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Basic technologies to build a complete metaverse

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Abstract. Since the development of computers and screens capable of displaying a wide range of colors, people are starting to look at the bigger picture, such as 3D projection, online society, virtual reality, and so on. Nowadays, more and more technology companies are entering the field of virtual reality, they call the ideal project a metaverse. This paper will introduce the basic concepts and technologies of the metaverse, from the fundamental construction to different areas' connections and a higher demand for services with advantages. So that there should have a comprehensive impression for people to understand how far from the final goal on the metaverse, how about the feasibility nowadays and development methods in the future. Although nowadays it still seems far from the ideal opinion, under the situation that many huge companies are making investment on it, we could presume the potentials of metaverse through its basics and have a better understanding of its benefits and limitations. Overall, the metaverse will change people's social lives a lot, so it's important to have a detailed understanding of this.

Keywords: metaverse, virtual reality, artificial intelligence, 5G & 6G, blockchain.

1. Introduction

In recent years, since the COVID-19 epidemic, online social activities have become more and more popular. Many people have turned to playing video games during the pandemic [1]. In this situation, one of the biggest game company, Roblox's profits have skyrocketed in the past few years. In March 2021, Roblox went public in New York. On the first day of trading, its stock prices increased a lot, and the company was valued at $45 billion [2]. In Roblox's prospectus, it compared its future game community as metaverse and defined eight key characteristics: identity, friends, immersive, anywhere, low friction, variety of content, economy, and safety. Not only Roblox, but many other technology companies also pay attention to the development of the metaverse. The most widely known case is that, in June 2021, Facebook announced their goal to turn Facebook into a metaverse company in five years' time and changed the company's name to meta.

2. Basic information about the metaverse

2.1. History of the metaverse

The word "metaverse" comes from Neal Stephenson's 1992 science fiction novel Snow Crash. The novel describes a world in which people not only live in real society but also use technological equipment to join in online communities. Such a system online is called "Metaverse". Many other science fiction or games have similar settings. For example, movie The Matrix shows us a grand

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imagine about metaverse. People's consciousness can be connected through the Internet in a virtual society. By lots of envision of such concept, it seems that metaverse is not really new. People began to think about and refine it many years ago.

2.2. Important technologies in the metaverse

A complete metaverse needs many different industries. Rendering technologies used in virtual reality and augmented reality are clearly necessary for the metaverse. To build safe and fast communication or trade systems between players online around different areas, the network construction needs lots of improvement. What else, comfortable and convenient service are still important in virtual reality for most players [3].

3. Technologies for metaverse

3.1. Simulation of real world

To achieve the effect of realistic three-dimensional space on a two-dimensional screen and let users to feel the things as real as possible, engineers always use some special technologies to enhance the object's reality. Virtual reality technology, abbreviated "VR", is computer technology as the core of the integration of digital image processing, computer graphics, and sensor technology such as visions, hearing, touching, and virtual simulation of three-dimensional space technology [4]. The equipment used in virtual technology is important in the creation of successful virtual experiences. In general, these devices can be distinguished as input and output devices [5]. Input devices help users to control their behaviors on VR devices. For example, players could use simple joysticks, keyboards, or even several complex trackers that are able to capture actions and postures and reappear as those actions in the virtual world. The opposite of input devices are output devices, which help the user receive information from applications. Different kinds of visual devices can provide different chances to feel the metaverse. The simplest or least immersive devices might just support easy rendering images, but some fantastic equipment with complete sense system could display complicated 3D images, and render various changes of the object in real time [6]. With perfect input and output devices, people can play in a virtual world as real. For example, if you take up a bottle of warm water in a VR game, your hand's devices would quickly become heavier and warm up to simulate the real feeling in physical way and when you open a door, you can really feel the rotation of the handle in games.

For a great immersive environment, there are a lot of research topics that developers need to study in the future to improve virtual reality. The easiest one is developing more versatile handheld haptic devices for VR. In recent years, because of the limitations of wearable haptic devices that are uncomfortable to wear and take off, as well as difficult to adapt with different hand sizes, handheld haptic devices became more popular in interaction interface for VR devices [7]. Hand-held devices have some advantages that can be used for VR compared to other haptics. They can support mass physical movement, and are easy to take on and off, and people can use them without tying anything on their fingers. A challenge is how to achieve richer tactile feedback modes within the compact volume of handheld devices, such as texture feedback, thermal feedback, skin-stretch and so on. These patterns need carefully designed so that users can easily distinguish them without long periods of learning [8].

However, in order to satisfy different demands on elaborate devices, it always needs to consider too many parameters to build perfect environments in virtual worlds. Machine learning could help us a lot with the rendering and simulation of different images and feelings. Depending on huge database and special model training, machine learning can be used to generate more realistic images by training on a dataset of 3D models and their corresponding rendered images. This can be used to improve the quality of images generated by traditional rendering algorithms, or to generate images that are not possible to produce with traditional methods [9]. In terms of efficiency, machine learning can be used to optimize the rendering process by predicting which areas of an image are most important and should be rendered with higher fidelity, and which areas can be rendered with lower fidelity without

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affecting the overall quality of the image. This can significantly reduce the time required to render an image, making it possible to render images in real-time or near real-time.

3.2. Communication

Because there are so many things that need to be considered in a complicated metaverse, when users using internet-connection devices, they need to wait a few seconds for the loading and preparation process. This is common in online games. When players move from one place to another, such as open a door and go into another room, or teleport to a very far place, there always show a progress bar on the screen. Sometimes users may feel it takes a lot of time and ruins game experiences. In metaverse world, this problem became even worse. It is important to reduce the loading time to create a great experience. The numerous computations required to build a great metaverse environment are too heavy for our devices. As the result, it is necessary to use offloading to ensure the fast processing and user experience. Because cloud offloading usually has some challenges: user experienced latency, real-time user interaction, network congestion, and user privacy [10], edge computing has the potential to tackle these challenges. Unlike other kinds of computation, which first upload your data to the cloud system and then deal with them, edge computation handles the data as close as possible from your devices. As more and more data is produced at the edge of network, therefore, it would be more efficient to also process at the edge of the network. Through edge computation, for example, using cloudlets to offload computing tasks for wearable cognitive assistance, the result shows that there is about an 80 to 200ms improvement in response time. In addition, it could save about 30% - 40% energy [11].

Recently, with the advent of 5G technology, edge computation could be more efficient. 5G is expected to become the next-generation wireless cellular networks. It has three more special features than the previous networks and has a higher network capacity to support a higher number of users [12]. Firstly, 5G's mm Wave communication, which uses high-frequency bands [13], provides high bandwidth. Secondly, small cell deployment lets users communicate using mm Wave in order to reduce transmission range and interference. Thirdly, massive MIMO (multiple-input, multiple-output) allows base stations to use many antennas to provide directional transmission and reduce interference, allowing neighboring nodes to communicate simultaneously.

By using 5G in edge computing, it could improve data management to handle more delay-sensitive data that needs to be processed locally in a real-time manner, predicting network demand to calculate the required resources to cater for the network demand in a local proximity, and then provide optimal resource distribution to handle local demand [14]. Because there are limited network resources available in the edge cloud as compared to the center cloud, this kind of operation improves resource management to optimize network resource utilization for network performance enhancement. The superior performance in reducing latency in virtual worlds has made edge computing become an essential pillar in the metaverse's creation. For instance, Apple uses Mac with an attached VR headset to support 360-degree VR rendering. Facebook Oculus Quest 2 provide VR experiences on its own without the connection between PC. With the development of 5G (promising down to one millisecond last mile latency) and future 6G, Multi-access edge computing is expected to boost metaverse user experience by providing standard and universal edge offloading services one-hop away from the cellular-connected user devices. With the development that it reduces the round-trip-time of packet delivery, it opens a door for near real-time orchestration for multi-user interactions [15].

3.3. Service and experience

There are many potential applications and use cases for a metaverse, ranging from entertainment and gaming to socializing, education, business, and so on. For example, people might visit a metaverse to participate in immersive experiences such as virtual reality games, attend virtual events and conferences, visit virtual recreations of real-world locations, or shopping for dizzying products [16]. As one of the most important sections in metaverse, there are many methods to create a convenient and a safe user environment. For example, some present online applications like to record users'

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preferences and analyze them, and then provide services or products that match their preferences. Many services, such as digital assets, financial logistics, are beginning to use blockchain, which means decentralization, to ensure fairness and accuracy.

Artificial intelligence (AI) is the basis for mimicking human intelligence processes through the creation and application of algorithms built into a dynamic computing environment. Simply stated, AI is trying to make computers think and act like humans [17]. AI has the potential to play a significant role in the development and operation of such methods. AI technologies have a lot of advantages when analyzing complicated user data. With special algorithms and several training cycles, AI can be used to provide personalized experiences for users, such as recommending content or activities based on their preferences and interests. This can help improve the overall user experience and make the metaverse more engaging for individuals. For some detailed user demands, AI could help users customize their experiences, such as by creating and training their own virtual assistants or personal avatars. Some behaviors could also be automated through AI's control. Many interesting and useful things, like moderating content or virtual environments, might be set up to automate certain tasks to improve the efficiency and effectiveness of services [18]. For instance, OpenAI, an artificial intelligence research lab, released one of the most famous AI language model called ChatGPT in late 2022. It trained on a wide range of information and can assist with tasks such as answering questions, summarizing text, and even generating creative writing. As a language model, it could potentially play a role in an AI-powered metaverse by assisting with natural language understanding and generation tasks. For example, it could help with generating dialogue for virtual characters or assisting users in navigating and interacting with the metaverse. Additionally, it could quickly process text-based search and retrieval of information within the metaverse, or for generating descriptions of virtual objects and environments.

Just like many other internet applications, people spend time and energy in the metaverse where they can make their own properties. However, there are many differences between players' trades in a virtual metaverse and in the real world. One way to address some of the issues related to the buying and selling of virtual property in the metaverse is using blockchain technology. Blockchain is a distributed ledger technology that allows for the creation of decentralized and transparent digital assets. By using blockchain, virtual property in the metaverse can be tracked and owned in a secure and verifiable way, making it similar to real-world property. This can help to ensure that virtual property ownership is clear and can't be disputed, and that transactions are secure and transparent. Additionally, the use of smart contracts on the blockchain can automate the buying and selling process of virtual property, making it more efficient and less prone to errors. Overall, blockchain technology can provide a more robust and reliable framework for the buying and selling of virtual property in the metaverse, making it more like real-world property transactions [19].

4. Conclusion

Although there are tremendous technologies that could be used in the metaverse, it's still far from an ideal virtual world. Many industries were developed just a few years ago and need more experiments and trials. Take some examples: the rendering of VR present always depends on expensive devices that not everyone can afford. There may be challenges in terms of infrastructure and cost associated with deploying 5G and even 6G networks. For AI and blockchain technologies, their controversies never less than their advantages. AI's scalability and regulatory compliance should be restricted by privacy and morality. The widespread adoption and use of blockchain technology is still in its early stages, and there are still concerns around security, scalability, and regulatory compliance that need to be addressed. Just like many other intergenerational technologies, people need more time to complete the rules and functions in the metaverse. This paper most focuses on modern technologies, which provide basic and complete functions for the metaverse, but lacks more detailed and in-depth analysis for those technologies. It would be better to have more parts from technology perspective which give more convincing opinions for the development stages. In the future, people would iterate more

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advanced methods that the expression of metaverse might have large differences from the image nowadays.

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