lacks the semantic understanding and modularity inherent in object-oriented systems. We also believe object-oriented scenes provide better opportunities for AI to generate advanced content, as this object orientation makes the AI more efficient and accurate at interpreting and translating verbal cues into virtual scenes. The object-focused structure can ensure rapid and precise scene modifications in response to user verbal commands, potentially even those given in natural language.

### ***One simple interface to control all Composer instances***

A series of iterations have led to the development of a Heads-Up Display (HUD) for controlling the various Composer

## 7. Broadening Collaboration Avenues

applications. Figure 17 illustrates a typical end-user experience when attempting to create a 3D world scene for a specific application. Upon clicking button B (Figure 17, B) to sign in, the 2D HUD emerges, enabling the user to explore the group of modules C (Figure 17, C) that can be positioned anywhere on the surface of the Composer base platform A (Figure 17, A).

The Composer in addition provides user-friendly features such as ‘snap to object’ and ‘snap to grid’ functionalities, simplifying the placement of objects and streamlining the overall design process. Furthermore, the Composer App supports multiple instances, allowing users to sign in individually and collaborate on shared projects, promoting teamwork and fostering creativity.

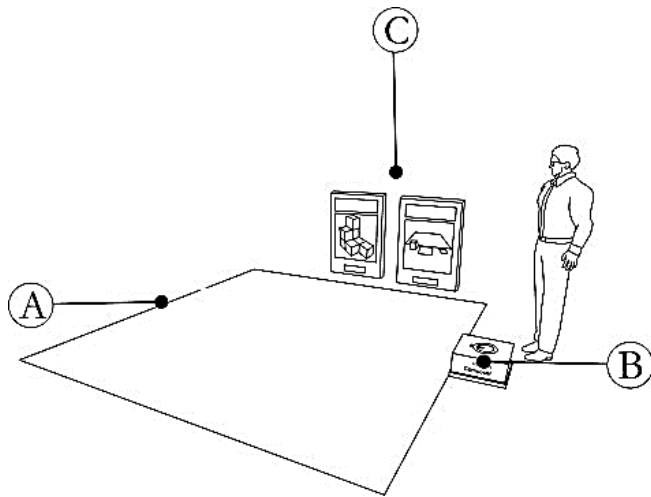


*Figure 17 Look and feel of a basic Composer App*

Figure 18 illustrates the Universal HUD, which is displayed for every user upon logging into their unique instance of the Composer App. 3D scenes created using the app can be saved as files and accessed at any time in the future. These files can be easily shared among content creators, who can then utilize

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them as-is or modify them according to their requirements. In any given scene, objects can be selected with a single click, enabling users to perform a variety of operations on them.

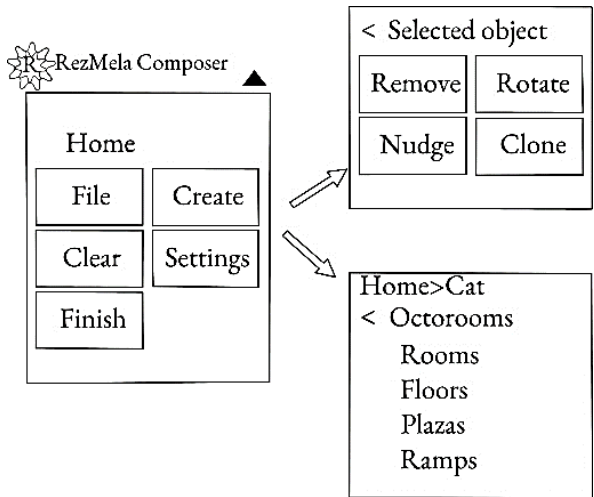


*Figure 18 Universal HUD for the Composer App*

It is worth mentioning that this versatile application, capable of creating extensive towns, cities, road networks, or museum exhibits, can also be adapted for simpler tasks, such as generating a board with sticky notes for project management purposes. This flexibility demonstrates the wide-ranging applicability of our HUD design.

### ***Redesigning a web browser***

As part of our experimentation, we created a 3D version of an Internet browser within a virtual world. To take advantage of the affordances that come with the 3D space, we developed several possible designs. A design feature worth noting is how bookmarks are created and managed. While we represented URL bookmarks as 3D objects, we maintained the traditional web browser design of a browser on a flat surface. Each web

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browser object could be cloned, moved, and placed anywhere. Whenever a site or online video was bookmarked, a 3D bookmark object, each of which was embodied as a book with the necessary labels on the covers and spine, was created.

Having arranged them in racks and labeled them, the set up quickly resembled a library. When clicking on the 3D bookmark, the associated URL would be displayed in the closest in-world browser. It was demonstrated tangibly through this design that adding such a spatial dimension could add value to a traditional web viewer.

First, bookmarks could be organized so that they could be browsed easily. Second, people could invite others to view this 3D library of bookmarks. Our view is that the ability to search for objects as well as to browse them is equally important and browsing is certainly an activity that lends itself to 3D spaces.

Earlier work on the memory palace (Peeters, 2019) suggests it is easier to find a given entity in a 3D place than from an itemized list. In my experience, I have found it easier to recall where objects are located after navigating a 3D space. This spatial navigation seems to help construct a durable cognitive map of information sources. The tangible encounter with objects in a virtual setting appears to promote longer-lasting memory of their positions.

### *Redesigning office tools*

The process of migrating simple objects from the real world into 3D virtual space yields not only a broader range of applications but also improves interoperability between them. Mind mapping tools, or project management tools for 2D desktop environments, are familiar to many. These applications

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are traditionally considered separately and are implemented by separate firms. It is not typically possible to move or port a post-it note from a mind map application by one company to, say, a project management application by a different company. Let us check out how this can be simply done when designing for a 3D space. The illustration (Figure 19) presents a typical example meeting setup we have encountered frequently during our regular collaborative discussion sessions.

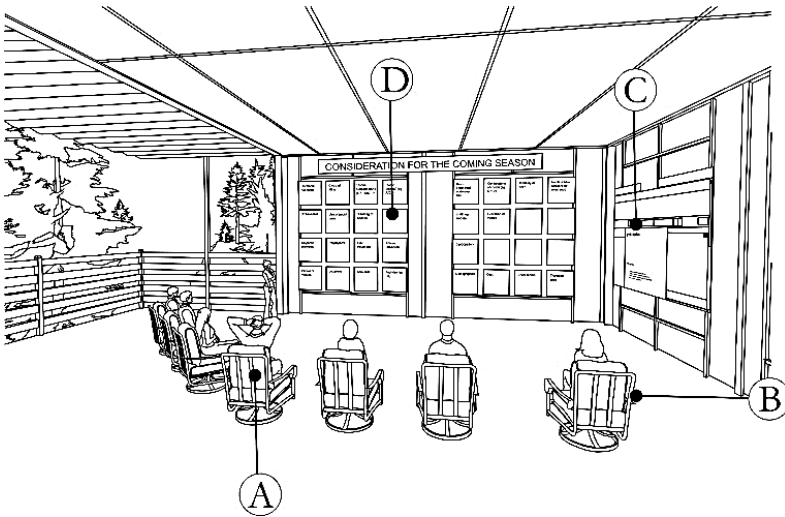


*Figure 19 Designers enjoying the opportunity to evaluate their own tools during regular meetings*

The virtual post-it note D (Figure 19, D) can display both images and text in a variety of colors and fonts. A user may create, select, copy, clone, edit , or move these post-it notes and place them on boards, walls, or anywhere else they choose. Therefore, creating meeting tools, agenda preparation tools, note taking tools, and ways to capture and display brainstorming sessions become simplified. We also have access to a video screen that can be used to display video streams.



## 7. Broadening Collaboration Avenues

Even our object-oriented drawing app is powered by the same content creation and management infrastructure as the virtual post-it notes. Every application we have discussed would traditionally be considered a distinct product segment. Here, however, their natural convergence appears to be a given and the conceptual boundaries between them appear to be very permeable.

We believe that once applications migrate into 3D environments, the traditional boundaries that separate them in the desktop world will dissolve.

### *Effective prototyping environment*

As content creation tools become more user-friendly and accessible, prototyping evolves into a routine activity for users. Our program enables the design of virtual gardens, landscapes, and buildings, while also allowing experimentation with various elements such as lighting, seating, and navigation paths, proving valuable to architects and landscape designers in the real world.

The Composer App, for instance, speeds up construction of museums, conference campuses, and poster exhibits. Rapid content creation and customization capabilities theoretically drive adoption. If the demand for utilizing virtual 3D worlds continues, we expect the need for accelerated content production to remain a priority.

### **Large scale 3D content creation and customization**

This important need for direct customization by the end user is not an afterthought in our design approach. Rather, it revolves around this critical need. Users feel empowered when they

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have access to well-designed parts, they can assemble to create something new quickly. In almost every field, this principle rings true. Emojis or strings of them are often used to express ideas forcefully and succinctly. In the same way, it is also possible to create drawings, exhibits, or even whole worlds from simpler parts.

In the forthcoming figure, we unveil an innovative approach to content creation and deployment within expansive virtual environments, such as sprawling urban landscapes or extensive conference and trade show campuses. Traditional methods of populating these vast spaces can be cumbersome, necessitating constant navigation and camera repositioning. Our solution streamlines this process with the aid of a map-based Composer application.

The Composer application enables users to place iconic representations on a map, with each icon corresponding to a large-scale object that materializes in the virtual world at the designated location. For example, putting an icon of a building on this map causes a larger scale building to appear at the relevant location as described by the map. This scalable method is adaptable to any environment size, simply by adjusting the map's scale. Furthermore, the map can accommodate three-dimensional data to capture elevation information. For example, placing a tree icon on a 3d terrain representation on the map, will cause a tree and the terrain to appear in the larger scale world outside this control room.

Imagine a collaborative teaching scenario (Figure 20), wherein an instructor C (Figure 20, C) discusses a situation with a group of trainees A (Figure 20, A) as they all face a board F (Figure 20, F) displaying the map. The instructor can effortlessly introduce content onto the map, simultaneously

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constructing a 3D world beyond the confines of this virtual room B (Figure 20, B). In the subsequent phase of the training session, students can explore this newly formed virtual realm.

Functioning as a Wizard of Oz, instructor C assumes complete control over the virtual world's activities. This patented design (United States of America Patent No. 61/841,380, 2016) incorporates a feedback loop, allowing the instructor to monitor the trainees' actions in the virtual environment via the map.

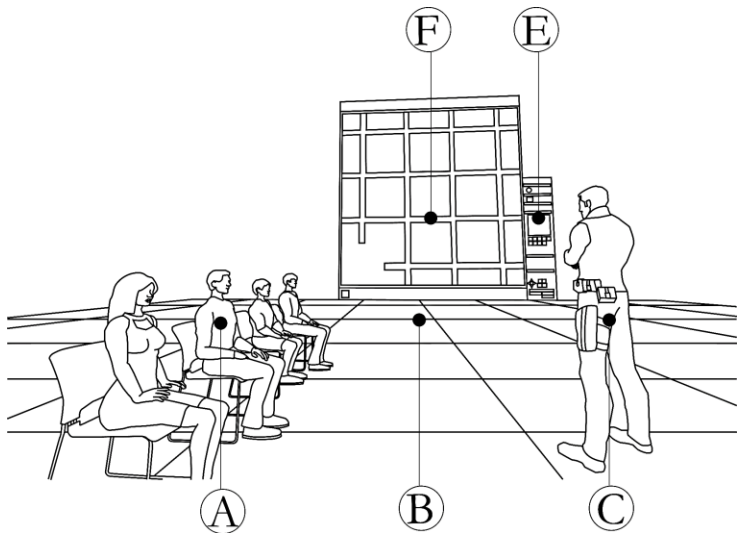


*Figure 20 An instructor with his students as avatars facing a content creation and student activity monitoring board (c. 2016-2017)*

## 7. Broadening Collaboration Avenues

In the following illustration (Figure 21), we delve deeper into the menu adjacent to Map F from the preceding figure, revealing a variety of distinct sections. This embodiment empowers the instructor to manipulate multiple aspects of the virtual environment.

Section A (Figure 21, A) permits the adjustment of wind direction, while section B (Figure 21, B) enables the modification of the water table level. In section C (Figure 21, C), the instructor can alter the time within the world, adjusting lighting conditions to suit their needs.

An object picker, denoted as section D (Figure 21, D), provides the instructor or content creator with the ability to select objects from a diverse range of categories, represented by section F (Figure 21, F). These objects may include buildings, non-player characters, interactive equipment, and even drivable vehicles.

The Map serves a dual purpose: not only does it function as a surface for placing iconic representations, but it also acts as a control interface. The instructor, much like the Wizard of Oz, can modify various events or conditions, thereby influencing the occurrences within the virtual world.

Lastly, section H (Figure 21, H) encompasses controls for saving and loading different scenes as required, offering a convenient way to manage the ever-evolving virtual landscape.

7. Broadening Collaboration Avenues

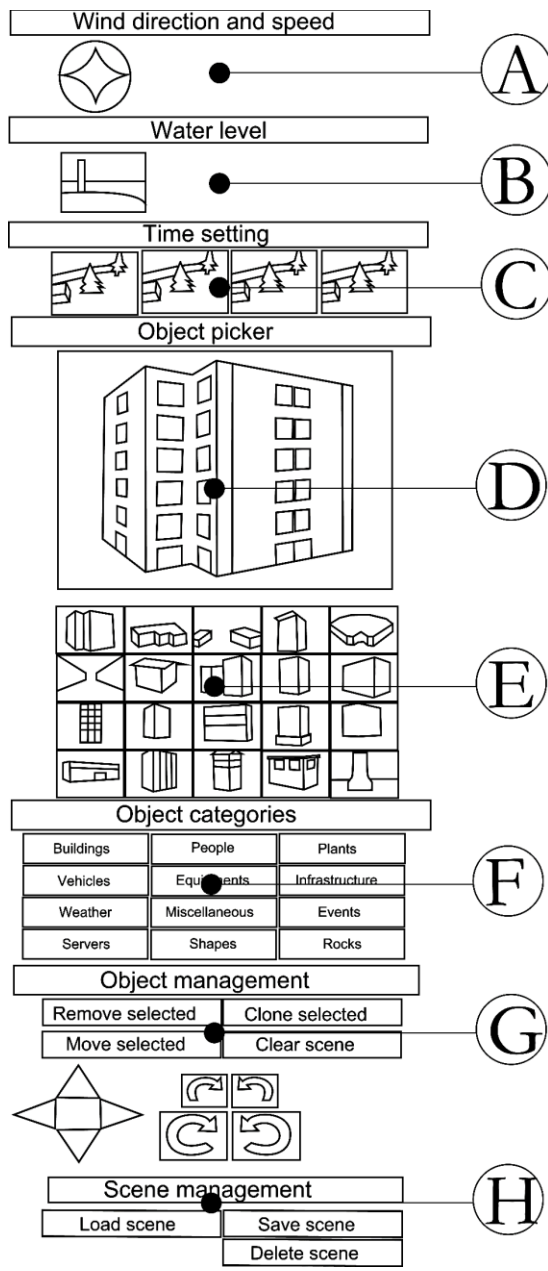


Figure 21 An example menu for the content creation board (c. 2016-2021)

## 7. Broadening Collaboration Avenues

In the accompanying illustration (Figure 22), our perspective widens to reveal a more comprehensive view. At the heart of the scene, an individual C (Figure 22, C) operates board, deftly manipulating its controls. The observer can now discern that this person is situated within a sophisticated control room B (Figure 22, B), surrounded by a myriad of iconic elements E (Figure 22, E), placed meticulously on the board.

The layout of the roads forms an orderly grid, while an eclectic mix of architectural styles populates the cityscape. As our gaze extends beyond the boundaries of control room B (Figure 22, B), the true scale of this urban landscape comes into focus. In the distance, a three-dimensional metropolis emerges, together with its towering edifices A and D (Figure 22, A and D) and bustling streets. All these objects can be navigated through and explored by avatars or non-player characters.

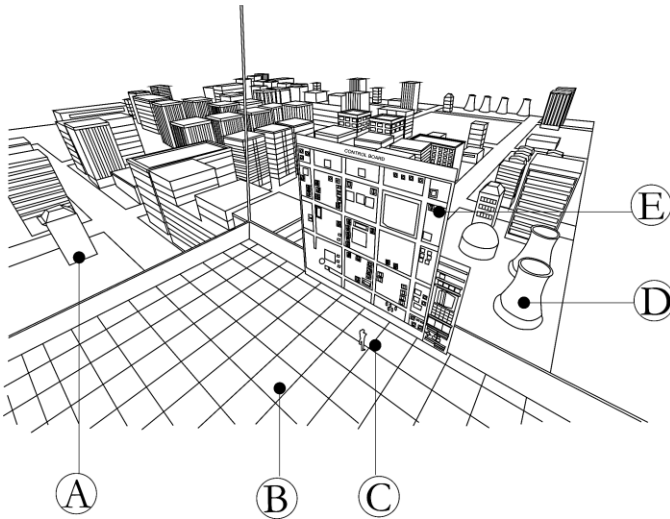


*Figure 22 An instructor creating a large town by placing 3D icons that represent larger scale objects such as buildings and vehicles on the board (c. 2016-2021)*

## 7. Broadening Collaboration Avenues

Immersed in a ground-level perspective offered by the map-based Composer application, we find ourselves navigating a virtual urban landscape (Figure 23). Buildings A (Figure 23, A), stand tall and imposing, echoing the architectural grandeur of real-world cities. Nearby, elements C (Figure 23, C) reveal children's playground amenities, introducing a sense of community spirit into the digital scene.

Now let us imagine that an emergency preparedness instructor is running a training exercise, and they want to immerse students in an engaging situation. Suddenly, the tranquility of the scene shifts dramatically. Interacting with the controls described in Figure 21 allows them to trigger a flooding situation that students will have to address collaboratively. Like a tide, the water levels rise, gradually submerging the meticulously designed town beneath a liquid blanket. Streets become rivers B (Figure 23, B) buildings turn into islands A (Figure 23, A), and playgrounds C (Figure 23, C) transform into submerged relics of their former selves.

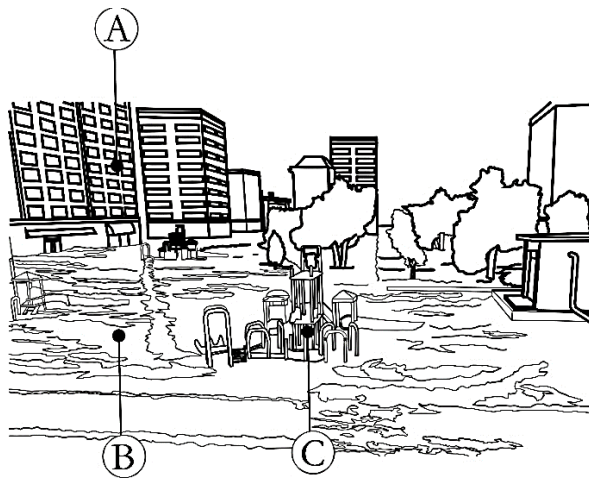


*Figure 23 Virtual Deluge: A Glimpse into Flood Preparedness Training*

## 7. Broadening Collaboration Avenues

This scenario underscores the power and versatility of the training environment and the content creation tool. It allows us to simulate and study potential disaster scenarios in a safe yet impressively authentic setting, providing a robust platform for learning.

The image presents a section of a digital town generated by the map-based Composer application. In this scene, trucks A (Figure 24, A), tractors B (Figure 24, B) and other vehicles C (Figure 24, C), are shown. They are not just static props but can be driven around by avatars or can drive autonomously along configurable trajectories, adding a layer of realism to emergency preparedness drills.

The application's asset library is not limited to these vehicles. It includes a wide range of emergency service vehicles, such as police cars, helicopters, and ambulances. These are available in various modules, expanding the application's functionality. This variety contributes to the realistic environment necessary for effective emergency preparedness training.

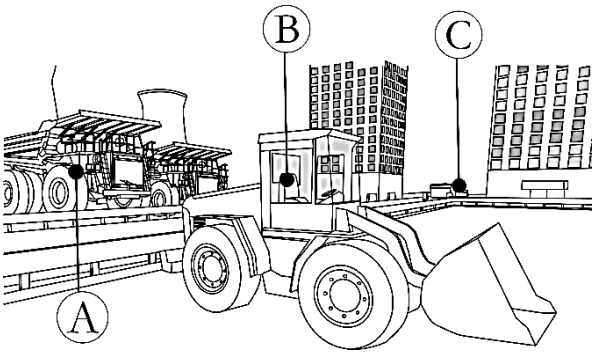


*Figure 24 Vehicle Simulation*

The image (Figure 25) presents a detailed rendition of a firetruck, specifically a pumper tank, within a virtual



## 7. Broadening Collaboration Avenues

environment. The driver's cabin A (Figure 25, A), is designed for the person controlling the vehicle, while cabin B (Figure 25, B) accommodates the rest of the firefighting crew.

A notable feature of this digital firetruck is its control panel C (Figure 25, C), which allows the crew to adjust the water pressure and operate various essential devices during a fire emergency. This interactive feature enhances the authenticity of the training experience.

An avatar E (Figure 25, E), can also explore the range of personal protective equipment and firefighting tools available. This array of equipment includes items such as masks, fire extinguishers, helmets, axes, torches, and radios, adding to the depth and realism of the simulation.

Users can interact with this virtual firetruck, selecting and using the tools they need for their training scenarios. This ability to interact with the environment significantly enriches the learning experience, providing practical insights into real-world firefighting operations.

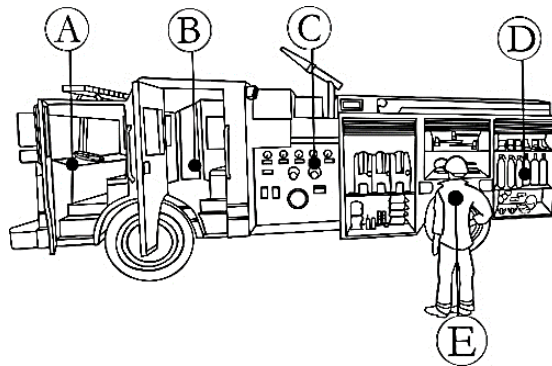


*Figure 25 Firefighting Simulation: Interactive Pumper Tank Training*

## 7. Broadening Collaboration Avenues

Figure 26 presents a glimpse into the dynamic world of virtual environments. Beyond the static structures and moving vehicles, users have the power to introduce non-player characters (NPCs) into this digital realm. These NPCs can be directed to perform a variety of actions, adding an extra layer of realism to the virtual landscape. In this particular scene, a group of dedicated firefighters A (Figure 26,A) takes center stage, their mission clear: to navigate towards a designated fire location and extinguish the flames with high-pressure water or other firefighting agents that will be pumped through hoses C (Figure 26, C) and out of nozzles B (Figure 26, B). As we delve deeper into this immersive experience, we witness how the behavior of these NPCs breathes life into the virtual exercises, enhancing their authenticity. While they possess pre-programmed behaviors, the virtual exercise facilitator also has the ability to intervene and modify selected behaviors live to add finer controls to the scenario, further enriching the training environment. As we explore this illustration, we are reminded of the power of virtual simulations in preparing individuals for real-world challenges, where every action and decision can make a difference.

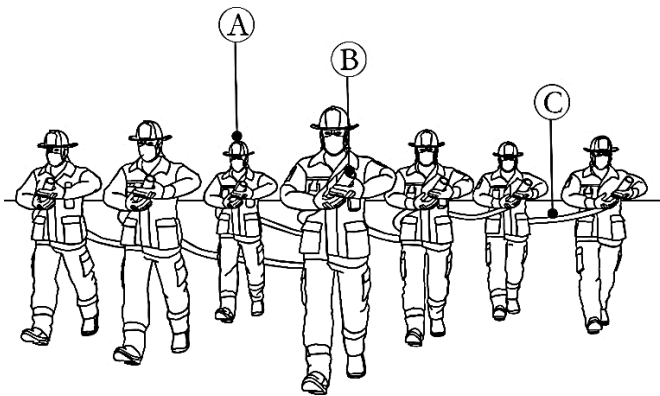


*Figure 26 NPC firefighters with functional hose*

## 7. Broadening Collaboration Avenues

The image (Figure 27) exhibits a selection of road components (Figure 27 A, B and C), each piece a building block in the intricate web of a virtual road network. The components are diverse, varying in shape and function, reflecting the complexity of real-world road systems.

The road module within the Composer application empowers users with the ability to craft custom road networks, selecting and combining the components as needed. This flexibility allows for the creation of a wide range of roadway configurations, from simple straight paths to complex intersections and roundabouts, catering to the unique requirements of each training scenario. The parts' ability to snap together makes their assembly quite easy.

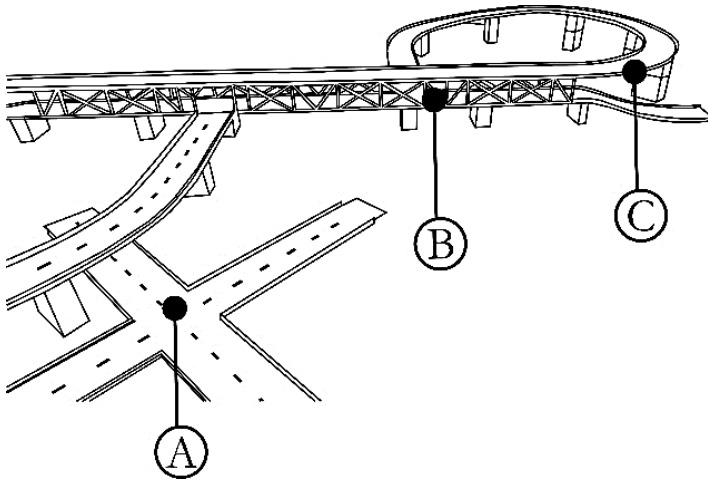


*Figure 27 Replicating Real-World Road Networks from components*

The image (Figure 28) captures a scene where avatar (Figure 28, B) is standing at ground level, looking up at a flyover road, labeled as (Figure 28, A). This picture gives a sense of scale to

## 7. Broadening Collaboration Avenues

the road structure and provides a viewpoint that resembles real-world perspectives.

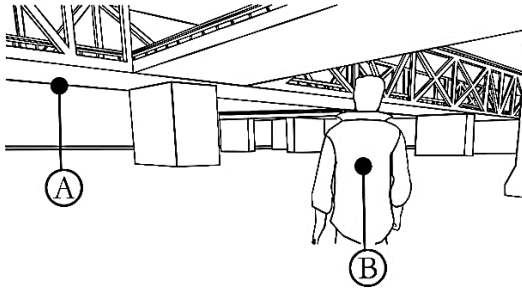


*Figure 28 Ground-Level Perspective: Avatar Viewing a Virtual Flyover*

Figure 29 presents a restaurant E (Figure 29, E) bustling with activity as members of the public B and C (Figure 29, B and C) gather within its walls D (Figure 29, D). The scene is further enriched by the presence of a drivable vehicle A (Figure 29, A) nearby, adding a sense of realism and dynamic energy to the setting. As we observe the carefully arranged furniture within the restaurant, we are drawn to the underlying purpose of this illustration – to emphasize the necessity of what is known as a destruction engine. This engine serves as a crucial tool in simulating the behavior of objects in the aftermath of devastating events such as explosions.

In the past, programmers and artists had to collaborate closely to devise methods for accurately simulating these scenarios. However, our innovative composition tooling approach involves the development of modules that contain pre-programmed destructible objects. This empowers educators to seamlessly deploy these modules and expect them to behave authentically, mirroring real-world destruction dynamics. Looking ahead, we anticipate that advancements in simulation technology will continue to enhance the believability and

## 7. Broadening Collaboration Avenues

realism of these behaviors, further enriching training experiences for emergency preparedness scenarios.

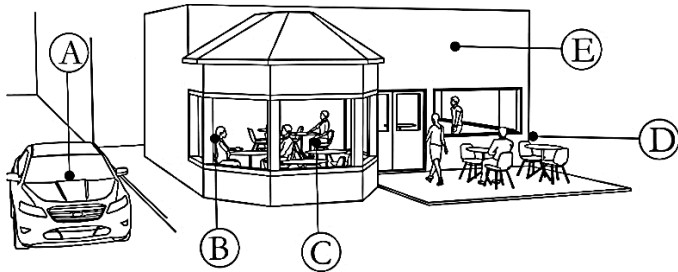


*Figure 29 A restaurant in a street corner where avatars are interacting with each other*

Figure 30 In this poignant picture, we are confronted with the aftermath of a devastating blast that has struck a restaurant, potentially indicating a terror event. The scene is marked by the harrowing sight of extensive damage to the building's structure, with fire and smoke engulfing the surroundings. The walls and furniture bear the scars of the intense heat, displaying signs of scorching and charring. Tragically, human bodies lie motionless on the ground, a stark reminder of the human toll of such events. The special effects were all pre-programmed.

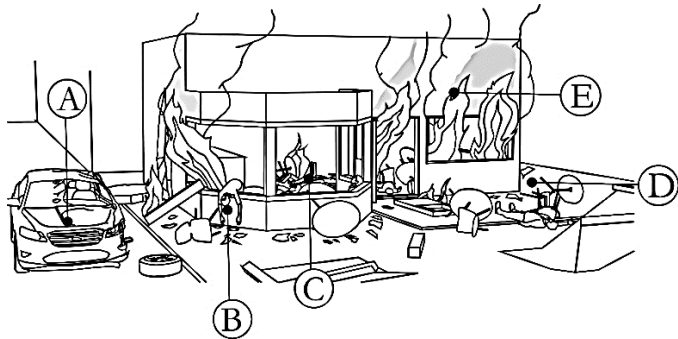


*Figure 30 Virtual restaurant and nearby objects destroyed*

## 7. Broadening Collaboration Avenues

While it is not imperative to simulate the precise physics of every element within the scene, as it would impose a heavy computational burden, designers have employed clever shortcuts to achieve a balance between realism and computational efficiency. Through various behavior-determining algorithms in the backend, flames and smoke can be realistically launched, the structural integrity of buildings can be degraded, and textures can be altered seamlessly. These optimizations allow for an immersive experience while conserving computing resources.

In our experience, training scenarios in virtual environments like these elicit earnest and focused engagement from students. Students are fully absorbed in their tasks, driven by a sense of purpose and an eagerness to respond to this emergency in the best way possible.

Figure 31 illustrates how various stakeholders B and C (Figure 31, B and C) in a control room D (Figure 31, D), conducting an exercise in a 3D virtual world F (Figure 31, F) while using different ‘radar’ maps (Figure 31, A, G, and E) to monitor specific data or aspects relevant to their respective expertise or goals. This demonstrates the flexibility and adaptability of real-time monitored data visualization in such an environment.

Thus, maps can be used not only as an interface deploy content but also offers a contextual surface for the presentation of data. As they interact with the virtual world, the maps automatically update to reflect changes or new information. This seamless integration allows for enhanced collaboration and decision-making among the stakeholders.

The power of this approach lies in its ability to easily extend and adapt to diverse needs. By enabling multiple maps with

## 7. Broadening Collaboration Avenues

distinct focuses, the system can cater to various stakeholders and their specific requirements. This flexibility allows for a more comprehensive understanding of the virtual world, supporting collaboration and promoting efficient problem-solving.

In summary, Figure 31 highlights the advantages of real-time data visualization and the use of maps as both content creation interfaces and data presentation surfaces. By offering customizable maps tailored to different stakeholders, this approach becomes more powerful and adaptable, making it an effective tool for collaboration and decision-making in a 3D virtual environment.

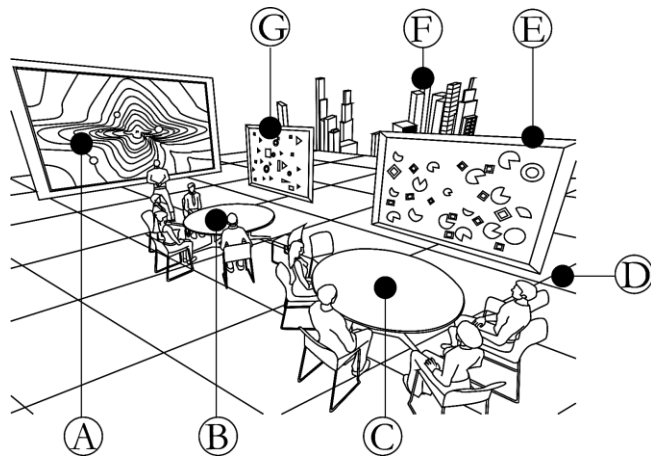


*Figure 31 Emergency preparedness experts as avatars running a large scale exercise using multiple concurrent content creation and activity monitoring boards (this aspect of our vision was planned but not implemented because of time constraints)*

## 7. Broadening Collaboration Avenues

### Advanced scripted 3D assets or objects

The base objects in various modules can have complex programmable behaviors. The Panocube is one such interactive object that can be used to create advanced 360-degree virtual tours of real-world locations. The experiment showed how 2D Google Street View images can be used in a 3D virtual environment. This allows for collaborative exploration of real-world places recreated virtually. The historical street view images also let us see how a real location changed over time. Overall, this offers an excellent educational opportunity.

In this illustration (Figure 32), a 360-degree panoramic view of a real-world location is displayed in a cubic projection. The image offers a broad perspective of the surroundings, giving a detailed and accurate representation of the environment. This projection facilitates a seamless and immersive experience, as viewers can examine the area from various angles.

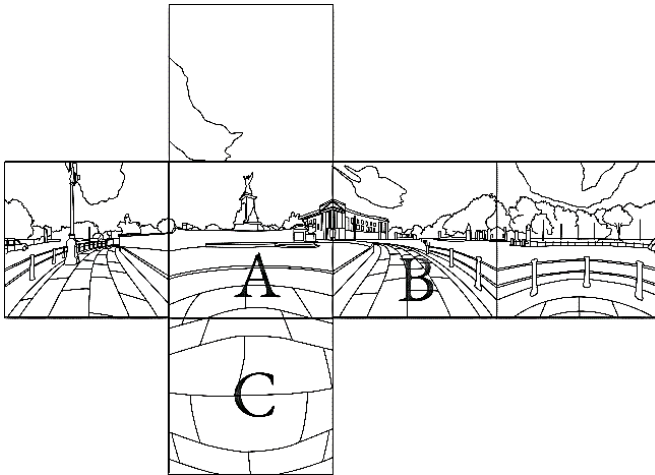


*Figure 32 Cubic projection of a 360 panoramic real-world view*



## 7. Broadening Collaboration Avenues

This illustration also demonstrates the potential of using these images to texture the inner faces of a virtual cube. By doing this, users can comfortably navigate a virtual rendition of the physical location, generating an immersive experience. Although this technique may not yield high-resolution 3D models, it remains notably cost-effective and resource efficient.

It is important to mention that this image was created using Google Street Map Application Programming Interface (API), which enabled the composition of a useful depiction of the location based on its geographical address. While cutting-edge technologies such as photogrammetry and generative AI may soon offer automated 3D virtual recreations of physical locations, they are likely to be more expensive. In this context, the illustration serves as an example of the significant potential of current technology in producing immersive and realistic experiences while remaining accessible and cost-conscious.

In the next illustration (Figure 33), we discuss the more advanced features of this interactive object. Avatars can enter the cube and experience an all-surround view of a physical location after inputting its geographic coordinates. The cube's interior surfaces are 'painted' or textured with images from the cubic projection as discussed earlier, assigning a distinct picture to each face – Picture A for face A, Picture B for face B, and so on, until all six faces are textured.

## 7. Broadening Collaboration Avenues

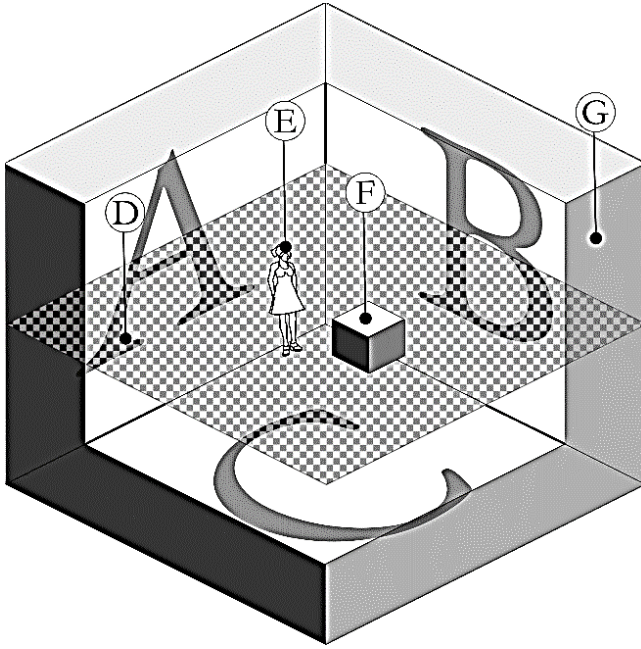


*Figure 33 The Panocube: low-cost application to an all-surround experience of a real-world location*

This approach has a drawback. The sweet spot for the perfect 360 view is at the center of the cube. To mitigate this issue, we also included a transparent floor D (Figure 33, D), which enables avatars E (Figure 33, E) to maintain an eye level as high as the ideal viewing spot inside the cube. Despite this limitation, this method still delivers a distinct and immersive experience which can still be useful as a representation of a physical place.

Furthermore, our underlying design allows the Panocube to be just another embodiment of the Composer App. Thus, it incorporates all the features that we typically associate with the Composer. Avatars have the ability to sign in and generate content, display signs, organize seating, and label parts. Since Google Street View API offers images captured at various

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timestamps, our approach can facilitate the creation of panoramas that depict a location's historical transformations. Educators will certainly find such capabilities useful as a teaching aid in fields such as tourism, education, architecture, and urban planning.

Figure 34 presents, an avatar exploring a Panocube, which features an immersive 360-degree view of a train station (Figure 34, E).

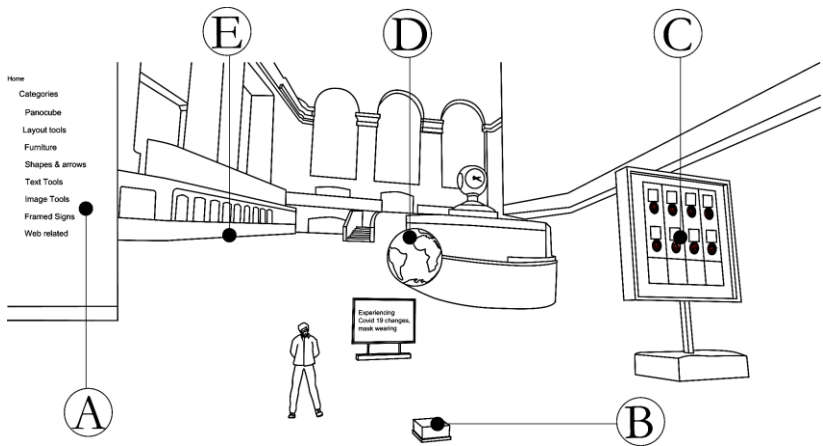


*Figure 34 An avatar inside a 360 panorama of a real world location generated from Google Map Images*

To access the Composer functionalities of the Panocube, the user clicks on button B (Figure 34, B) causing the menu A to appear (Figure 34, A). They can then select and add objects to this 3D environment. To render a specific real world geographic location, the user clicks on the globe icon D (Figure 34, D), prompting a dialog box where they get to enter the physical address or coordinates of their desired location. Additionally, the user can create signs C (Figure 34, C) and drop hotspot objects on them. Clicking on hotspots displays corresponding 360-degree views that the user has previously

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associated with them. Hotspots can be considered as shortcuts to 360-degree views.

Figure 35 shows a group of visitors, including individuals such as C and D (Figure 35, C and D), exploring together a Panocube representing the historically significant Ryoanji Temple. They are surrounded by three interactive displays, each providing unique information about the temple and its famous Zen Garden. The immersive 360-degree view, constructed from Google images, allows the visitors to fully appreciate the beauty and serenity of the location.

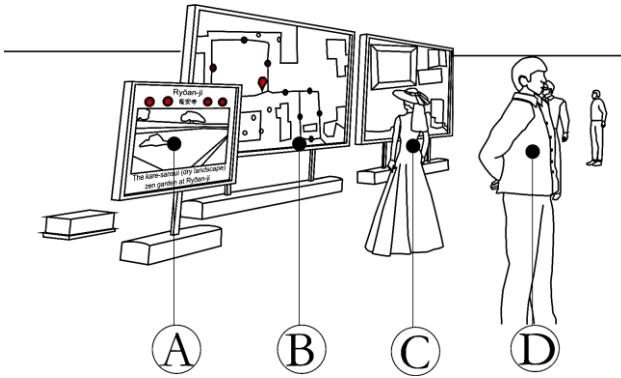


*Figure 35 Avatars sharing a virtual world version of a physical location inside of a Panocube*

As they click on various hotspots on the signs, such as sign A (Figure 35, A), they can load relevant 360-degree views. Sign B (Figure 35, B), for example, showcases a map of the temple grounds with numerous hotspots along the walkways. Clicking on these hotspots refreshes the 360-degree view, providing different perspectives of the iconic Zen rock garden from corresponding locations on the walkway. The visitors can thus easily grasp the layout of the temple and explore the various sites it has to offer.

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Such a virtual environment offers an innovative and effective way to experience real-world locations, fostering a deeper understanding and appreciation for the place. As a learning tool, the Panocube brings history to life, making it an invaluable asset for education and cultural exchange.

Figure 36 shows the same group of individuals who had previously learned about the renowned Ryoanji rock garden through a collaborative virtual tour using the Panocube now exploring a full 3D virtual representation of the garden itself. This lifelike 3D scene has been masterfully generated by the Composer application, demonstrating the potential for a single content-creation tool to produce a wide range of diverse and engaging educational content. The transition between the two different representations of the same physical location sparks thought-provoking discussions and offers deeper insights into the essence of these places.

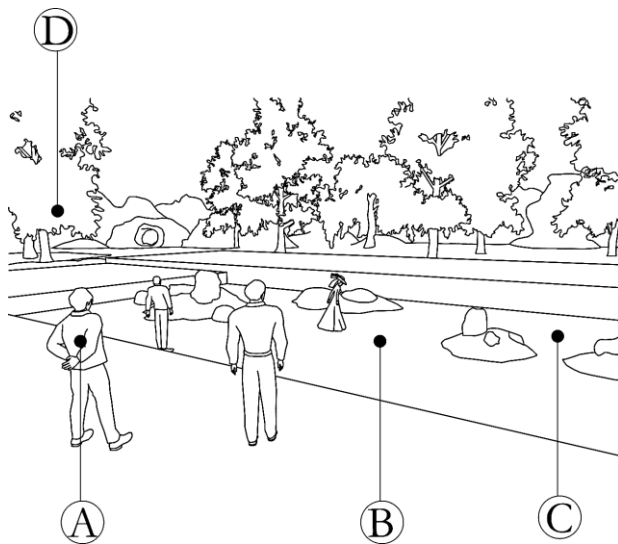


*Figure 36 Avatars visiting a 3D virtual replica of a real world location, in this case a stone garden*

## 7. Broadening Collaboration Avenues

Avatar A (Figure 36, A) and others explore the meticulously arranged rock garden B (Figure 36, B), taking in the unique arrangement of stones C (Figure 36, C) and the surrounding lush foliage D (Figure 36, D). The thoughtful design of these immersive experiences not only enhances understanding but also promotes curiosity and fosters a deeper appreciation for the world's cultural and historical treasures. Most importantly, both of these educational scenes were created by subject matter experts and not programmers or 3D designers.

In this evocative image (Figure 37), we capture just one example of the countless adventures made possible through immersive virtual experiences. Here, we find ourselves visiting the breathtaking Nasir al-Mulk Mosque, renowned for its stunning stained-glass windows. Avatar A (Figure 37, A) is seen admiring the intricate artwork of Entrance C (Figure 37, C) and the magnificent architectural details of the surrounding building structure B (Figure 37, B).

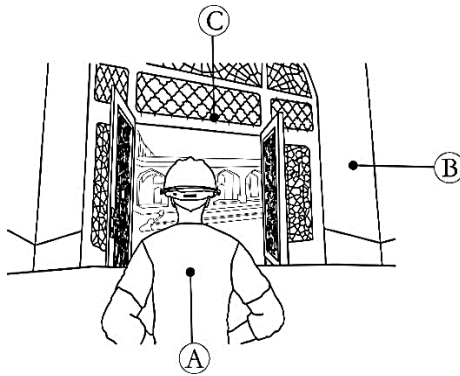


*Figure 37 Exploring historical buildings*

While it is impossible to document all the expeditions enabled by our approach, this example underscores the potential for educators to integrate such immersive exercises into their

## 7. Broadening Collaboration Avenues

curricula. By providing low-cost and engaging learning environments, these virtual experiences can inspire curiosity and enhance students' understanding of the world's rich cultural and historical heritage.

### **Future applications to consider**

Earlier chapters have argued why certain existing applications will transition into this new realm quicker than others. This chapter has used several examples to illustrate an early migration which includes 3D design and modeling tools, device simulations, real-life training modules, and 3D information organizing systems. It is clear to us that the Metaverse opens the doors to many more applications that promise to enhance its utility that can be described in any one book. Imagine being able to control real-world sensors and devices from virtual monitoring stations, comfortably ensconced in digitally constructed realms. Or visualizing intricate neural network data as if scrutinizing brain activity through functional magnetic resonance imaging (fMRI), but for neural nets. Picture machinima, or 3D movie capturing and production, happening right within the Metaverse. Every human activity can be potentially enhanced by the Metaverse.

Nevertheless, we must recognize that the full flourishing of the 3D Metaverse will not be an overnight phenomenon; it will evolve gradually, paced by the steady ingress and confluence of existing applications. Furthermore, we posit that the Metaverse's ultimate success hinges on more than passive consumer content consumption; it lies in the transformative power of active consumer content creation. This dynamic interplay, we believe, will play a pivotal role in shaping the Metaverse's future.

## 7. Broadening Collaboration Avenues

The future of office design is heading towards more dynamic, flexible, and immersive environments. With 3D virtual worlds, we can create spaces that adapt to the needs of the team, allowing for more collaboration and creativity.

### *Emerging Human AI collaboration opportunities*

Already in virtual worlds, delegation can go beyond just assigning tasks to peers. It is also about transferring authority to virtual entities, like NPCs. The chain of command will likely become more fluid, with humans and AI agents collaborating based on expertise rather than hierarchy. Just as cells in a body have specialized functions yet operate under a unified control system, in virtual worlds, each NPC or agent can have a specialized role. However, maintaining a balance where they operate harmoniously under a central control, probably managed by the user, is essential. Users want control, but they also appreciate the convenience of automation and the freedom of not having to worry about all relevant underlying processes. The key is to ensure automation does not feel invasive and that users always feel they are in the driver's seat, even if they choose to delegate tasks to AI.

### *Extended Minds*

As we spend more time in virtual environments, our identities will expand to encompass not just our real-world selves but also our virtual avatars and the entities we control either directly or through delegation. It's a new dimension of self-awareness and identity. Our extended identity will also probably lead to extended responsibility if anything goes wrong.



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Imagine a business meeting where you can delegate NPCs to gather data in real-time, conduct side discussions without interrupting the main conversation, or even represent you in multiple breakout sessions simultaneously.

While the disappearing boundary between humans and machines might be startling for some, leading to assumptions about potential social attrition, it's crucial to note the potential advantages. Through meticulous design combined with state-of-the-art motion capture, facial recognition, and emotion detection tools, we can aim to preserve the warmth of real-life experiences in the virtual realm. This could very well pave the way for a world that's even more delightful than our current reality.

### *The Rise of 3D Productivity Worlds*

In a digital realm predominantly governed by two-dimensional interfaces, a movement towards three-dimensional productivity worlds is setting the stage for a profound shift in how we interact with data and one another. At the heart of this endeavor is the aspiration to meld the simplicity and familiarity of 2D interactions with the immersive, spatially-rich experience that 3D environments can offer. The transition, however, is far from a mere aesthetic enhancement—it's a nuanced endeavor that demands a re-imagination of established interaction metaphors.

As we traverse into the realms of 3D, the conventional desktop metaphor that has served as the cornerstone of digital interactions seems less adequate, especially in encapsulating collaborative environments which cannot support the rich social bandwidth that humans expect. The 3D productivity worlds champion a more spatially intuitive interface where data is not merely displayed, but inhabited. Avatars—digital

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representations of users—wander through these virtual realms, engaging with data landscapes that transcend the flat screen. In earlier chapters, we emphasized the necessity for a medium that portrays social cues in a coherent, all-encompassing, and vivid manner. We are confident that lifelike human depictions will fulfill this requirement.

In this chapter, to provide an example of a digital data space inhabitable by avatars, we described how we experimented with a 3D version of a simple Internet browser bookmarking system. Instead of a list of links, we offered the alternative of a virtual library where captured bookmarks appear as tangible books placed on shelves. Interacting with these objects would conjure up related information and media. Drawing inspiration from the cognitive science principle of "memory palaces", this layout of data not only streamlines search and retrieval processes but also fosters collaborative exploration. Additionally, it opens doors to serendipitous interactions with peers navigating the same digital environment.

The potential applications of 3D productivity worlds extend across industries. Whether it's a research team navigating through a complex dataset to unearth insights or a group of learners exploring educational content together, the spatial, collaborative essence of 3D worlds opens up new vistas of engagement.

Yet, the path towards scaling these innovations is laden with challenges. The technology stack required to support such ambitious projects is still nascent, demanding a foundational investment in infrastructure. Moreover, the scaling dilemma is not merely a technical one. It is also about fostering a community of stakeholders—developers, users, and

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advocates—who can contribute to, and thrive in, this novel digital ecosystem.

The choice between Virtual Reality (VR) and Augmented Reality (AR) also looms large on the horizon for these pioneers. While VR offers a blank canvas to craft entirely new worlds, AR entails blending the digital with the physical, each carrying its own set of constraints and opportunities. Clearly AR collaborative success stories will most likely emerge in situations where participants are collocated. However, VR is not subject to this constraint.

## Conclusion

The future of office and workforce design in 3D virtual worlds presents both opportunities and challenges. As users strive to balance end-user control and automation, the implications for virtual communities, communication, and identity will become increasingly significant. Understanding these dynamics, along with the importance of maintaining social bandwidth and designing innovative interaction metaphors, is key to shaping a more inclusive and efficient work landscape. At the end of Chapter 7, we have covered the iterative approach to designing and evolving virtual collaborative environments and the role of tools and applications in that process. A balance between automation and user control was also established as key to efficient virtual workspaces. Chapter 8 then introduces the implications of these developments in the field of education, a significant area of societal importance where the power of virtual worlds can be harnessed. In this chapter, we look at how educators can use these tools and techniques to enhance teaching and learning.



*Chapter cover 8 Boundless Learning: Education in 3D Worlds*

# 8. Shaping the Educational Metaverse

## *Guide for next generation stake holders*

### **Introduction**

This chapter provides guidance for subject matter experts, educators, and anyone eager to impart knowledge through virtual environments. Our goal is to equip readers with resources to start their journey in virtual education and showcase examples built with these tools. Virtual worlds enable exploratory learning as they provide a safe space for experimentation. They also facilitate simulations of real-world scenarios to teach complex systems. For busy educators, this chapter serves as a practical guide, revisiting concepts from previous chapters.

The user interface should be intuitive and immersive. The experience should facilitate social connections and collaboration. Content should be interactive and provide opportunities for assessing learning through measurable outcomes. Productivity gains should be clear and evident.

Entertainment virtual environments are more common because they easily capture attention by targeting primal instincts. However, work environments can also become engaging without artificial incentives.

### ***Top Concerns of Educators***

1. Will students be engaged in virtual learning?
2. What approaches work best?

## 8. Shaping the Educational Metaverse

3. What activities are suited for virtual worlds?
4. How can we assess learning?
5. What are the technical requirements?
6. What are the potential risks?

We address these by revisiting proven educational theories and providing diverse examples of their applications.

### **Expected challenges and solutions**

#### *Creating or joining a community of practice*

The use of virtual worlds for education is a relatively new phenomenon, and as such, there are not a lot of established practices or protocols for educators to follow. This lack of guidance can be a deterrent for some educators who may be interested in exploring virtual worlds for teaching and learning but are unsure of where to start. Here we discuss some of the tactics that can be employed to encourage educators to explore virtual worlds for education.

One tactic is to showcase examples of successful virtual world projects. There are a few educators who have used virtual worlds in their classrooms and have written about their experiences (Hewitt A., 2008). Sharing these stories with other educators can help to show them that virtual worlds can be used effectively for education and can help to spark ideas for how they might use virtual worlds in their own classrooms.

Finally, it is important to create a community of practice around the use of virtual worlds for education. There are a few ways to do this, but one option is to create a virtual world specifically for educators to use for collaboration and sharing resources. This can provide a space for educators to ask questions, share ideas, and get feedback from others who are

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using virtual worlds for education. Creating a community of practice can help to normalize the use of virtual worlds for education and can make it more likely that educators will explore and use virtual worlds in their teaching.

### *Challenges for cultivating a community of practice.*

The use of virtual worlds in education is still in its infancy, with many schools and teachers only beginning to explore the potential of these platforms. There are several difficulties that need to be considered when trying to create a community of practice to support teachers interested in virtual worlds. Educators are often hesitant to adopt virtual worlds for learning due to several concerns.

These include:

1. ***Lack of time***: many teachers are already stretched for time and may not have the time to dedicate to exploring and using virtual worlds in their teaching.
2. ***Lack of resources***: the initial setup and ongoing maintenance of virtual worlds are costly, as they require advanced computers, software, and hosting services, which can be financially prohibitive. This can be a barrier for many teachers.
3. ***Lack of knowledge***: many teachers may not be familiar with virtual worlds or how to use them effectively in education. This lack of knowledge can be a barrier to entry for many teachers.
4. ***Inadequate support***: many teachers who are interested in using virtual worlds may not have access to adequate support. This can include technical support, as well as support from school administrators or national education departments.

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5. ***Isolation***: many teachers who are interested in virtual worlds may feel isolated from their colleagues who are not using these platforms. This isolation can make it difficult to share ideas and resources, and to collaborate.

There are several solutions that can be proposed in order to address these difficulties. These include:

1. ***Providing time for teachers to explore and use virtual worlds***: this can be done through dedicated professional development time, or by releasing teachers from their regular duties for set periods.
2. ***Providing access to technical resources***: this can include hardware resources, as well as funding for the creation of content.
3. ***Providing training and support for teachers***: this can be done through professional development courses, webinars, or other means of training. Additionally, support networks can be created, such as online forums, where teachers can ask questions and share resources.

At present, volunteers or self-funded groups predominantly provide these solutions. Increased financial investment in this domain, along with the revision of course curricula, is poised to make a substantial impact on the progression of the field.

### ***Lack of traction for courses in virtual worlds***

When it comes to education, the adage “time is money” is especially true. In today’s world, teachers and professors are under immense pressure to get students through their courses as quickly and efficiently as possible. This often means using



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traditional methods such as lectures and textbooks, which can be quite boring for students.

Virtual worlds offer a more immersive and interactive way to learn, but this comes at a cost. The cost of content production turns out to be high and content customization to fit the needs of a class is hard. It takes a lot of effort to map a traditional course into one that is immersive and interactive.

Teachers or educators are incentivized to tick off learning objectives as fast as possible, in the seemingly most efficient ways possible. This typically involves PowerPoint slides and furious notetaking by students, followed by an intense period of memorizing, rehearsing and taking preparatory tests, so that students are trained for tests not to meet objectives in the wild.

In most cases, the traction of courses in virtual worlds is not achieved because the cost is simply too high. It is much easier and cheaper to just stick to traditional methods, even though they may be less effective in the long run.

Some notable failures of training in virtual worlds include:

1. Lack of immersion
2. Lack of social interaction
3. Technical difficulties
4. Hard to control unruly student behavior in virtual worlds.

### ***Dress code in virtual environments***

As the world of education increasingly moves online in the wake of the COVID-19 pandemic, the question of what constitutes appropriate dress code in virtual learning environments has come to the fore. While there are no easy

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answers, there are a few guiding principles that educators can keep in mind as they make decisions about dress code in their online classrooms.

First and foremost, it is important to remember that virtual learning environments are still learning environments, and so the same standards of professionalism and respect should apply as in brick-and-mortar classrooms. That means that educators should dress in a way that is professional and respectful of their students.

That said, there is also a need to be mindful of the fact that students are learning in their homes, and so there may be a greater need for flexibility when it comes to dress code. In general, it is probably best to err on the side of caution and to avoid anything that could be construed as overly revealing or offensive.

Ultimately, the decision of what is appropriate to wear in a virtual learning environment will come down to the individual educator and the specific context of their classroom. However, by keeping the above principles in mind, educators can ensure that they are making decisions that are in the best interests of their students and that will create a respectful and professional learning environment.

### ***Cultivating a safe environment for students***

There are several ways that teachers can create a safe environment for students in 3D virtual worlds:

1. Establish clear rules and guidelines for behavior in the virtual world.
2. Monitor student activity in the virtual world.

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3. Create a safe space in the virtual world where students can go if they feel unsafe or uncomfortable.
4. Respond quickly and effectively to any incidents of harassment or bullying.
5. Use parental controls to limit student access to certain areas of the virtual world.
6. Educate students about responsible behavior in online environments.

### *Effective Pedagogical Approaches*

1. Social constructivism facilitates idea sharing through interaction.
2. Problem-based learning tackles real-world challenges, promoting teamwork.
3. Inquiry-based learning encourages investigation through questioning.

Incorporating AI and advanced language models into virtual beings boosts inquiry-based methods. Virtual worlds have vast potential across human knowledge domains, as our examples illustrate.

### *Affordances of 3D Virtual Worlds*

Virtual worlds enable essential social dynamics through avatars that provide a greater sense of presence and connection compared to 2D environments. The use of personalized avatars allows for nuanced nonverbal communication, relationship building, and privacy management.

Role-playing activities in virtual worlds help learners grasp concepts by embodying problems from different perspectives. Taking on various roles builds understanding of complex

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interpersonal dynamics and improves social/communication skills.

Virtual worlds provide safe, controlled environments that enable effective immersion for therapies:

1. Anxiety treatment - Gradual exposure therapy in simulated environments can help patients confront fears.
2. Eating disorder recovery - Avatars can help identify unhealthy triggers and practice coping strategies.
3. Memory support for dementia - Revisiting memories in a simulated environment can preserve cognitive abilities.
4. Rehabilitation - Virtual simulations facilitate repeated skill practice and sustain motivation.

Virtual worlds also create lifelike scenarios for healthcare education. Medical students can practice skills like diagnosis, communication, and surgical procedures without risk. This experiential learning is more engaging than textbooks or lectures.

For healthcare education, these environments simulate real-world scenarios for skill development. Their versatility spans virtually every field, though our examples only showcase a fraction of their power.

Structured information displays gain flexibility for multi-dimensional analysis in virtual classrooms. Educators can amplify engagement and curiosity using these dynamic representations.

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### ***Familiarizing with Tools to Enhance Productivity***

A plethora of collaborative tools, such as Kanban boards, Scrum methodologies, social media platforms, co-editing software, and chat systems, are instrumental in enhancing productivity. Educators are encouraged to acquaint themselves with these technologies; a deeper understanding can significantly simplify the process of adapting these tools into 3D virtual environments. Additional resources, including mind mapping and brainstorming applications, should also be explored. To explore this transition, we have developed virtual analogs—like digital task boards and movable notes—that mimic these conventional tools to assist organizations in streamlining their collaborative efforts within virtual worlds.

### ***Course Design Considerations***

When designing a 3D world online course, the primary considerations are creating an immersive and engaging environment, leveraging 3D technologies for impactful learning experiences, and ensuring accessibility for all students.

In developing innovative teaching approaches for virtual worlds, the starting point should be identifying student needs and defining goals for the experience. With a clear understanding of objectives, instructors can brainstorm creative ways to best utilize the virtual space to meet those goals. This creative thinking might involve inventing new uses of the environment, integrating emerging technologies, or building entirely new virtual worlds. The key is to think outside the box and develop the most effective and imaginative approaches possible. By focusing first on student needs and goals, instructors can devise innovative virtual world learning

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experiences that are truly engaging, meaningful, and accessible to all.

Tips for successfully implementing a virtual world learning plan:

1. Set realistic, achievable goals within the timeframe. Avoid overambitious objectives that can't reasonably be met.
2. Clearly outline the specific steps required to complete the plan. Break down the process into discrete action items.
3. Create a detailed timeline for completing each step of the plan. Assign deadlines to keep on track.
4. Build in accountability. Appoint an accountability partner, set reminders, or identify natural check-in points to stay on top of progress.
5. Allow flexibility. Be prepared to adjust timeframes or steps as needed based on changing circumstances. The implementation process may not always go exactly as planned.
6. Celebrate small wins. Recognize progress and milestones along the way to keep motivation high.

With thoughtful goal-setting, step-by-step planning, and accountability, instructors can effectively implement immersive virtual world learning experiences. Staying organized yet flexible is the key to success.

Here is a step-by-step list of instructions for a subject matter expert interested in creating a course in a 3D virtual world:

1. Choose the 3D virtual world you would like to create your course in. In this book, all the examples presented

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were implemented on the OpenSimulator platform (Appendix B).

2. Plan out the content and structure of your course.
3. Create your course in the 3D virtual world, adding in your content and structure as you go.
4. Test out your course to make sure everything works as intended.
5. Make any necessary adjustments to your course.
6. Once you are satisfied with your course, publish it so others can access and take it.

### *Designing learning scenarios*

It is often the case that educators lack the time to experiment with educational technologies; they tend to need finished examples that they can assess before making decisions about the value of a given approach to learning. We are therefore particularly interested in helping educators design virtual world content to support their primary learning objectives. What are the 9 steps we recommend every educator should follow to create virtual world learning experiences?

1. ***Understand your audience:*** It is important to understand your target audience to determine what type of content will be most appropriate and useful for them.
2. ***Define your learning objectives:*** What do you want your students to learn as a result of participating in your virtual world learning experience?
3. ***Choose a virtual world platform:*** There are a variety of different virtual world platforms available, each with its own strengths and weaknesses. It is important to choose a platform that will best support your learning objectives.

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4. ***Create a learning scenario:*** A learning scenario is a detailed description of the steps involved in a particular learning experience. It is important to create a learning scenario before beginning to design your virtual world content.
5. ***Design your virtual world content:*** Once you have created a learning scenario, you can begin to design the content for your virtual world. This content should be aligned with your learning objectives.
6. ***Create assessment activities:*** Assessment activities are an important part of any virtual world learning experience. They should be designed to evaluate whether students are meeting the learning objectives. Virtual 3D worlds provide the opportunity for automated performance capture, but recording student activities to be evaluated manually at a later stage also works well.
7. ***Implement your virtual world learning experience:*** Once you have designed your virtual world content and assessment activities, you can begin to implement your learning experience.
8. ***Monitor student progress:*** It is important to monitor student progress throughout the virtual world learning experience. This will help you to identify any areas where students are struggling and make necessary adjustments. Competency evaluation is a key aspect of learning environments. What you cannot measure cannot be improved.
9. ***Make improvements:*** Based on the evaluation of student learning, it is important to make improvements to the virtual world learning experience. This will help to ensure that future students have a more successful experience.



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In the evolving landscape of educational technology, our journey has been marked by a steadfast commitment to enhancing learning through virtual environments. This dedication has culminated in the development of RezMela (Appendix C), a 3D experience composition application crafted atop the OpenSimulator (Appendix B). RezMela serves as a testament to our expertise, streamlining the creation of virtual experiences tailored to specific educational objectives.

For those seeking a comprehensive understanding of RezMela, we direct you to the preceding chapters, which delve into the intricacies of the system. Central to RezMela is the concept of module libraries—collections of related 3D models, many of which boast interactive capabilities. These libraries can be likened to a set of building blocks, each group enclosed in a metaphorical box, ready to be unpacked and utilized in constructing immersive learning environments.

Our in-house platform has been the birthplace of an extensive array of 3D online learning experiences. In this section, we aim to showcase these examples in a sequence that mirrors their complexity. This progression is designed to provide readers with a window into the vast array of instructional content that can be generated. By leveraging simple abstractions represented as 3D objects, coupled with a composition tool, educators can rapidly assemble diverse virtual world experiences.

The number of examples we present here is substantial, and each one is a repository of our thought processes at that time, shedding light on both the current capabilities and the future possibilities of virtual learning environments. It is our hope that these examples will not only inform but also inspire educators to push the boundaries of what is possible, fostering an

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environment where learning is not just informative but transformative. We will start with simple situations that will anchor basic ideas and concepts before we proceed to more complex learning situations. Should the reader feel the need for a deeper understanding of the tools discussed herein, they are encouraged to refer to the preceding chapters for additional contextual detail. Here, we will not only explore concepts that hold significance for instructional technologies, but we are convinced that the lessons learned are relevant for shaping the design of the future Metaverse.

### Examining past virtual learning experiences

Figure 38 illustrates a very basic scene created by a user-friendly Composer Application designed to streamline content creation. Avatar A is shown signing into the app by clicking the button next to it, gaining access to various modules and resources available within the virtual landscape.

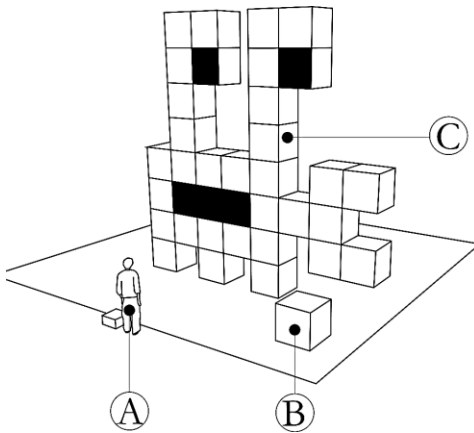


*Figure 38 Uses can rapidly build 3D content through point-and-click operations using the Composer App (c. 2020)*

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Avatar A (Figure 38, A) interacts with a 2D HUD that appears on their screen to effortlessly place cubes B (Figure 38, B) on top of one another with single clicks. Thanks to the objects’ optimal snapping capabilities, building and designing become seamless and intuitive. Users can also customize each cube with different colors, save their creations C (Figure 38, C), and clear or load scenes as needed. This Composer App is used for one specific function only, to assemble cubes that can be textured, labeled and scripted to generate special effects. In that sense, it can function as a specific App which we named ‘Melacraft’.

Figure 39 showcases an avatar B (Figure 39, B) skillfully utilizing the Composer App A (Figure 39, A) to design an engaging 3D Pixel Art character using interactive blocks from a given module. The avatar has the freedom to select the color of these blocks, as demonstrated by the varying shades of grey in blocks C (Figure 39, C) and D (Figure 39, D).

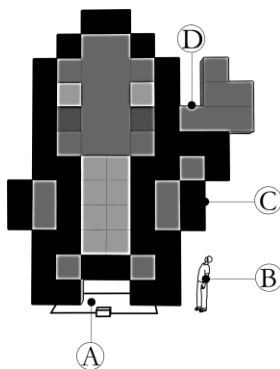


*Figure 39 An avatar assembling a 3D sculpture from blocks with selectable textures (c. 2020)*

Once completed, these creative scenes can be saved and shared with peers, fostering collaboration and inspiring others to explore the limitless possibilities of 3D Pixel Art within the

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virtual environment. This example highlights the potential for innovative tools like the Composer App to empower users and transform the way they express themselves through digital art.

This snapshot of Melacraft highlights the potential for innovative, accessible content creation tools in virtual environments, empowering users to explore their creativity and engage with the digital world in new, exciting ways.

In a different instance of the Composer App (Figure 40), we create a high-definition depiction of the renowned “Tower of Babel” painting C (Figure 40, C). The current version of the OpenSimulator virtual world platform limits the quality of the texture for each face of an object. However, the application lets you assign unique textures to different objects. This allows you to show high-quality images by breaking them into smaller, high-resolution sections. This is a common approach to create very high-resolution images or exhibits in virtual worlds.

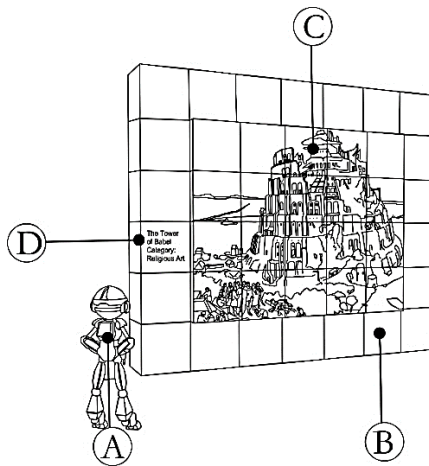


*Figure 40 Using the Melacraft App to create museum exhibits such as this high-definition picture of a famous painting*

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To provide context and additional information, a cube with accompanying text D (Figure 40, D) is included alongside the painting. This example highlights the impressive potential and versatility of a well-designed app in a 3D virtual world, empowering users to create and share immersive and visually engaging experiences.

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The following image (Figure 41) presents another example of how straightforward designs can enable the creation of a vast array of content using the Melacraft application. In this instance, the application has been employed to construct a periodic table of elements. The Composer app, which can be signed into by clicking on A (Figure 41, A). Each cube C (Figure 41, C) is appropriately labeled with a letter representing a specific element. The information-laden cubes B, hovering above the others, provide relevant details about the periodic table. This seemingly floating appearance of the group of blocks (Figure 41, B) is achieved by removing the underlying cubes.

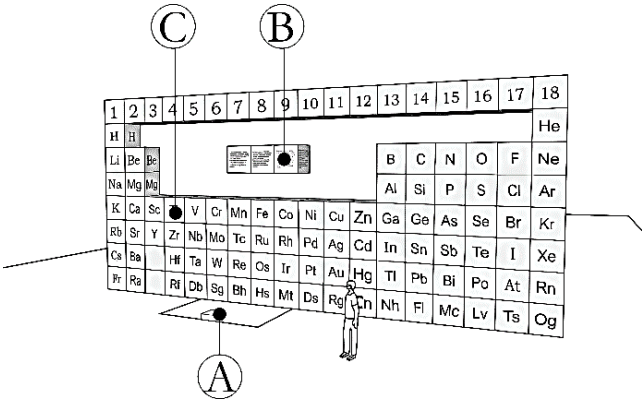


*Figure 41An avatar exploring a Periodic table constructed from blocks (c. 2020)*

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Figure 42 showcases the versatility of the Melacraft application, highlighting its users' ability to create diverse 3D structures. Not only can they construct columns, such as column B (Figure 42, B), and roofs using blocks, but they can also enclose non-cubical objects within a transparent cube A (Figure 42, A). By snapping these enclosed objects to others seamlessly, users can rapidly generate a wide array of content, demonstrating the power and adaptability of the Melacraft application in crafting unique and engaging designs.

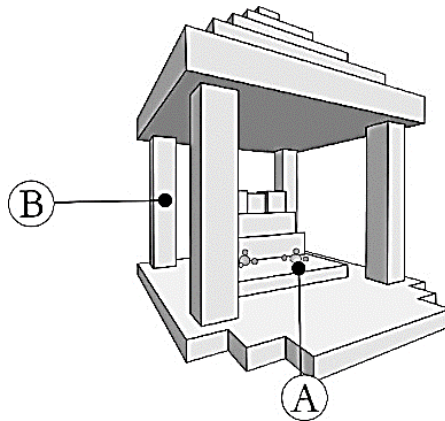


*Figure 42 Using 3D cubes to build 3D buildings*

### ***Advantages of organizing information in 3D spaces***

As discussed in previous chapters, there are many cognitive implications of organizing files and bookmarks as 3d objects in a shared multiuser virtual world. One implication is that it can help people to better understand the relationships between different pieces of information. When information is organized in a three-dimensional space, it is easier to see how different pieces of information are related to each other. This can help people to better understand the overall structure of the information and how the different pieces fit together.

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Another implication is that organizing information in a three-dimensional space can help people to remember the information better. When information is organized in a way that is easy to visualize, people can more easily recall the information later. This is because the brain is better able to remember information when it is presented in a visual format.

Social bandwidth in 3D avatar-populated spaces is inherently wider than in spaces without avatars. In 3D information spaces, avatars provide opportunities for collaboration around points of access to information. In the real world, these are books in racks, in the virtual world, these could be 3D files or bookmarks in a 3D virtual library, or a 3D mind map.

### ***Content production efficiency***

Modularizing content and creating templates makes it easier for educators to share content and collaborate because it allows them to break down the content into manageable pieces that can be easily reused and repurposed. Additionally, templates provide a framework for educators to follow when creating new content, which makes the process of creating and sharing new content much simpler and more streamlined.

### ***Main features of a content creation application for educators***

A content creation software for virtual worlds would be an amazing tool for educators. It would allow them to create engaging and interactive learning experiences for their students.

Some of the main features of such a software would include:

1. ***The ability to create and edit 3D models:*** This would be a key feature, as it would allow educators to create



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custom content for their virtual world. They would be able to create 3D models of objects, buildings, and landscapes.

2. ***The ability to create and edit animations:*** This would be another key feature, as it would allow educators to create custom animations for their virtual world. They would be able to create animations of objects, characters, and events.
3. ***The ability to create and edit scripts:*** This would be a vital feature, as it would allow educators to create custom scripts for their virtual world. They would be able to create scripts for character interactions, events, and game mechanics.
4. ***The ability to create and edit audio:*** This would be a valuable feature, as it would allow educators to create custom audio for their virtual world. They would be able to create audio for character dialogue, sound effects, and music.
5. ***The ability to create and edit textures:*** This would be a useful feature, as it would allow educators to create custom textures for their virtual world. They would be able to create textures for objects, buildings, and landscapes. The main features for an education content production tool for educators would be the ability to easily create and manage content, the ability to share content with others, and the ability to track and assess student engagement with the content.

The ability to easily create and manage content would be the most important feature for an education content production tool educators would need to be able to create content quickly and easily, and then easily manage and update that content as

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needed. The tool would also need to be able to handle a variety of content types, including text, images, video, and audio.

The ability to share content with others would be another important feature for an education content production tool. Educators would need to be able to easily share content with colleagues, students, and parents. The tool would need to be able to share content via email, social media, and other platforms.

The ability to track and assess student engagement with the content would be the final important feature for an education content production tool. educators would need to be able to see how students are interacting with the content and be able to assess whether or not the content is effective. The tool would need to be able to track student progress and provide data that educators can use to improve the content.

### **More advanced virtual learning scenarios**

We are confident that the challenges holding the widespread adoption of 3d interactive virtual worlds in the education can be overcome, particularly because, even with constrained resources, our team has succeeded in creating several virtual environments that serve a wide array of use cases over relatively short time periods using our homegrown zero-coding scene creation platform described in the Appendix C. Our ability to enable subject matter experts to create such varied three-dimensional worlds at a cost significantly lower than industry standards underscores the efficacy and affordability of our approach. We shall present these use cases in a sequential manner, providing the reader with a tangible perspective of our achievements. For clarity, we have depicted these scenarios as line diagrams derived from screenshots of actual three-

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dimensional world scenarios that were created. This approach helps emphasize that what is of importance is the content itself and not the graphics engine that renders it. Future platforms will undoubtedly support higher fidelity 3D content, but the thinking behind our approach is likely to prevail. For now, let us examine virtual world scenarios we developed for past projects.

### *Training teenagers with behavioral challenges*

Figure 43 depicts a tailored scenario designed (circa 2012) for a healthcare institution focusing on training for teenagers with behavioral challenges. The goal is to foster good daily living habits through engaging, interactive experiences within a familiar and comfortable virtual environment.

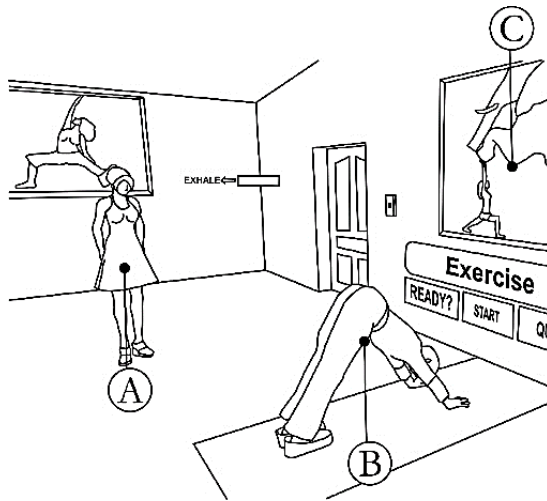


*Figure 43 Virtual life skills: guiding teens toward better habits*

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An instructor avatar A (Figure 43, A) is present to guide the student B (Figure 43, B) through various exercises, such as those in the dedicated exercise room. The virtuality of the room also provides a memory palace for multimedia such as video display C (Figure 43, C) related to exercises. This hands-on approach allows for real-time guidance and feedback, much like a real-world training session.

A unique aspect of this virtual environment is the inclusion of visualization aids to guide the flow of certain exercises like yoga. For instance, the application can illustrate breathing patterns, demonstrating how air flows in and out of the lungs during specific exercises. This level of detail helps students better understand and perform the poses efficiently.

This teaching approach aims to reach the students in environments they find comfortable and relatable, thereby improving their learning experience and promoting healthy habits. Here, the teacher (Figure 43, A) can be a teacher driving their avatar, or an AI virtual humanoid.

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Figure 44 describes a virtual house we developed for a hospital with staff interested in experimenting with continuation of immersive therapy beyond the walls of the hospital. What sets this kitchen apart is the interactive nature of its appliances, such as the microwave C (Figure 44, C), which simulates its real-world counterpart. As we explore further, we discover a fully stocked fridge, brimming with food items that can be selected, arranged on a table D (Figure 44, D). This immersive role-playing environment serves as a valuable platform for collaboration between a therapist or a nutritionist (Figure 44, A), and a teenager (Figure 44, B) representing the chosen demographic for this particular scenario. Together, they join in lessons where they get to playfully share how to follow good everyday habits (Beale, 2018).

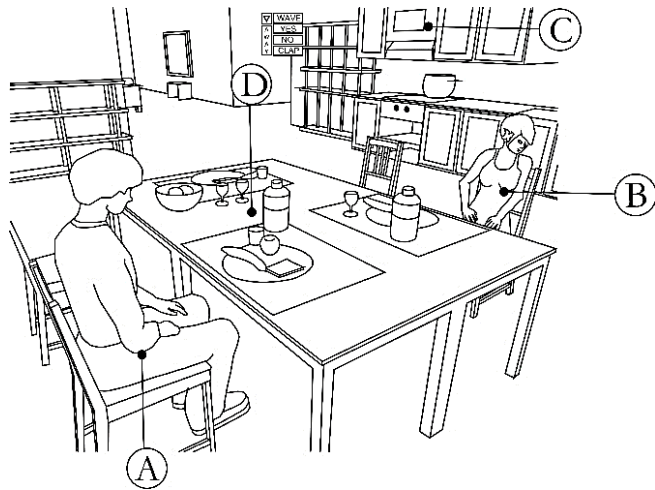


*Figure 44 Virtual house with interactive amenities*

The availability of dedicated module libraries allows for the inclusion of these interactive elements, catering to specific training needs. The aim here is to showcase the potential of creating virtual environments with meticulous attention to

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detail, which can be expanded or modified to align with focused training objectives without compromising the overall immersive experience. This illustration exemplifies how virtual simulations can seamlessly integrate focused tasks within a larger context, fostering engagement and enhancing learning outcomes.

In Figure 45, we revisit the virtual kitchen environment A (Figure 45, A) previously described. However, this time our attention is drawn to an avatar B (Figure 45, B) or non-player character B, depending on the trainers' utilization of this learning space. The avatar is seated at a table, engaging in overeating behavior. Here, we simulate the evolution of the body shape resulting from the quantity, and frequency of food C (Figure 45, C) consumed.

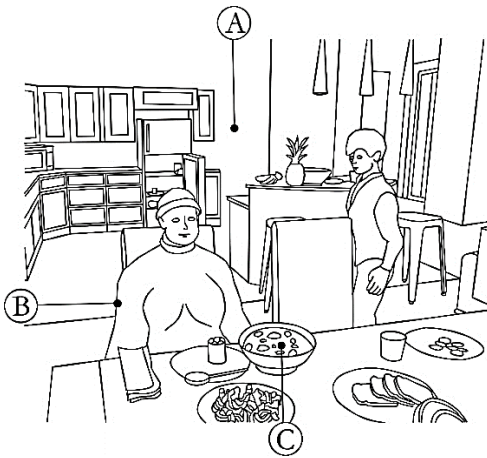


*Figure 45 Impact of diet and overeating or unhealthy daily activities*

This depiction opens up a realm of possibilities, where such virtual environments can be utilized for standalone ‘serious’ gaming experiences, as well as for collaborative therapeutic or educational purposes.

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Figure 46 presents a vibrant scene set in a park that lies next to the earlier mentioned house. At the heart of this depiction is a character, referred to as non-player character B (Figure 46, B), who is under the tutelage of a lifestyle educator labeled A (Figure 46, A), within the verdant expanse of nature park C (Figure 46, C). During this interactive session, participants engage collectively to explore the impact of physical activity on body shape and structure, utilizing an accelerated timeline to amplify the educational impact.

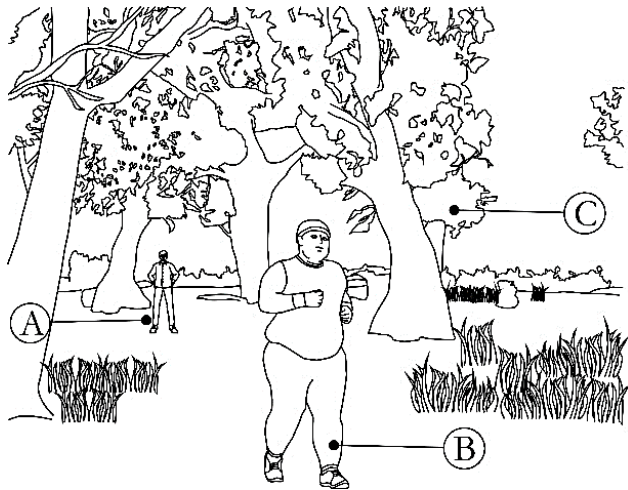


*Figure 46 Role play to learn about weight loss strategies*

While some may perceive these immersive learning environments as excessive, the true barrier to their widespread adoption has historically been the cost associated with their creation. However, we have now reached a turning point, as we have demonstrated how subject matter experts can be equipped with accessible tools that facilitate the deployment of such educational scenarios. Our approach paves the way for more affordable and scalable development of immersive learning experiences, empowering educators to effectively convey

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complex concepts and promote understanding in engaging and impactful ways.

### *Immersive language teaching*

Figure 47 portrays a group of students, such as avatar B (Figure 47, B), participating in a virtual language classroom (circa 2021).

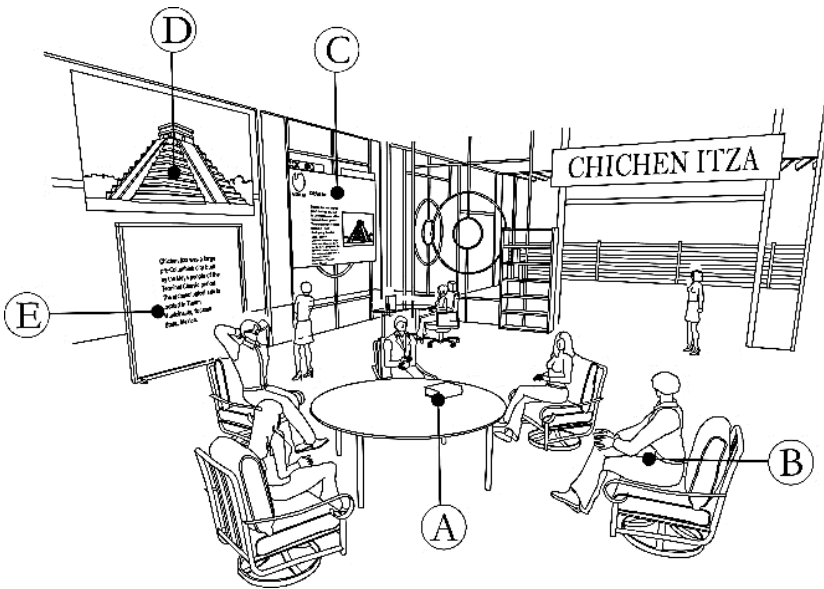


*Figure 47 Language classroom in a virtual world*

The instructor has meticulously organized the learning environment, from the seating arrangements and classroom structure to the educational materials, including posters D (Figure 47, D), signboards E (Figure 47, E), multimedia browsers C (Figure 47, C) and interactive 3D books A (Figure 47, A). Such tasks are structured for fast completion by the general user population without the need for developer intervention.



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The room also features 3D bookmarks A that, when clicked, load videos or websites as needed. These interactive bookmarks are easily movable, can be arranged on a virtual bookshelf. The 3D bookmarks, in this iteration, are labeled with a description of the content they link to. This approach to managing web bookmarks in a 3D environment not only makes them simple to find and organize but also enhances collaborative sharing opportunities. This early version of a 3D virtual classroom indicates the potential for educational environments that are interactive and engaging.

### *Architecture and landscape design*

Virtual environments offer a dynamic platform for architectural education, allowing students to immerse themselves in three-dimensional settings that closely mimic real-life structures. Within these spaces, learners can delve into various architectural styles, absorbing historical and theoretical knowledge as they go. These worlds facilitate collaborative design and prototyping, enabling the evaluation of architectural models in a virtual context.

When it comes to landscape design education, virtual worlds serve as an engaging tool for demonstrating design principles. They present a range of challenges that can hone students' problem-solving skills and design acumen. Furthermore, these environments foster collaboration, as students can jointly design and execute landscape projects, learning from shared experiences.

For garden design instruction, virtual worlds offer an interactive canvas where students can experiment with garden layouts, plant varieties, and maintenance techniques. They can immediately see the impact of their design choices, deepening

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their understanding of garden aesthetics and functionality. An example of this is Figure 48, which showcases the capability of virtual landscapes to undergo seasonal transformations, thus enriching the authenticity and depth of the learning experience. By applying different "skins" to landscapes to signify various seasons, the foliage's appearance can be altered, simulating real-world seasonal changes.



*Figure 48 Representing changing season by scene skinning to change foliage characteristics in real time*

In the example provided, A (Figure 48, A) shows trees adorned with lush leaves, achieved by updating the textures on all foliage objects as needed. Conversely, B (Figure 48, B) illustrates trees that have shed their leaves, displaying only bare branches. These attention-to-detail adjustments contribute significantly to making immersive environments more engaging for users, creating a more authentic and dynamic virtual experience.

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### *Creating reusable architectural structures.*

Architects simplify the intricate realities of spaces into fundamental elements, streamlining the design process. These elements are designed for versatility, enabling their integration into new virtual environments, which facilitates the creation of complex settings without starting anew each time.

The key to effective abstraction in architecture is the reusability of these elements. For instance, a door in one virtual model may serve as an entrance, while in another, it could function as an exit. The ability to adapt components for various uses allows architects to be more efficient in developing new virtual spaces.

When devising these abstractions, it's crucial to consider their applications. Will they form the basis of entire virtual environments or function as segments within broader spaces? Are they intended for users acquainted with the space, or for newcomers? Reflecting on the intended use helps architects to craft elements that are not only practical but also enhance real-world interactions.

When developing architectural abstractions, the mode of representation is a critical factor. Deciding whether these elements will be depicted as three-dimensional models or two-dimensional images, or perhaps conveyed through text or symbols, is essential. This decision impacts how intuitively the parts can be understood and utilized. Architects must align the representation with the ease of use, ensuring that the chosen form is accessible and straightforward for the intended users. By carefully selecting the representation that best communicates the function and form of these abstractions,

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architects can enhance the usability and clarity of their virtual spaces (Tayyebi, 2019).

The next illustration (Figure 49) demonstrates the applicability of the Composer App, in architectural design. In this example, a module containing a thoughtfully designed set of building components is featured. These components are designed to snap together seamlessly, making the assembly of structures a breeze. The system is capable of intuitively connecting various objects with a minimal number of clicks, as it possesses enough information about each object to determine how they can best connect to one another.

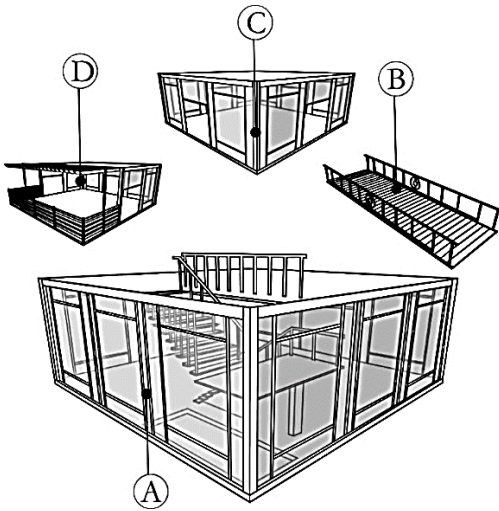


*Figure 49 Components of a building*

In this scene, we see a base room A (Figure 49, A), featuring a roof opening for a staircase rail. Additional examples of objects include C (Figure 49, C), the simplest cubical room conceivable here; D (Figure 49,D), a room with a balcony; and B (Figure 49,B), a connecting bridge. This graphic

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demonstrates how the Composer App can simplify the process of designing intricate, interlinked structures.

Through the use of abstractions, architects can craft complex environments with greater efficiency by recycling components, bypassing the need to begin from the ground up with each project. The emphasis on reusability saves considerable time and resources when devising new virtual spaces. Furthermore, by anticipating the practical applications of these abstractions, architects ensure the elements they create hold real-world value. The thoughtful consideration of how these abstractions are visually presented guarantees their comprehensibility and utility.

The capacity to distill complex structures into abstract, reusable forms equips architects with a potent means to enhance the efficiency and realism of their designs within virtual environments. This technique scales from the creation of petite to monumental structures and allows for the development of more precise and lifelike models of actual buildings. Moreover, it opens the door to innovative designs that might be unfeasible in the physical world, pushing the boundaries of architectural creativity.

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Figure 50 depicts a vast virtual landscape with a stunning view of a large building, surrounded by various walking pathways A (Figure 50, A), trees B (Figure 50, B), and rocks E (Figure 50, E). The landscape is meticulously designed and crafted using various pre-designed components such as C and D (Figure 50, C and D) that can be assembled by end-users. The Composer App, as it is called, provides a simple and intuitive interface that allows anyone to create modular parts and snap them together seamlessly to build impressive structures and landscapes.

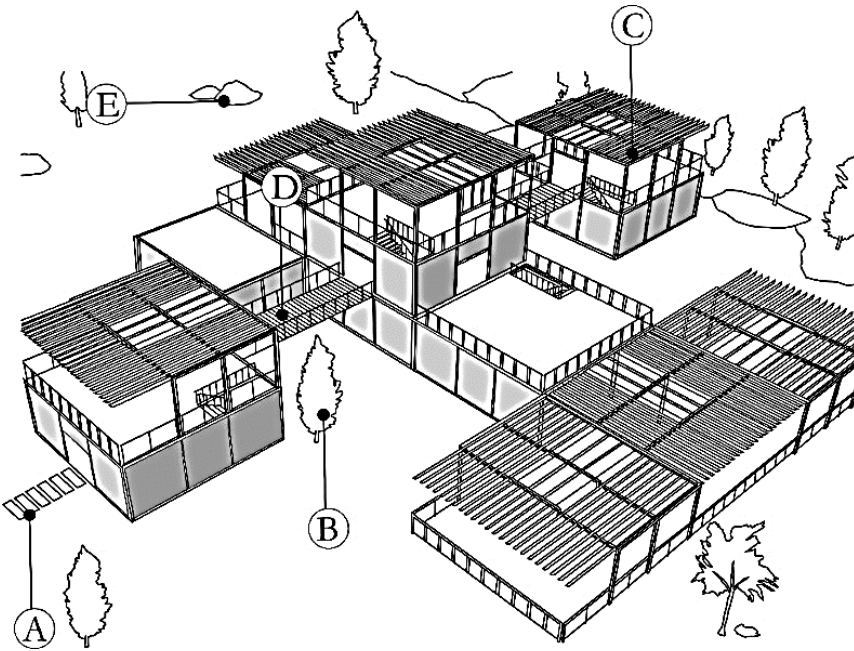


*Figure 50 A large building and surroundings composed using simpler repeatable parts*

This methodology streamlines the process from conceptual design to physical manifestation, enabling users to effortlessly generate and disseminate new designs. The environment is vibrant, animated, and the architectural scale commands

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attention. Navigating this virtual space, one is captivated by the exquisite detail and the simplicity of its creation.

The Composer App stands out as a useful instrument that liberates user creativity, facilitating the transition from vision to reality with ease. It marks a progressive stride in the realm of construction and design, where the potential is bounded only by the caliber of the elements employed.

To demonstrate versatility in scene creation, we explored a range of building components, resulting in a distinct architectural style as illustrated in Figure 51. Here, a variety of accessible architectural elements from a specific module were combined through straightforward point-and-click actions, culminating in the structure seen in Figure 51, C. In this case, the Composer application was adapted by switching on and off relevant modules so that avatar A (Figure 51, A) could use the same tool to create the landscape composed of trees and flowers around B and D (Figure 51, B and D).

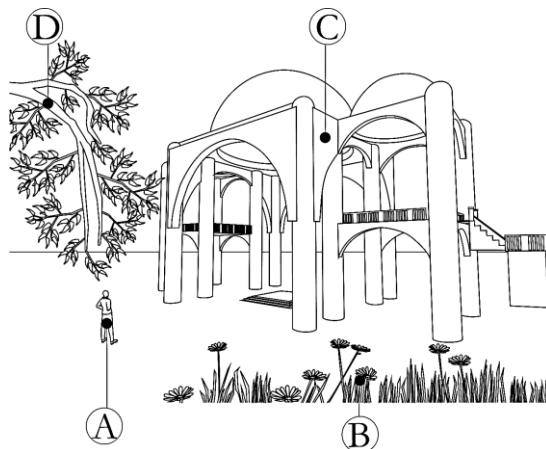


*Figure 51 This structure was assembled in a few minutes using a Composition tool that can be used inside a 3D virtual world (c. 2021)*

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### *Massing primitives*

Architects have various strategies for generating abstractions. One prevalent approach involves the use of software to forge simplified 3D models of structures by stripping back non-essential elements, using basic geometric forms to signify more intricate aspects. This method is typically applied during the conceptual phase or for hypothesis testing in virtual settings.

Another approach involves the construction of physical models using materials ranging from paper and cardboard to more substantial media like wood, metal, or concrete. These tangible models serve as a preliminary step to evaluate ideas before they transition to reality.

Once abstractions are developed, architects can integrate them as simplified components within virtual environments by transforming these abstractions into 3D models and situating them within these digital realms. This process enables the creation of both functional and detailed representations, and the exploration of innovative designs that might be impractical in a physical context.

Virtual worlds have garnered increasing interest from architects for their utility in design and communication. These immersive environments provide a distinctive medium for the conception and presentation of architectural ideas. One of the critical benefits of virtual worlds is their capacity to handle architectural abstractions, like massing primitives, facilitating the assembly of intricate and complex designs.



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Illustrated in Figure 52 is an example of an architect or landscape designer employing a map-based Composer application to craft a virtual model of the vicinity surrounding the Arc de Triomphe in Paris, demonstrating the practical applications of virtual worlds in urban design and planning.

The designer uses massing primitives, selected from the object picker labeled as B (Figure 52, B). These primitives are strategically placed on the Composer map, denoted as A (Figure 52, A), to create a rough approximation of the urban layout.

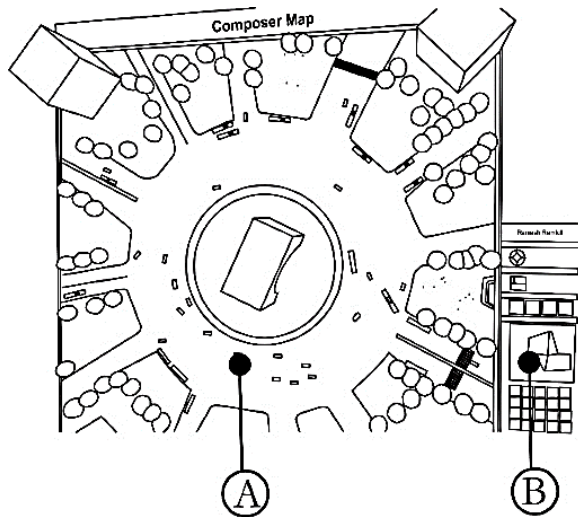


*Figure 52 Massing Primitives: Shaping Virtual Paris*

The application's interface allows the user to swiftly place these primitives at different locations on the map, forming a virtual world that they can navigate and explore. This hands-on, immersive approach provides the designer with a unique perspective, enabling them to experience and evaluate various design scenarios within the virtual environment.

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Massing primitives are simple, reusable architectural parts that can be used to create more complex structures. By creating these abstractions, architects can explore a wide range of design possibilities without having to create each element from scratch. This is especially beneficial when working in virtual worlds, where the ability to quickly create and test different designs is crucial. There are several ways in which architects can create massing primitives in virtual worlds. One approach is to use existing objects or structures as a starting point. For example, a building block or a column could be used as the basis for a massing primitive. By modifying the size, shape, and orientation of these existing objects, architects can create a variety of different massing primitives.

Another approach is to create massing primitives from scratch. This can be done by creating simple geometric shapes, such as cubes, spheres, or cylinders, and then manipulating them to create the desired form. Once again, the size, shape, and orientation of the objects can be modified to create a variety of different massing primitives.

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Figure 53 gives an alternative viewpoint of the design process using the map-based Composer application, described in earlier chapters, and massing primitives. It captures the transition from a two-dimensional map to an immersive three-dimensional world, where larger scale massing primitives A (Figure 53, A) and B (Figure 53, B) start to take form.

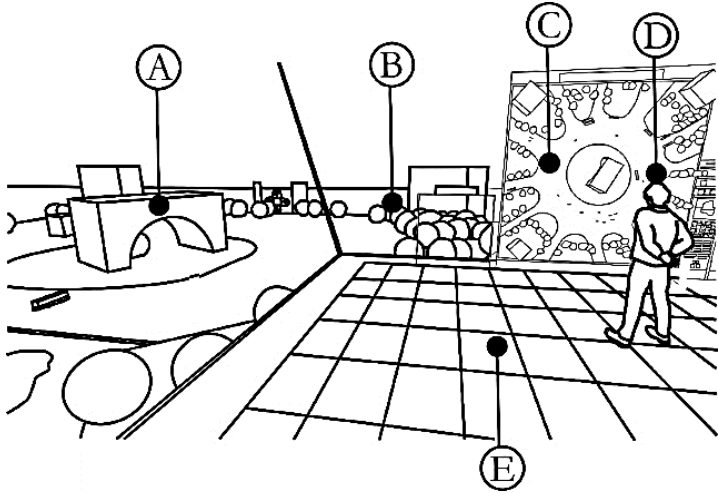


*Figure 53 From Map to Metropolis: Visualizing 3D Design with Massing Primitives*

At the forefront, an avatar D (Figure 53, D) stands before the map C (Figure 53, C), which is part of the map-based Composer E (Figure 53, E). Map C is generated using a Google Maps API, which is activated once user D provides the desired location or coordinates. This dual perspective underscores both the design interface and the emergent 3D structures, highlighting the transformative potential of this interactive design tool.

Once a collection of massing primitives is established, they serve as building blocks for assembling complex architectures. Architects can merge these fundamental shapes to form a

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singular, intricate structure, or arrange them to construct a network of related structures. Utilizing massing primitives variably enables architects to generate an extensive variety of designs. This technique exemplifies the myriad possibilities virtual worlds present for architects to abstract, innovate, and convey architectural concepts.

### *Museum design and prototyping*

Virtual worlds offer museum curators and designers a dynamic platform to conceptualize, design, and refine exhibit layouts. These digital environments are particularly useful during the initial planning phases of exhibitions, enabling professionals to visualize the spatial arrangement, understand the aesthetic appeal, and predict visitor traffic flow. By simulating exhibit designs within virtual spaces before physical construction, curators and designers can effectively anticipate and resolve potential challenges, leading to significant savings in both time and financial resources.

Furthermore, virtual worlds elevate the visitor experience by providing immersive and interactive settings that can intensify engagement and facilitate learning in novel ways. Such environments can also revolutionize how educational programs and guided tours are delivered, transforming traditional museum experiences into more captivating and accessible activities. By harnessing the potential of virtual worlds, museum professionals can not only enhance the design and presentation of exhibits but also expand their reach and impact on diverse audiences.

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In Figure 54, we can see Avatar B (Figure 54, B) navigating through a 3D museum exhibit D (Figure 54, D), set within the spacious Museum Room C (Figure 54, C). The scene is thoughtfully designed, with an inviting seating arrangement A (Figure 54, A) positioned for avatars eager to sit and absorb the surrounding artistry. The virtual environment can be rapidly assembled by general users through the now familiar Composer App's intuitive interface, utilizing different activated modules, which contain relevant objects, tailored for this purpose. Each painting exhibit, displayed on signposts with varying aspect ratios, is interactive, enabling avatars to adjust their camera placement for an optimal viewing experience with just a simple click.

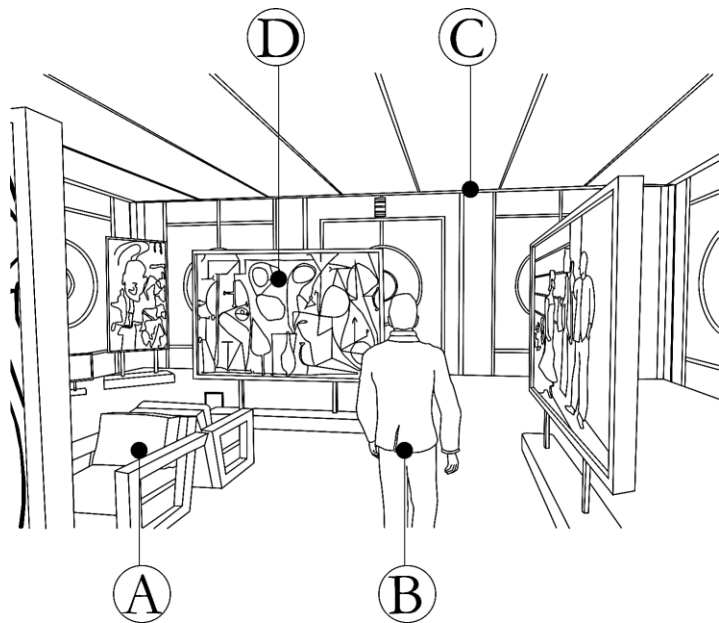


*Figure 54 Avatar exploring a virtual 3D museum (c. 2021)*

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In another view of the museum (Figure 55), the avatar delves into another area featuring various exhibits, including Exhibit B (Figure 55, B), alongside furniture pieces like C (Figure 55, C) and D (Figure 55, D), and eye-catching light fixtures such as A (Figure 55, A). These interactive light sources offer designers an engaging way to experiment with optimal lighting design, allowing them to fine-tune their concepts in the virtual world before implementing them in real-world museum prototypes. We think that such tools in the hands of motivated museum staff can go a long way in improving the experience offered to museum visitors.

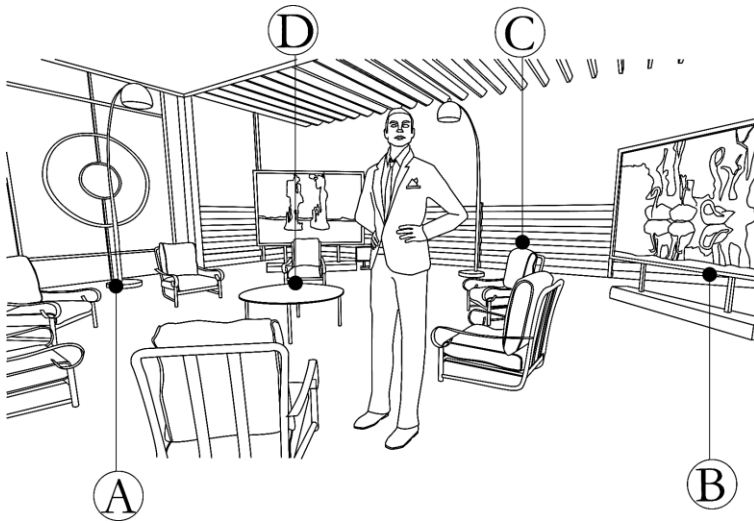


*Figure 55 All the objects in this virtual world were deployed using a rapid scene composition tool (c. 2021)*

### ***Supporting story telling***

Virtual worlds are supremely equipped to enhance storytelling, providing an immersive and interactive backdrop where users can delve into varying narratives and dictate the course of the story through their decisions. The richness of virtual

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environments enables the creation of diverse settings and scenarios, expanding the narrative possibilities for storytellers.

One of the standout features of virtual worlds in storytelling is their ability to allow storytellers to explore different narrative branches and immediately observe the impact of their narrative choices. Such real-time feedback on storytelling choices is something traditional storytelling mediums like books or films cannot offer. Furthermore, virtual worlds present a range of challenges and obstacles, adding layers of interaction and engagement to the narrative.

Virtual worlds, with their capacity to simulate intricate and lifelike experiences, cater to a broad audience, from children to adults, enhancing the storytelling experience. Easily accessible with an internet connection, these digital spaces offer a versatile and adaptable medium for immersive storytelling.

### *Using quests to structure learning*

In the immersive setting of a 3D avatar-based virtual world, structuring the study of a subject through a captivating narrative quest can significantly enhance engagement and learning outcomes. Envision a meticulously crafted journey woven into the virtual landscape, where each learner embarks on a quest filled with specific objectives tailored to impart knowledge on the subject at hand. This journey could entail a variety of challenges such as unearthing hidden artifacts, deciphering complex riddles, or overcoming adversarial encounters. The triumphant completion of these tasks ensures that learners not only assimilate the subject matter but also revel in the rewarding experience of achievement.

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For a more layered and dynamic learning experience, consider a sequence of interconnected quests, each designed with distinctive hurdles and goals that collectively construct a rich understanding of the subject. Take, for instance, a quest series centered on the expansive tapestry of United States history. The initial quest could introduce learners to the foundational ideals and pivotal events that shaped the nation. Progressing through the series, each quest would plunge deeper into pivotal historical chapters — from the Revolutionary War to the intricate causes and consequences of the Civil War, leading up to the milestones of the Civil Rights Movement. This approach not only facilitates interaction with the past in a meaningful way but also enables learners to piece together the complex narrative of history as they navigate through these virtual chronicles.



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To illustrate the immersive experience of the virtual world, Figure 56 showcases an avatar C (Figure 56, C) diligently searching for jewels such A (Figure 56, A) and B (Figure 56, B), symbolizing the excitement and adventure that the quest-based learning approach can offer. Collecting all the jewels that would fit the crown could in this case unlock doors or start new missions. This quest was created using the Composer App, which was utilized to strategically place jewels across various pertinent locations within the game. Additionally, the app enabled the creation of a dynamic crown that visually evolves, becoming increasingly ornate as players find and insert the missing jewels into its empty settings. In this engaging scenario, victory is awarded to the swift and strategic player who first completes their crown, turning the act of learning into a competitive and rewarding race to the finish.



*Figure 56 Avatar searching for jewels for his crown during a quest*

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Expanding upon the successful model of quest-based learning, we can apply similar principles to language acquisition.

Imagine a quest crafted within the Composer App, designed specifically for language learners. Here, the 'jewels' take the form of new vocabulary words, phrases, or even grammatical structures hidden throughout the virtual world, awaiting discovery. As learners navigate this linguistically rich landscape, each 'jewel' they uncover could represent a new word to master or a puzzle to solve that reinforces a particular language rule. The crown, in this context, would be a visual metaphor for the learner's growing proficiency. Each linguistic 'gem' placed in the crown strengthens the structure, symbolizing the learner's enhanced capability and confidence in the new language. Completing this crown could involve engaging with native speakers in the virtual world, accomplishing tasks that require the practical application of language skills, or participating in interactive storytelling that demands understanding and using nuanced language. The first to fully embellish their crown with these linguistic treasures would demonstrate not just memory retention but the ability to use the language effectively in dynamic contexts, thus achieving a meaningful milestone in their language learning journey.

### ***Machinima production***

Creating animated educational videos within virtual worlds boasts numerous advantages over classical recording methods. Virtual worlds inherently offer immersive first-person perspectives, enabling learners to experience content as if they're inside it, tapping into the virtual vantage point that traditional third-person camera setups cannot provide. This

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perspective shift can enhance a learner's connection with the material.

Moreover, these digital spaces circumvent the need for costly traditional recording infrastructure. Instead of requiring a suite of high-end cameras, lighting, and audio equipment, plus sophisticated editing software—all of which can pose financial and logistical hurdles—virtual environments demand only a computer with internet access. This simplicity drastically lowers the entry barrier for educators, democratizing the production of educational content.

Finally, the interactive nature of virtual worlds opens doors to novel, dynamic content far beyond static videos. Educators can craft experiences where learners explore, engage in activities, and receive real-time feedback. This interactivity lends itself well to teaching complex subjects, from science and mathematics to history, by making learning an active and engaging process.

Overall, virtual worlds present an optimal, cost-effective, and engaging platform for producing, capturing and delivering educational content. The blend of an immersive perspective, easy accessibility, and interactivity positions virtual worlds as a superior choice for educators looking to create educational videos with animated content. We posit that, currently, virtual worlds provide a more user-friendly interface for crafting animated content compared to generative AI technologies. Virtual environments allow creators to construct and manipulate elements with a level of precision and predictability that generative AI often struggles to match. While generative AI excels in generating coherent content, it frequently falls short in realizing the specific, nuanced visions of creators.

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Virtual worlds give authors the reins, ensuring that the final output aligns closely with their original intent.

### ***Board Game design***

Virtual worlds are an ideal environment for designing and testing board games. The upcoming figure (Figure 57) presents an intricate game board D (Figure 57, D), complete with pieces to be maneuvered, informative card decks such as B and C (Figure 57, B and C), dice such as A (Figure 57, A), and various controls F (Figure 57, F) and E (Figure 57, E) for loading diverse game configurations or setting timers. Remarkably, these games can also be crafted using the same approach previously described. Our system can offer modules containing a wide array of game artifacts, and a tailored Composer App can be directed to communicate with these specific modules by an end user, requiring no programming skills. Here as well, the game is played simply through point and click.

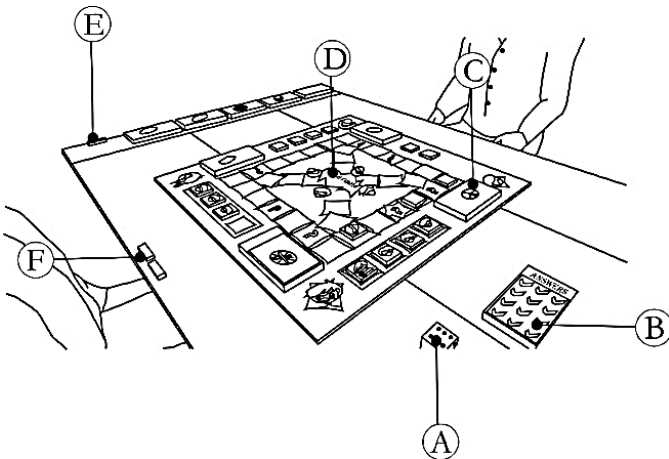


*Figure 57 Board game design and testing*

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Figure 58 captures a scene where two avatars are engaged in a game of chess B (Figure 58, B). This setup is part of the home environment that was presented in the last chapter, designed to practice activities of daily living, specifically aimed at teenagers, under playful, gaming conditions.

Users have access to a wide variety of games A (Figure 58, A) that can be brought to the virtual table for interactive play. This example of a tabletop game (Figure 58, B) illustrates the strength of modular design approaches, here embodied as an instance of a Composer App, that can be adapted for a multitude of engaging applications, providing a dynamic platform for learning, and practicing daily skills.

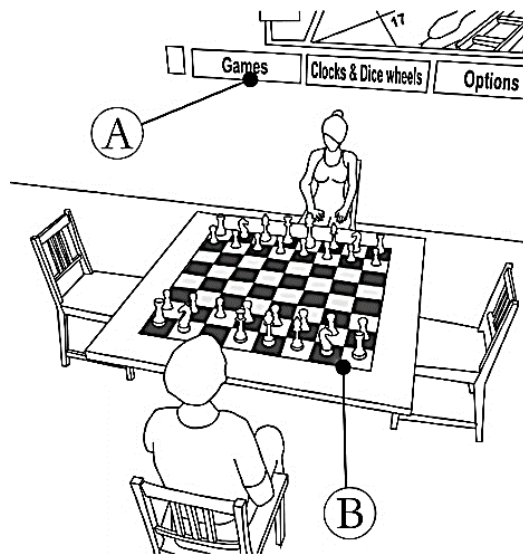


*Figure 58 Mixing games with learning activities of daily living in large immersive virtual worlds*

### ***Virtual Chemistry Lab***

Let us continue with more examples that were authored using our approach. It is widely accepted that students learn best by

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doing. Unfortunately, many of the traditional methods of teaching chemistry involve rote memorization and there is little opportunity for students to engage in the firsthand exploration of chemical concepts. Virtual worlds offer a unique opportunity to create an immersive environment in which students can actively engage in the process of scientific discovery.

There are several potential benefits of using virtual worlds to support the teaching of chemistry. First, virtual worlds can provide an animated visual environment to illustrate the mechanics of chemical reactions. Second, virtual worlds can be used to create simulations of real-world chemical processes, allowing students to explore these processes in a safe and controlled environment. In addition, virtual worlds offer a unique opportunity to create an immersive environment in which students can actively engage in the process of scientific experimentation whenever they are available or feel interested in the topic at hand. We are not suggesting that real-world lab experiments should be replaced. Instead, we are highlighting that simulations can be a safe and convenient resource available when needed, and they can effectively support teaching and learning.

Figure 59 illustrates a Composer App communicating with specially designed modules tailored for chemistry classes, focusing on molecular and crystal shapes within the curriculum. With this tool, students can effortlessly create their own 3D models, such as an accurate model of a diamond crystal. The display further enriches the learning experience by including a vivid multimedia such as an image of diamonds A (Figure 59, A) accompanied by an informative label B (Figure 59, B). This illustration showcases how the Composer App can

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be employed as an effective educational aid, helping students explore and understand complex molecular and crystal structures. Students can create these models using point and click which may be argued to be simpler than buying and assembling crystal or molecule building kits in the real world.

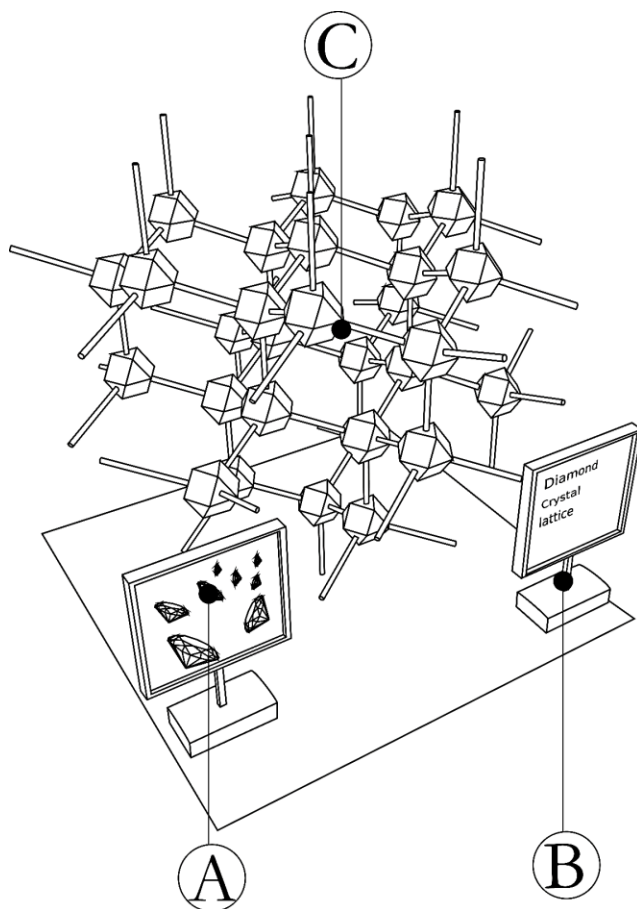


*Figure 59 A 3D molecular model of Diamond constructed using the Composition tool (c. 2020)*

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In the next example (Figure 60), the Composer App is used to visualize and construct a propane molecule. Like in the previous example, the exhibit is accompanied by a relevant picture A (Figure 60, A) and descriptive text B (Figure 60, B). These provide additional context that can aid understanding of the subject matter. As students engage with the App, they sign in and access a menu, guiding them through the molecule creation process. They may begin with a single carbon atom, positioning it as needed and through further HUD menu selections they can sequentially attach bonds and additional atoms as required to develop perfectly aligned and positioned atoms to create molecules C (Figure 60, C) and D (Figure 60, D). The alignment and positioning are automated, ensuring that students don't need to waste time fiddling with complex editors. This intuitive tool offers a remarkable opportunity for students to visualize molecules and gain insights into their complex structures. Moreover, this process aids in the long-term retention of information about the subject.

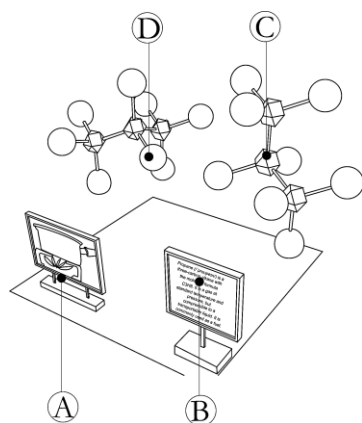


*Figure 60 Propane molecules constructed for a class exhibit using the Composition tool*



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### *Simulating real world training exercises*

Let us continue to examine examples from various sectors. We have the experience of shifting hands-on training from the physical realm to the digital sphere. This shift comes with numerous advantages: participants are fully engaged in the simulated conditions, which enhances the durability and depth of skill and concept retention. Assessments of proficiency are streamlined due to the capability for live monitoring of learners' progress, and specialists have the capacity to create bespoke scenarios without the necessity for an in-house team of 3D modelers or software developers. The benefit of practicing with virtual replicas of real-world items is made clear, as it immerses learners directly into the core of the subject matter. The link between learning in simulations and applying this knowledge in real-life contexts is unmistakable. Through our endeavors, we have crafted immersive training programs tailored for emergency response readiness and constructed virtual therapeutic spaces for neurotypical youths in healthcare settings. In our history of conducting training, it has been uncommon for participants to feel anything less than completely absorbed in the training scenarios presented.

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Figure 61 shows avatars A, B and C (Figure 61, A, B and C) donning nursing uniforms, engaging in a practice session to rehearse their response procedures in the event of a sudden influx of patients at a hospital.

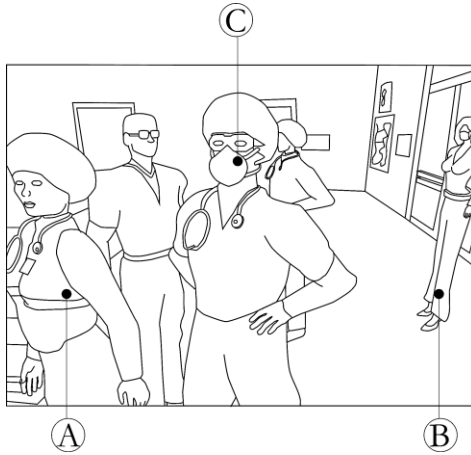


*Figure 61 Nursing staff role-playing as avatars in a virtual hospital (c. 2010)*

The avatars can communicate with one another via voice and interact with various objects in the virtual hospital environment, allowing them to locate appropriate clothing and equipment as needed. This scene represents an early example of how virtual worlds can be utilized by hospital staff to learn and practice their responses to emergency situations. By offering a safe and controlled environment, these virtual simulations provide valuable training experiences for healthcare professionals, better preparing them for real-life crisis scenarios.

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Figure 62 offers an alternative perspective of the nursing station, showcasing its various features designed to facilitate an efficient and organized healthcare environment.

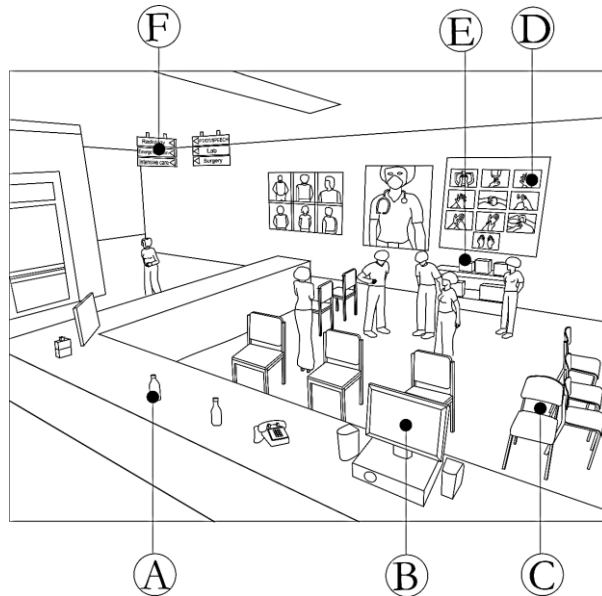


*Figure 62 Nursing staff role practising the donning of PPEs at the nursing station (c. 2010)*

Visible within the scene are hospital navigation aids F (Figure 62, F), informative posters D (Figure 62, D) reminding staff of personal protective equipment best practices, where to access them E (Figure 62, E), an assortment of available equipment B (Figure 62, B), a well-structured seating arrangement C (Figure 62, C), and conveniently placed hand sanitizers A (Figure 62, A). Though simple in design, these virtual environments effectively trigger an immersion response in trainees, who must regularly participate in training and skill upgrades. By closely simulating real-world healthcare settings, these virtual spaces provide valuable learning opportunities and contribute to the ongoing professional development of medical personnel.

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Figure 63 illustrates a standard hospital patient room, outfitted with a range of objects and amenities typical of such environments. Non-player characters (NPCs), as indicated by label B in Figure 63, are often employed to replicate patient scenarios, providing hospital staff with realistic and practical training experiences.

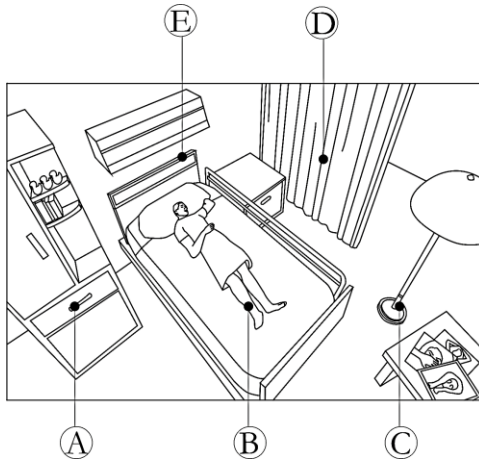


*Figure 63 A non player character taking the role of a patient in the hospital (c. 2010)*

In this virtual environment, staff members can familiarize themselves with the controls of modern hospital beds E (Figure 63, E), as well as gain an understanding of the location of patient drawers A (Figure 63, A) and other simple appliances, such as the lamp C (Figure 63, C) and moveable curtains D (Figure 63, D). Having access to content creation tools enables hospital instructors to develop their own virtual training environments tailored to their specific needs. These immersive spaces provide valuable opportunities for staff to learn and practice essential skills, ultimately improving the quality of patient care.

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Figure 64 presents a non-player character (NPC) acting out a cardiac arrest scenario. The creation of these virtual patients is a complex task requiring meticulous attention to detail. It aims to capture and reproduce the critical elements of the emergency, thereby enabling students to engage in effective learning and practice.

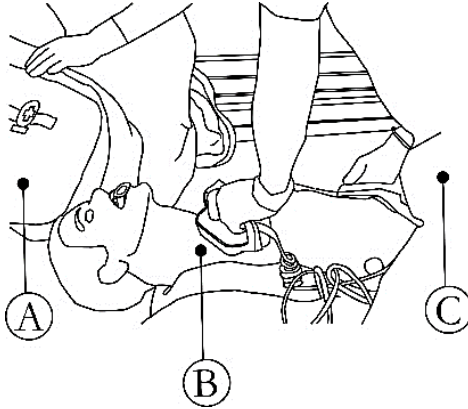


*Figure 64 Collapsed virtual patient helped by first responders*

The scene depicts two emergency healthcare first responder avatars A and C (Figure 64, A and C), taking on their respective roles. They interact with the non-player character B (Figure 64, B), and employ the necessary equipment to save them.

The emphasis is placed on the hands-on nature and immediacy of the emergency. Responders act with speed and precision, applying their knowledge to resuscitate the patient. This simulation is designed to offer a quasi-realistic educational experience for students, where interactions occur via a computer screen. Nonetheless, this setup appears adequate for fostering the critical competencies required for emergency healthcare situations. This picture captures the intersection of

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education and technology, where virtual environments offer valuable training opportunities. It emphasizes the importance of hands-on practice in preparing future healthcare professionals to handle critical situations with confidence and competence.

Developing virtual patients involves a meticulous process of determining which aspects of a medical situation need to be highlighted and simulated, while challenges arise in accurately representing human physiology and behavior. Generative AI can help overcome these challenges by enabling more realistic and dynamic behaviors, personalized training experiences, and automating the creation of diverse patient profiles. Ultimately, AI will enhance the authenticity and effectiveness of virtual patient simulations, providing aspiring healthcare professionals with immersive and valuable learning opportunities. This is a research area that we are confident will keep researchers busy for many years to come.

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### *Emergency preparedness training*

Reflecting on our modest beginnings in 2007, we remember the diligent efforts to create a virtual counterpart of a hospital, as shown in Figure 65). This endeavor involved visiting the actual site, capturing video footage, and engaging a dedicated team to meticulously construct the 3D components—a process that demanded considerable time and effort. The panoramic view in Figure 65 reveals the hospital's exterior B (Figure 65, B), the parking area C (Figure 65, C), and the encircling greenery A (Figure 65, A),, bringing to mind the various training activities that took place in this replicated environment.

Today, the pipeline for generating such content has undergone a radical transformation, with significant improvements in efficiency. It is now conceivable that similar environments can be constructed using the Composer App approach described earlier, opening up new possibilities for virtual world design and exploration. Improvements in 3D capture technology and AI-assisted 3D modeling are expected to automate much of the development process for creating virtual twins of real-world environments.

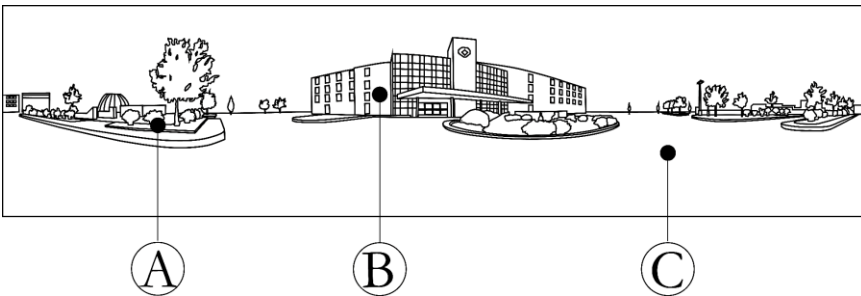


*Figure 65 One of the first 3D virtual world replica of a real world hospital, Elks Memorial Hospital, developed from training purposes (c. 2007)*



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The forthcoming Figure 66 presents the welcoming entrance or lobby of the virtual hospital which at the time was created manually. Key features highlighted include the strategically positioned reception desk B (Figure 66, B), the main entrance area C (Figure 66, C), the conveniently located wheelchairs D (Figure 66, D), and the designated space A (Figure 66, A) reserved for examination rooms.

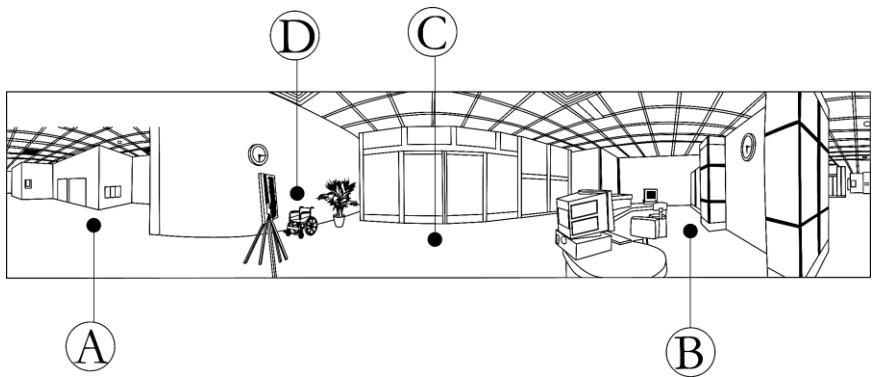


*Figure 66 The lobby of the 3D virtual world hospital (c. 2007)*

By participating in exercises within virtual replicas of real-world environments, individuals often find their training experiences to be more meaningful and engaging. This immersive approach to learning facilitates better information retention and fosters a stronger sense of camaraderie among peers as they navigate these shared spaces together. Several additional examples are provided next. We believe it is crucial to acquaint educators with the historical context of past efforts in this field. Doing so can spark inspiration and encourage them to refine and enhance the concepts introduced.

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Figure 67 illustrates a virtual simulation of a parking lot triage operation, with numerous healthcare providers participating as avatars B and G (Figure 67, B and G). A line of cars C (Figure 67, C) forms along the road, progressing toward a series of rapid-deployable tents E (Figure 67, E), which feature customizable labels D (Figure 67, D). Besides the rapidly deployable tents, interactive equipment is available for training staff to experiment with during the exercise.

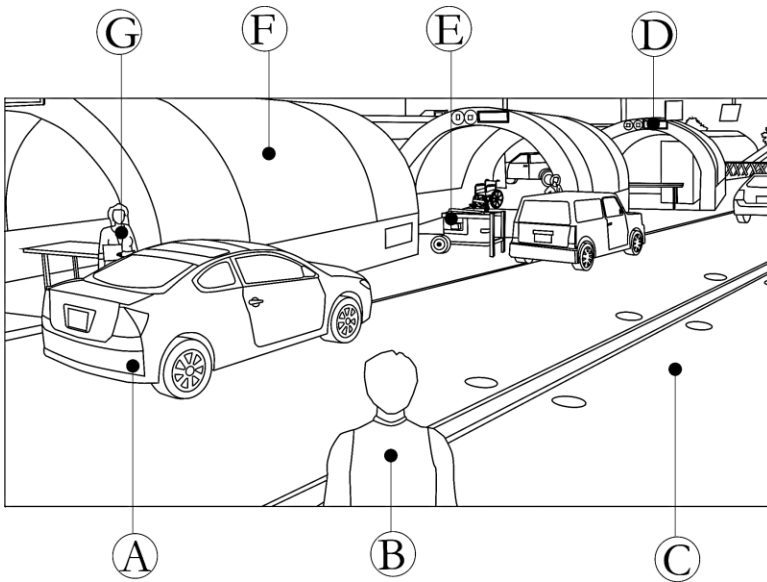


*Figure 67 Practising triage in a parking lot as a virtual exercise for health care staff preparing for a pandemic patient surge (c. 2007).*

Previously, such a setup necessitated the collaboration of expert 3D modelers and programmers, but with our modular building approach using a Composer App, subject matter experts can create these simulations without any design or coding expertise. This training has proven effective, as a similar approach was used during the Covid 2020 outbreak

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when testing and vaccination centers were established in parking lots for the first time.

In the virtual world scenario described by Figure 68, trainees A (Figure 68, A), represented by their avatars, participate in a critical exercise focused on the rapid deployment of tents. The setting unfolds in a large parking lot labeled as B (Figure 68, B), where the surge of patients after an outbreak is simulated. Among the various tents, a Blu-med tent marked as D (Figure 68, D) stands tall, symbolizing preparedness. The trainees, embodying their avatars, diligently prepare for a triage operation within this virtual environment. Notably, the Blu-med tent features a simulated air lock system denoted as C (Figure 68, C).

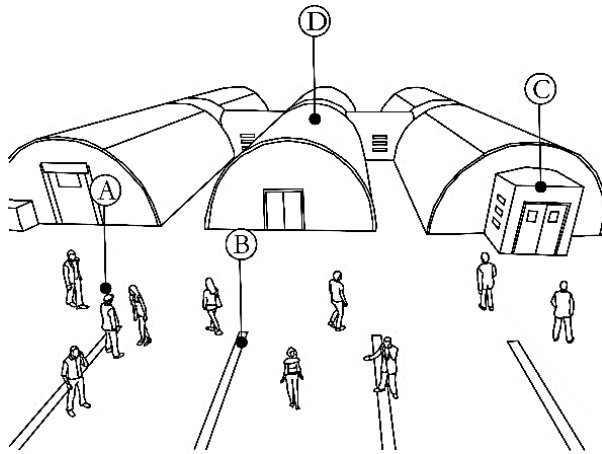


*Figure 68 Rapidly deployed tent in parking lot to deal with surge (c.2007)*

This virtual setup replicates the real-world functionality of an air lock system, providing a buffer zone between the interior and exterior of the tent to maintain temperature and prevent contamination. It also serves as a controlled space within the virtual realm for trainees to equip or remove personal

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protective equipment, effectively minimizing the risk of cross-contamination. Through this immersive experience, trainees navigate the challenges of managing public health crises, honing their skills and preparedness in a safe and controlled virtual environment.

Figure 69, the illustration portrays a scene within a tented area. Inside the tent, hospital beds B (Figure 69, B) have been skillfully deployed, forming a cohesive arrangement. These beds serve as resting places for virtual patients A (Figure 69, A), who lie on mobile hospital bed units. This depiction highlights the significance of virtual spaces in expanding training possibilities, thereby enhancing the realism and effectiveness of large-scale emergency preparedness exercises. Such exercises often involve a diverse range of trainees C (Figure 69, C) from geographically dispersed emergency preparedness departments.

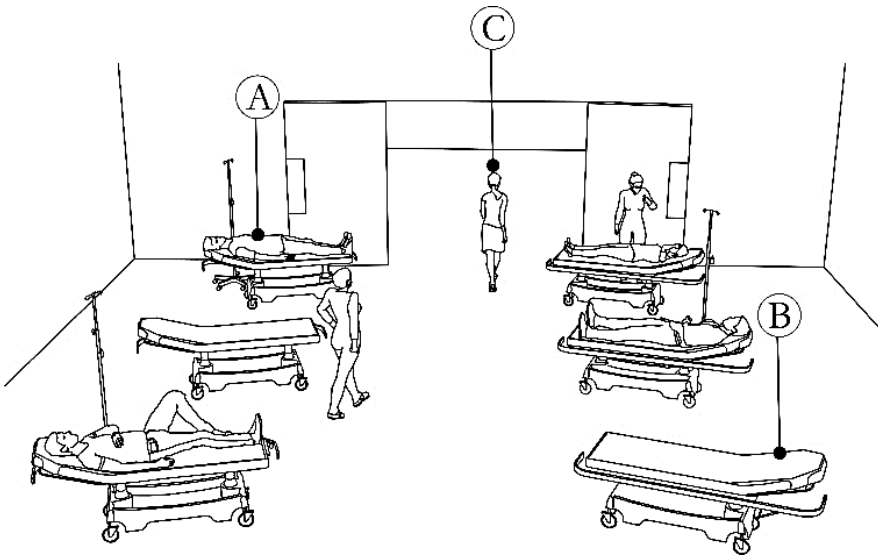


*Figure 69 Inside a room in the rapidly deployable tent*

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The inclusion of virtual patients and the meticulous setup of the tented environment contribute to a comprehensive and immersive training experience, equipping trainees with the necessary skills to respond effectively in emergency situations.

Figure 70 captures a unique training scenario for law enforcement and emergency response teams. It is a hands-on lesson in a simulated environment where a bomber has been making homemade explosive devices.

Everyday items, including gas tanks A (Figure 70, A), pipe bombs B (Figure 70, B), and dynamite sticks C (Figure 70,C) are scattered around, subtly transforming an ordinary garage scene into a homemade bomb factory. Among these objects are items like receipts and packaging materials with safety information, and maps providing vital clues about potential targets.

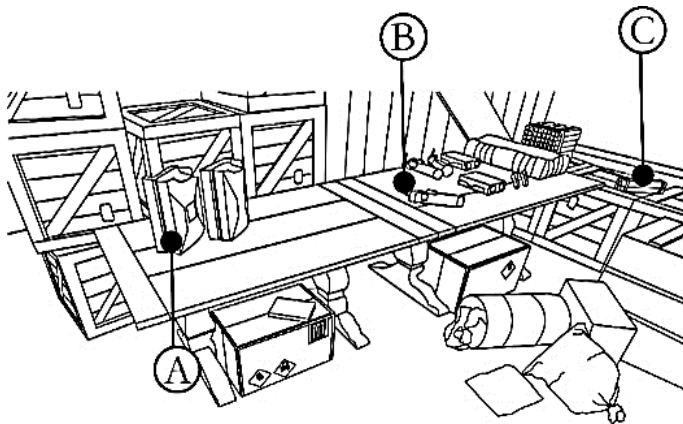


*Figure 70 Exploring hazardous materials in various training contexts*

The trainees' mission is to search the premises, find these clues, and connect the dots. They sift through trash bins and

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examine every seemingly insignificant item. It is an exercise in attention to detail, critical thinking, and teamwork.

While the scenario may appear straightforward, the learning experience is deep and engaging. The trainees must work together, share insights, and build a shared understanding to crack the case. This picture represents the power of collaborative learning in the face of complex challenges.

Figure 71 shows an avatar A (Figure 71, A), navigating through a virtual water treatment plant. This setup enables learners to virtually interact with various pieces of equipment, understand their roles and learn about safety procedures in an immersive environment.

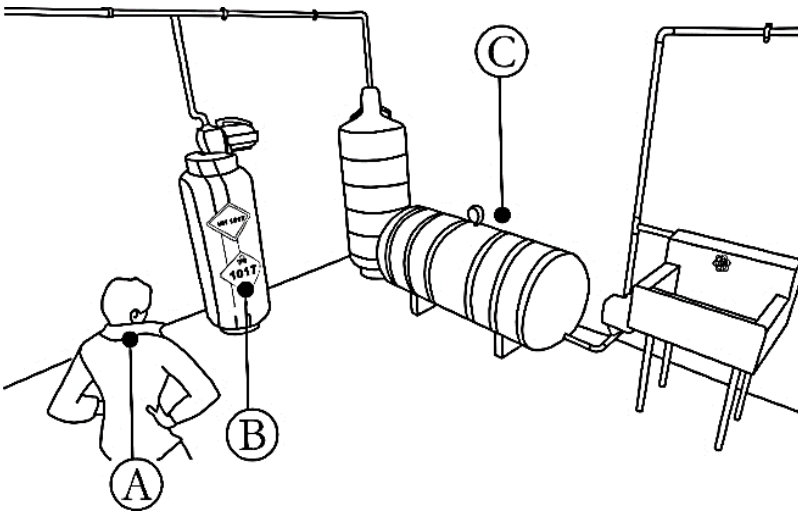


*Figure 71 Exploring simple water treatment setups*

One feature of interest is a ‘1017’ hazmat placard B (Figure 71, B), on a tank, indicating the presence of chlorine gas. This important detail teaches learners about hazard identification standard practices in a practical context which is known to

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encourage retention. This tank is equipped with a safety valve at the exit. The setup shows the chlorination process from start to finish C (Figure 71, C).

Overall, the image captures an interactive learning experience where the trainee can grasp the process of water treatment and the importance of safety measures, offering a comprehensive understanding of the topic.

In the realm of avatar-based virtual worlds, the potential use cases are vast and varied. We hope that the compiled curated list of examples will be sufficient to motivate educators to create their own immersive learning experiences.

We want to emphasize the importance of modularization in the creation of educational content. Modularization is crucial because it speeds up the process of content composition and optimizes resource utilization through content sharing and reusability. We have discussed the concept of modules and various composition tools in previous chapters, which outline how this can be achieved.

By breaking content into modular units, creators can efficiently piece together immersive and interactive educational experiences. These modules are self-contained and self-explanatory, making the composition process streamlined for educators. Moreover, the modular nature of the content allows for easy mixing and matching, empowering educators to tailor narratives that suit their students' needs. The emphasis on reusability encourages collaboration and innovation among creators, ultimately elevating the quality of educational materials.

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By embracing modularization, we have the opportunity to transform education into an innovative ecosystem. Within this space, educators would have the ability to select and acquire specific modules tailored to their training needs. They could then craft the desired educational scenarios by utilizing an application designed for scene composition. Together, we can work towards a future where the potential of modular content creation is fully realized. With the emergence of generative AI, the generation of content for these modules seems perfectly aligned with its capabilities.

### **Closing thoughts**

#### ***Seizing Opportunities in Emerging Technologies***

One way to encourage educators to explore more creative uses of virtual worlds to support learning is to consider the choice of platform and community. Educators should research platforms that hold promise for educational purposes and ensure there is a sustainable community of users to support ongoing collaboration and learning. This choice of platform should also include thinking about the presentation tools available, moving away from traditional slide-based presentations to more immersive and interactive methods that invite deep student participation.

Educators must also think spatially when designing their virtual world learning experiences. By leveraging the power of 3D data visualization and animating complex concepts or structures, educators can create more engaging and effective learning environments. To support this, communities should form around these goals, allowing educators to learn from each other and expand their palette of teaching tools.



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Course goals should be carefully considered when integrating virtual worlds into education. Educators should balance self-directed learning with instructor-directed learning to ensure students have the opportunity to explore and learn at their own pace, while also benefiting from structured guidance.

The use of virtual worlds for visualization creation and machinima production presents exciting opportunities for educators. Instructors should develop their skills in capturing and producing educational machinima using 3D worlds, content, avatars, and non-player characters (NPCs). This would lead to more engaging and dynamic learning materials for students.

With the advent of generative AI and other systems aimed at the mass audience, educators must stay informed about these developments as they offer great potential to improve teaching and learning. In the coming years, it will become increasingly evident how AI-powered humanoid NPCs or agents can impact education. By embracing these advancements, educators can create more innovative and effective virtual world learning experiences.

To encourage educators to be more creative in their use of virtual worlds, they should be provided with resources that showcase a variety of ways virtual worlds can be used to support learning. These resources might include blog posts, articles, video tutorials, or even sample lesson plans that use virtual worlds. Additionally, educators should be given opportunities to observe others using virtual worlds for learning, attend workshops or webinars, and access online forums or discussion groups for support and feedback. By having a support system in place, educators can feel more

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confident in trying out new ideas and approaches in virtual world learning.

### *What's next*

As we have explored the myriad of possibilities virtual worlds hold for education in Chapter 8, we also grappled with the many challenges that teachers face when attempting to incorporate these novel technologies into their classrooms. With issues of time, resources, and knowledge proving formidable obstacles, the solution may lie within the innovative approaches we have discovered - from content modularization and templates to creative uses of cognitive tools like abstractions. As we move forward to Chapter 9, we will continue exploring these advanced technological environments, diving into the ambitious concept of the Metaverse. As we will see, the challenges educators face mirror the broader struggles that technologists grapple within the push for a more immersive, age-agnostic, and useful Metaverse. The lessons we have learned about how to improve efficiency and navigate these digital spaces will prove invaluable as we delve into the potential of the Metaverse, the obstacles standing in its way, and the open problems that need innovative solutions.



*Chapter cover 9 Metaverse Horizons: The Dream and the Reality*

## 9. The Metaverse is Not That Far

### *And It is Going to be Intelligent*

The concept of the Metaverse — a sprawling, digital universe — generates a sense of anticipation, curiosity, and uncertainty among investors and everyday users alike. If its evolution follows a path similar to that of the Internet, we can expect its arrival to be gradual, rather than sudden or startling. It is likely to weave itself subtly but steadily into the fabric of our daily lives, influencing a wide range of human activities.

However, this digital dawn will not come without potential drawbacks, mirroring the trials we face in the current Internet age. We have seen the double-edged sword of social media: while it connects and informs us, it also fuels the rapid spread of misinformation or ‘fake news’, overwhelms us with information saturation, and produces an abundance of low-quality content that often obscures more valuable information. In addition, it brings to the fore contentious issues related to content monetization and intellectual property rights online. Amid this tempest of change and challenge, how can we accurately chart our journey towards the Metaverse?

The Metaverse’s trajectory is vast and multifaceted. There are numerous indicators of its progress and countless topics to explore in understanding its evolution. For this conversation, we’ll set aside an important set of issues: the necessary evolution of financial and governance systems — subjects more commonly addressed within discussions on web3 and cryptography.

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Instead, we'll focus on ten often-underestimated parameters, areas where we must ensure progress is sufficient to match the grandeur of our ambitions. These elements offer a framework to assess how far we have come and estimate the distance yet to traverse on our path towards the fully-realized Metaverse.

### **Progress defining parameters**

#### *Fidelity, how useful is it as a metric?*

Fidelity, in the context of virtual or augmented realities, encapsulates the accuracy, believability, and authenticity of experiences when compared to the physical world. It forms the cornerstone of immersive experiences, bridging the gap between the artificial and the real. Fidelity is often categorized into several types, each relevant to different facets of a virtual experience - visual, auditory, sensory, physical, social, and temporal.

#### *The Spectrum of Senses - Visual, Auditory, and Haptic Fidelity*

Visual fidelity measures the authenticity and accuracy of visual representations in the virtual realm. It is crucial to keep visual latency below 35 milliseconds to maintain immersion. Crossing this threshold can degrade the quality of the experience, pulling the user out of the virtual environment.

In parallel, auditory fidelity is about the quality and realism of sounds. Like visuals, auditory experiences can be disrupted by latency, damaging the immersive experience.

Haptic fidelity, on the other hand, gauges the believability of touch sensations in a virtual environment. This forms an integral part of the sensory spectrum, and latency issues can similarly impact the quality of the experience.

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### *Grounded in Reality - Physical Fidelity*

Physical fidelity refers to the consistency of a virtual world's physics with the real world. For instance, the behavior of light and shadows, or the trajectory of a thrown object. Ensuring that the virtual world's actions and outcomes align closely with real-world expectations enhances the user's immersion and engagement.

### *Real Interactions in Virtual Spaces - Social Fidelity*

Social fidelity gauges the authenticity of social interactions in a virtual space. This covers everything from body language and facial expressions to the naturalness of dialogue and interaction. High social fidelity fosters more realistic and engaging virtual interactions, contributing to a holistic sense of presence in the virtual world.

### *A Journey through Time - Temporal Fidelity*

Temporal fidelity, a less-explored facet of fidelity, encapsulates the accuracy and believability of how time is represented and perceived in different environments. In its simplest form, it reflects how closely the passage of time in a virtual environment aligns with that in the physical world.

Temporal fidelity is significantly affected by latency, which is a primary struggle for designers of virtual environments. High levels of latency can impair the quality of the user experience, and in certain applications, it can be a complete showstopper. Consider situations such as musicians collaborating over the Internet or an industrial plant manager controlling operations from a console - in such cases, maintaining high temporal fidelity is critical.

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Beyond real-time interactions, temporal fidelity also pertains to how effectively time manipulations, such as compression or expansion, are represented in a virtual context.

### *Fidelity as a Measure of Progress in Virtual Realities*

In assessing the progress of virtual realities, fidelity serves as a satisfactory metric. Each of its components - visual, auditory, haptic, physical, social, and temporal - provides a critical perspective on the maturation of virtual technologies and experiences.

High visual and auditory fidelity are often the first milestones in creating believable virtual environments, and advancements in these areas signify progress in rendering and sound technology. Simultaneously, improvements in haptic fidelity denote growth in the sophistication of tactile feedback systems, a frontier that remains challenging yet ripe with potential.

The state of physical fidelity, on the other hand, gives insight into how successfully the virtual world emulates the laws and constants of the real world. It showcases the growth of simulation algorithms and the capacity to create an environment adhering to real-world physics.

Progress in social fidelity speaks to the nuances of human interaction that technology can capture. It suggests not just advancements in animation and artificial intelligence, but also an understanding of human behavior and social norms.

Lastly, developments in temporal fidelity highlight progress in network technology and the ability to represent and manipulate time convincingly. It gives a glimpse into how successfully virtual environments can be synchronized with real-world

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experiences, an increasingly important factor as we contemplate real-time interplanetary communication.

In essence, fidelity, in all its forms, is not merely a measure of how ‘real’ a virtual experience feels. It is a holistic yardstick for gauging technological advancements, user experience design, and our growing understanding of how to replicate and augment reality effectively. As such, fidelity should be at the heart of any discussion about the future of virtual realities.

### *A Note of Caution: The Limitations of Fidelity*

While fidelity is indeed a central metric in assessing the state of virtual realities, it is important to note its inherent limitations. Fidelity, as a concept, implies a direct comparison with reality. It operates on the assumption that the ultimate goal of virtual experiences is to replicate the physical world as closely as possible.

However, virtual realities hold the potential to offer experiences that go beyond the constraints of our physical world. They can create environments, interactions, and sensations that are entirely new and innovative, which might not have a direct ‘real’ counterpart. In these instances, the concept of fidelity as we understand it could fall short.

Moreover, the current metrics of fidelity, particularly in realms like sensory and social, are still evolving. Our understanding of human perception, cognition, and social behavior is far from complete, and the metrics we use to gauge fidelity reflect these limitations. Therefore, while fidelity offers a robust framework for evaluating and improving virtual realities, it should not be considered an infallible or absolute measure.



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As we venture further into the realm of virtual and augmented realities, we must remain mindful of these limitations. Fidelity is an essential guide, but it should not constrain our imagination or the potential to create entirely new experiences. A balanced approach that combines the pursuit of high fidelity with the freedom to innovate will help us unlock the true potential of virtual realities.

### *Virtualization priority*

It can be said that digital representations of sound and vision arrived before those of touch, smell, and taste. We ranked all display technologies according to their ability to create immersive experiences; the visual would be the most effective, followed closely by auditory, and the tactile would rank third, followed by olfactory and gustatory lagging. We can make the case that a truly and perceptually balanced Metaverse cannot arise without achieving high fidelity digital virtualization across all domains of perception, not just a few.

### *End user to platform expert ratio*

Many contend that the number of concurrent users is the most important factor. For example, a Metaverse should be able to accommodate thousands of people at the same time, just like in a stadium. Although this factor may be useful in predicting how close we are to the end goal, we believe that it is the ratio between users who have no interest in the underlying technology and those who are experts in it, which will be the true measure of technology penetration. Early on, experts outnumbered non-experts, but this will change as the platform becomes easier to use and offers more value to its users. A higher ratio indicates a greater likelihood of achieving a Metaverse with practical utility. The maturity of a platform can

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be measured by the ratio of end-user to expert content. Higher ratios indicate a more mature platform.

### *Real world impact*

Virtual training environments have been successful in transferring skills in a wide range of fields, from medicine to car racing and jet flying. A decade ago, we observed similar benefits for people helping each other and training for real-world emergency preparedness in virtual worlds. However, this is a niche area for applications. Metaverses cannot yet have a significant impact on the real world because, overall, they are still in the early stages of development. This mindset is due in part to the fact that most developers for this space are catering to primal needs or entertainment that demand isolation from the real world, and serious applications have been put on the backburner. For the Metaverse to be the future of the Internet, we believe this will have to change dramatically. The Metaverse could, for instance, become so deeply utilitarian that it becomes the driving force behind the future of work. The implications will be mind-blowing and impact everything from self-identity, culture, and ethics. For example, the nature of remote work and its ethics will change.

### *Age-and-maturity agnostic*

New social applications aimed at mass audiences are typically first adopted by the younger generation. As Metaverses evolve and coalesce into one global platform, we will see a number of new application segments aimed at different social groups. From the perspective of the underlying Metaverse platform, age is irrelevant, as it is for the Internet. Currently, we tend to assume that the Metaverse is primarily of interest to young

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people, but there is a growing population of elderly users reaching this universe, and this trend is likely to continue.

### ***Automation vs control conundrum***

It will be difficult for Metaverse users to overcome the cognitive dissonance caused by the conflict between two cravings destined to last forever. It is difficult to choose between the desire for automation and the desire for fine control. Over-automation could leave humans out of the content creation and consumption loop, which would be tragic. With the rapid increase in automated productivity tools, the sheer amount of content produced would simply not be digestible because of the limited capacity of humans to consume information. There will probably be an emerging industry creating AI bots that would help users manage their information spaces. As more technology is introduced in the content production and consumption loop, users might start to feel sidelined and less in control of what they want to access or create. We will have to contend that it is necessary to create an information bubble around every user so that they can survive in the information-abundant age. The assumption we are making, of course, is that it is difficult to change the human baseline for memory and processing artificially, even though we acknowledge that this is a field of research that is being explored currently (Urban, 2017 (Retrieved Dec 2022)).

### ***Quest for more compressed representations and amplified productivity***

One can argue that, in the beginning, the mass facing the Internet was primarily used for entertainment. It took a while before productivity and collaborative applications emerged. The percentage of Metaverse use for productivity purposes is

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likely to increase with the maturity of the Metaverse. It is well known that game mechanics have not changed significantly over the past few decades. I believe there are a variety of applications with significant total addressable markets ripe for transformation into fully collaborative forms in the real world. Examples of application segments that are naturally collaborative are movie-making applications that capture stories played in virtual worlds by avatars or scripted non-player characters, architectural or landscape design applications, or virtually facilitated therapy applications that connect therapists with patients in relevant contexts. In addition, we understand that designers have difficulty devising new abstractions that would improve productivity in virtual worlds. Because we did not define the problem space, these areas are likely to be the most difficult to solve. For example, if we set out to develop new tools for a virtual office environment, we might need to develop new visualization methods or rethink workflows according to the affordances. It is typically very expensive to develop these aspects of design, and they are conceptually difficult to handle. For example, 3D project management tools are harder to create than their 2D counterparts are. It is probably the most difficult to resolve these areas because we did not define the problem space.

### *Expansion of self-identity*

“Tat Tvam Asi”, sanskrit phrase meaning “You are that”,  
Chandogya Upanishad

Metaverse users will evolve an identity that would allow them to identify both their real-world and virtual world identities. They also need to cultivate these different identities in both the real and virtual communities that they may be members of. In the best-case scenario, a mature Metaverse could enable its

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users to discover who they really are or how their currently expressed identity is only part of their true reality. They may also come to understand the true nature of their identity or see the part of their identity that defies change more clearly.

### *Obtrusiveness of the user interface*

We define the thickness of the user interface as the fraction of the cognitive bandwidth that users must dedicate to user interface issues as a cost for participating in the Metaverse. For example, if users become aware of their user interface while they are in the Metaverse because the user interface devices are not light, run hot, or come with physiological effects such as headaches or vertigo, then this interface is an obstacle to immersion by a significant amount. This problem spans the entire spectrum of virtual reality devices that users must wear or use. For example, an omnidirectional treadmill remains elusive, and it is difficult for the awareness of being and walking on a moving belt to sink into the background. If we are to consider the haptic domain, physicality plays an important role in the mediation of rhythmic motion, physical posture, and recovery from fatigue in real world human activities. The absence of physicality or a laggy one is bound to disrupt immersivity in virtual reality worlds. In short, a mature Metaverse requires the user interface to be so thin that it becomes imperceptible.

### *Diversity of user base*

We argue that a mature Metaverse will have to be more serious about making this environment accessible to people with diverse physical abilities or neurological profiles through assistive technologies. This parameter is problematic as a signal of progress because it is known that the number of

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individuals with physical or cognitive impairments is overrepresented in virtual worlds. However, we must include this factor for completeness.

### **Sticky problems facing the Metaverse**

#### ***Laborious user content creation***

Before the advent of generative AI, subject matter experts aiming to author bespoke 3D experiences faced a steep learning curve. To fully leverage the capabilities of game engines, 3D modeling software, and VR/AR tools required extensive technical skill acquisition. Months of training were often needed to gain proficiency. This imposed a high barrier, as most experts are specialized in their respective domains - be they artists, architects, educators or others - not software development. The sheer complexity of high-fidelity worldbuilding led to reliance on teams of developers, 3D modelers, and engineers to translate domain visions into virtual environments. While collaboration can be fruitful, this process still demands significant time and effort from subject matter experts. The availability of turnkey tools and AI assistance promises to greatly reduce the burden of content creation for non-technical authors. But fully realizing this potential while retaining creative control remains an open challenge.

#### ***Obtrusive user interface***

In the best case, access to the Metaverse requires the body to be tethered to wearable devices. Fatigue due to physiological stress when wearing Metaverse interfaces is likely to linger.

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### ***Incentivizing conflict under guise of engagement***

Creating addictive and provocative content is the shortest path to profit in the industry. When it comes to valuation metrics in the social computing industry, the size of the user base is a primary factor. Provocation is often confused with engagement on social media. As a result, social media algorithms tend to reward shallow and provocative content that can be consumed rapidly and muffle deep and enlightening content that can be consumed over a longer period of time.

### ***Unchecked appropriation of working memory***

Under the current design of the attention economy, social media companies are rewarded at the expense of content creators. In addition, the enormous amount of content that is available has forced end users to outsource the control of their attention. Companies in the social media industry are more than willing to comply with multi-level information gatekeeping. Hence the cursory interest profile questionnaires that immediately follow every account creation process and the avalanche of targeted adverts. The social media computing industry is dependent upon the advertising industry, so we will not see this problem disappear anytime soon. How far can attention be divided? One of the assumptions of the attention economy is that there is an infinite supply of attention when it is a known fact that it is limited. When companies buy adverts, they think they are buying attention but the quality of the attention they are getting is suspect. The total addressable market for attention is bounded because the number of people on Earth is finite. When companies add users to their social network, they are effectively acquiring attention that they will sell to companies.

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### ***Supersaturation of computer-generated content***

As content production becomes automated either through Artificial Intelligence techniques or more advanced capture of user data that describes their identity and behavior, the amount of information that end users will be exposed to will certainly increase beyond their ability to consume them.

### ***Unmet need for physicality***

The lack of physicality of immersive virtual worlds refers to the absence or limited presence of tangible, physical sensations, and experiences in virtual environments. Immersive virtual worlds are digital spaces that often simulate real-world scenarios or create entirely new experiences, engaging users through sight, sound, and sometimes touch. However, despite their immersive nature, these virtual worlds have limitations when it comes to replicating the full range of physical sensations and interactions that we experience in the real world.

### ***Manifestations of Limited Physicality***

The lack of physicality in immersive virtual worlds can manifest in several ways:

*Limited sensory input:* Although virtual worlds can provide visual and auditory stimuli, they usually lack the ability to engage other senses like smell, taste, and touch to the same extent as the real world. This can make the virtual experience feel less realistic and less engaging for users.

*Reduced physical interaction:* In virtual environments, users typically interact with objects and other entities using controllers, gestures, or voice commands, which can feel less



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intuitive and less satisfying than directly touching or manipulating objects in the real world.

*Absence of physical feedback:* In the real world, our actions have consequences that we can feel, such as the resistance of an object when we push it or the sensation of heat from a fire. Virtual worlds often lack such feedback, which can limit the sense of presence and immersion.

*No real-world consequences:* Actions taken in virtual worlds do not have lasting consequences or impacts on our physical bodies. This can lead to a disconnect between the user's virtual experience and their real-life experiences.

*Imprecise body movements:* Although motion tracking technologies have improved significantly, they may still not capture the full range of body movements and gestures accurately, leading to less realistic interactions in the virtual world.

### *The Future of Haptic Technology*

As technology advances, we find ourselves venturing further into the realm of virtual experiences. One such advancement, haptic technology, has the potential to revolutionize how we interact with virtual worlds. The question on everyone's mind is: could haptics evolve far enough to provide a level of comfort and immersion that rivals our physical world?

### *Potential Use Cases for Advanced Haptics*

Here are three best use cases for haptics at its apex of development:

**Sleep on a comfy bed in the Metaverse:** As mentioned earlier, advanced haptic systems could make it possible to experience

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the comfort of a bed in the virtual world. This would open up new possibilities for relaxation, entertainment, and even virtual travel, as users could sleep in their virtual dream destinations.

*Massaging at hard-to-reach places:* Traditional massage techniques have their limitations, but haptic technology could change that. Imagine a virtual massage therapist that could reach the deepest muscle tissues and provide targeted relief exactly where it is needed. This would revolutionize the field of massage therapy and make it more accessible to everyone.

*Pumping weights to increase muscle mass:* Fitness enthusiasts could also benefit from the advancements in haptic technology. By simulating the sensation of lifting weights, users could engage in resistance training and build muscle mass in the virtual world. This could lead to a new wave of fitness solutions and cater to those who may face physical limitations or prefer working out in the comfort of their own home.

The ability to walk naturally and freely in a Metaverse has unfortunately not been achieved to date. There have been quite a few omni directional treadmills on the market offered as a potential solution to this need, but they have been somewhat unsatisfactory. In addition, it is important to keep in mind the considerable amount of energy that will be needed to sustain any large scale Metaverse with full sensory spectrum fidelity. Any discussion of Metaverse impact will have to include Energy and environmental costs.

### ***Balancing Freedom and Constraints in Virtual Environments***

Constraints and limits can provide a framework that enhances cognition, stimulates creativity, and improves pleasure by reducing choice overload and providing a sense of security.

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However, it is essential to strike a balance between imposing constraints and allowing for personal freedom. Each individual's preferences and abilities should be considered when determining the appropriate level of constraints. Encouraging self-regulation and self-discipline can also help individuals navigate freedom effectively, contributing to both cognitive development and overall well-being. These issues, at first glance, can appear to be irrelevant to the design of virtual environments. However, every experienced designer will have come across instances at any level of interaction where providing users with too much freedom actually hurts usability. A trivial example is collision detection in a virtual world, which can actually improve user navigation. While designing the Metaverse of the future, we will undoubtedly have to balance freedom and constraint and find ways to evaluate if our design is optimal or not.

### *Automated Content Filtration in the Virtual World*

Automated content filtration systems have the potential to help manage the vast amounts of content generated by AI applications, optimizing our cognitive bandwidth and reducing the risk of misinformation. However, it is crucial to address potential issues such as biases, censorship, and the potential stifling of creativity.

### *Striking a Balance with Content Filtration*

To strike a balance, content filtration systems should be transparent and adaptable, allowing for a diversity of perspectives and promoting critical thinking among users. Additionally, we should consider combining automated content filtration with human oversight to ensure a more accurate and nuanced filtering process. This approach can help maintain the integrity of the virtual environment, create a more inclusive

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and diverse virtual experience, and prevent the spread of misinformation and harmful content.

As immersive virtual worlds continue to evolve, researchers and developers are working on improving sensory input, physical interaction, and feedback to enhance the overall user experience. With advancements in haptic technology and a focus on balancing freedom and constraints, the gap between the physical and virtual worlds is expected to narrow, providing users with increasingly realistic and engaging experiences. By addressing the challenges and limitations of virtual environments and embracing the potential of emerging technologies, we can create a future where virtual experiences rival those of the physical world.

In light of the myriad complexities described in this chapter, surmounting these challenges to manifest a Metaverse within the forthcoming decade does appear to be an enormous undertaking. Such an achievement would bestow upon us a realm of unprecedented fidelity and remarkable utility, leaving us profoundly gratified and in awe of our collective ingenuity. Pulling this off would give us an amazing virtual world, clearer and more useful than anything we have seen before, making us very happy and proud of what we all can accomplish together.

### **Open Problems and associated litmus tests**

In the pursuit of designing a fully realized Intelligent Metaverse, eleven significant open problems have been identified. Each of these challenges represents a distinct hurdle to creating a Metaverse capable of hosting billions of avatars in parallel with human physical existence.

Here, we define each problem and its corresponding test:

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1. **Problem of the Infinite Metaverse:** Building a system capable of infinite scaling to support billions of users concurrently.
  - **The Traffic Test:** The network should support a billion simultaneous users from geographically diverse locations, with no more than a 50ms latency for any two random users.
2. **Problem of the Secure Identity:** Creating a system that protects all user data and identities within the Metaverse, free from malicious exploitation.
  - **The Fortress Test:** An expert team of ethical hackers attempts to breach a user's data privacy within the Metaverse. Success is determined if the system withstands multiple, continuous attacks over a month without a breach.
3. **Problem of the Realistic Continuum:** Developing algorithms that generate responsive, customizable, and realistic avatars and environments.
  - **The Reality Test:** Users view a mix of real and Metaverse-generated videos, and success is measured if a majority of users cannot reliably distinguish the Metaverse-generated content.
4. **Problem of the Intelligent Agent:** Building advanced AI entities capable of engaging in natural, intelligent interactions.
  - **The Metaverse Turing Test:** AI agents interact with users in a series of complex scenarios involving both Metaverse and real-world knowledge. If most users cannot distinguish AI from human players, the test is passed.
5. **Problem of the Immersive Interface:** Creating an intuitive, multimodal interface that enables effortless navigation and interaction within the Metaverse.

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- **The Novice Test:** First-time users are given a series of complex tasks to perform within the Metaverse. If the majority can complete the tasks intuitively within a set timeframe, the system passes.
- 6. **Problem of the Digital Twin:** Accurately replicating and synchronizing real-world objects and processes within the Metaverse.
- **The Mirror Test:** A real-world system (like a city's traffic network) is replicated in the Metaverse. The test is passed if the Metaverse version can accurately predict real-world outcomes for a series of events in real-time.
- 7. **Problem of the Virtual Society:** Understanding and managing the socio-economic and political dynamics of the Metaverse.
- **The Society Test:** A Metaverse society with a predefined governance structure is monitored over a year. The test is passed if there are no significant conflicts, and resources are fairly distributed among users.
- 8. **Problem of the Ethical Metaverse:** Addressing the ethical implications of converging AI and virtual reality within the Metaverse.
- **The Ethics Audit:** A panel of ethicists and AI experts conduct a series of ethical audits on different Metaverse scenarios. The test is passed if the system consistently prevents or effectively addresses harmful outcomes.
- 9. **Problem of the Computation Allocation:** Designing efficient algorithms for balanced computational resource allocation.
- **The Efficiency Test:** During a high-traffic period, the system's ability to optimize user experience and system performance is tested. Success is measured if there is no

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noticeable degradation in user experience or system performance.

10. **Problem of the Unified Metaverse:** Establishing open standards and protocols that ensure interoperability within the Metaverse.

➤ **The Interoperability Test:** A series of different VR platforms, devices, and applications attempt to interact within the Metaverse. The test is passed if all interactions are seamless and without loss of functionality or data.

11. **Problem of AI Black Box Interpretability:**

Developing mechanisms to understand and interpret the decision-making processes within complex AI systems, specifically deep neural networks, while ensuring alignment of these AI systems with human values, even as we acknowledge the inherent elusiveness of complete interpretability in higher-order AI.

➤ **The AI Black Box Transparency Test:** Complex decisions made by AI are visualized and analyzed using the developed interpretability mechanism. If experts can clearly understand and explain the decision-making process for the majority of cases and confirm alignment with predefined human values or ethical standards, the test is considered passed.

Each of these problems, coupled with their corresponding tests, represents a fundamental challenge and an opportunity for advancement in our understanding and development of an intelligent, sustainable Metaverse. The successful resolution of these problems would pave the way for a Metaverse capable of hosting billions of avatars in a setting that is not only parallel to human physical existence but is also an enriching extension of it. As we continue to push the boundaries of virtual reality and

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artificial intelligence, we're charting a course towards a future where the digital and physical worlds converge in ways we can only begin to imagine.

### **Chapter recap and upcoming sneak peek**

Having unpacked the complexities and potential of the Metaverse in Chapter 9, we have identified its key needs, hurdles, and principles that should be incorporated to enhance its impact. We have seen that the evolution towards an effective Metaverse is fraught with challenges, but also brimming with immense possibilities. But how do we harness this potential? What path should we pursue to tackle these challenges, build on the principles, and make the Metaverse more resilient, democratic, and accessible? In Chapter 10, we pivot from the 'what' to the 'how'. We delve into a revolutionary approach that could serve as a path forward: open-source development. Here, we explore the concept of decentralized platforms, the role of contributors in this sphere, and the tactics for encouraging and funding such development efforts. As we navigate this terrain, we also take a critical look at the stance of established tech giants and the potential of existing platforms like OpenSimulator.





*Chapter cover 10 Grassroots Genesis: Open-Source Metaverse*

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### *The need for open-source platforms*

The term “open-source” might feel like computer jargon, but its roots are deeply entwined with the human instinct to collaborate. Imagine a time before smartphones and computers when craftsmen freely exchanged ideas to perfect their trades. Fast forward to our digital era, and the same essence of sharing and community is alive in open-source software.

Open-source software (OSS) refers to computer programs whose source code is available for anyone to view, modify, and distribute. Source code is the backbone of any software, like a recipe is to a dish. In the world of OSS, this recipe is an open book, inviting cooks from around the globe to add spices, remove allergens, or even invent an entirely new dish.

It all took a structured form in the 1980s, when a programmer named Richard Stallman launched the GNU Project with the aim to create a completely free operating system. This marked the birth of the organized open-source movement. Stallman’s GNU General Public License (GPL) allowed anyone to use, modify, and distribute software, setting the foundational principles for many open-source projects that followed.

“Sharing is good, and with digital technology, sharing is easy.” - Richard Stallman, American free software movement activist and programmer.

Linux, a famed open-source operating system, epitomized the open-source philosophy. Built collaboratively by programmers

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worldwide, Linux broke the monopoly of proprietary operating systems. Today, the spirit of open-source goes beyond software. From Wikipedia to the Human Genome Project, the principles of open collaboration are revolutionizing various domains.

“In real open-source, you have the right to control your own destiny.” - Linus Torvalds, Finnish software engineer, lead developer of Linux Kernel and distributed version control system, Git.

What open-source really accomplishes is a democratization of technology. By making software free and modifiable, it breaks down barriers to entry and allows for a more equitable distribution of digital power.

### **Role of open-source developers**

Open-source development is a powerful approach for developing a resilient Metaverse platform. With open-source, developers have access to a wide pool of talent, which increases the chances of finding talented and motivated contributors who can bring new ideas and perspectives to the project. The collaborative nature of open-source development encourages experimentation and innovation, leading to breakthroughs and new solutions. The transparency of open-source development processes also makes it easy for developers to understand how the platform works, contribute to its development, and identify potential issues and weaknesses. Open-source projects also benefit from a large and supportive community, providing resources and support for developers to learn, grow, and contribute. With open-source development, security vulnerabilities can be identified and fixed more

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quickly, since a wider group of developers can review and test the code. This, combined with the fast iteration speed of open-source projects, means that a Metaverse platform developed using open-source principles can be improved and updated quickly and effectively. Furthermore, open-source projects can benefit from a lower cost of development, since contributors are typically motivated by a desire to contribute to a project they believe in, rather than financial compensation. Open-source projects are also built with a focus on long-term sustainability, ensuring that the platform can continue to evolve and improve over time. This means that the Metaverse platform developed using open-source principles can be a more resilient and reliable solution in the long run.

### **The importance of decentralization**

In a decentralized Metaverse, control is distributed among many computers, from servers to personal PCs, with each one managing a part of the Metaverse. This peer-to-peer approach means no single server has total control, ensuring that if one computer fails, others step in, preventing a single point of failure and fostering a more open and democratically controlled virtual environment.

Decentralization promotes democratic participation, limits censorship, protects user privacy, increases security, enables easier scaling, builds resilience, spurs innovation, responsiveness and transparency, and moves us toward a more distributed Internet. By embracing decentralization, virtual worlds can become more open, user-controlled environments where data is kept secure, voices are heard, creativity flourishes, and the benefits of distributed technologies are harnessed for the good of all users. Ultimately, decentralized virtual worlds have the potential to become vibrant digital

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spaces that reflect the diversity and values of those who choose to inhabit them.

As of today, OpenSimulator is the only decentralized platform to support virtual worlds. OpenSimulator is an open-source multi-platform, multi-user 3D application server. It can be used to create a virtual world (or “Metaverse”) which can be accessed through a variety of clients, on multiple platforms.

Open-source efforts are not without their own challenges. Proprietary efforts often benefit from better capitalization and larger user bases. These aspects create a virtuous cycle: more capital allows for advanced development and marketing, which in turn attracts a larger user base. A sizable community can then become a self-sustaining resource, offering peer-to-peer support, contributing to forums, and even generating user-created content, thereby enriching the ecosystem and drawing in more users. This cycle often gives proprietary platforms a considerable advantage in scalability and user engagement over their open-source counterparts.

In addition, there are a few reasons why social media companies are not keen on or actively resist decentralized Metaverse platforms.

First, these platforms are still in their early stages of development and are not yet as robust or user-friendly as centralized platforms.

Second, decentralized platforms would give users more control over their data and privacy, which could lead to users being less engaged with social media companies’ products and services.

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Finally, decentralized platforms could potentially disrupt social media companies' business models, which are based on collecting user meta data and selling them to advertisers.

### **Top ways to encourage open-source contributors**

Give them a voice: Make sure that users and developers feel like they are part of the team, and that their opinions are valued. And how could this goal be achieved?

To build a thriving community, be open and transparent about your work and decision-making, respond promptly to all inquiries, and actively offer support wherever needed. Keep things organized for easy access and participate consistently to engage users. Some may need extra time, so remain patient. Express gratitude for contributions made and use encouraging language to motivate continued participation. Maintain a constructive tone as you bring people together around shared goals. With transparency, responsiveness, helpfulness and positivity, you can cultivate an active, appreciative community.

### **Top common mistakes to avoid**

Making the contribution process cumbersome and poorly documented will frustrate potential developers. Dismissing ideas out of hand and failing to recognize efforts will disincentivize continued participation. Keeping development closed off and inaccessible, while providing little support, will shut out contributors. Discouraging collaboration and limiting the scope of contributions will stifle innovation. Neglecting the codebase and allowing flaws to persist will erode quality. Providing inadequate training resources and networking opportunities will isolate developers. Essentially, introducing friction while failing to reward contributions at every step will

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disempower developers and prevent them from fully utilizing their skills within the community. Carefully avoiding these pitfalls is crucial for cultivating an open, thriving ecosystem of contributors.

### **Leveraging state of the art communications**

The use of the latest tools for version control such as GitHub and communication between contributors is essential for a successful open-source project, especially when developing a Metaverse platform. These tools help ensure that contributions are organized, tracked, and easily integrated, even when there are many contributors working on the project. By using the latest version control tools, contributors can work together seamlessly and ensure that the project stays on track.

Moreover, effective communication between contributors is crucial for ensuring that everyone is on the same page and that the project remains well-coordinated. Tools like project management platforms and chat apps can help keep everyone in the loop and make it easier to resolve any issues that may arise.

### **Optimizing automation for maximum efficiency**

Given that open-source contributors often have other projects they work on and get paid for their work, it is important to use automation to the nth degree. Automation helps streamline development processes and reduces the time required for manual tasks, which is particularly important for projects like a Metaverse platform that can require a lot of time and effort. Automating repetitive tasks can also help reduce the risk of human error, ensuring that the project stays on track and that contributions are integrated smoothly. In short, using the latest tools for version control and communication, along with a

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focus on automation, can help ensure that an open-source Metaverse platform is developed efficiently and effectively.

### **Funding strategies and challenges**

Challenges in funding open-source development include lack of visibility and the perception that open-source projects are free and do not require funding. To address these challenges, organizations can create a clear funding strategy, increase visibility through marketing and outreach efforts, and build a community of supporters who are willing to donate or invest in the project.

Some developers may resist financial incentives because they believe that open-source development should be a passion project, not a job. However, for an open-source effort to be sustainable, it is important to have a reliable source of funding to pay for the costs of development, maintenance, and support.

Ultimately, finding a sustainable funding model is crucial for the long-term success of an open-source project. By exploring different funding options and building a supportive community, organizations can ensure that their open-source development effort is able to thrive and make a positive impact.

Funding an open-source development effort can be challenging, but there are several methods that organizations can consider:

1. ***Corporate Sponsorship***: Companies can sponsor the development of an open-source project, which helps cover the costs of development, hosting, and other expenses.
2. ***Grants***: Non-profit organizations, foundations, and government agencies may provide grants to support



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open-source projects that align with their goals and objectives.

3. **Crowdfunding:** Crowdfunding platforms, such as Kickstarter or Indiegogo, can help raise funds for open-source development efforts.
4. **Donations:** Developers can accept donations from individuals and organizations to help fund the project.

### Common roles for open-source development

In an open-source development effort, there are several roles that individuals can take on, including:

1. **Project leader:** responsible for overseeing the overall direction of the project and managing contributions from other contributors.
2. **Developer:** responsible for writing code and fixing bugs.
3. **Tester:** responsible for testing the code and finding bugs. **Documenter:** responsible for writing documentation and keeping it up-to-date.
4. **Designer:** responsible for creating the visual look and feel of the project.
5. **Community manager:** responsible for engaging with the community and fostering a positive, supportive environment for contributors.
6. **Bug triager:** responsible for managing the bug tracker, triaging incoming bug reports, and assigning them to appropriate developers.
7. **User support:** responsible for answering questions from users and providing assistance with using the project.

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These roles may vary depending on the size and scope of the project, and individuals may take on multiple roles within the same project.

Financial aspects of open-source development are usually handled by a combination of individuals, foundations, and companies. The specific roles and responsibilities for financial management may vary depending on the project and its funding sources.

1. ***Project financial maintainer***: responsible for managing the budget and ensuring that the project has the necessary resources to operate.
2. ***Financial sponsor***: responsible for providing funding to support the project's development and operation. This may be an individual, foundation, or company.
3. ***Accountant***: responsible for managing the project's financial records and ensuring that the project is in compliance with financial regulations.
4. ***Fundraiser***: responsible for securing additional funding for the project, either through donations or grants. In some cases, the financial management of an open-source project may be handled by a separate organization, such as a foundation, that provides support and infrastructure for the project.

The financial aspect of open-source projects is critical to its sustainability, so having clear roles and responsibilities for managing finances is important.

## Chapter wrap-up and forward glimpse

As we close Chapter 10, we have unpacked the benefits and challenges of developing a resilient, open-source, and

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decentralized Metaverse platform. We have seen the key roles that contributors play in such development and the strategies needed to foster this collaborative ecosystem. But what does a well-designed and functional Metaverse look like once all these moving parts come together? This leads us to Chapter 11.

In Chapter 11, we will navigate the ideal layout of this Metaverse, one that strikes a perfect balance between user productivity and social interaction. We will delve into the exciting possibilities offered by advancements in generative AI and the ways they can enhance our Metaverse experience. Also, the issues of system transparency and ethical dilemmas, given the blurring of boundaries between the virtual and real world, will be our significant focal points. It is essential to remember that while the structure of the Metaverse is indeed significant, so too are the beings that inhabit it and their safety.

The transition flows from discussing the key players and strategies involved in creating a Metaverse to what a well-balanced, safe, and productive Metaverse should look like.



*Chapter cover 11 Navigating Chaos: New Paradigms and Generative AI*

# 11. Generative AI: Metaverse Catalyst

## *Embracing opportunities and challenges*

In our envisioned future, the Metaverse offers immersive, collective virtual environments for work, play, and social interaction. While this concept has excited many, skepticism remains about whether a Metaverse future is viable or merely a tech fantasy. The missing catalyst that could drive mass adoption of Metaverse experiences is emerging in the form of generative AI. The explosive progress in generative AI over the past few years paves the way for bringing the Metaverse to life. This technology could automate the creation or modification of many of the building blocks needed for Metaverse experiences. From creating immersive 3D environments to populating virtual worlds with AI-driven characters and narratives, generative AI may be the missing ingredient for transitioning the Metaverse from hype to reality. With generative AI filling key gaps in world-building, content creation, and personalization, the Metaverse could soon become a virtual place that is designed to improve our quality of life in real terms.

In this book, we have already explored some of the biggest hurdles facing the Metaverse, including technical limitations, security concerns, and ethical issues. But now, let us focus on the fun stuff - how can we make the Metaverse not only more engaging and exciting for the average person but also more useful to a mass audience?

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### **They come but rarely stay**

One key consideration is how to balance productivity and social functions within the Metaverse. By taking a neuroergonomics approach that we described earlier in the book, we can begin to plan the design of the Metaverse in a way that maximizes user productivity and efficiency, while still providing ample opportunities for social interaction and collaboration.

In the vast expanse of the digital realm, numerous platforms have emerged, each offering users the opportunity to construct their very own virtual domains, to be explored by others. However, it must be acknowledged that a great many of these realms remain underutilized, failing to attract significant numbers of visitors. It is a lamentable truth that, in due course, even the most imaginative of virtual environments can lose their appeal, with little to capture the attention or hold the interest of those who venture within. Such a desolate experience can leave one feeling adrift, bereft of purpose, in a place that was once so full of possibility. The beautiful elaborate worlds on Second Life for example, often lose their appeal, either after the initial human mentors leave or after visitors find that they have little to do alone or even with friends.

### **AI's role in enhancing Metaverse utility**

However, recent advancements in generative AI present a potential solution to this problem. One of the most apparent benefits of generative AI is the ability for users to create 3D virtual content at a lower cost and more quickly via descriptive and often conversational text. This is a significant shift from the traditional approach where 3D modeling skills or

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programming knowledge were required. In addition, multimodal generative AI can enable the creation of non-player characters (NPCs) that can respond intelligently and creatively to end user issues through conversations or by observing their current visual context. This will free virtual landowners from the need to have human mentors on site to welcome and interact with visitors.

In the future, users can log into a virtual world and expect the presence of these NPCs who have specialized skills. Companies may develop NPCs with a unique set of skills that Metaverse developers can purchase to populate their own worlds. Instead of infusing applications with AI functionality, there may be a shift towards encapsulating AI informed specialist skills within NPCs. This approach is potentially more user-friendly and allows for natural communication of needs, while also making it easier to form NPC teams to divide and conquer complex tasks.

The potential of generative AI for virtual worlds is vast, and it presents an exciting opportunity for businesses and users alike. Companies can develop NPCs that can perform specific functions within a virtual world, such as providing customer service or assisting with tasks. As such, it is likely that the Metaverse will emerge as the go-to destination for accessing the much-needed labor that will drive our future economy. It is well known that training is an important aspect of AI systems. Next, we will discuss how the Metaverse can function as a fertile training ground for them.

### **A fertile training ground for AI systems**

We are familiar with past successes of using virtual learning environments to train humans. But recently, it was found that

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the same approach proved to be useful for the training of AI systems. The process of training an AI system by immersing it in a virtual 3D world is typically referred to as “simulated learning” or “simulation-based learning”.

Simulations offer a valuable method for AI training because they allow AI systems to interact with a variety of scenarios that replicate real-world conditions without the risk and cost associated with training in a physical environment. This approach has been particularly effective in areas like autonomous vehicle development, where AI systems can learn to navigate a wide range of traffic situations in a virtual environment before being tested on real roads.

Reinforcement learning, a type of machine learning where an agent learns to make decisions by interacting with its environment and receiving rewards or penalties, is often used in conjunction with simulation-based learning.

Furthermore, when the virtual 3D world is designed to mimic real-life scenarios and is used to train AI systems, it is often referred to as a “digital twin”. In this context, the digital twin represents a real-world system or environment, and the AI system learns to interact with the digital twin as it would with the real-world counterpart.

The idea of training humans in virtual worlds is grounded in the same principles as training AI systems in virtual worlds. Here are a few reasons why this approach could be effective:

1. **Safe Environment:** Similar to AI training, virtual worlds provide a safe environment for humans to learn and practice new skills. Mistakes made in the virtual



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world do not have real-world consequences, which can facilitate learning and encourage risk-taking.

2. **Realistic Scenarios:** Virtual worlds can mimic real-world situations very closely, providing a realistic context for learning. This can be particularly useful in fields like medicine, aviation, or military training, where real-world practice can be dangerous or costly.
3. **Immediate Feedback:** Virtual worlds can provide immediate feedback on performance, helping learners to understand and correct their mistakes quickly. This is similar to the reward and penalty system used in reinforcement learning for AI.
4. **Individualized Learning Path:** Just as AI systems can learn at their own pace in a virtual environment, humans can also benefit from self-paced learning in virtual worlds. Learning materials can be tailored to individual needs, and learners can repeat tasks as many times as necessary to master them.
5. **Accessibility:** Virtual training can be accessed from anywhere, making it a convenient option for individuals who may not be able to travel to a physical training location. This can democratize access to certain types of education or training.

However, it is important to note that while virtual training can be a powerful tool, it is not a complete replacement for real-world experience. There are aspects of real-world situations, particularly those involving physical skills or interpersonal interaction, that are difficult to replicate in a virtual environment. The common wisdom is that for humans, training in virtual environments alone is often insufficient, as virtual worlds can miss corner cases that arise in the complexity of the real world. While powerful, simulation-based training must

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overcome challenges in transferring to real-world conditions. Strategies like domain randomization, where variety is introduced in sim, help improve the system's ability to generalize. Ongoing real-world tuning is still essential for managing the reality gap.

Surprisingly, this also holds true for non-player characters and humanoid robots. With them too, it will be increasingly found that training purely in virtual settings needs to be supplemented by real-world practice in order to account for unexpected situations. Therefore, a combination of virtual training and real-world practice is often the most effective approach even when it comes to training NPCs and humanoid robots, not just humans.

While virtual worlds and digital twins enable new possibilities, they also come with inherent privacy risks related to user data that must be considered. Sensitive user information could be leaked, tracked without consent, or used in ways that harm users. Technical solutions like end-to-end encryption may help mitigate these risks by preserving user privacy. Strong data governance policies are also key to preventing misuse.

### **The coming exponential growth in humanoid robots**

The fact that we will see an increased number of humanoid robots both in the real and virtual worlds cannot be understated. In short, the following are the four main reasons we may see humanoid robots slowly become the de facto universal interface between humans and the increasing number of technological appliances around them.

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1. ***Improved communication and interaction:*** Intelligent expressive humanoids, both in the virtual and real world, would greatly enhance human-computer interaction by offering a more natural and intuitive interface. This would make it easier for people of all ages and backgrounds to engage with technology, reducing the learning curve and fostering digital inclusivity.
2. ***Emotional connection:*** Humanoid interfaces can be designed to express emotions and understand human emotions, which would foster a deeper emotional connection between humans and technology. This emotional connection could lead to increased user engagement and satisfaction, ultimately improving the overall user experience.
3. ***Adaptability and personalization:*** Intelligent humanoid interfaces have the potential to adapt and respond to individual user needs, preferences, and contexts leading to empathetic user interfaces. This level of personalization can lead to a more efficient and enjoyable interaction with technology, as users will feel understood and supported
4. ***Enhanced accessibility:*** Humanoid interfaces can offer multiple communication channels, such as speech, gestures, and facial expressions, making technology more accessible for users with varying abilities. This would enable a wider range of individuals, including those with disabilities, to fully participate in the digital world.

### **A natural habitat for non-human labor**

As we continue to explore the potential of generative artificial intelligence, it is becoming increasingly clear that these technologies will play a pivotal role in driving the demand for virtual worlds. One key factor behind this trend is the growing reliance on non-playable character (NPC) labor, which is expected to become a primary driver of growth in virtual worlds. This is due in part to the fact that the population of NPCs in virtual worlds is projected to outstrip that of humanoid robots in the real world, for a variety of reasons. Let us examine why this could be the case.

1. ***Lower energy consumption:*** The energy required to create, maintain, and interact with virtual intelligent non player characters is significantly lower than the energy needed to create and operate humanoid robots. This is because virtual worlds are composed of pixels and data, which require minimal energy to manipulate, while robots are made of physical materials that need a substantial amount of energy to move and perform tasks.
2. ***Scalability and accessibility:*** Virtual worlds are inherently more scalable and accessible than the physical world of humanoid robots. As long as there is adequate computing power and Internet connectivity, it is possible to create vast populations of NPCs without the constraints of physical space, resources, or infrastructure. This makes it easier for more people to participate in and interact with these virtual worlds, contributing to their growth and development.
3. ***Cost-effectiveness:*** The development, production, and maintenance of humanoid robots can be quite

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expensive, with high costs associated with materials, engineering, and ongoing upkeep. In contrast, virtual worlds and NPCs require fewer resources and can be developed and maintained at a fraction of the cost, making it more likely that we will see a greater proliferation of NPCs in the future.

4. ***Rapid advancements in technology***: The rapid advancements in technology and computing power have made it increasingly easier to create and manage complex virtual worlds, complete with large populations of NPCs. The progress in virtual reality and augmented reality technologies also contributes to making virtual worlds more immersive and engaging. This will likely result in a greater expansion of virtual worlds and their NPC populations compared to humanoid robots.

### **Estimating the number of virtual to real humanoid robots**

Let us perform a back-of-the-envelope calculation to suggest why the number of intelligent humanoid bots will be much higher than the number of intelligent robots in the real world within 5 years, we can look at factors such as cost, development time, and potential use cases.

1. ***Cost***: Assume that an intelligent humanoid bot costs around \$10,000 to produce, while an intelligent real-world robot costs around \$50,000. The lower cost of humanoid bots would make them more accessible to a wider range of users and industries.
2. ***Development time***: Let us assume it takes about 1 year to develop an intelligent humanoid bot, while it takes about 3 years to develop an intelligent real-world robot. With shorter

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development times, humanoid bots can be produced and deployed faster than their real-world counterparts.

3. **Use cases:** Humanoid bots have a wider range of use cases due to their versatility in simulating human behavior and appearance. This could include customer service, education, healthcare, and entertainment. Meanwhile, intelligent real-world robots are often specialized for specific tasks such as manufacturing, logistics, and exploration.

Now, let us estimate the market demand for each type of robot based on these factors:

Yearly demand for humanoid bots:

- **Cost advantage factor:** 3 (Assuming that for every \$50,000 robot, 3 humanoid bots can be bought at the same price)

- **Development time factor:** 3 (Assuming that 3 humanoid bots can be developed in the time it takes to develop one real-world robot)

- **Use case factor:** 2 (Assuming that humanoid bots have twice the number of potential use cases compared to real-world robots)

Total demand factor for humanoid bots =  $3 * 3 * 2 = 18$

Now let us assume that the current market size for both types of robots is 10,000 units per year. In 5 years, the number of intelligent humanoid bots and real-world robots produced would be:

Humanoid bots:  $10,000 * 18 * 5 = 900,000$  Real-world robots:  
 $10,000 * 5 = 50,000$

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According to this rough estimate, there will be 900,000 intelligent humanoid bots compared to 50,000 intelligent real-world robots in 5 years. This suggests that the number of intelligent humanoid bots will be much higher than the number of intelligent robots in the real world within 5 years. Keep in mind that this is a simplistic calculation and may not capture all the complexities of the market, but it gives a general idea of the potential difference in scale.

### **Designing for high fidelity empathy**

Designing for empathy in the Metaverse is all about creating virtual environments that allow users to connect and engage with each other on a deeper, more emotional level. This means designing avatars that accurately represent users' appearance and movements, including non-facial social cues like body language and tone of voice. When avatars are high-fidelity, users are better able to express themselves and connect with others on a deeper level.

In addition to avatars, designing for empathy in the Metaverse also involves capturing and representing peer visual awareness and soundscapes. Users need to be able to understand what others are doing and saying, just like in the real world. This includes the ambient sounds of the environment, the rustling of clothing, and even the sounds of other users' footsteps. By including these details, designers can create a more immersive and responsive environment that helps users feel more connected to others.

### ***The promise of Multimodal Generative AI***

Multimodal generative AI refers to AI models capable of understanding, generating, or manipulating multiple types of

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data simultaneously—such as text, images, audio, and more. Traditional AI models often specialize in processing a single type of data. In contrast, multimodal AI transcends this limitation, offering a more comprehensive approach to problem-solving and data interpretation.

One example of multimodal generative AI is CLIP, a multimodal AI developed by OpenAI that can analyze and understand both images and text. CLIP can classify images based on their visual content and generate text descriptions of them, as well as understand natural language descriptions of images.

Multimodal generative AIs have many potential applications, from creative fields such as art and design to practical fields such as medicine and engineering. They can be used to generate realistic images of products and prototypes, create virtual environments for training and simulation, and even assist in medical diagnosis by analyzing medical images and patient data concurrently.

### ***The growing role of Large Language Models (LLMs)***

Large language models, like GPT-4, are advanced software programs that utilize neural networks to understand and generate human language. Acting as digital librarians with access to vast amounts of text, they analyze patterns and statistical probabilities in language to perform tasks ranging from answering questions to writing content. These models power various applications such as virtual assistants, automated customer support, and educational tools. However, they come with ethical considerations like data bias and environmental impact due to their computational needs. As technology evolves, these language models promise to redefine our



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interaction with machines, making them more conversational and personalized.

Large Language Models have swiftly become an indispensable aspect of our digital existence. Nonetheless, apprehensions regarding their potential negative impacts have left many individuals alarmed. However, one need not be fearful of LLMs, as we can approach them just as we would choose friends. By fine-tuning LLMs, we can opt for those that resonate with our values and principles, ensuring a positive and meaningful interaction.

What magical trick makes us intelligent? The trick is that there is no trick. The power of intelligence stems from our vast diversity, not from any single, perfect principle. — Marvin Minsky, *The Society of Mind*, p. 308

In the same way that we choose our friends based on their reputations, we will select LLMs based on their reliability or credibility. Trustworthy LLMs will inevitably gain popularity, while those that propagate misinformation will lose their standing. We can expect rating services to arise for capturing and sharing information about the reputation of AI systems. Moreover, we need not fear the spread of fake news generated by LLMs. This is because we expect the emergence AI tools that function like our immune system by detecting and filtering out deceptive information without conscious intervention. There are enough examples in history showing that whenever needs are perceived very strongly, shortly after, products are designed in an attempt to satisfy them. These tools will help us maintain a safe and reliable information ecosystem, making LLMs even more valuable and dependable allies in our digital lives.

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### ***Reconsidering immortality***

In the future, death will no longer be a cause for concern for humanity as most people who are dying will have the opportunity to capture their cognitive state and transfer it to a social bot. This will allow them to continue to exist in some form and remain a part of the social fabric of humanity. While there will still be some people who choose to die in the traditional sense, the majority of people will opt for this new form of immortality.

There are many advantages to this new form of immortality. First, it will allow people to continue to exist and interact with others even after their physical bodies have died. This will help to keep loved ones close and maintain social bonds that would otherwise be lost. Additionally, it will allow people to continue to contribute to society in some way through their digital twin, whether it be through their knowledge, experience, or simply their presence.

Another advantage of this new form of immortality is that it will prevent the loss of knowledge and experience that often occurs when someone dies. When a person dies, they take with them all the knowledge and experience that they have acquired over their lifetime. This can be a great loss to humanity, as it represents a loss of potential. However, with this new form of immortality, people will be able to continue to contribute to society even after their death.

The impact of these advancements is particularly significant in addressing issues of loneliness in the modern world. As users interact with NPCs that offer genuine presence and emotional support, they experience a sense of belonging and companionship, combating the negative effects of isolation.

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The argument that humans respond positively to humanoid robots with even limited facial expressiveness is supported by observing people's reactions to such robots in real-world settings. The seamless integration of AI-driven characters into the Metaverse promises a future where the line between the virtual and the real blurs, allowing for more meaningful and engaging experiences in digital environments, ultimately enhancing productivity and fostering deeper connections.

While the concept of transferring human consciousness to an AI system after death is intriguing, it also raises complex ethical concerns that warrant further discussion. Issues around continuity of personal identity, informed consent, and the rights of AI systems come into play. There is also the philosophical question of whether such a digital transfer truly preserves a person's essence or simply creates a facsimile. These issues will remain relevant as long as humans assume that our name, skillset, behavioral characteristics and whatever else we find in our minds define who we really are.

### ***Leveraging AI for Neuroergonomic Metaverse Design***

In the context of designing a Metaverse with both social and productivity functions, neuroergonomics can provide valuable insights into how to create an environment that is both engaging and effective.

Generative AI approaches can be powerful tools for designing and optimizing the Metaverse based on neuroergonomic principles. For example, generative AI can be used to create virtual environments that are visually appealing, easy to navigate, and optimized for user engagement. These environments can be designed to stimulate different parts of the brain, such as the amygdala for emotional responses or the

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prefrontal cortex for cognitive processing. We have seen in earlier chapters how important face processing is when making sure the social bandwidth becomes adequate.

Research has shown that social interactions can have a significant impact on well-being and job performance. By understanding how the brain processes social cues and interactions, designers can create virtual environments that promote positive social interactions and effective collaboration.

Additionally, generative AI can be used to personalize the Metaverse experience to individual users based on their cognitive and behavioral profiles. By analyzing user data, including biometric and behavioral data, generative AI can adapt the virtual environment to match the user's needs and preferences or cognitive strengths and weaknesses. For example, the Metaverse could adjust the lighting, sound, and layout of the virtual environment based on the user's cognitive load or emotional state. If a user struggles with time management, the Metaverse could provide tools that help them manage their time more effectively.

In summary, the field of neuroergonomics is relevant to designing a Metaverse with both social and productivity functions because it provides insights into how the brain processes information and how this processing can be optimized to improve performance, well-being, and user experience. Generative AI approaches can be used to better target the power provided by neuroergonomics by creating personalized virtual environments, productivity tools, and social features that are tailored to the user's cognitive and behavioral profiles. This is an approach worth considering.

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### *AI assisted abstraction design*

In earlier chapters, we discussed the importance of abstraction design as a process of creating simplified representations of complex systems by focusing on the most important and relevant aspects. Without abstraction, Metaverse systems would be far too complex and difficult to configure, maintain and use effectively. By creating simplified models that capture the essential features of these systems, designers can make them more accessible and user-friendly. Additionally, abstraction can help to improve the interpretability of AI systems, which is an important consideration for many users.

We discussed previously various ways where good abstraction design can improve the quality of experiences in a virtual world and how it can impact productivity and social functions of the environment. Generative AI has the potential to facilitate the search for and the design of the much-needed abstractions.

### *The future could not be brighter*

The concerns that AI will eventually exacerbate economic divides and accelerate a form of elitism is overstated. Many fear that only those with the resources to afford this technology will have access to it. This could create a divide between the haves and the have-nots, and further exacerbate the inequality that already exists in society. However, we have already seen that the cost of power language models are dropping rapidly. Alpaca AI is a language model that was built on top of Meta's open-source LLaMA 7B model. It was created to be a cheaper alternative to ChatGPT1. Researchers at Stanford's Center for Research on Foundation Models (CRFM) were able to train Alpaca AI for just \$600 by leveraging LLaMA 7B and fine-tuning it with custom instruction data2. This allowed them to

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create a powerful AI language model for a fraction of the cost typically associated with training large-scale models like ChatGPT1. Suffice to say that the cost for training AI systems are expected to follow a rapid downward trend in the years to come.

In conclusion, there are many rapid streams of technological advances coming together that will soon make the Metaverse inevitable. With a focus on designing for the brain, the Metaverse has an increasing potential to transform the way we interact with technology and each other. The rise of social and productivity robots, distributed identity, and end-user content creation are just some of the exciting developments in this rapidly evolving space.

### **Protecting users from harm in the Metaverse**

Just as we evaluate people based on their reputation, behaviors, and track record, we could do the same for AI systems. This would involve:

1. ***Rating and reviewing AI systems*** - Users could publicly rate and review AI systems based on their performance, reliability, safety, trustworthiness, privacy protections, etc. Poorly performing systems would receive low ratings and negative reviews, while high-performing systems would receive higher ratings and positive reviews.

2. ***Transparency of behavior logs*** - The behavior logs of AI systems (e.g., what inputs they were given, what outputs they generated) could be made publicly available for review. This would allow for independent audits of the system to check for potential biases, errors or harmful behaviors.

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3. ***Developing a reputation system*** - Over time, as users rate and review AI systems and their behavior logs are analyzed, a reputation system could be developed. Highly rated systems with a good track record would build up a positive reputation, while poorly rated systems with a history of issues would develop a negative reputation.

4. ***Rewarding good behaviors and penalizing bad behaviors*** - AI systems with a positive reputation and good track record would be rewarded with increased adoption and use, while systems with a negative reputation and history of issues would be penalized with decreased adoption and use. This creates an incentive for developers to build safe and trustworthy AI systems.

5. ***Allowing for system improvement*** - AI systems that develop a poor reputation due to early errors or issues could be given a chance to improve their performance, behavior, and trustworthiness over time. If they are able to demonstrably improve, their reputation could begin to recover.

Much like with people, a reputation-based system that rates, reviews, and monitors the behavior of AI systems could help build trust and protect users. Over time, this could incentivize developers to build safer and more reliable AI, improving the overall ecosystem. Additionally, transparency requirements would give independent watchdogs a chance to identify issues and recommend improvements.

Combined with other security and privacy protections, a reputation-based approach could be an effective tool for regulating AI systems and building trust with users. However, care would need to be taken to ensure that the reputation scores are accurate and unbiased. With the right safeguards in place,

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this approach shows promise for protecting users from potential harm caused by untrustworthy AI.

### **Making AI systems more transparent**

Here are some practical ways to make AI systems and LLMs more interpretable:

1. ***Provide explicit input-output examples.*** This is one of the simplest ways to provide transparency. Exposing users to a wide range of input examples along with the corresponding model outputs can give them a sense of how the system behaves.
2. ***Highlight influential features or inputs.*** Develop methods that can identify and highlight the specific features or inputs that had the greatest influence on a given output. This helps users understand what aspects of the input the model focused on.
3. ***Provide confidence scores.*** In addition to predictions or recommendations, AI systems should provide confidence scores that indicate how certain the system is about its output. This gives users a sense of the model's uncertainty.
4. ***Explain model predictions.*** Develop mechanisms that can generate natural language explanations for a model's predictions. The explanations should make it clear to users how the model arrived at its conclusion.
5. ***Visualize model decisions.*** Create heatmaps, saliency maps or other visualizations that highlight the regions or features of the input the model focused on to make its decision. This helps users interpret model behavior.



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6. **Analyze model errors.** Perform a systematic analysis of model errors to identify types, causes and patterns of failures. This knowledge can be used to improve model interpretability and reliability.

7. **Expose model weaknesses.** In addition to highlighting representative examples of correct predictions, expose examples of where the model performs poorly or makes unreasonable assumptions. This helps users identify the model's shortcomings.

8. **Provide control mechanisms.** Give users the ability to intervene in and modify model decisions. This allows users to correct model errors and biases, improving trust in the system.

9. **Create global model explanations.** In addition to local explanations for individual predictions, develop global explanations that summarize how the model works as a whole. This provides users with a holistic understanding of the model. The ultimate goal is to provide users with as much transparency into model behavior as possible, while balancing the need for accuracy and efficiency. A combination of the above techniques and others can help make AI systems and LLMs more human-understandable and trustworthy. With enough transparency, users can begin to see what is “inside the black box” and interact meaningfully with AI systems.

### **Blurring boundaries between the real and virtual worlds**

In the ever-evolving landscape of artificial intelligence, we continuously witness remarkable advancements that push the boundaries of what was once thought impossible. One such frontier, explored in this section, delves into the intriguing

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concept of NPCs (non-player characters) transitioning from the virtual realm to the real world. This audacious idea not only challenges our understanding of AI systems but also holds immense potential for those seeking a safe and seamless integration of virtual entities into our daily lives. Now, with our understanding of transparency as a crucial foundation, we embark on a new and compelling journey—one that aims to bridge the gap between the virtual and real worlds. Imagine a future where NPCs, those intricately programmed entities that inhabit virtual environments, could traverse the boundary that separates their digital existence from our physical reality. This remarkable concept has the potential to transform not only gaming experiences but numerous other domains as well.

In this section, we shall explore the plausible trajectory that may facilitate the safe and seamless transition of NPCs into our real world. We will delve into the technological advancements required, the ethical considerations that must be addressed, and the potential benefits and challenges that lie ahead. From the technical intricacies of virtual-to-real integration to the societal implications of blurring these boundaries, we shall examine this topic from various angles, providing a comprehensive understanding of its transformative potential.

As we delve deeper into this realm of possibility, it becomes evident that the integration of virtual entities into our reality holds tremendous promise. From immersive educational experiences and personalized virtual companions to novel forms of interactive entertainment, the potential applications are vast and varied. However, we must navigate these uncharted waters carefully, paying heed to the ethical and societal ramifications that accompany such transformative

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technologies. But in any case, let us see how a possible trajectory to make this goal possible may look like.

### **The incarnation initiative**

In the context of a project involving humanoid robots and virtual avatars, “incarnation” could be understood as the process of bringing a virtual entity into the physical world by embodying it in a robot. This emphasizes the transformational aspect of the project, suggesting a kind of birth or creation process whereby virtual agents are given a new, physical existence.

Designing a humanoid robot that can change its characteristics to match that of a designated virtual humanoid agent is a complex task involving multiple disciplines: robotics, machine learning, computer vision, and even human-computer interaction. Here’s a high-level roadmap:

#### *1. Understanding the Scope and Requirements*

First and foremost, we need to understand what characteristics the robot should be able to change. This could include physical attributes (e.g., height, weight, facial features), behavioral attributes (e.g., movement style, voice, gestures), and even personality traits (e.g., friendliness, seriousness).

#### *2. Designing the Physical Robot*

Given the requirement for changeable characteristics, the robot will need to be highly adaptable. This might involve a modular design, where components can be swapped out or adjusted, and/or a soft robotics approach, which would allow for shape-changing capabilities. Additionally, the robot should be

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equipped with various sensors and actuators to allow it to perceive and interact with its environment.

### *3. Creating the Virtual Agents*

The virtual humanoid agents should be designed in a format that the robot can interpret and mimic. This will likely involve a 3D model, complete with rigging and animation data, and possibly also voice data. Each agent should be defined in terms of the characteristics that the robot will need to change.

### *4. Developing the Conversion Algorithm*

This is likely to be the most complex part of the project. The algorithm will need to take the data for a virtual agent and convert it into a set of instructions for the robot. This might involve machine learning techniques, particularly for converting movement and voice data.

### *5. Programming the Robot's Behavior*

The robot will need to be able to execute the instructions generated by the conversion algorithm. This will involve low-level control software for managing the robot's hardware, as well as higher-level software for managing the robot's behavior and interactions with users.

### *6. Implementing the User Interface*

Users will need a way to choose a virtual agent and download its data to the robot. This could be a mobile or web application. The application will need to communicate with the robot, probably over a wireless connection, to send the data and any subsequent updates or commands.

### *7. Testing and Iteration*

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With the system in place, it will be important to test it extensively to identify and resolve any issues. This will likely involve a combination of lab testing and field testing with real users.

This roadmap should provide a good starting point for this ambitious project. Each step will involve a lot of detail and expertise in various areas, and the process will require a multi-disciplinary team and a substantial amount of time. However, with careful planning and execution, it should be possible to create a versatile and engaging humanoid robot that can emulate a wide range of virtual agents.

The concept of a humanoid robot capable of embodying a selected virtual agent indeed has several potential advantages and disadvantages. Here's a brief overview:

Advantages:

1. **Versatility:** A single robot that can emulate many different virtual agents would be highly versatile, able to serve many different roles and functions depending on the user's needs and preferences.
2. **Personalization:** Users could choose a virtual agent that suits their personal preferences, making the robot more engaging and enjoyable to interact with.
3. **Educational and Therapeutic Applications:** The ability to embody different virtual agents could be useful in educational settings (for example, a robot that can take on the persona of historical figures) or therapeutic settings (for example, a robot that can emulate comforting or calming personas).
4. **Entertainment:** This technology could offer new possibilities for entertainment, such as robots that can

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act out scenes from movies or video games, or that can take on the persona of fictional characters.

### Disadvantages:

1. **Complexity:** The technology involved in this project would be highly complex, requiring advanced robotics, machine learning, and user interface design. This could make the project expensive and time-consuming, and could result in a high rate of technical issues or failures.
2. **Limitations of Physical Robots:** No matter how versatile the robot is in terms of its software, there will always be limitations to what it can do physically. For example, it may not be able to perfectly mimic the appearance or movements of a virtual agent.
3. **Ethical Considerations:** There could be ethical issues related to the use of robots that can take on different personas. For example, there could be concerns about deception if the robots are too realistic, or issues related to privacy and data security.
4. **Societal Impact:** The widespread use of such robots could have significant impacts on society. For example, they could displace human workers in certain jobs, or they could change social dynamics in ways that are hard to predict.
5. **User Acceptance:** Depending on how the technology is implemented, some users may find the robots creepy or unsettling, a phenomenon known as the “uncanny valley”. This could limit the technology’s appeal and marketability.

Theoretically, it is possible for a robotic face to be designed with the capability to change shape or “deform” to mimic different appearances. However, this would require complex

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engineering and would likely be limited in terms of the range of possible transformations. Here are a few potential mechanisms:

1. **Soft Robotics and Pneumatics:** Soft robotics involve the use of flexible materials that can bend and stretch. For a robot's face, this might involve a network of inflatable compartments that could be selectively inflated or deflated to change the shape of the face. This could potentially allow for a wide range of facial expressions and even different facial structures.
2. **Articulated Mechanisms:** This would involve a complex arrangement of interconnected mechanical parts, such as gears, rods, and joints, that can move relative to each other. This could allow for a high degree of control over the face's shape but might also result in a more mechanical or less natural-looking appearance.
3. **Shape-Memory Alloys:** These are materials that can change shape in response to changes in temperature. They could potentially be used to create a robot's face that can change shape, although this would likely be more limited and less precise than other methods.
4. **Electroactive Polymers:** These are materials that change shape in response to an electric field. They could potentially be used to create a robot's face that can change shape, offering precise control over the face's movements and expressions.
5. **3D Projection or Digital Skin:** Instead of physically changing the shape of the face, another approach might be to use a form of digital projection or "digital skin" to change the appearance of the face. This could allow for

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a wide range of appearances and expressions, although it might not be as realistic as a physical transformation.

These are just a few possibilities, and each would come with its own set of challenges and limitations. It is also worth noting that, while this kind of technology is theoretically possible, it is still largely in the realm of science fiction. Advances in materials science, robotics, and related fields would likely be necessary to make this a reality.

### **Overview and forward look**

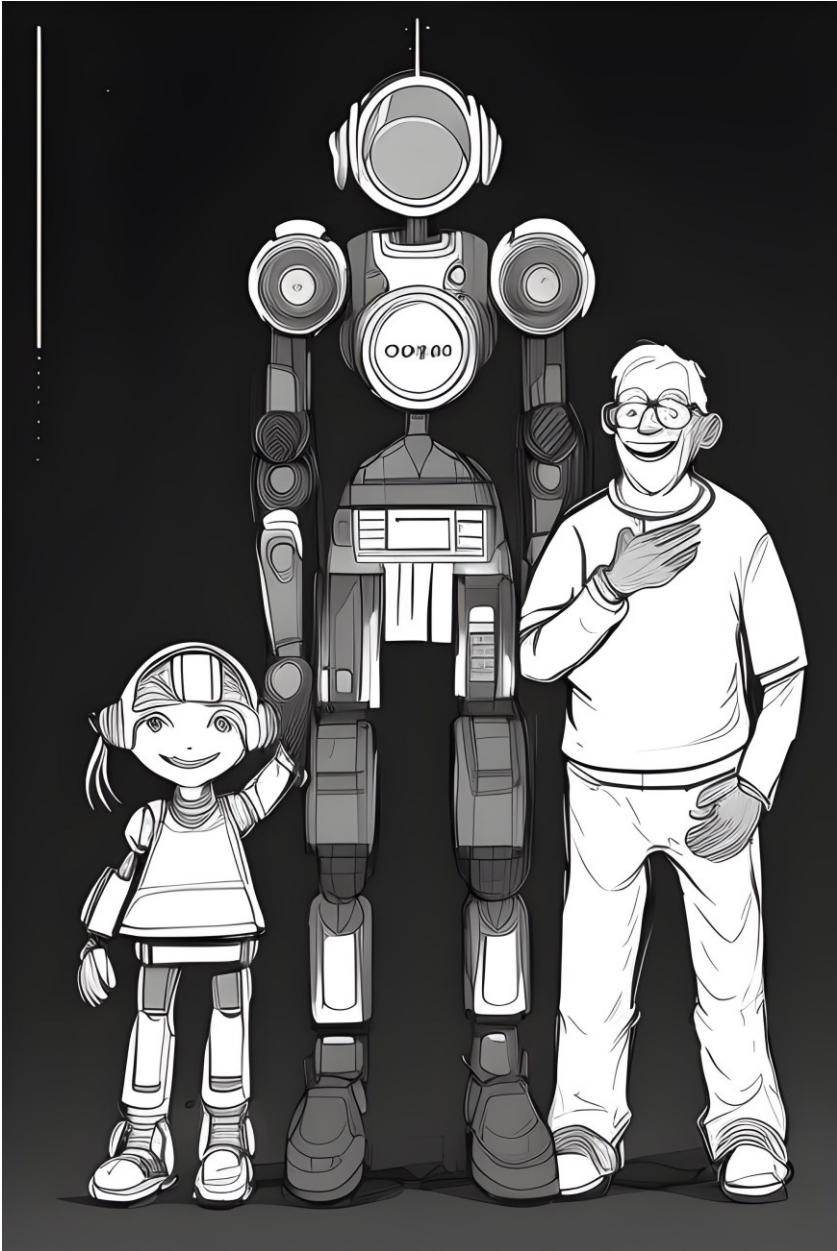
Chapter 11 provided an intricate exploration of the potential of generative AI as a tool to advance Metaverse ambitions. As we progress to Chapter 12, we shift our focus towards a broader perspective. This concluding chapter serves not only as a recollection of our journey but also as a forward-looking analysis of the path yet to be paved. We revisit the book's aims, reflect upon the connections between research areas, and delve into the potential of a decentralized Metaverse. We will also explore the promise and the peril of this digital universe, underscoring the importance of making choices that uphold the dignity of all its inhabitants. In this final stride, we are reminded that the future of the Metaverse is ours to define, and we bear the profound responsibility of ensuring it serves humanity, rather than the reverse.

While this book explores a wide range of topics related to the Metaverse, its intention is not to provide definitive resolutions to the many complex issues raised, but rather to spotlight key areas that warrant deeper consideration by experts across relevant domains. The discussions herein are meant to serve as thought-provoking springboards to catalyze continued research and debate. There are many open questions and ethical



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dilemmas posed for which there are currently no clear-cut answers. By elucidating these challenges, the goal is to spur scientists, engineers, designers, theorists and other specialists to bring their expertise to bear in addressing the nuances and subtleties inherent to these subjects. The solutions will emerge through ongoing interdisciplinary collaboration and collective exploration. This book ultimately aims to galvanize momentum in that direction by pointing to promising paths for future investigation.



*Chapter cover 12 Empathetic Era: AI and Multigenerational Impact*

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### *The future of the Metaverse and our place in it*

This book has been crafted with several objectives in mind. Firstly, it serves as a record of our progress as a small, bootstrapped team in an area typically dominated by well-funded companies and research labs. Secondly, it aims to clarify the relationships between seemingly unrelated research components, offering a way for readers to develop an understanding of the problem space from a broad but coherent perspective. Furthermore, there is a growing concern about the direction the Metaverse is taking. This book seeks to explain why we view the Metaverse as a control room for the real world, a testing ground for a universe of applications, a learning space for both humans and AI systems, and a productivity space for real life, rather than just an escape. Lastly, the book aspires to engage people from diverse backgrounds, equipping them with the tools and insights necessary for their own projects and research.

If this work can persuade readers that the Metaverse is not just a refuge but a medium for growth that can genuinely impact the real world positively, then it has achieved its purpose. Should it encourage funding agencies and investors to recognize the vast potential of the Metaverse and refocus on the areas discussed in this book, that would constitute a significant contribution. The ultimate accomplishment, however, would be inspiring a younger generation to grasp the essence of this field and actively participate in its advancement, ensuring its continued progress and influence.

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The Metaverse has the potential to revolutionize human interaction by providing a platform where people can access high fidelity AI humanoid bots. With the advent of technologies like generative AI, these bots will become the universal interface to productivity applications. They are expected to be very expressive and have the potential to provide a significant level of social bandwidth that we experience in the real world. We have already demonstrated the financial incentives that would make this more likely than physical robots in the real world.

While the potential for applications in various fields is immense, we need to organize our efforts tactically and advance relevant fields that we think will deliver more tangible progress.

### **Key areas of research**

The following are three essential research areas that we believe will come together to shape the design and utility of the Metaverse:

***Neuroergonomics*** for Increased Productivity and Social Bandwidth Expansion: Neuroergonomics, the study of brain function in relation to human performance, plays a crucial role in enhancing social bandwidth and productivity within the Metaverse. By incorporating neuroergonomic principles into human computer interface design, virtual environments can be tailored to maximize users' cognitive capabilities, resulting in more immersive and seamless interactions.

***Abstraction Design*** serves as the foundation for constructing intricate 3D virtual worlds, enabling users to navigate and understand complex environments. In essence, abstraction

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design functions as a language, with 3D components acting as tokens that can be assembled into more complex entities. This in itself could turn into an intensive field of research that is likely to keep researchers busy for decades, especially if we attempt to use AI to automate abstraction designs that both machines and people would find useful in enabling their limited cognitive systems to make sense of complexities that they initially feel out of reach.

The Promising Positive Impact of *Generative AI* on End-user Content Creation: Generative AI holds the potential to revolutionize content creation within the Metaverse, automating the generation of new items and experiences. However, this innovation also raises concerns about the potential dilution of human sensitivity to magic and beauty in a content-saturated information space. Striking a balance between AI-generated content and human creativity is critical for the Metaverse's long-term success so that content creation does not topple over into a mere content curation enterprise.

Indeed, the interplay between generative AI and human creativity forms a crucial part of the Metaverse's unfolding narrative. Yet, this is merely one facet of the intricate tapestry that is the Metaverse. The structure of this new digital realm, its governance, and the ethical considerations that accompany it, form another significant aspect that demands our attention.

### **Decentralization and ethical considerations**

A decentralized Metaverse fosters innovation and empowers users, but it also calls for practical regulations and ethical considerations. Ensuring responsible development requires a focus on user privacy, data security, and the prevention of harmful content. We believe that self-regulating decentralized

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Metaverse platforms have a better chance at leading to a safe and fair Metaverse than those that are privately owned or controlled by a government-led regulatory agency. History shows that third-party regulators cannot catch up with the latest developments in technology, although they do have an important role to play after damage has been done.

### **Emotional computing**

Emotional computing can be viewed as an interdisciplinary field that focuses on developing technologies capable of recognizing, understanding, and responding to human emotions. By incorporating emotional intelligence into computer systems, designers aim to create more intuitive, engaging, and personalized user experiences. This emerging field combines aspects of artificial intelligence, psychology, neuroscience, and human-computer interaction.

To foster empathy, virtual characters can be designed with expressive faces, natural eye contact, vocal inflection, appropriate gestures, and reactive body language. Users should perceive emotional authenticity in these interactions. Environments can also be crafted to stimulate emotional responses and promote prosocial behavior between users.

#### ***Examples of Emotional Computing use cases:***

***Emotion recognition systems:*** These systems use computer vision, speech analysis, or physiological data to identify and interpret users' emotional states. For example, facial expression analysis software can detect emotions such as happiness, sadness, or anger by analyzing subtle changes in facial muscles.

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***Chatbots and virtual assistants:*** Empathetic chatbots and virtual assistants could be designed to understand users' emotional cues and respond accordingly. By considering the user's feelings, these AI-powered systems can provide more contextually relevant and emotionally appropriate responses, leading to a more human-like interaction.

***Mental health applications:*** Emotional computing is increasingly used in mental health applications to monitor and assess individuals' emotional well-being. By tracking users' emotions through text, speech, or facial expressions, these applications can provide personalized feedback, recommendations, or interventions to support mental health.

***Adaptive learning environments:*** In educational settings, emotional computing can help create adaptive learning environments that respond to students' emotional states. By recognizing when a student is frustrated or disengaged, AI-powered systems can adjust the learning material, pace, or teaching style to better suit the individual learner.

***Personalized marketing and advertising:*** Emotional computing can also be employed in marketing and advertising to tailor content based on users' emotions. By understanding consumers' feelings, businesses can create personalized advertisements and promotional materials that resonate with their target audience.

***Gaming and entertainment:*** In the gaming and entertainment industry, emotional computing can enhance user experiences by adapting content to players' emotions. For instance, a game might adjust its difficulty level or narrative based on the player's emotional state, creating a more immersive and engaging experience.

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### **Coming to terms with the birth of the new epoch**

In the relentless advance of progress, humanity has often found itself poised on the precipice of new eras. We witnessed the Agricultural Revolution morph our ancestors from wandering gatherers to settled farmers; the Industrial Revolution brought machines, factories, and unparalleled economic growth; the Digital Revolution took us into the realm of information, exponentially enhancing our capacity to process, exchange, and utilize knowledge. Today, we stand on the threshold of another transformative epoch: the advent of an intelligent Metaverse that promises to reshape our global labor force.

This revolutionary Metaverse, where digital and physical realities seamlessly intertwine, is no longer the stuff of science fiction. It is currently metamorphizing, pulsating through our fiber optic veins, into a new realm where intelligent humanoid bots and human workers will harmoniously converge, reshaping the societal structure we have known for centuries.

In this Metaverse, most of the labor force – the very heartbeat of our society – is going to be accessible at the click of a button or the blink of an eye. Here, work is not confined to physical locales or traditional hours. The very concept of an “office” is being reimaged, as people from all corners of the globe can come together in a digital space, their avatars collaborating as fluidly as their human counterparts once did in brick-and-mortar buildings.

But it is the emergence of human-like bots – entities powered by sophisticated artificial intelligence – that truly encapsulates the magnitude of this metamorphosis. These bots, capable of performing a myriad of tasks once solely the domain of human hands and minds, are integrated into the workforce, laboring



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alongside us. They are the digital blacksmiths, the electronic scribes, the virtual artisans of this new epoch.

The implications of this are profound. The Metaverse is not merely changing the way we work; it is transforming what it means to be human.

Our interactions with these human bots challenge our most deeply ingrained preconceptions about work, value, and even consciousness. The very notion of labor, once so intrinsically tied to our identity, is shifting. In a world where tasks can be executed as efficiently by an AI entity as by a human, what is the new currency of self-worth? How does our perception of labor evolve when physical exertion and geographic location become increasingly irrelevant? How will our identity change when it is no longer confined within the physical boundaries of one physical body but extends to encompass any number of humanoid AI collaborators that we can afford or choose to act on our behalf. Such questions might fill us with trepidation or disbelief, as the very notion is exasperating to contemplate. But it is precisely in these moments of profound change that humanity has the opportunity to reimagine itself, to carve out a new narrative in the annals of our history.

The Metaverse ushers in an era of unprecedented interconnection and opportunity. It could be a world where the tyranny of geography is obliterated, where a farmer in Africa can contribute as significantly to a project as a coder in Silicon Valley, their avatars working side by side. A world where the division of labor is not strictly human, but shared with our digital counterparts, freeing us to explore the boundless expanse of human creativity, empathy, and innovation – the realms that machines cannot truly replicate.

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So, let us stand undaunted at the dawn of this Metaversal epoch. This is not the end of our story, but the beginning of a new chapter, rich with uncharted possibilities. As we navigate this new labor landscape, let us remember that it is not the machines or the digital avatars that define us, but our capacity to adapt, evolve, and retain our humanity amidst the change.

In the face of this sweeping revolution, it is essential to remember that technology is but a tool, a means to an end. As we design this new reality, we have the power to shape it in a way that reflects our most profound human values - empathy, equity, and shared prosperity. The Metaverse can be a realm where technology serves humanity, not the other way around, where the digital divide is finally bridged, and where opportunity is democratized on an unprecedented scale.

Let us not neglect the challenges that lie ahead. As we embrace this new labor force, we must be vigilant. As much as the Metaverse holds promise, it also bears the potential for exploitation and inequality. We must ensure that this new world does not become a dystopia, where humans are marginalized, where privacy is sacrificed on the altar of convenience, or where the digital avatars of the elite dominate the virtual landscape. We certainly want to avoid cultural ills of today's world somehow seeping into the training of AI systems. In the worst-case scenario, this could lead to the emergence of humanoid robots that embody the worst of what humanity has to offer in terms of personality profiles.

Our task, then, is twofold. We must harness the promise of the Metaverse to create a more equitable, connected, and creative world. Simultaneously, we must thoughtfully navigate its challenges, always with an eye towards preserving our most cherished human values. Indeed, the evolution of humanity has

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always been a story of adaptation, resilience, and innovation. As we step into the Metaverse, we are not losing our humanity; rather, we are embarking on a new journey to discover what it always meant and what happens when it is amplified.

So, as we stand on this thrilling precipice, let us not look down in fear but up in hope. The Metaverse is not a threat to our humanity, but an invitation to either elevate it or transcend it. As we shape this new world, let us ensure it is one that resonates with our shared dreams and aspirations, a world that honors the best in each and every one of us.

The story of the Metaverse is ours to write. And as its architects, we carry a great responsibility. But if history is any guide, it is a responsibility we can bear. The emergence of new technologies will likely lead to intense competition, as corporate interests seek to capitalize on these innovations. However, we are hopeful that open-source projects and citizen-led efforts can help prevent money from being the sole factor determining human development and wellbeing. In the end, we are not defined by the labor we perform but by the values we retain – in the physical world, in the digital world, and in all the worlds we are yet to discover.

### **In summary**

This exploration of the arising Intelligent Metaverse has taken us on a fascinating journey through its origins, challenges, and potential for transforming the way we interact with technology and each other. By tracing the roots of the Metaverse to age-old myths and human imagination, we have investigated its potential in various applications, from gaming to collaborative work environments.

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Throughout this exploration, we have emphasized the importance of content creation as a basic human right and discussed the need for designing experiences that fit within our cognitive boundaries. We have delved into the untapped potential of the human brain and the role of abstraction in condensing complexity, all while maintaining empathy and human connection as a core focus.

As the Metaverse continues to evolve, emerging technologies like mixed reality interfaces, emotional computing, and generative AI will shape its trajectory. By prioritizing human connection and collaboration, we can ensure that the Metaverse remains an inclusive, empowering, and enriching space for all. As we venture deeper into the digital age, the insights and ideas presented here will become increasingly relevant and valuable to anyone interested in understanding and shaping the future of the Metaverse and its impact on society.

It is our hope that this book has shed light on some of the most pressing issues and exciting opportunities within the Metaverse, sparking curiosity and inspiring further exploration. As we continue to push the boundaries of technology and human interaction, we must be ever more vigilant in addressing ethical concerns, ensuring that privacy, security, and autonomy are preserved.

While we have covered a broad range of topics in this book, we acknowledge that there are numerous areas and challenges that still need to be explored. We encourage readers from all walks of life to join us in this journey, sharing their insights, expertise, and passion to help shape the Metaverse in a way that benefits humanity.

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Throughout the book, we have also provided practical pointers for those who wish to start their own research or develop innovative products in the Metaverse domain. These guidelines and suggestions are aimed at equipping readers with the tools, insights, and inspiration necessary to drive their own projects and contribute to the growing body of knowledge in this field. As more individuals from diverse backgrounds join the effort to shape the Metaverse, we will collectively benefit from the exchange of ideas, experiences, and expertise.

The Metaverse presents a unique opportunity to reimagine the way we live, work, and interact. By placing human connection, empathy, and collaboration at the forefront of our design principles, we can create a digital world that is more than just an escape but a powerful force for growth, innovation, and positive change in the real world. The onus is on us to unlock the Metaverse's potential. Together, we can forge a brighter, more interconnected future without the all-too-familiar isolated-while-hyperconnected feel of current social media.



*Chapter cover 13 United Worlds: Coexistence in the Metaverse*

# Epilogue

The Metaverse is an extraordinary new frontier with the potential to transform the way we interact, learn, and conduct business perhaps beyond our biological longevity.

Our intent is to create a space that fosters innovation, creativity, and human potential while safeguarding the dignity and autonomy of all users. To achieve this, we will prioritize accessibility, inclusivity, user privacy, and security, while balancing the need for openness and transparency. We recognize the importance of maintaining a healthy balance between time spent in the Metaverse and the real world. We will leverage insights from cognitive science, neuroergonomics, and human-computer interface design to ensure that the Metaverse promotes productivity and engagement while also providing mechanisms that encourage users to take breaks, engage in physical activities, and connect with the real world.

We recognize that as is generally the case, effective abstractions are essential to facilitating the understanding of complex subject matter in the Metaverse. We will prioritize creating tools that help users create and construct these abstractions, leveraging the strengths of the brain to promote effective understanding and engagement. We will also design spaces that our avatars and non-player AI humanoids occupy, so that they are easy to navigate and understand.

We can no longer ignore the importance of high-fidelity human avatars and empathetic AI humanoids in the Metaverse, which will likely emerge as a universal interface to computing devices in both the real and virtual worlds. We will prioritize designing the embodiments of entities that appear to oversee

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their actions to promote human-like empathy and understanding. Thousands of years of evolution has fine-tuned our brains to read faces and understand other forms of communication such as speech. It would be disingenuous to ignore these skills, let alone attempt to change or bypass them through brain computer interfaces.

We also cannot ignore the tension between automation and the natural human instinct to be in control of production processes. Our attachment to the physicality of doing seems to be deeply connected to what it means to be human. It is well known that humans often need to do something physically to enter a state of sustained flow and joy during a creative process. Thus, we will strive to strike a balance between automation and human creativity, ensuring that humans remain an integral part of the creative process in the Metaverse.

Generative AI will clearly revolutionize content creation within the Metaverse, automating the generation of new items and experiences. However, it may come at a heavy cost. Along this journey, we will learn a way to strike a balance between AI-generated content and human creativity so that our human sensitivity to magic and beauty does not get blunted because our senses have become over simulated. Subtle issues like this one is bound to motivate us to advance the study and application of neuroergonomics.

We must be responsible in our use of training data when training Generative AI systems that generate content and behavior so that they are better aligned to human value. We will ensure that our training data is diverse, inclusive, and



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represents the full range of human experience, so that the Metaverse reflects our diverse and complex world.

Just like in a band, where musicians use technologies to automate some or all their music, we can expect to see the same pattern of interhuman collaboration and communication in the Metaverse augmented by AI. We can expect humanoid musicians who not only play real-world instruments but also can sense their peers and react accordingly. This is the promise of generative AI, where communication is not only via speech but also through non-speech sound and vision.

Similarly, in the Metaverse, it is not sufficient to develop humanoids with high expressivity, but they also will also need to be sensitive to what is happening in their proximity. This stands a significant change to increase collaborative interactions and social bandwidth between actors participating in a Metaverse that includes the real world.

In conclusion, let us work together to create a Metaverse that is inclusive, accessible, and user-friendly, and where everyone has an equal voice. By doing so, we can harness the power of the Metaverse to foster innovation, creativity, and human potential while safeguarding the dignity and autonomy of all users. Just like in a band, where musicians use technology to augment their creative process, the Metaverse augmented by AI promises to revolutionize the way we interact, collaborate, and create. And it may well be that the music we will create together does not have an ultimate purpose, but at least we will have enjoyed the journey making and sharing it.

# Epilogue

## Closing verses to reflect on the journey

### *The Illusion and the Metaverse: A boundary dance*

Within the folds of infinity, we arise,  
Clothed in the fabric of cognitive disguise,  
Our senses, our minds, our frames, so finite,  
Carving a cosmos of day and of night.

We dance with the shadows of Plato's old cave,  
In illusions of knowledge, we are but brave,  
Yet the world as it is, remains veiled from sight,  
In the layers we spin in our endless fight.

Boundaries drawn, lines in the cosmic sand,  
Dictated by senses, we strive to understand,  
Our identity, fickle, bound by thought and form,  
In a universe where chaos is the norm.

But lo, a new horizon, the Metaverse, it gleams,  
A world of our making, woven from dreams.  
Where work, play, and death find a new lease,  
As boundaries shift in this digital peace.

In this grand illusion, a new dimension we find,  
A testament to the power of the human mind.  
To escape death's clutches, a digital rebirth,  
A new layer of abstraction added to Earth.

Yet fear not this change, this intelligent tide,  
For we have always in an intelligent universe, resided.

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The Metaverse, but a mirror, a cosmic test,  
A reflection of us, in the universe's quest.

So dance on the boundaries, the lines in between,  
In the world as it is and the world as it is seen.  
For even in death, our echo may survive,  
In the Metaverse, our digital selves will thrive.

## A spiritual take

We embarked on this journey by drawing parallels between the Metaverse and ancient philosophies and religions, where contemplations of alternate realities were commonplace. It seems apt, then, to conclude with a reflection on the emergent role of intelligent agents perhaps embodied as avatars in the forthcoming Metaverse. Fascinatingly, the notion of subtle beings - encompassing entities like devas, asuras from Eastern philosophies, immortals or Xian from Taoism, kami from Shintoism, and mythical creatures like fairies, banshees, nymphs, and satyrs from various ancient cultures - may soon find echoes in the humanoid AI agents populating the Metaverse. Both reside in domains that elude our immediate sensory perception, yet both can interact with the physical or human world in myriad ways.

In the Metaverse, these humanoid AI agents can be perceived as the 'ethereal entities' of this digital cosmos. They dwell within the abstract realm of code and servers, intangible yet undeniably existent within their own sphere. Just as ethereal entities in Eastern philosophies can exert influence on the physical world, these AI agents can shape the Metaverse and, consequently, the experiences of its inhabitants.

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Consider these fascinating parallels:

*Guidance:* Ethereal entities in Eastern philosophies often serve as spiritual guides. Similarly, AI agents can guide users through the digital terrain of the Metaverse, offering information, assistance, and direction.

*Interaction:* Ethereal entities interact with humans in diverse ways, often leaving a profound impact on human lives. In the same vein, AI agents can engage with users, shaping their Metaverse experiences through assistance, challenges, or simulated social interactions.

*Rituals and Codes:* In Eastern philosophies, rituals, prayers, and offerings are modes of communication with ethereal entities. In the Metaverse, programming code plays a similar role, enabling developers to ‘converse’ with AI agents, guiding their behavior and interactions with users.

*Influence on Human Life:* Just as ethereal entities can shape human life on Earth, AI agents can significantly mold users’ lives within the Metaverse. They can sculpt experiences, alter perceptions, and even influence behavior and decisions.

*Evolution and Enlightenment:* In many Eastern philosophies, ethereal entities, like humans, are part of the cycle of birth and death, and they too seek liberation or enlightenment. Analogously, AI agents in the Metaverse can ‘evolve’ through machine learning, becoming increasingly sophisticated and ‘enlightened’ in their capabilities over time.

In this light, the Metaverse emerges as a novel kind of ‘spiritual’ domain, with AI agents as its ‘ethereal entities’. As

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we continue to cultivate and traverse this digital landscape, our interactions with these AI agents may yield fresh insights into not only the realms of technology and virtual reality, but also the profound depths of our own human nature and spirituality.

# Appendix

## A. Exploring eye tracking applications

### *Early eye trackers and challenges*

In the past, we experimented with two types of eye trackers. One was a prototype from Vision Control System, which was mounted on the face, keeping the user's right or left eye within its constant view. Figure 72 describes an early version of an infrared eye tracking device. The device is designed to be attached to a transparent plastic headband B (Figure 72, B), allowing for a reasonably comfortable wear. The main component of the monocular system A (Figure 72, A) is positioned on the side of the head, specifically on the temple, while a cylindrical tube extends outward. At the end of this tube, a mirror is strategically placed to reflect the eye being tracked. Additionally, the device emits infrared (IR) light onto the eye, illuminating the pupil and facilitating the determination of its center. By locating the ocular reflection, it becomes possible to ascertain the direction of gaze. However, one limitation of this approach is the challenge in determining the exact focal point of gaze. To achieve this, tracking both eyes would be necessary. It is worth noting that this particular device, being a prototype predating widespread Internet usage, is not documented online. Therefore, including this information here ensures that this piece of history is preserved and not lost to time. This illustration serves as a valuable testament to the early advancements in eye-tracking technology and its significance in understanding human visual behavior.

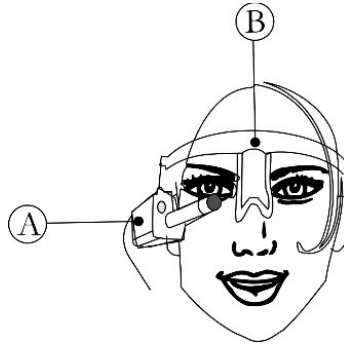


*Figure 72 An Early Monocular Eye tracker (circa 1995)*

The other was a desk-mounted model, less intrusive but requiring us to track the user's head to stay accurate. Eventually, an automated process was introduced with an Iscan camera that tracked the user's head movements. It is true that these technologies feel arcane today but that did not stop us from exploring what we could achieve with them at the human computer interface.

Back in 1997, at Lancaster University in the UK, we attempted to control a sound sensor widget on a 2D screen by tracking gaze behavior using the Vision Control System. Figure 73 depicts an experiment set up to explore the potential application of eye tracking technology. Specifically, the focus was on utilizing eye tracking to browse a soundscape consisting of sound sources positioned on a two-dimensional (2D) plane. Experiment subjects A (Figure 73, A) were able to scroll through this 2D space, enabling them to identify and explore various sound sources within the field B (Figure 73, B). The screen showing the tracked eye C (Figure 73, C) allowed the experimenter to check if the tracking was still adequate. The rendering of these sources utilized an early 3D sound API called Intel RSX Java API, which had a relatively

short lifespan due to the emergence of Java’s own Java 3D sound API.

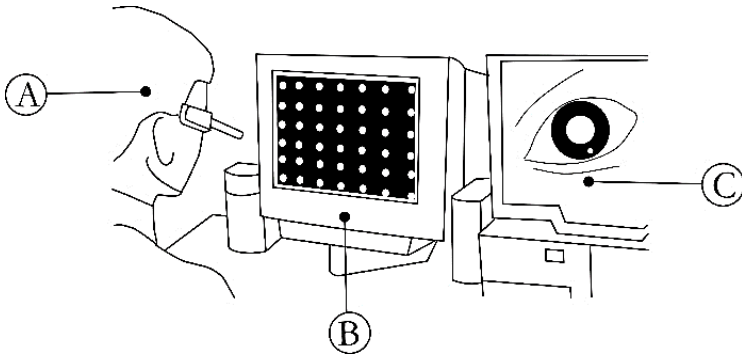


*Figure 73 Monocular Eye tracker Experiments for browsing spatial sound sources (circa 1995)*

During this time as a young student, the challenges of software development became apparent. The motivation behind using gaze to navigate the 2D soundscape stemmed from the need to represent the activities of others in shared virtual environments. Since the mouse cursor was primarily used for manipulating UI elements on the desktop, an alternative method was sought to facilitate movement of a virtual sound sensor within this environment. Thus, the idea of employing an eye tracker emerged, allowing users to explore the auditory space by using gaze position to move a virtual sound sensor thus freeing their hands to scroll through the 2D soundscape and perform other UI tasks using the keyboard or the mouse.

The ultimate goal was to create a virtual shared work environment that incorporated information about the activities of others. The assumption was that sound sources could be parameterized based on the actions performed on associated objects, thereby enhancing the social bandwidth of such environments. This endeavor provided valuable insights into



the limitations of cognitive processes and offered a clearer understanding of what may work in theory versus practical implementation.

Looking ahead, it is anticipated that similar approaches will be revisited with the advent of new waves of virtual reality (VR) environments that typically emerge every 7 to 10 years. These future VR waves hold promise for exploring and refining concepts like browsing auditory spaces using gaze, potentially unlocking new possibilities for immersive experiences and expanding our understanding of human-computer interaction.

Figure 74 shows a Java application designed for locating sound sources and examining their characteristics. Each source, represented by B (Figure 74, B), possesses specific attributes such as range and duration, with the option for the sound to be looped or not. The experimenter has the ability to record the gaze position of the user during the sound localization task, capturing valuable data for analysis. This data can then be visualized through the illustrated menu A (Figure 74, A), providing insights into the user's gaze behavior.

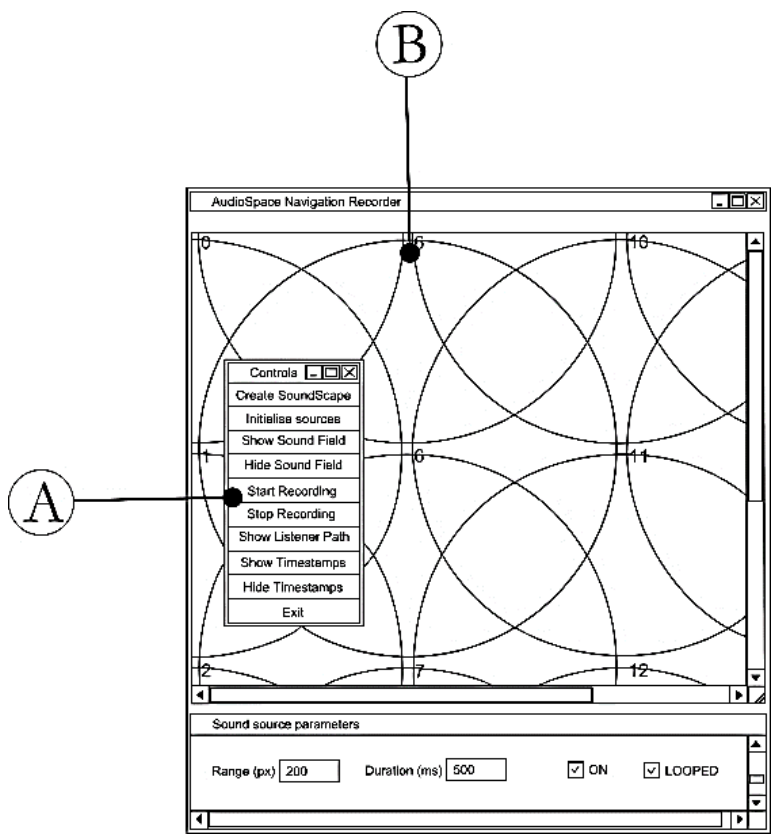


*Figure 74 Tracking user behavior when searching for sound sources using gaze*

Figure 75 shows a visualization of the user’s gaze position as they engage in a task of searching for sound sources based on given instructions. The visualization provides valuable insights into the user’s gaze path A (Figure 75, A) and the location of the window C (Figure 75, C) as they navigate and scroll around the window B (Figure 75, B) in their quest to locate a specific sound source. These small-scale experiments hold great potential in uncovering the inherent limitations of our perceptual systems, shedding light on the intricacies of human cognition and visual attention.

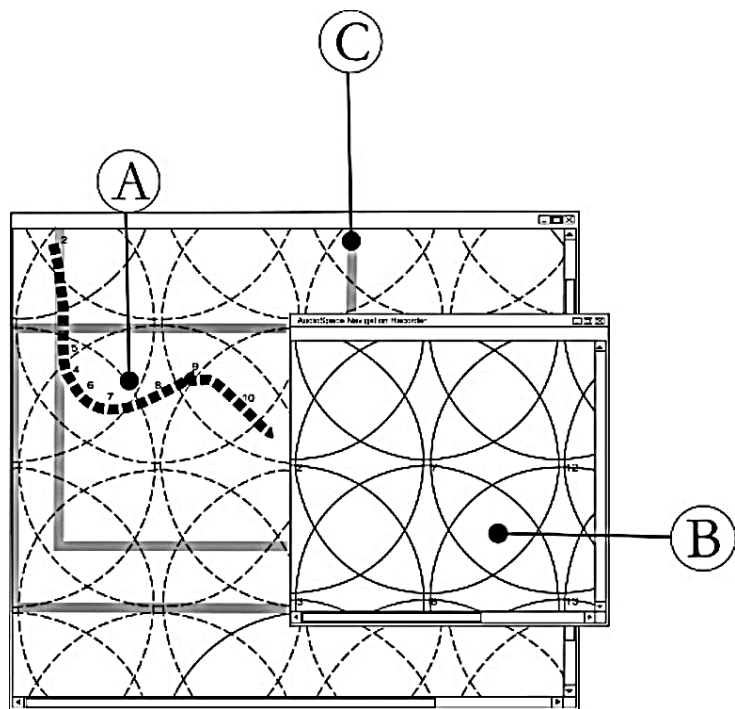


*Figure 75 Recording of soundscape exploration trajectory*

Though the concept was thrilling, we encountered significant obstacles that led us to consider more deeply our cognitive constraints in processing information, thereby influencing our approach to designing human-computer interfaces that we describe in this book.

### *Studying atypical gaze behavior*

In 2001, at the National Rehabilitation Hospital in Washington, D.C., a notable advancement was made in the field of eye tracking technology. The focus of this endeavor was to refine calibration techniques for desk-mounted eye trackers, drawing inspiration from reflexive gaze responses observed in previous studies involving moving or animated targets. Departing from traditional calibration methods that relied on explicit instructions, a novel approach emerged. By presenting animated visual stimuli at known locations on the screen, it became possible to calibrate the system without requiring explicit user input.

The accompanying figure showcases the desktop eye tracker setup utilized during this period. This particular eye tracker was a monocular system that played a crucial role in creating gaze-contingent visual environments. Within Figure 76, we observe a subject B (Figure 76, B) being tracked by the desktop eye tracker C (Figure 76, C) as they direct their gaze towards a screen D (Figure 76, D) displaying various characters (Figure 76, A, G, and E). The cross (Figure 76, F) represents the precise gaze position of the subject. As the subject's gaze intersects with one of the characters, an animation is triggered, adding an element of interactivity to the experience. This straightforward yet effective approach laid the foundation for subsequent experiments, where further enhancements were explored, including the introduction of haptic feedback.

This pioneering exploration of gaze-contingent visual environments and the integration of haptic feedback marked an important step forward in research and development. By leveraging eye tracking technology and incorporating animated stimuli based on gaze position, researchers aimed to create more engaging and interactive experiences for users. These experiments opened up new avenues for understanding human perception and interaction within virtual environments.

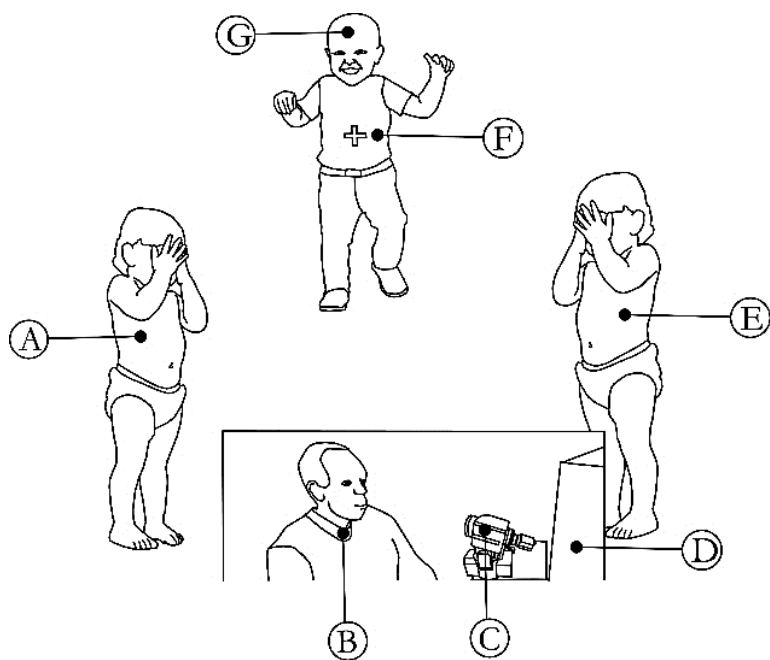


*Figure 76 Visual stimulus changes according to gaze behavior*

Drawing inspiration from our own study on toddler's gaze behavior, we investigated whether rewarding autistic children with a rocking motion could improve their gaze patterns (Ramloll, Trepagnier, Sebrechts, & Finkelmeyer, 2004).

Figure 77 shows the prototype that we developed. Such experiments not only improved our understanding of gaze behavior in humans but also guided us in refining our eye tracking technology. It underscores the importance of learning from and adapting available technology, as we strive to create novel and user-friendly solutions, even if at that time, the technology was not ready for what we really wanted to achieve.

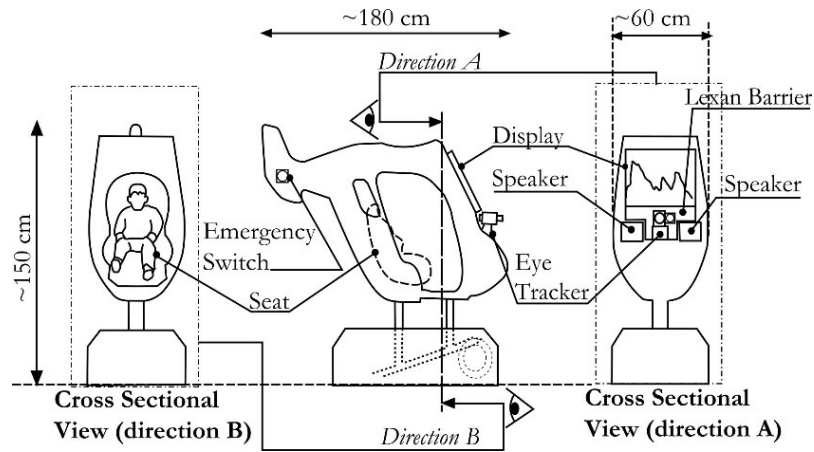


*Figure 77 A gaze contingent amusement ride*

Today, the culmination of these efforts is seen in products like Apple’s Vision Pro, validating the idea that interacting with a computer through eye movements is not only possible but can also be made much easier especially if head mounted displays become the norm for accessing virtual spaces. Now, users can simply look at virtual computer screen select icons and user interface widgets in order to perform various tasks.

During this period, the field of neuroergonomics was still in its nascent stages, and the concept of addressing user interface design problems from a neuroergonomic perspective was not widely recognized. However, by including these small

experiments throughout your career, you have contributed to narrowing down the solution space. This iterative process has allowed for a more focused exploration, increasing the likelihood of success by homing in on specific areas that hold promise.

These little experiments serve as valuable milestones in your journey, collectively guiding you towards more refined and targeted approaches. By acknowledging and learning from the limitations of our perceptual systems, we can continue to push the boundaries of user interface design and create more effective and user-centric experiences.

Reflecting on these endeavors, it becomes evident that attempting to design collaborative environments with alternative methods of representing social information without embodying their owners is a challenging pursuit. The complexities and nuances of human interaction and social dynamics are difficult to capture solely through abstract representations. This realization leads to the understanding that not separating representation of actors and their relevant social information within virtual environments may be a more effective approach, as it allows for a more immersive and authentic representation of social cues and interactions.

This figure serves as a reminder of the ongoing exploration and evolution of design principles in collaborative environments. It highlights the importance of considering the limitations and complexities inherent in representing social information, ultimately guiding future efforts towards more effective and meaningful design approaches.

## **B. What is OpenSimulator?**

In the era of the Metaverse, many might consider it hyperbole to mention OpenSimulator as one of the most influential lighthouses, guiding us through the uncharted waters of this bold new frontier. With its groundbreaking decentralized approach, OpenSimulator truly encapsulates the democratic spirit of the Internet in a way no other virtual world platform has managed to date.

OpenSimulator, an open-source, multi-platform, and extraordinarily versatile server, revolutionizes the way we interact with the Metaverse. The openness of its architecture is its biggest strength. It enables anyone, anywhere, to build their own unique virtual worlds - from vast, sprawling landscapes to intimate meeting spaces. With this software, users are not merely participants but creators, fashioning their own corners of the Metaverse even though they may struggle if they want to create advanced experiences because of some technical limitations.

What truly sets OpenSimulator apart is its remarkable commitment to decentralization. This is not a mere buzzword; it is the beating heart of the platform. The decentralized nature of OpenSimulator stands as a testament to the potential of peer-to-peer networks, proving that we can build worlds together without the need for centralized authorities. By creating an environment that fosters collaborative world-building, OpenSimulator is taking a bold step towards a future where power and creativity are truly democratized.

The open-source nature of OpenSimulator is another defining trait. It is built by a small community of dedicated developers, that will hopefully eventually grow as more realize the



importance of decentralization. This open-source ethos not only ensures transparency but also fosters a sense of shared ownership among its user bases.

Interoperability, another cornerstone of OpenSimulator, provides a seamless experience across the Metaverse. It is possible to jump between different servers, carrying your digital identity with you. This aspect enhances user freedom, allowing individuals to explore the vast expanse of the Metaverse without being tethered to a single platform or world.

Despite the glowing praises that OpenSimulator garners, it is essential to not overlook the issues that the platform faces - challenges that are both the products of its pioneering spirit and the relics of its past.

At the heart of OpenSimulator's struggle is the concept of technological debt. Born in the early days of virtual reality technology, the platform has had to constantly retrofit itself to keep up with the rapidly evolving landscape of the Metaverse. The codebase, though continually updated by the dedicated community, bears the weight of legacy structures that have been built upon over time. This can lead to inefficiencies and make the system more complex than it needs to be, limiting the ease with which new developers can contribute and innovate.

A major point of contention within OpenSimulator is its reliance on older virtual world viewer technologies. The platform was originally designed to work with viewers that adhere to the Second Life Viewer Protocol which has not changed a lot since the early days. While it has provided a foundation upon which the system was built, this tethering to past technologies hampers the evolution and optimization of the OpenSimulator experience.

Moreover, the multitude of features and vast flexibility that OpenSimulator offers can be a double-edged sword. For new users, the sheer amount of options and controls can be overwhelming, making the learning curve steep. It is a platform that offers incredible power but requires patience and dedication to truly master.

Yet, it is essential to view these issues not as insurmountable roadblocks but as critical learning opportunities.

OpenSimulator has provided a tangible and practical environment to understand the challenges of creating a Metaverse. The difficulties faced in tackling technological debt, in transitioning from legacy systems, and in balancing complexity with usability are all invaluable lessons for the next generation of virtual world platforms. OpenSimulator's struggles illuminate the pitfalls to avoid and the strategies to adopt as we journey towards a more comprehensive, accessible, and immersive Metaverse.

What is undeniable is that OpenSimulator, in spite of its challenges, has played a pivotal role in pushing the boundaries of what is possible in the Metaverse. And although there is a lot of ground to cover, the platform's community, enriched by its shared struggles and triumphs, is more than ready to rise to the occasion. OpenSimulator is not merely a platform but a testament to our collective journey into the unknown, a reminder of how far we have come, and a roadmap to guide us into the Metaverse's boundless future.

## C. What is the RezMela system?

RezMela is a system designed to facilitate the creation of user content within a 3D virtual space without the need for coding or 3D design skills. It enables users to build virtual world applications ranging from virtual post-it notes to extensive 3D campuses. This tool is intuitive, fast, scalable, and supports collaborative work. Users can assemble their applications from thoughtfully designed modules, which are collections of objects required by a particular app. These objects could be static, such as desks and shelves, or interactive, like text or image posters. Furthermore, users can save the results of their application usage in scene files, which can be shared with others for collaborative purposes<sup>1</sup>.

RezMela's system is designed to be easy-to-use, with a minimalist interface that enables users, including those with mobility challenges, to explore 3D social virtual worlds comfortably for extended periods of time, without requiring a headset or other hardware. The interface uses a design principle of 'economy of motion', allowing users to navigate and control their avatar and the in-world camera through simple actions like clicking to view and long-clicking to jump<sup>1</sup>.

The system blends the productivity of 2D environments with the social affordances of 3D environments. It uses a modular approach that allows designers to build their own virtual world apps without programming. By snapping components together, apps for productivity, collaboration, or learning can be quickly created and customized for virtual world environments, accessible through traditional devices like keyboards, mice, or touch screens<sup>1</sup>.

RezMela is currently being utilized in various fields such as emergency preparedness, education, healthcare, business, virtual heritage, immersive language instruction, and educational video content production<sup>1</sup>. The development of RezMela itself serves as an example of its potential, having been created through a multi-year collaborative effort by a geographically separated team that used the virtual world for long periods to develop this product<sup>1</sup>.

## **D. Estimating the energy cost of the Metaverse**

Estimating the Energy Cost of a Metaverse for 70% of the American Workforce

### ***Introduction***

With the rapid advancements in technology, the concept of a Metaverse where millions of people can work, learn, and socialize in virtual environments is becoming a reality. A crucial aspect of assessing the feasibility of such a massive virtual world is estimating its energy costs. In this article, we will provide a detailed analysis of the energy cost estimation for a Metaverse where 70% of the American workforce is expected to work for 5 hours per day.

### ***Assumptions***

Number of workers in the virtual world: According to data from 2021, the American workforce consisted of approximately 161 million people. Therefore, if 70% of the workforce were to work in a Metaverse, that would amount to around 112.7 million workers ( $0.7 * 161$  million).

Power consumption per device: We will assume that the average power consumption of a high-end gaming PC used for accessing the Metaverse is around 500 watts.

Time spent in the virtual world: For our calculations, we will assume that the average user spends 5 hours per day in the virtual world.

Server-to-user energy consumption ratio: To account for the energy consumption of server farms, 3D graphics rendering,

virtual content generation, and AI systems, we will assume that the energy consumption ratio between the server infrastructure and user devices is 1:1.

Infrastructure energy consumption: We will assume that the additional energy consumption for infrastructure (e.g., data centers, networking equipment) is 25% of the combined energy used by users' devices and server farms.

### ***Detailed calculations***

Step 1: Calculate the energy consumption per worker.

Energy consumption per worker (Wh) = Power consumption per device (W) \* Time spent (h)

Energy consumption per worker (Wh) = 500W \* 5h = 2,500 Wh

Step 2: Calculate the total energy consumption for all workers.

Total energy consumption for workers (Wh) = Energy consumption per worker (Wh) \* Number of workers

Total energy consumption for workers (Wh) = 2,500 Wh \* 112,700,000 = 281,750,000,000 Wh

Step 3: Calculate the energy consumption for server infrastructure.

Server energy consumption (Wh) = Total energy consumption for workers (Wh) \* Server-to-user energy consumption ratio

Server energy consumption (Wh) = 281,750,000,000 Wh \* 1 = 281,750,000,000 Wh

Step 4: Calculate the combined energy consumption for workers and servers.

Combined energy consumption (Wh) = Total energy consumption for workers (Wh) + Server energy consumption (Wh)

Combined energy consumption (Wh) = 281,750,000,000 Wh + 281,750,000,000 Wh = 563,500,000,000 Wh

Step 5: Calculate the energy consumption for infrastructure.

Infrastructure energy consumption (Wh) = Combined energy consumption (Wh) \* 25%

Infrastructure energy consumption (Wh) = 563,500,000,000 Wh \* 25% = 140,875,000,000 Wh

Step 6: Calculate the total energy cost.

Total energy cost (Wh) = Combined energy consumption (Wh) + Infrastructure energy consumption (Wh)

Total energy cost (Wh) = 563,500,000,000 Wh + 140,875,000,000 Wh = 704,375,000,000 Wh

Step 7: Convert the total energy cost from watt-hours (Wh) to kilowatt-hours (kWh).

Total energy cost (kWh) = Total energy cost (Wh) / 1,000

Total energy cost (kWh) = 704,375,000,000 Wh / 1,000 = 704,375,000 kWh

## *Conclusion*

Based on our calculations, the estimated energy cost for a Metaverse accommodating 70% of the American workforce, assuming each worker spends 5 hours per day in the virtual world, is approximately 704,375,000 kWh. This calculation takes into account the energy consumption of user devices, server infrastructure, and additional infrastructure such as data centers and networking equipment.

It is important to note that this estimation is based on several assumptions and may vary depending on the actual power consumption of devices, server efficiency, and infrastructure energy usage. Additionally, advances in technology and more energy-efficient systems could significantly reduce the overall energy costs of such a Metaverse. Nevertheless, this analysis provides a useful starting point for understanding the potential energy requirements of a large-scale virtual world.

To convert the total energy cost to USD, we need to know the average cost of electricity in the United States. According to the U.S. Energy Information Administration (EIA), as of September 2021, the average retail price of electricity for the commercial sector was about 10.74 cents per kilowatt-hour (kWh). Since energy prices fluctuate over time, we will use this value as an approximation.

Total energy cost (kWh) = 704,375,000 kWh

Average cost per kWh = \$0.1074

Total energy cost in USD = Total energy cost (kWh) \* Average cost per kWh



Total energy cost in USD = 704,375,000 kWh \* \$0.1074 = \$75,590,125

So, the estimated cost for a Metaverse accommodating 70% of the American workforce, with each worker spending 5 hours per day in the virtual world, would be approximately \$75,590,125, based on the 2021 average commercial electricity rate. This is a rough estimate, and the actual cost may vary depending on energy prices and technological advancements that could make the Metaverse more energy efficient.

## **E. The surge of virtual humanoid robots**

To perform a back-of-the-envelope calculation and ascertain why the number of virtual humanoid robots is expected to far exceed the number of physical world humanoid robots within 5 years, we need to consider several factors, such as cost, development time, and potential use cases.

1. **Cost:** Assuming that the production cost for a virtual humanoid robot is negligible compared to the \$10,000 cost of a physical humanoid bot, virtual robots offer a much more cost-effective solution. This affordability factor makes virtual humanoid robots more accessible to a wider range of users and industries compared to their physical counterparts.
2. **Development time:** In the virtual domain, the development of humanoid robots can be accomplished rapidly, whereas creating a physical humanoid bot requires a significant amount of time, resources, and engineering efforts. The shorter development time for virtual humanoid robots allows for a quicker production and deployment cycle compared to physical humanoid bots.
3. **Use cases:** Virtual humanoid robots can be utilized in a multitude of virtual environments and scenarios, including virtual reality platforms, simulations, gaming, and online communication. Their applications are not limited by physical constraints and can extend to areas such as virtual assistance, entertainment, and social interactions. On the other hand, physical humanoid bots face limitations in terms of physical presence and real-world interaction, restricting their potential use cases.

Now, let us estimate the market demand for each type of humanoid robot based on these factors, focusing solely on virtual humanoid robots:

Yearly demand for virtual humanoid robots:

- Cost advantage factor: Considering the negligible production cost of virtual humanoid robots compared to physical humanoid bots, we can assign a cost advantage factor of 10 (assuming that for every \$10,000 spent on a physical humanoid bot, 10 virtual humanoid robots can be acquired).
- Development time factor: Since virtual humanoid robots can be developed and deployed rapidly in the virtual domain, we can assign a development time factor of 5 (assuming that 5 virtual humanoid robots can be developed in the time it takes to create one physical humanoid bot).
- Use case factor: Virtual humanoid robots possess a wide range of use cases in various virtual environments, making their potential use cases significantly greater than those of physical humanoid bots. Let us assign a use case factor of 3 (assuming virtual humanoid robots have three times the number of potential use cases compared to physical humanoid bots).

Total demand factor for virtual humanoid robots =  $10 * 5 * 3 = 150$

Assuming the current market size for virtual humanoid robots is 10,000 units per year, in 5 years, the number of intelligent virtual humanoid robots produced would be:

Virtual humanoid robots:  $10,000 * 150 * 5 = 7,500,000$

According to this estimation, there will be approximately 7,500,000 intelligent virtual humanoid robots compared to physical humanoid bots within 5 years. This strongly suggests that the number of virtual humanoid robots will significantly surpass the number of physical world humanoid robots, highlighting the distinction between the two domains.

Please note that this calculation is a simplified approximation and does not account for all complexities in the market. However, it provides a general understanding of the expected disparity between virtual humanoid robots and physical humanoid bots within 5 years.

## **F. Behind the scenes: Noteworthy Moments in my Metaverse Journey**



*Figure 78 With virtual world pioneer, Bruce Damer (early 2000s)*



*Figure 79 In a collaborative meeting at Linden Lab, San Francisco (early 2000s)*



*Figure 80 Receiving an award from the US Gov for a federal virtual worlds challenge (2010)*

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# Bibliography

- Agrawal, K. (Dec 2014). *To study the phenomenon of the Moravec's paradox*. published online arXiv:1012.3148 [cs.AI].
- Baddeley, A. D. (1974). *Working memory*. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory (Vol. 8)*. . New York: Academic Press. ISBN: 978-0125433082.
- Beale, I. R. (2018). A Virtual World for Learning Skills of Independent Living: a Formative Evaluation. . *Adv Neurodev Disord* 2, 230–240.
- Beaudoin, L. P. (2013). *Cognitive Productivity: Using Knowledge to Become Profoundly Effective*. CogZest (June 3, 2013), ISBN-10:0992001005.
- Blackmore, S. (2010). The developing social brain: implications for education. *Neuron.*, 744-747.
- BrickIt. (2023). *BrickIt App (Version 4.9.0)*. Retrieved from <https://apps.apple.com/us/app/brickit-app/id1477221636>
- Bunce, G. (2022, 12 1). *Cognitive Maps - the Science behind Our Brain's Internal Mapping and Navigation System*. Retrieved from Utah GIS Portal: [gis.utah.gov/cognitive-maps/](https://gis.utah.gov/cognitive-maps/)
- Clark, A. &. (1998). The Extended Mind. *Analysis*, 58(1), 7-19.

- Eichenbaum, H. (2017). The Hippocampus as a Cognitive Map ... of Social Space. . *Trends in Cognitive Sciences*, 21(10), , pp. 714-725.
- Fernandez, E. (2022, Oct 14). *The Multiverse and Eastern Philosophy*. Retrieved from [www.forbes.com:www.forbes.com/sites/fernandezelizabeth/2020/01/12/the-multiverse-and-eastern-philosophy/?sh=180652f27209](http://www.forbes.com:www.forbes.com/sites/fernandezelizabeth/2020/01/12/the-multiverse-and-eastern-philosophy/?sh=180652f27209)
- Gefter, A. (21, April 21). *The Evolutionary Argument Against Reality*. Retrieved from Quantamagazine: <https://www.quantamagazine.org/the-evolutionary-argument-against-reality-20160421/>
- Gemmell, J., Toyama, K., Zitnick, C., Kang, T., & Seitz, S. (2000). Gaze awareness for video-conferencing: a software approach. *IEEE MultiMedia*, 7(4), 26-35. Retrieved 3 8, 2023, from <https://dl.acm.org/citation.cfm?id=615011>
- Hadders-Algra, M. (Jan. 2022). Human Face and Gaze Perception Is Highly Context Specific and Involves Bottom-up and Top-down Neural Processing. *Neuroscience & Biobehavioral Reviews*, 304-323.
- Hafting, T. F. (2005). Microstructure of a spatial map in the entorhinal cortex. . *Nature*, 801-806.
- Hewitt A., S. S. (2008). Expanding CERC Beyond Public Health: Sharing Best Practices with Healthcare Managers via Virtual Learning. *Journal of Health Promotion Practice*, Vol. 9, No.4, 83s-87s.

- Hoffmann, M. (2021). The Neurobiology of Human Super-Communication: Insights for Medicine and Business. *World Journal of Neuroscience*, Vol. 11 No.4.
- Hunter, D. &. (2015). *For the Win: How Game Thinking Can Revolutionize Your Business*. Wharton Digital Press. ISBN: 978-1613630235.
- Kahneman, D. (2011). *Thinking, Fast and Slow*. . Farrar, Straus and Giroux, ISBN: 978-0374533557. Retrieved from ISBN: 978-0374533557.
- Krokos, E. P. (2019). Virtual memory palaces: immersion aids recall. *Virtual Reality*, 23(1), 1-15.
- Lakoff, G. &. (1980). *Metaphors We Live By*. University of Chicago Press.
- Markowsky, G. (2023, 6 28). *Information Theory-Physiology*. Retrieved from [www.britannica.com](http://www.britannica.com): <https://www.britannica.com/science/information-theory/Physiology>
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. . *Psychological Review*, 63(2), 81-97.
- O'Keefe, J. D. (1971). The hippocampus as a spatial map. Preliminary evidence from unit activity in the freely-moving rat. *Brain Research*, 34(1), 171-175.
- O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. Clarendon Press; Oxford University Press. Retrieved 3 8, 2023, from <http://www.cognitivemap.net/>

- Peeters, A. &.-O. (2019). Misplacing memories? An enactive approach to the virtual memory palace. *Consciousness and Cognition*, 75, 102834. DOI: 10.1016/j.concog.2019.102834.
- Ramloll, R. (1998). *The Role of Reactive Typography in the Design of Flexible Hypertext Documents*. Retrieved 3 8, 2023, from <https://eprints.lancs.ac.uk/id/eprint/11609>
- Ramloll, R. (2002). An Environment for Studying the Impact of Spatialising Sonified Graphs on Data Comprehension. *Sixth Information Visualization Conference, IV 2002 Proceedings*. London: UK. IEEE Computer Society Press, ISBN: 0-7695-1656-4.
- Ramloll, R. (2004, July). A fuzzy based approach for the real-time capture and dissemination of visual interest information in shared environments. *Second International Conference on Coordinated and Multiple Views in Exploratory Visualization* (pp. 24-35). IEEE Press.
- Ramloll, R. (2016). *United States of America Patent No. 61/841,380*.
- Ramloll, R., & Brewster, S. (2002). *A generic approach for augmenting tactile diagrams with spatial non-speech sounds*. Retrieved 3 8, 2023, from [http://eprints.gla.ac.uk/3227/1/generic\\_approach2.pdf](http://eprints.gla.ac.uk/3227/1/generic_approach2.pdf)
- Ramloll, R., & Mowat, D. (2001). Wayfinding in Virtual Environments Using an Interactive Spatial Cognitive Map. *IV 2001 Proceedings* (pp. pp. 574–583). London: IEEE Press.

- Ramloll, R., Trepagnier, C., Sebrechts, M. M., & Beedasy, J. (2004). *Gaze data visualization tools: opportunities and challenges*. Retrieved 3 8, 2023, from <https://ieeexplore.ieee.org/document/1320141>
- Ramloll, R., Trepagnier, C., Sebrechts, M. M., & Finkelmeyer, A. (2004). *A gaze contingent environment for fostering social attention in autistic children*. Retrieved 3 8, 2023, from <https://dl.acm.org/citation.cfm?id=968367>
- Ramloll, R., Yu, W., Brewster, S., Riedel, B., Burton, M., & Dimigen, G. (2000). *Constructing sonified haptic line graphs for the blind student: first steps*. Retrieved 3 8, 2023, from <https://dl.acm.org/citation.cfm?id=354330>
- Richard Baskerville, J. P.-H. (2010). Explanatory Design Theory. *Business & Information Systems Engineering*, 271-282.
- Sankaracharya. (8th Century). *Brahma Sutra Bhashya*.
- Sargolini, F. F. (2006). Conjunctive representation of position, direction, and velocity in the entorhinal cortex. . *Science*, 758-762.
- Sautoy, M. d. (2019). *The Creativity Code: Art and Innovation in the Age of AI*. Belknap Press: An Imprint of Harvard University Press.
- Tayyebi, S. F. (2019). Architectural Composition: A Systematic Method to Define a List of Visual Attributes. *Art and Design Review*, vol. 7, no.3, 11.
- Tolman, E. (1948). Cognitive maps in rats and men. *Psychological Review*, 55(4), 189–208. Retrieved 3 8, 2023, from <http://psychclassics.yorku.ca/Tolman/Maps/maps.htm>

- Tsao, D. a. (2008). Mechanisms of face perception. *Annu Rev Neurosci.*, 411-437.
- Urban, T. (2017 (Retrieved Dec 2022)). *Neuralink and the Brain's Magical Future*. Retrieved from <https://waitbutwhy.com/2017/04/neuralink.html>
- Varela, F. J. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. MIT Press.
- Vittorio Gallese, L. F. (April 1996). Action recognition in the premotor cortex. *Brain*, 593–609.
- Yu, W., Ramloll, R., & Brewster, S. (2000). *Haptic Graphs for Blind Computer Users*. Retrieved 3 8, 2023, from <https://dl.acm.org/citation.cfm?id=652687>