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Metaverse Applications for Location-Based Virtual Reality

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ABSTRACT

Recently, the metaverse has considerably dominated tech headlines for researchers in the fields of human-computer interaction and human factors and ergonomics around the world, due to the advancement of its software and hardware. With its ability to immerse humans in a virtual, inexpensive, and safe world, it has greatly become popular in recent years, particularly in virtual reality. Nevertheless, despite the extremely increasing attention to virtual reality, there is still very limited research work for summarizing and analyzing location-based virtual reality in which virtual reality tools are utilized for assisting humans to experience virtual reality by physically interacting with the environment. This paper proposes a new research study for investigating recent works of location-based virtual reality applications. After that, the evolution of virtual reality using location-based features is explored. Finally, we conduct a comparative analysis of virtual reality and augmented reality works, including location-based works in the past five years.

Keywords: Virtual reality, Augmented reality, Metaverse, Location, Human factors, Location-based features

INTRODUCTION

The metaverse is a network of three-dimensional virtual worlds facilitated using extended reality, augmented reality, or virtual reality tools for particularly beneficial purposes, such as social connection, productivity improvement, and virtual game creation. In recent years, it has gradually been a symbol of the future because it integrates many related areas of computer science and human factors to produce uniquely interactive experiences using tools and headsets of virtual reality and augmented reality—an immersive experience of a real-world environment that is added by graphical items. In addition, it has become tremendously popular with location-based features that allow an immersive interaction between human factors for both augmented reality and virtual reality—a completely simulated experience that can be like or totally different from the physical world using generated graphical information.

In fact, there are pieces of research for building and/or investigating location-based augmented reality applications, such as Khan et al.'s work (Khan et al. 2021) for estimating the viewed position of virtual objects in

three-dimensional optical see-through (OST) augmented reality using HoloLens and Capece et al. work (Capece et al. 2016) for visualizing geolocated data on a client-server framework utilizing location-based augmented reality. More specifically on game design, there are also some existing works focusing on games of location-based augmented reality, such as Windleharth's work (Windleharth 2020) for safety, identity, and information management of location-based augmented reality games in communities of practice, Pyae et al.'s work (Pyae et al. 2017) for studying experiences of the users in mobile location-based augmented reality applications and games, and Bhattacharya et al.'s work (Bhattacharya et al. 2021) for reconceptualizing the three main foundations of location-based games (exercise, exploration, and social interaction) during the pandemic period, particularly augmented reality. There are also several summarizing works for analyzing location-based augmented reality works, including Oleksy and Wnuk's work (Oleksy and Wnuk 2017) for exploring the purpose of location-based augmented reality applications and games in altering place-human relations, and Kerdvibulvech's works (Kerdvibulvech 2021) (Kerdvibulvech 2022) for location-based augmented reality gaming market analysis. However, despite the recently considerable attention to the metaverse, very small amounts of works study and summarize location-based virtual reality applications, especially in game design. Thus, in this paper, we present a new research study for investigating recent works of location-based virtual reality applications. We then explore the evolution of metaverse games for virtual reality using location-based features in an interdisciplinary perspective of human factors and ergonomics.

LOCATION-BASED VIRTUAL REALITY

To begin with, location-based virtual reality is sometimes defined as a place of business or exhibition where virtual reality tools are used for helping people to experience virtual reality by physically interacting with the environment in a way they cannot, in their own home. For instance, the location-based virtual reality can allow people to hang around in a ghost house and a museum, run around in amusement parks, and/or walk around a warehouse with obstacles that are made of paper but look virtually like concretes or woods in the location-based virtual world. Therefore, due to the flexibility of many custom-designed spaces, it is deemed to give more possibilities to explore in many aspects, including multi-user virtual reality scenarios. Nevertheless, location-based virtual reality installations may have different requirements than virtual reality used in private settings. This section explores interesting location-based virtual reality works in the last five years in terms of human-computer interaction and human factors.

Wölfel et al. (Wölfel et al. 2020) give a good overview for discussing some challenges and possible solutions for improving and staging the experience of location-based virtual reality works. This is because these solutions can make more people who pass by the site participate and have an influence on the well-being of actual head-mounted display users, including maintaining a feeling of presence in the actual surroundings. In their work, they suggest several

design aspects for location-based virtual reality, such as safety and environment blindness. For example, for safety standards, they recommend clearly defining a separation between each interaction area, so it can increase felt safety while using location-based virtual reality. For environment blindness, they suggest letting people rapidly blend realities, so that it is able to easily help them to solve some problems of blindness in setting up a location-based virtual reality installation.

In addition, Salandra et al. (Salandra et al. 2018) built a virtual reality location-based mobile application, called PeakLensVR, for detecting mountain peaks with an inexpensive virtual reality headset. Their application allows people to capture scenic images of 360° panoramic mountains using a smartphone and then depict such images enhanced with metadata about the mountain peaks, such as name peak, distance from the viewer, and altitude. Their application can later convert annotated panoramic images into Adobe's XMP format aiming to help people to share easily and virally on social media. PeakLensVR is designed to extend the project from PeakLens—an augmented reality location-based mobile application built for taking and collecting photos of mountains. But this location-based virtual reality mobile application enables the recording of 360° panoramic images and their immersive replay virtually with a virtual reality device. Furthermore, Nash et al. (Nash et al. 2021) designed and presented a methodology utilizing a collaborative zine for generating knowledge on virtual reality experiences using location-based features for young people from a network project from The Arts and Humanities Research Council (AHRC) and the Economic and Social Research Council (ESRC). In their work, during the pandemic lockdown period, they ask each participant to give details to consider the recollections of their personal experiences of events and activities on the virtual reality network. Besides, Lugrin et al. (Lugrin et al. 2019) proposed a framework for creating and investigating location-based virtual reality applications as a new kind of virtual reality museum (Lugrin et al. 2018). This location-based virtual reality museum is built to support many physically co-located users simultaneously in a hangar-scale tracking area (approximately 600 sqm) with more than ten times larger virtual space (about 7,000 sqm). Therefore, in their work, every visitor can walk and share the same real world, while he/she can share the same virtual space too. Moreover, Wienrich et al. (Wienrich et al. 2018) studied the gain of positive social cooperation and presence, including mutual importance, to enhance the experience of location-based features, specifically the social experience, in wide-reaching multi-user virtual reality for an adventure in Germany's Immersive Deck of Illusion Walk. In their study, interdependence can largely establish social cooperation and presence in a virtual reality setting indicated by the social experience of location-based features. They suggest scientific design principles for collective and social aspects by assisting the possible effects of cooperatively mastering a valorous challenge for location-based virtual reality hosts. More recently, Turkay et al. (Turkay et al. 2021) also studied qualitatively for understanding the attitudes toward virtual reality esports and the experiences of participating in a location-based virtual reality game using both a pre-interview and a post-interview design. In their work, eight competitive Counterstrike: Global

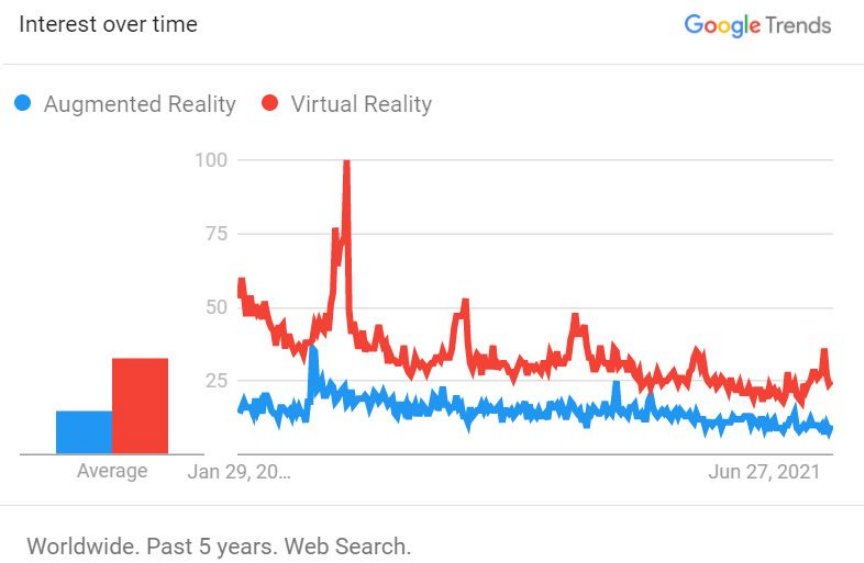

Figure 1: Comparison of Google trends worldwide for the keywords of "Augmented Reality" in blue color and "Virtual Reality" in red color in the past five years, collected on 24 January 2022.

Offensive players are selected from an esports club of a university in Australia for considering visceral and affective experiences in the virtual reality esports game. Therefore, using their qualitative study can assist design competitive location-based virtual reality esports more interactively.

In this way, it can be observed that location-based virtual reality can be used for different purposes to support and improve the experiences of people in the metaverse world. However, the works of location-based virtual reality we found are relatively low, if compared with location-based augmented reality. Therefore, the following section will explain a comparative analysis between location-based augmented reality and location-based virtual reality for understanding the essential trends.

COMPARATIVE ANALYSIS BETWEEN LOCATION-BASED AUGMENTED REALITY AND LOCATION-BASED VIRTUAL REALITY

In this section, we do a comparative analysis of augmented reality and virtual reality for the last five years. To analyze the trends of augmented reality and virtual reality comparatively, we collect data from Google Trends from 2017 to 2022. The collected data are analyzed from the popularity of top search queries in Google Search which is the largest market share among every available search engine. First, we compare the trends for two keywords with the same keyword length (two): "Augmented Reality" and "Virtual Reality". Figure 1 shows Google Trends worldwide for the "Augmented Reality" and "Virtual Reality" keywords between 2017 and 2022. The vertical axis depicts the number of search interests of two keywords in Google Search, while the horizontal axis shows the period of the research study. The average number

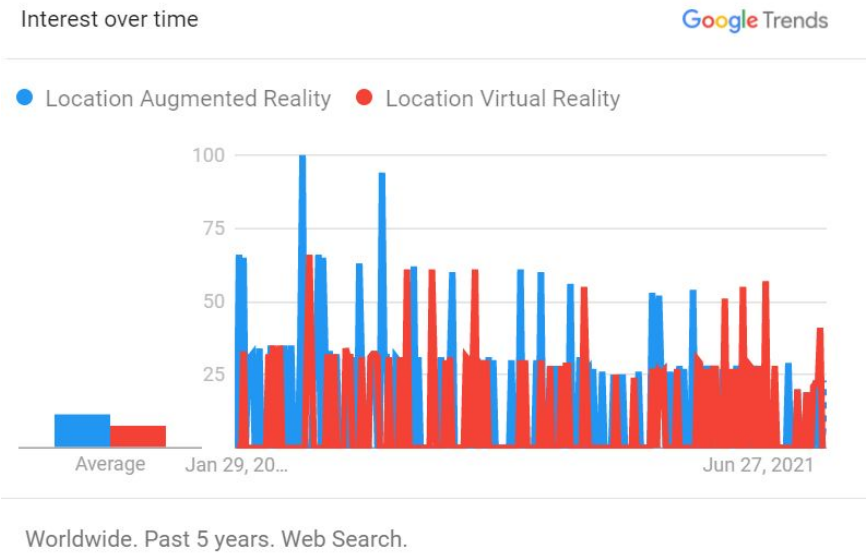

Figure 2: Comparative Analysis for the keywords of "Location Augmented Reality" in blue color and "Location Virtual Reality" in red color in the past five years from Google Trends, collected on 24 January 2022.

of search interests for "Augmented Reality" is 15, while the average number of search interests for "Virtual Reality" is higher than two times at 33. This means that augmented reality is more popular than virtual reality in terms of search queries. Next, we compare the trends for two keywords with the same keyword length (three): "Location Augmented Reality" and "Location Virtual Reality". Figure 2 illustrates Google Trends worldwide for the "Location Augmented Reality" and "Location Virtual Reality" keywords between 2017 to 2022. Nonetheless, the average number of search interests for "Location Augmented Reality" is 12, while the average number for "Location Virtual Reality" is 8 which is lower. Obviously, virtual reality receives more popularity than augmented reality in terms of search queries. But when adding up the keyword "Location", location-based augmented reality gains more popularity than location-based virtual reality. A possible reason is partly because of the variety and diversity of location-based applications in augmented reality coming together with the high-speed internet in smartphones during these last five years. But, we believe, the trend can be reversed if giant tech companies, such as Meta, Apple, Google, Amazon, and Microsoft, are interested in majorly investing in location-based virtual reality research in the next five years.

CONCLUSION AND FUTURE DIRECTION

This paper has investigated recent location-based virtual reality applications in different specific aspects of human-computer interaction and human factors and ergonomics to understand how the metaverse can help humans interact with the environment in a unique way. This is since location-based

virtual reality applications have various possibilities to improve the experiences of people in the metaverse world. We have also discussed the evolution of virtual reality using location-based features in the past five years. After that, a comparative analysis of virtual reality and augmented reality works in the past five years has been studied. We then compare location-based virtual reality and location-based augmented reality to see and predict the trends of the future.

Due to the trend rises and developments in the metaverse world generally, we believe that location-based virtual reality applications will receive a positive impact from these in the future. However, we predict that it will not get a significant impact just like augmented reality or virtual reality generally. This is because of the need for physical places or exhibitions in some specific cases for location-based virtual reality, especially during the COVID-19 pandemic period, even though we believe that the metaverse and related technologies will be the heart of the post-COVID-19 era.

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