A Systematic Literature Review on Metaverse

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Abstract. The metaverse, a virtual reality space with significant potential, is gaining popularity due to technological, social, and economic convergence, necessitating scholarly debate and understanding. The purpose of this study is to provide a structured evaluation of current literature using bibliometric analysis. This research uses bibliometric analysis tools to evaluate 2,490 publications in the metaverse area from diverse angles. The findings suggest that the metaverse technical revolution has cleared the ground for its implementation in various research fields throughout the last few decades. Researchers' interest in the metaverse has grown significantly in the previous two years. Computer science, engineering, social sciences, business management and accounting, and mathematics are the critical fields of Metaverse applications. In the face of continual change, advances in computer science substantially impact daily life, improving social interactions, communication, and human interaction. According to the data, intriguing information regarding the number of studies providing more significant levels of customer satisfaction, the most sought-after journals, the most referenced research papers, and top writers with Metaverse topics in their research work emerges. This study intends to provide academics with deeper insights through knowledge accumulation and contribute to advancing metaverse research. More in-depth content analysis may be explored in future studies. The metaverse research domain provides a wide range of avenues for exploration in all aspects of its investigation, making it a rich ground for future scientific inquiry.

Keywords: Metaverse, Systematic Literature Review, Bibliometric Analysis.

1 Introduction

Neal Stephenson first used the phrase "metaverse" in his critically praised 1992 book "Snow Crash," a work of fiction. It portrays a digital realm existing in parallel with the physical world, where real-world individuals possess interactive digital avatars, enabling them to interact and coexist within this virtual domain. The metaverse encompasses a spectrum of technologies, including 5G, AI, blockchain, content creation, and various other elements. The metaverse is fundamentally driven by the continued development of XR technologies and gear and by continuously optimizing users' digital life experiences through Extended Reality. This central objective aims to enhance users' digital existence by enabling seamless interactions and engagements through their avatars within the metaverse [1]. The infant, early, maturity, and final periods of the

metaverse's evolution are clearly distinguished. The early stage, which lasted from 2016 to 2020, was highlighted by crucial advancements in virtualization technology. From 2021 to 2030, the early stage involved incorporating online applications and technological innovations across diverse industries. The mature stage is predicted to start in 2031 when the metaverse is independent of various sectors. This development continues until the metaverse enters the final scene when the industry is more advanced and human involvement in the metaverse increases so that a sophisticated metaverse ecosystem is formed [2]. The metaverse presents promising prospects, particularly in engaging the attention of the newest generation, Generation Z [3]. The metaverse serves as a platform for individuals to convene and engage in social interactions; its application carries significant promise for educational and learning advantages. Additionally, the metaverse can transform the industrial sector by streamlining operations like maintenance and repair, initiating new production lines, remote monitoring and troubleshooting, remote control, and training new users and managers through simulation [4]. Technology assumes a crucial role as the driving force that propels the shift from the existing Internet paradigm to the metaverse [5]. Although still experimental, the Metaverse is poised to transform management and marketing across diverse sectors, including tourism, business, social interactions, economics, and education [6]. Despite presenting multiple industries with diverse prospects for digital transformation, knowledge remains scarce regarding the metaverse's evolution and the unresolved challenges that lie ahead [7]. This study distinguishes itself from prior research through the following differentiating factors: (a) it conducts a comprehensive literature review within the Metaverse domain; (b) it employs citation and keyword analysis to delve deeply into the literature, diverging from the conventional literature review method; and (c) it encompasses the entirety of Metaverse research endeavors, striving to present a bibliometric overview of significant trends in this realm.

2   Result and Findings

2.1   Demographic Characteristics Metaverse

A year-by-year distribution of publications in Metaverse from 1995 to 2023. A paper published in the Association for Computing Machinery by [8] in 1995 was the first in Scopus. There were only 17 papers found in the period 1995-2007 that discussed the metaverse. Across the years, there was a notable uptick of 113 in the total publication count between 2008 and 2014. In 2015-2021, the number of papers related to metaverse applications increased by 106. Since then, there has been a rapid increase in publications. According to the latest year, 2022, there were publications of 1.138 papers, and in 2023, the number increased to 1.220 documents on this topic. This shows that the metaverse has been widely applied in various fields with the speed of digitization and the increasing need for understanding in metaverse development. Regarding impactful nations, the United States holds the primary position with 373 publications and the most noteworthy citation count of 3,214 total citations. Following suit is China, which has the highest publication volume of 558 and accrues 2,373 citations. These two countries stand out as dominant forces in the Metaverse sector, excelling in publication

contributions and citation recognition. Metaverse research, in total, has been published in 2,490 journals based on the database listed in Scopus. Notably, Lecture Notes In Computer Science (Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics), published by Springer Science and Business Media Deutschland GmbH, takes the lead with the highest number of publications, totaling 80. The Acm International Conference Proceeding Series of the Association for Computing Machinery follows, with 39 publications. All studies' cumulative citations were analyzed to identify the most impactful research within the Metaverse domain. Notably, the work authored by [9] garnered the most significant citation count, amassing 240 citations in the Metaverse field, being the most cited paper because, when viewed from the topic raised, it is an excellent step to explore understanding and analyzing opportunities in the metaverse. Following it, the article from [10] received as many as 110 citations, demonstrating that the research on the subject is a solid foundation for using the metaverse. Among these notable authors, Wang Y. secures the foremost position with the highest TC value of 638 total citations, earning the top rank. Subsequently, Li J. attains the second position with a TC value of 517 citations. Furthermore, when assessed through the metric of Total Link Strength, Wang Y. emerges as the leading contributor with a notable 60,634 publications within the Metaverse field. Then Zhang Y has the second largest total link strength with 57,322 but is ranked third in total citation.

## 2.2 Top Five Subject Area
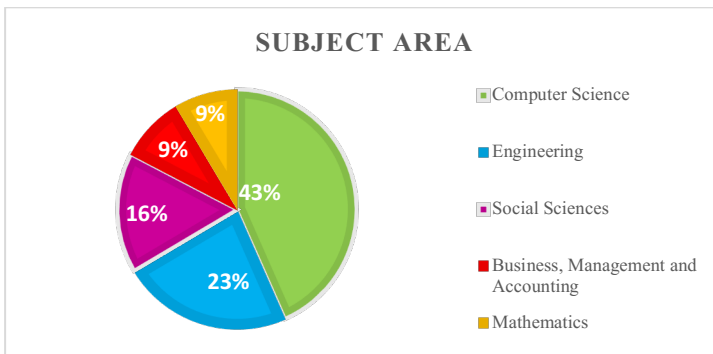
Source: Authors compilation

Fig. 1. Top Five Documents by Subject Area

Figure 1 shows the classification of various research areas where research on the Metaverse has been conducted. The author classifies the investigation into five subject areas based on the summarized Scopus data results. The first most significant contribution is in Computer Science at 43%; this is still related to the second largest gift, which is in the field of Engineering with a contribution of 23%. Innovation in computer science significantly impacts daily life, enhancing social relationships, communication, and human interactions in the face of ongoing change. Three significant waves of technical progress have been identified from the viewpoint of the end user, centered on the

arrival of personal computers, the Internet, and mobile devices. VR and AR two spatial and immersive technologies, are at the forefront of the fourth wave of computing innovation [11]. One of Southeast Asia's leading AR technology development companies. PT WIR ASIA Tbk was founded in 2009 by Daniel Surya Wirjatmo, Michel Budi Wirjatmo, Philip Cahyono, and Jeffrey Budiman, MA. WIR Group specializes in immersive AR, VR, and AI technologies in Southeast Asia and has provided solutions to various sectors worldwide [12].

2.3   Research Clusters in Metaverse

The authors employed keyword co-occurrence analysis using the VOS viewer to identify research clusters within the Metaverse domain. The bibliometric dataset revealed the presence of 11,951 keywords utilized in Metaverse research. Subsequently, a keyword co-occurrence threshold of 30 was established, and the top 64 items were integrated into the visualization, as illustrated in Figure 2. The size of the circles within this visualization corresponds to the co-occurrence frequency of keywords, with larger circles denoting stronger thematic associations within the Metaverse publication realm. Additionally, the proximity between keywords on the visualization signifies their relative strength and thematic similarity. Moreover, circles sharing the same color indicate research clusters encompassing similar subjects within these publications. The findings from the keyword co-occurrence analysis reveal the existence of four distinct clusters. Cluster 1, depicted in red at the top-middle position with 24 items, primarily centers on supportive components within metaverse applications. Moreover, Cluster 2, illustrated in green at the bottom-right quadrant with 17 items, this cluster is more oriented toward discussions on research topics that present opportunities for the benefits of metaverse applications. Cluster 3 is represented in blue (bottom left, 14 items), suppose it is concluded to have a focal point on matters closely related to human interaction when entering the metaverse world. Cluster 4 is yellow (bottom center, nine items) has a focus area on learning systems.
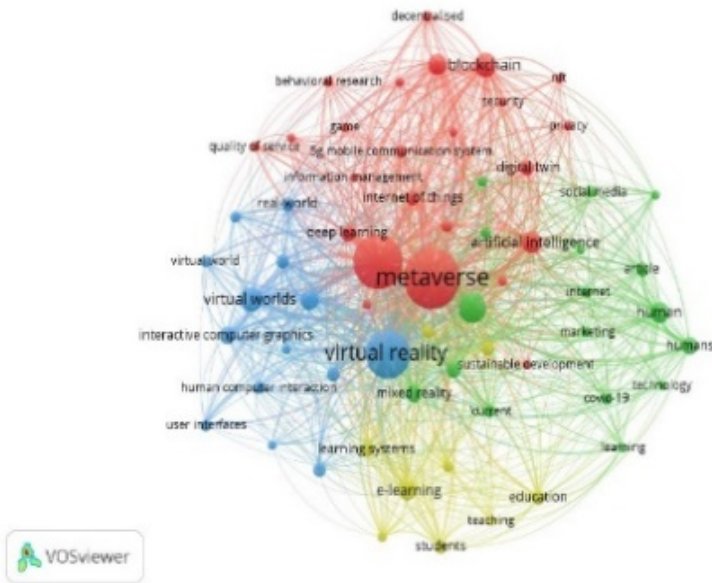
Source: Image generated by VOSviewer

Fig. 2. Keywords Co-occurrence Network
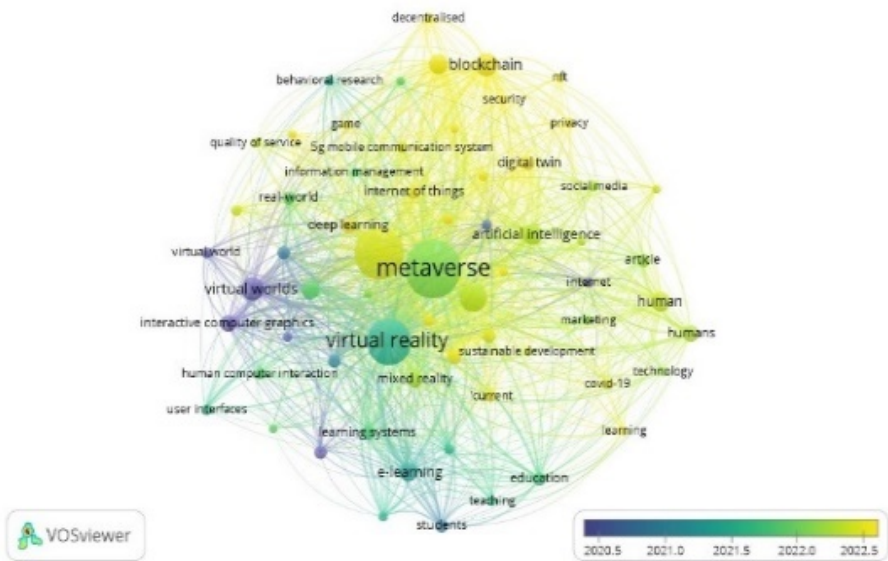
Source: Image generated by VOSviewer

Fig. 3. Keywords Co-occurrence Overlay

Furthermore, depicted in Figure 3 is an overlay showing keyword occurrences across recent years, ranging from 2020 (denoted by a dark color) through 2021 (represented in green) to 2022 (featured in yellow). The purpose of this visualization is to spotlight the thematic focus of contemporary publications within the Metaverse field. As discerned from Figure 3, prevalent keywords in 2021 encompass artificial intelligence, deep learning, the Internet of Things, digital twins, and social media. Furthermore, Table I illustrates the aggregate link strength linked to the ten most frequent keywords. Within this context, a link signifies a co-occurrence connection between two keywords, with each link attributed a positive numerical value that represents its potency. The substantial value indicates a robust association, while the opposite holds true [13]. Moreover, the total link strength delineates the frequency of co-occurrences between two keywords within a single publication [14]. Significantly, "metaverse" demonstrates the most substantial cumulative link strength when correlated with other keywords investigated in this study.

Table 1. Total Link Strength of Top 5 Occurrence

Metaverse				
Keyword	Cluster Number	Links	Total Link Strength	Occurrences	Average Publication Year
Metaverse	1	63	3890	1272	2022
Virtual Reality	3	63	3203	813	2021
Augmented Reality	2	63	1464	324	2022
Blockchain	1	60	956	205	2022
Virtual Worlds	3	62	979	203	2019

Source: Authors Compilation

3   Discussion and Conclusion

The Metaverse has a promising potential future and opens opportunities in various fields of application that are closely related to life. This study aims to offer a systematic literature review by applying bibliometric analysis. Within this paper, we meticulously scrutinize 2,490 publications within the realm of the Metaverse, employing a multifaceted approach that integrates bibliometric analysis. This investigation examines diverse bibliometric indicators, including identifying extensively referenced articles, noteworthy authors, nations, and research collectives. Additionally, the study divulges discernible trends within Metaverse publications, academic journals, and research spheres. Firstly, the research relied on the Scopus database for selecting Metaverse-related publications, potentially overlooking articles published in non-Scopus-indexed journals. Secondly, bibliometric analysis is contingent on the available information within Scopus, encompassing complete records and cited references. Future research could delve into deeper content analysis. The domain of Metaverse research offers expansive

avenues for exploration within each of its research facets, thereby providing fertile ground for future scholarly inquiries.

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