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EXPLORING THE METAVERSE: A COMPREHENSIVE BIBLIOMETRIC REVIEW USING SCOPUS DATABASE

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ABSTRACT
Metaverse is fast growing and emerging technology domain which has been adopted all around the world by organizations in different facets of business. The penetration of the internet and social media all around the world has paced the adoption where Gaming and social media companies are torch-bearers of the metaverse. As the metaverse becomes popular among various domains which include education, health, marketing, fashion, finance, and many more, the field of research has also seen the adoption of metaverse as a field of study by academicians around the world. Despite the growing domain of research, there is a dearth of review studies in the field of the metaverse, to fill the void authors conducted a bibliometric analysis. The Scopus database is taken into consideration to perform bibliometric analysis using the Vosviewer tool. The study identified the top publication and growth trends, domains, geographical distribution of documents and keyword analysis. Key results depict that as metaverse is related to technological advancements, the maximum research has also been done in the field of computer science and engineering. The contribution in the field from technologically advanced countries is highest, whereas from less developed countries the contribution in the field is negligible.
Keywords: *Metaverse, Bibliometric Analysis, Scopus Database, Citation Analysis.*

1. Introduction

A USD 1.3 trillion market size by the end of 2023 will make metaverse not just a fad technology but classify it as a fast-growing and emerging technology domain to watch out for. Metaverse is a term coined in 1992 by Neal Stephenson in his Novel Snow Crash (Ritterbusch & Teichmann, 2023). Metaverse is a virtual world that maps and interacts with the real world (Zheng & Yuan, 2023). Metaverse consists of two words Meta and Universe, Meta can be defined as transcending and the universe as a hypothetical next-generation Internet (Cheng et al., 2022). Metaverse can also be referred to as a virtual physical blended world in which multiple users can simultaneously interact (Lee et al., 2022). The metaverse is an integrative immersive network where boundaries between the actual and virtual worlds are unified and permit users to create their digital avatars to work, socialize and interact. Schroeder (2002) defined metaverse as, "computer generated, multi-user, three-dimensional interfaces in which users can also experience other users as being present in a virtual environment".

Till its inception, metaverse had seen progress in the last few years where various organizations are trying to explore the opportunity to adopt metaverse in different facets of business. At the same time, gaming and social media companies are torch-bearers.

Metaverse was popularized among users during the pandemic when dependency on the internet and the virtual world has been increased for education, business, and entertainment. Games like Roblox and Minecraft were the pioneers in adopting metaverse where users can not only create their own environment rather can communicate with other players with the help of their avatars (Rospigliosi, 2022). Metaverse is a social and innovative platform which has been leveraged by digital brands like Apple, Microsoft, Meta and non-digital brands Gucci, Nike, Samsung, Hyundai etc. (Mancuso et al., 2023). The penetration of Metaverse will still take time. Still, leading brands around the world are trying to take first mover advantage, hence in the year 2021, metaverse-related firms raised 10 million dollars in year 2021 (Hazan et al., 2022).

As the metaverse becomes popular among various domains which include education (Singh et al., 2022) health (Garavand et al., 2022), marketing (Barrera & Shah, 2023), fashion

(Sayem, 2022), finance (Dubey et al.,2022) and many more, the field of research has also seen the adoption of metaverse as a field of study by academicians around the world.

The key focus of the present study is to furnish an all-inclusive overview of top nations, domains, publications, authors, and most cited papers in the field of metaverse. The present study augments and advances already published work on metaverse, taking a specific approach like domain-specific, technology-specific, or methodology-based approach. The current research will try to find answers to the following:

RQ 1: What is the current statistical breakdown of metaverse publications, author contributions and specific domains adopted for metaverse-based research?

RQ2: How do various authors contribute to the field of the metaverse and what are the future trajectories in the metaverse research field?

2. Methodology

Bibliometric analysis is a widely accepted method for analyzing large datasets (Donthu et al., 2021), with the help of bibliometric analysis, researchers can analyze past data and chart future directions. The bibliometric analysis is a quantitative study of available material (Merigó et al., 2017), pertaining to a specific topic, authors, citations, or publications in a journal. Bibliometric analysis is a technique which provides a bird's eye view of a huge academic literature (Van Nunen et al., 2018). Broadus explained Bibliometric analysis as," the quantitative analysis of physical published units, or bibliographic units or of surrogates for either (Broadus, 1987). Bibliometric analysis is an approach to assess and monitor the development of research by organizing and linking the basic information of documents such as citations, authors, keywords, coauthors etc(Ferreira, 2018).

The bibliometric analysis consists of two groups; Performance analysis and scientific mapping (Donthu et al., 2021), where performance analysis explains the contribution of research components while scientific mapping explains structural and intellectual connections between the research (Agac et al., 2023).

While carrying out a bibliometric analysis is very important to select a database, its availability suitability, and consequences of use (Sánchez et al., 2023). The validity of the analysis also depends upon the selection of the database, as it should sufficiently cover the selected field of research.

The paper is organized as follows: First, the authors overviewed the relevant literature pertaining to the topic and framed research questions. Then the methodology part includes the loading, extraction and conversion based on specific keyword searches. The keywords used to identify, the past research happened in the area selected for analysis and provide useful analysis while searching for documents in the database (Broadus, 1987). Initially, in the Scopus database, the authors searched for the keyword metaverse, which resulted in all the documents including keywords like metaverse, metaverses, virtual reality, augmented reality, blockchain, artificial intelligence, virtual world, e-learning, immersive, human, digital twins, mixed reality, digital reality, extended reality, deep learning, internet of things and avatar name the few. In the present research, authors limit their search to the keywords 'metaverse' and 'metaverses". The Boolean expression of keyword search is as follows:-

TITLE-ABS-KEY (metaverse) AND (LIMIT
(EXACTKEYWORD , "Metaverse") OR LIMIT
TO (EXACTKEYWORD , "Metaverses"))

With these keywords, authors tried to capture the main concepts, technologies and trends associated with the metaverse industry.

The major gap in the metaverse-related bibliometric analysis is the use of databases, in the past web of Science *databases were* taken into consideration for bibliometric analysis (Wider et al., 2023), while the current research considered *the Scopus* database, as it is the most accepted database all around the world and has better user interface than other present databases.

The data of this research was retrieved from the Scopus database in October 2023. Scopus database was chosen as the search engine because it is the most used and widely accepted

database. Scopus delivers the most comprehensive view of research in the areas of computer science, technology, business, arts and humanities (Sweileh, 2018).

2.1 Inclusion and Exclusion Criteria

The authors conducted preliminary research related to the keyword 'metaverse.' In the Scopus database after searching for a given keyword, it retrieved 1882 documents from year 2006 to 2023. It is interesting to note that the maximum research on the metaverse has taken place in the last five years, only 68 papers were published in the field of metaverse from year 2006 till 2018. Based on the study's objectives, the second part of screening literature started by limiting the search to the English language, which further eliminated 91 documents, resulting in 1791 documents. English is a primary and dominant language in research publications across various fields, with most articles published in English. Analyzing articles published in English provides a broad representation of global research trends (Piwowar et al., 2018).

The authors included all types of research, the maximum of which consisted of articles and conference papers. The other types of documents include conference papers, reviews, book chapters, editorials, notes, letters, books, short surveys, retraced and data papers.

For constructing and visualization of bibliometric data VOSviewer software has been used (Van Eck & Waltman, 2017). Vosviewer plays an important role in visualization and bibliometric networking (Van Eck & Waltman, 2010). The data from Scopus was exported in .csv files, which is as per the requirements of Vosviewer.

3. Results and Discussions

3.1 Publication Output and Growth Trend

With the help of analysis, it has been discovered that the maximum number of manuscripts with 'metaverse' as a keyword was published during the years 2022 and 2023. The Scopus database shows very few manuscripts were published in the area of metaverse before 2021. In the year 2022, a total of 623 documents were published on keywords pertaining to Metaverse, while in the year 2023 total of 1156 documents were published. The detailed analysis of documents published and growth trends is presented in Figure 1. The reasons may include the rapid advancement of technology that has facilitated access to Metaverse anytime, anywhere (Tlili et al., 2022), the rapid acceptance of Metaverse also generated the interest of the research fraternity. In recent years, Metaverse has been analyzed from various perspectives including environment, health, education advertising, finance and many more, this could also be one of the reasons for sudden growth (Piñeiro et al., 2024).

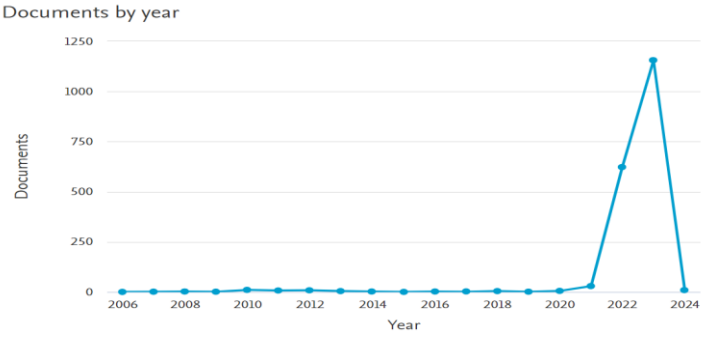

Fig. 1. Publication Outputs and Growth Trends

3.2 Types and Research Directions of Metaverse Publications

There are 1791 papers published in the area of metaverse listed in the Scopus database, and their bifurcation includes (Figure 2), 49.9% of articles, 39.5% of conference papers, 5.5% of review papers, 2.6% of book chapters, 0.9% editorials and others are Notes (0.7%), letter (0.4%), Books (0.3%) short survey (0.2%), Data Paper (0.1%) and others (0.1%). The findings imply that the articles and conference papers are the majority of Metaverse research. The lack of other sources indicates that metaverse is still in its early stage of research as the domain.

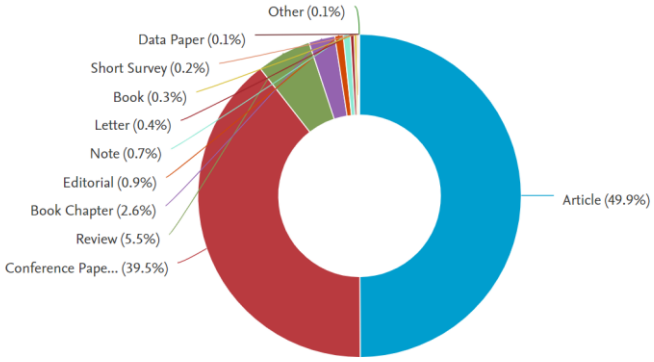

Fig. 2. The Distribution of type of publications related to Metaverse research

Figure 3 depicts the distribution of metaverse-related research in various categories, where a maximum number of papers has been published in the computer science domain followed by engineering. The results indicate the potential of metaverse-related research and wide future applications in all potential domains.

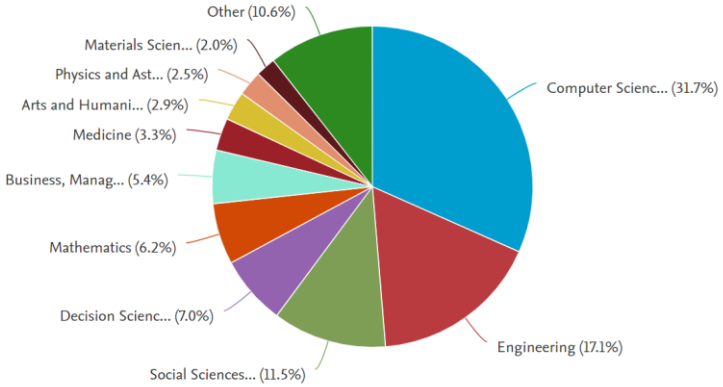

Fig. 3. The Distribution of Metaverse-Related Research In Various Categories

3.2 Authors and Their Cooperation

As per the gathered data (figure 4), 160 authors published a minimum of three documents in the metaverse domain from the year 2006 to 2023, D. Niyato from the School of Computer Science and Engineering published a maximum of 41 documents in the field, followed by Z. Xiong (26 documents), J.Kang (22 documents) and M.Deveci (12 documents). 76 authors published a minimum of three documents during the period and indicated the acceptance and interest of academia in the field of metaverse.

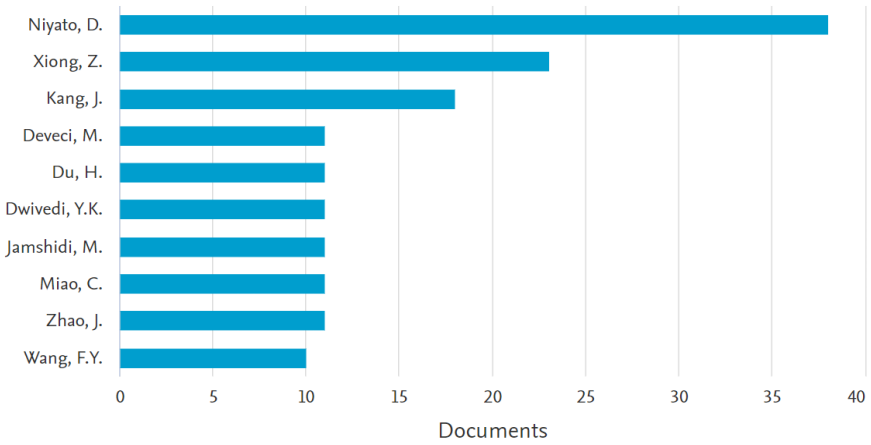

Fig. 4. Documents published by authors

3.3 Geographical Distribution

The analysis discovered that the maximum contribution had been made by China with 399 documents (Figure 5) published in the Scopus database. Authors from the United States of America surged to second place, followed by South Korea in third place with 258 and 216 documents respectively. Based on the addresses of the authors as per the Scopus database, the individual document has been assigned based on the country of origin of the manuscript and the institution where the author is affiliated too. Authors spread around 93 countries have published their findings out of whom 103 documents are undefined, this may happen as authors did not disclose their affiliation in publication.

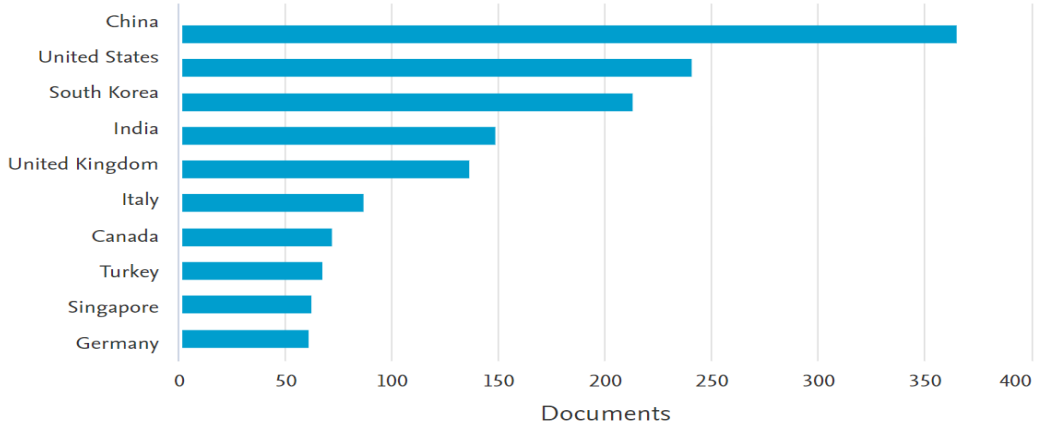

Fig. 5. Geographical Distribution of Documents

3.4 Top Cited Articles

Citation analysis is the most common technique used for science mapping. In citation analysis, the impact of a publication can be measured through its citation. Citation of publications also determines its importance, acceptance, and quality in the field of research. In the analysis of top-cited articles, researchers found that the paper titled 'A Metaverse: Taxonomy, Components, Applications, and Open Challenges' (Park et al., 2022) received 411 citations and topped the citation list. It has been followed by a paper titled 'Metaverse beyond the hype: Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice, and Policy' (Dwivedi et al., 2022 & Dwidevi et al., 2023), which received 357citations to date. It is interesting to note that among the top two cited articles one is from the engineering domain while the other paper is from the business management domain, hence it can be concluded that the metaverse is research of interest in all the domains.

For visual analysis of citations authors also performed citation analysis on Vos viewer. The minimum 3 citation criteria per document have been set on software, which results in 36 clusters of 308 items. Out of these 36 clusters, 3 consist of only one item.

Furthermore, to find the most influential authors collaborative relationship analysis has been done.

For the analysis, the authors have used VOS viewer Software. The size of the circle represents the occurrence frequency of the author. Vos viewer has given output of three clusters of a total of 12 items being created, it is noteworthy that authors who have relationships in one group also have relationships with other groups. For instance, D. Niyato collaborated primarily with red-group authors, but he has also a strange relationship with J. Kang & Z. Xiong of the blue group and Z. Han, and M. Xu from the green group. The interpretation of the same can be that Niyato has collaborated with a maximum no. of authors (Figure 6).

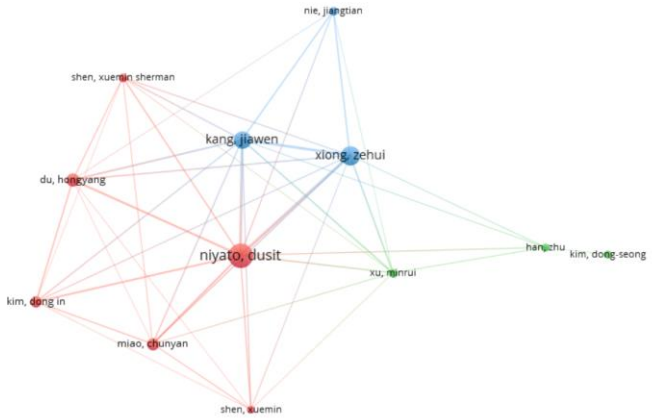

Fig. 6. Collaboration between Authors

3.5 Co-authorship Between the Countries

Based on bibliometric data collected from the Scopus database, the country co-authorship visualization was created with the help of VOSviewer (Figure 7). The threshold of a minimum of 5 documents was set. Out of a total of 124 countries, only 65 met the threshold. Vosviewer generated a total of 10 clusters with 10 links. The size of the circle represents the number of documents, the larger circle interprets more documents (Guo et al., 2019). For instance, cluster 3 which is the biggest cluster (Figure 5) consists of China, Hongkong and Macau authored a lot together with 405 documents. On the other hand, cluster, 1 consists of 14 countries but only has 20 documents, which means authors of 14 countries co-authored 20 papers.

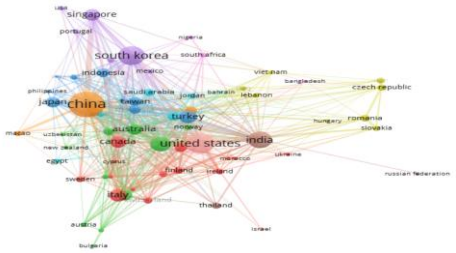

Fig. 7. Co-authorship between Countries

3.6 Bibliographic Coupling

Kessler defined Bibliographic coupling as a single item shared by two documents is defined as a unit of bibliographic coupling (Kessler, 1963). Bibliometric coupling is the most accepted and widely used technique for citation analysis, one of the main reasons behind this is it can successfully cluster over 92% of documents (Boyack et al., 2010). Authors performed bibliometric coupling of documents and bibliometric coupling of authors using Vosviewer. The bibliographic coupling of documents is shown in Figure 8. A total of 12 clusters were obtained from the analysis. Cluster 1 has the highest 45 items, while the smallest is cluster 12, with only 6 items. Further, while performing the bibliometric coupling of documents in the present research authors found that there are four major clusters which are anchored by Park, Rauschnabel, Dwivedi and Duan.

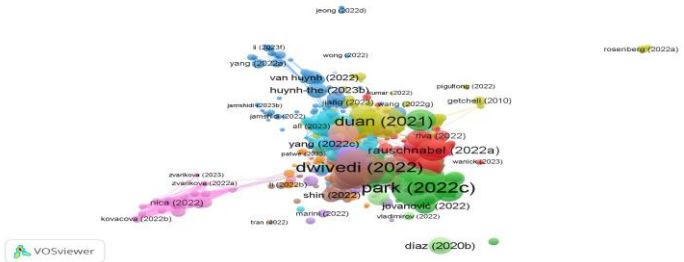

Fig. 8. Bibliographic Coupling of Documents

To understand the phenomenon of two authors citing the same paper for metaverse-related research, we performed the author bibliographic coupling (Figure 9). A total of 8 clusters are being created by Vosviewer, where cluster 1 is the biggest one consisting of 14 items, and cluster 7 & is the smallest consisting of two items each.

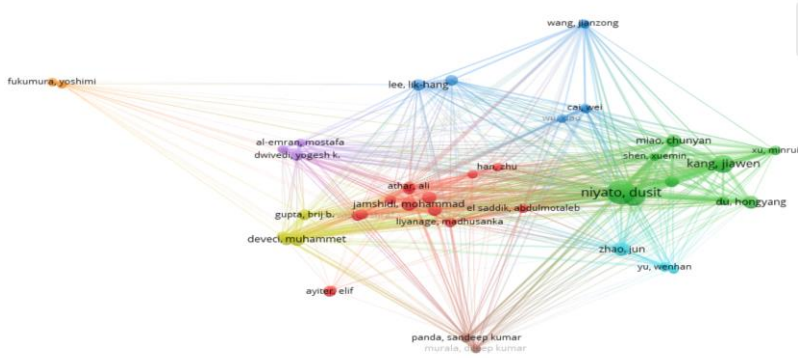

Fig. 9. Bibliographic Coupling of authors

3.7 Keyword Analysis

Although authors limited their research to only the keyword ‘metaverse’, there are many keywords which coappear in the documents with metaverse. To understand the content association and characteristics related to metaverse research authors performed a co-occurrence analysis of keywords (Pan et al., 2023). Co-occurrence analysis can reveal the content association and characteristics implicit in metaverse research based on the quantitative study (Kraus et al., 2020). A total of 9724 keywords appeared in the selected documents other than metaverse. The threshold of a minimum of 5 words has been set for the co-occurrence of keywords, only 647 keywords met the criteria, and a total of 12 clusters have been created (Figure 10).

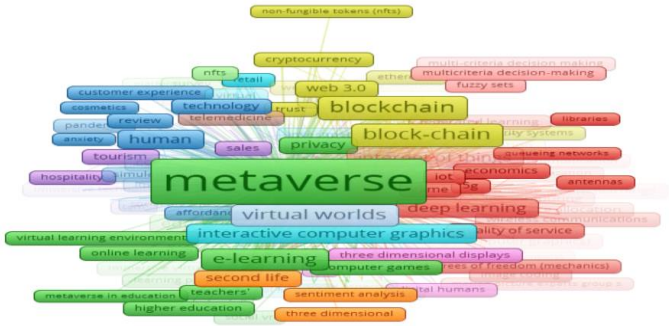

Fig. 10. Keyword Analysis

3.8 Co-Citation Analysis

Co-citation analysis is used to study the academic construction of the metaverse domain. Co-citation analysis is a type of content analysis that can be applied in the context of co-cited refrences that occur in the reference list of two or more citing articles(Mustafee, 2014). The co-citation analysis generated three clusters, and content analysis was then performed on clusters. Subsequently, a comprehensive review of articles within each cluster was conducted to identify and categorize their respective topics.

Cluster 1: Metaverse Concepts and its Framework

Cluster 1 is the largest among the clusters and consists of 11 items, and its primary focus is on the metaverse as a concept. The metaverse as technology is comparatively new for many scholars as a field of study. The articles in this cluster specifically discuss metaverse taxonomy and framework. The most influential study in this cluster Park & Kim, (2022) describes the concept of metaverse from the technological development of deep learning and generative models. Mystakidis (2022) provides contemporary development of the metaverse, where he

discusses street and oasis as metaverse protocols and metaverse implementations in the virtual world.

Cluster 2: Metaverse and Enabling Technologies

Cluster 2 focuses on the enabling technologies of the metaverse from a societal perspective and answers how a technology like Metaverse helps society to improve and answer various stereotypes i.e. gender, race and physical disability (Duan et al., 2021). There are various technologies like Extended Reality, User Interactivity (Human-Computer Interaction), Artificial Intelligence, Blockchain, Computer Vision, IoT and Robotics, Edge and Cloud computing, and Future Mobile which enable the current virtual scenario to transform into a metaverse universe (Lee et al., 2022).

Cluster 3: Metaverse and its Applications

The last and smallest cluster focuses on applications of a metaverse in various fields like advertising, blockchain, marketing, multimedia government, augmented reality, virtual reality etc. The presence of Ball M., (2022) work, how metaverse will revolutionize everything suffice the nomenclature of the cluster in the multidisciplinary domain. Further, another paper in the same cluster by Kim (2022), tried to explore opportunities of a metaverse in the advertising field. The paper also created a future research direction for the metaverse specifically in the advertising domain which includes computational advertising, interoperability, cross-cultural impact, ethical and privacy issues etc.

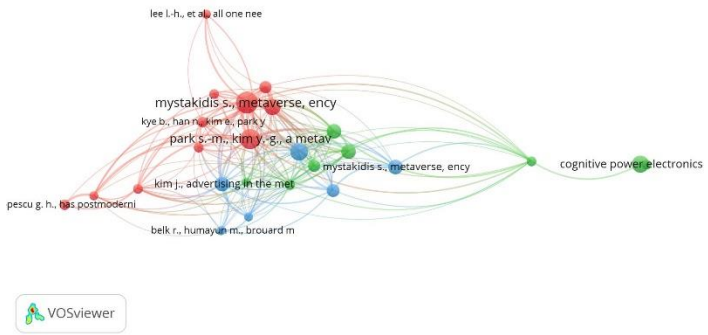

Fig. 9. Co-Citation Analysis

4. Conclusions

This research will help future studies to understand the metaverse domain, as well as better prepare to explore the world of the metaverse. The interest of scholars in the metaverse has increased in the last few years, although some excellent research is being conducted in the field, which is being reflected through citation analysis. The results of the analysis will provide an overview of the promising research field which will allow scholars to locate their research in this area and open new research avenues.

The present research also depicts that business management, medicine, arts & humanities, physics, and material sciences are still unexplored fields of research, scholars may explore these areas for metaverse-related research. The maximum number of articles in the metaverse field are published in the computer science domain, followed by the engineering domain.

The top five countries with the most publications in the field of metaverse are China, the USA, South Korea, India, and the United Kingdom, with China topping the list with 401 documents. As the metaverse is related to technological advancements, the maximum research has also been done in technologically advanced countries, while from less developed countries the contribution in the field is negligible. Manager technological companies developing metaverse-related applications can consider this finding and trickle down in developing countries. Another managerial implication is to develop metaverse applications as per the needs of target segments in developing countries. The research community can also contribute by suggesting and making scholarly contributions in a few domains like antecedents of metaverse adoption, infrastructure availability or development, cost-profit analysis etc.

Most of the articles published in the metaverse domain were in the book series, followed by conference proceedings. Interestingly, two articles authored by Dwivedi have been listed in the top 10 most cited articles, and both are published in management journals (Dwivedi et al., 2022 & Dwidevi et al., 2023).

There are some limitations of the present study, first, the research is limited to publications listed in the Scopus database, although Scopus is the most accepted database around the world, it does not contain all the publications in the field of metaverse. The author of future studies can consider other databases for study or compile two or three databases together to have a complete picture of the metaverse domain. Secondly, the authors of the present study adopted bibliometric analysis where output is quantitative, hence research did not analyze the content of documents. Based on these limitations, future research can plan content analysis-related research in the metaverse field.

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