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TOPICAL REVIEW

A Review of Metaverse's Definitions, Architecture, Applications, Challenges, Issues, Solutions, and Future Trends

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ABSTRACT Metaverse is a vision enabling to constitute an environment in which someone could see real and virtualized worlds. The Metaverse is a product (or something similar as we do not yet know its final form) of such technologies. In this circumstance, when applications that utilize the Metaverse are used, there seem to be no transportation charges, and there is no cap on amounts of individuals, users, players, learners, or trainee who can take part. Hence, and due to such a feature, the Metaverse has attracted various researchers from different fields where it has been exploited by them to contribute to those fields and research areas. As for example, it is possible to teach various target audiences by offering different events and classes from any location in the globe. In order for a participant to utilize the Metaverse, there are necessary conditions to be considered as well as other settings to be initialized. In line of this, virtual reality, augmented reality, availability of required sensors, smart glasses, headsets, and few others are considered some examples of such conditions and settings that the Metaverse requires. Despite the advantages that Metaverse offers us, there are a number of considerations that must be taken into account while developing it by interested researchers. One of these concerns is the Metaverse privacy regarding the participants (represented as avatars inside the Metaverse environment). Another issue is that since the Metaverse is still in its early stages, many attempts have to be made from interested researchers who engage to develop it to enhancing it. This review aims to survey related articles that concern the Metaverse and its development providing a review of the chronological stages throughout the history of the development of Metaverse. It aims also to list a number of recent technological advances allowing the Metaverse. Besides, Metaverse's definitions, properties, architecture, and applications have been discussed and listed in this review. The novelty of this article is that it has suggested a framework to a number of issues that are still paid attention for potential solutions by researchers aiming to contribute to researchers and designers to consider such an issue and its corresponding solution for future research works and enhancement. Challenges faced by researchers and other relevant concerned issues related to Metaverse have been in detail discussed and highlighted. Besides, future trends have been clarified.

INDEX TERMS Metaverse, virtual reality, augmented reality, web 3.0, metaverse privacy, games, graphics, Internet of Things (IoT).

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I. INTRODUCTION

Metaverse was not a product of the present era [1], in addition to all its accessories such as physical devices (e.g., sensors, glasses, and headsets) [2], [5] and software (e.g., 3D object design, graphics, and others) that have been specially manufactured to improve Metaverse services [6], [8]. On the contrary, the Metaverse had gone through several stages and phases throughout a long period of history, where attempts to improve its services and the developments accompanying it are still taking place daily [7], [9], [13]. There is a significant effort being made by researchers, designers, developers, decision makers, and others to enhance the Metaverse [14]. They are racing against time to make the fantasy world of Metaverse look very cool and attract many users to enter its world [15]. Currently, there are many people who are actively involved in accessing the Metaverse world, due to the successive developments in this field that the Metaverse is witnessing on a daily and increasing basis. However, with this actual increase, there are many risks, for example, the issue of privacy.

The Metaverse is still needed to be discovered and understood well by researchers so that they can improve it and contribute to be developed and improved [15]. There is still a gap in this direction. The motivation of this review paper is to collect and survey a number of recently published researches related to the Metaverse and its associated topics such as security, privacy, graphics and few others in order to show what are the recent advancements of the Metaverse.

Comparing this review to other Metaverse's reviews can highlight that this paper provides and lists a number of challenges faced by the Metaverse according to a selected theme. Also, this review lists a number of trends and their corresponding needed improvement in the future. Besides, this review suggested a framework related to the Metaverse's issues and their corresponding solutions. The suggested framework aims to initialize a high-resolution, light-weight, strong private, and secure Metaverse.

A. A WINDOW TO METAVERSE HISTORY

A number of developments and attempts that have been directed to the Metaverse through multiple stages over time, will be reviewed.

1) METAVERSE BEFORE 1990S

To make lenses that use the optical sensation of depth, a 3D image was produced from two single images [16], [17]. VR headsets use that conceptual idea. Stanley Weinbaum's 1935 book *Pygmalion's Spectacles*. In this tale, a character used spectacles to see, hear, taste, feel, and touch a fictional world.

In the 1970s, MIT created the Aspen Movie Map, a computer-generated tour of Aspen. VR was originally used to transport people [18].

2) METAVERSE IN 1990S

Neil Stevenson's 1992 novel *Snow Crash* coined the term "Metaverse". Stevenson's protagonists used the Metaverse to escape authoritarianism [19].

Sportsvision broadcast the first NFL game using a yellow yard flag in 1998. Since then, other sports broadcasters have begun superimposing graphics over real-world visuals [20].

3) METAVERSE IN 2000S AND BEYOND

"Ready Player One" (2011) is another immersive world by Cline [21]. Steven Spielberg adapted the novel into a 2018 film [22].

In 2014, Sony, Samsung, and Google unveiled VR headsets [23], [24]. Cheap smartphone VR viewer Google Cardboard. 2016 HoloLens headsets offered AR and VR [25]. HoloLens can create and edit holographic images using AR. Pokémon GO was played worldwide in 2016 to catch Pokémon.

In 2017, IKEA's Place app allowed users to share their home's contents [26]. Apple added Lidar to iPhones in 2020 for AR and MR headsets [27]. Facebook was renamed Meta in 2021 to emphasize its role in Metaverse development [28]. Two additional companies have released eyeglass-like VR headsets (Ray-Ban Stories and HTC Vive Flow) and wearable technologies (Ray-Ban Stories).

In 2021, Facebook officially was renamed to Meta to reflect the commitment to being a driving force in the development of the Metaverse [28]. Wearable technology (Ray-Ban Stories) and very portable VR headsets (HTC's Vive Flow) designed to appear like eyeglasses have also been released by two other businesses.

B. CONTRIBUTIONS

There are a number of contributions mentioned in this article which will be highlighted as follows:

1. This article has reviewed latest and recently published articles that focus on the Metaverse.
2. It has provided an analysis on articles reviewed considering several criteria.
3. It has discussed and reported a number of challenges faced by researchers in the field of Metaverse to be concerned out.
4. It has listed several future trends and directions that might be addressed in the so near future for the Metaverse development.
5. It has suggested a framework to a number of issues that are still paid attention for potential solutions by researchers.
6. It has highlighted and listed a number of concluded remarks that look to be of interest to many researchers for Metaverse development.

C. ARTICLE'S ORGANIZATION

This article has been organized as follows: Section I is dedicated for the Introduction in which a historical brief related to the development of Metaverse has been provided.

In Section II, a background has been provided highlighting relationship between Web 3.0 and Metaverse alongside a brief on recent technological advances allowing the Metaverse. Section III has listed a number of Metaverse's definitions and its properties. In Section IV, the Metaverse architecture has been presented and illustrated. The Method applied in this review to select the articles reviewed has been explained in Section V. Findings from literature reviewed have been highlighted in Section VI. In Section VII, Analysis and Discussion have been presented and discussed. Conclusion has been drawn in Section VIII including limitations.

II. BACKGROUND

A. WEB 3.0

One way to think of the Metaverse is as an Internet that is entirely immersive. In this World Wide Web (WWW), everyone can have access to augmented reality (AR) as well as virtual reality (VR), and humans could be able to interact with a wide variety of settings by using permanent avatars and cutting-edge digital technologies [29]. As we work to build cutting-edge technologies for Web 3.0, now we could look back at a number of the most important historical achievements that have brought us to today's development. That is the Metaverse universe.

There has been a significant technological advancement with the arrival of Web 3.0 (Web3). The WWW (commonly known as the web) is the underlying platform upon which all other internet services are built [30], [31].

There is no final, agreed-upon definition of Web 3.0 since it is still in the process of developing and being defined. One thing that is certain, however, is that Web 3.0 will place a premium on decentralized software. Machine learning and artificial intelligence (AI) will also be used in Web 3.0 to facilitate the development of smarter and more flexible software [30].

To what end does Web 3.0 serve? The answer simply is that Hypertext Markup Language (HTML) specifies the layout and delivery of websites using Web 1.0 and Web 2.0 technologies. Web 3.0 will still rely heavily on HTML, although the language's connections to and locations of data sources may seem different from those of previous iterations of the web [30].

B. RECENT TECHNOLOGICAL ADVANCES ALLOWING THE METAVERSE

We will briefly provide here a summary to the recent technological advances allowing the Metaverse.

Metaverse is an Internet-based 3D universe featuring virtual land and things. Imagine a future where you may work remotely, tour virtually museums, and attend virtual concerts from home.

Industries use cutting-edge technologies such as blockchain, AR, VR, 3D reconstruction, AI, and Internet of Things (IoT) to power the 3D Metaverse [32].

1) BLOCKCHAIN

Blockchain technology enables decentralized digital evidence of possession, digital collectability, value transfer, transparency, and connectivity. Cryptocurrency lets people transfer wealth in 3D while working and socializing. Decentraland's virtual lands may be bought using bitcoin. With the game's cryptocurrency, players may buy 16 × 16-meter non-fungible tokens (NFTs). Blockchain technology can safeguard virtual land ownership. In the future, crypto might possibly serve as an incentive for individuals to participate and work in the Metaverse [32].

2) AR AND VR

AR and VR provide an immersive 3D experience. AR morphs the actual environment with digital visuals and characters. It's more accessible than VR and works on practically any smartphone or digital camera. VR already integrates fictitious visuals. AR and VR function like a proto-Metaverse. VR can add physical simulations to the Metaverse.

3) AI

In latest years, AI has been used for corporate strategy planning, decision making, face recognition, and speedier computing. Recently, AI specialists have studied creating immersive Metaverses. AI can analyze data quickly. AI algorithms may learn from past iterations and historical data to provide distinct output and insights. AI might create Metaverse avatars. AI algorithms can evaluate 2D and 3D photos to create lifelike avatars [32].

4) 3D RECONSTRUCTION

The usage of 3D reconstruction had increased throughout the epidemic, notably in real estate since lockdowns prohibited purchasers from viewing houses in person. Some organizations use 3D reconstruction to provide virtual property tours. Like in the Metaverse, customers might see new houses from any location and purchase items without entering. The Metaverse must build a digital environment as realistic as feasible. 3D reconstruction creates natural-looking environments. Special 3D cameras produce lifelike 3D representations of buildings, environments, and items online.

5) INTERNET OF THINGS (IOT)

IoT links our real environment to the Internet via sensors and gadgets. once a connection to the Internet, such devices are given a unique identifier and can automatically send or receive data. IoT connects thermostats, speakers, medical gadgets, and more to data. IoT may gather and deliver physical world data in the Metaverse. This increases digital precision. IoT data streams might modify how Metaverse items work dependent on weather or other variables [33].

6) EDGE COMPUTING

Edge is simply a distributed form-work like cloud computing but it's a small data center near to user. Users may access

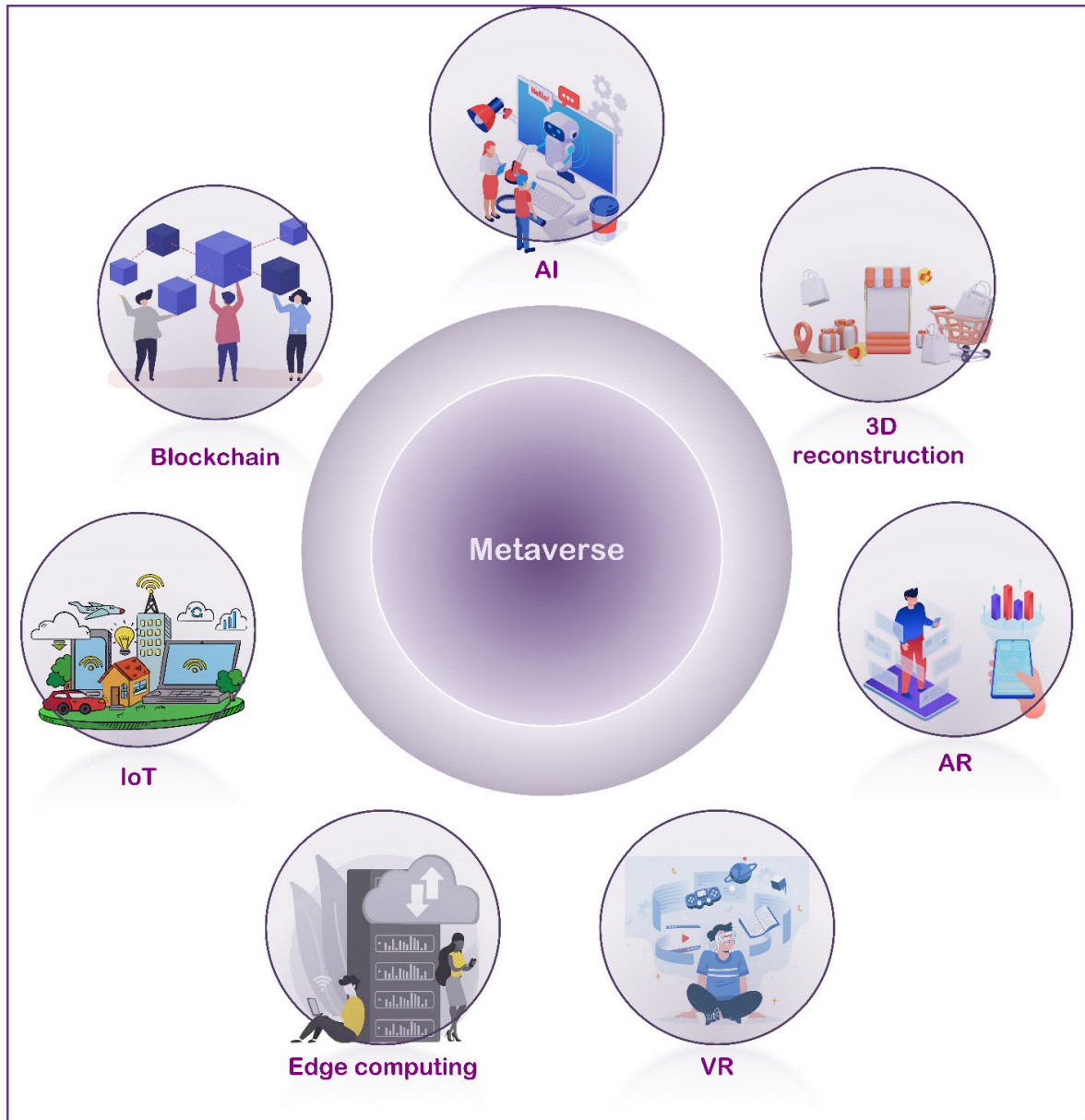


FIGURE 1. A graphical representation of the technological advances allowing the Metaverse. Images are licensed. Design is made by authors.

computing, storage, data, and application capabilities similar to those offered by the cloud on the edge. Engaging the user and allowing them to get fully submerged in the Metaverse are essential if they are to have an experience on par with the actual thing. Due to this, the lag between a user's input and an effect should be made negligible. Edge computing enables fast reaction times by placing a collection of computers and networks in close proximity to their consumers [33].

Discussed above are the recent technological advances allowing the Metaverse. For a more clarification, these elements are encapsulated in one drawing. Illustrated in Figure 1 is a graphical representation of the technological advances allowing the Metaverse.

To interpret why this mix of varied technological terms are highlighted in Figure 1, we need to say that these seven elements highlighted in Figure 1 point out those technologies initialized the metaverse to be. These elements (technologies) are the basic core of Metaverse. Meaning, the Metaverse rely on them.

III. METAVERSE DEFINITIONS AND PROPERTIES RETRIEVED FROM THE REVIEWED LITERATURE

A. METAVERSE DEFINITIONS

A number of Metaverse definitions extracted from the literature and reviewed articles will be mentioned and highlighted. Provided and listed in Table 1 are few samples of definitions of Metaverse.

TABLE 1. A list of summarized Metaverse definitions retrieved from the reviewed articles.

No.	Metaverse definition	Ref.
1.	The Metaverse is a virtualized cloud world where users may use their own avatars to communicate and trade with virtual pals. It's possible to roam about and participate in Metaverse.	[34]
2.	Metaverse is a location, where virtual and actual salespeople may meet to market their goods. As a result, all of the games are being renamed the Metaverse Portal.	[34]
3.	The term "Metaverse" refers to a collection of completely immersive digital environments in which users may speak with each other via 3D avatars. This mode of interaction has the potential of becoming an extremely prevalent means by which persons/ friends engage among each other.	[35]
4.	To put it another way, the Metaverse seems to be a communal virtual shareable place, generated by the confluence of virtually improved actual world with permanent virtual space.	[36]
5.	The convergence of virtually enhanced physical reality and digital reality gives rise to the phenomenon known as the Metaverse.	[1]
6.	Metaverse is a setting through which users in various environments may benefit from better immersive experiences.	[37, 38]
7.	The Metaverse is an enlarged and synchronized means of communicating that enables its members to tell their stories with one another.	[39]
8.	The Metaverse is a permanent as well as persistent multiple user environment that combines actual universe plus digital virtual world. It is also known as the post-reality world.	[1]
9.	The real and digital worlds are both incorporated into the Metaverse to create a new visual universe.	[40]
10.	The Metaverse is an enlarged virtual environment where reality and virtual reality reside alongside one another and where interoperability and openness are evolving as essential components.	[1, 41]
11.	The Metaverse is a virtual environment that lies near reality.	[42]
12.	A virtual world with its roots in a computer and a foundation in a variety of different ideas is what people mean when they talk about the Metaverse.	[19, 43]
13.	The Metaverse ecosystem is either a simulation of a 3D world or a parallel universe.	[44]
14.	The term "Metaverse" was coined by combining the words "Meta" and "Universe," and it refers to a new kind of virtual world that goes beyond the norms of the physical one.	[45]
15.	The Metaverse is a cyberspace that will eventually manifest itself as an extension of the physical reality of the existing world.	[3]
16.	The term "Metaverse" refers to the concept of a hypothetical always-on 3D network of virtual spaces where users can do a wide variety of activities such as socializing, connecting, learning, working, shopping, playing, and more through the use of data-driven and immersive technologies.	[46]
17.	Virtual worlds, augmented realities, mobile lifelogging, and mirror universes all make up the Metaverse.	[3]
18.	Typical Metaverse gadgets include virtual helmets and smart eyewear.	[47]
19.	The Metaverse is a type of virtual environment that can imitate the natural world through the use of interactions with many senses and 3D objects.	[44]
20.	In the Metaverse, the screen is now closer to the viewer's eyes.	[3]
21.	The Metaverse is an alternative to the concept of "smart cities of the future" that is based on the idea of a "parallel virtual world." This "parallel virtual world" would embody different methods of working and living in virtual cities.	[48]
22.	Users can anticipate that the Metaverse's virtual worlds will be vastly different from anything they've seen or experienced before, encapsulating lifestyles in convincingly rendered digital cities.	[46]
23.	As a result, terms associated with immersive realities such as augmented reality, virtual reality, and mixed reality, which were formerly only used in computer science programs, entered the common lexicon. This trend was particularly accelerated by the official statement that Facebook will indeed move to create the "Metaverse."	[49]
24.	The term "Metaverse" refers to a vision that many people working in the technology industry have of a 3D virtual environment that is also an "embodied Internet" that contains people as well as the actual reality.	[50]
25.	The word "Metaverse" or "metauniverse" first appeared in Neal Stephenson's novel "Snow Crash," which was published in 1992, along with the abbreviation "meta," which stands for both beyond and the universe.	[11, 51]
26.	The Metaverse is a method of replacing the internet, and future market growth is predicted to be exponential.	[3]
27.	When seen from a social and economic point of view, Metaverses are settings that allow humans to interact in the form of avatars inside a metaphor of the actual world. These interactions are not constrained in any way. This iteration of the Internet is carried out by software that is located in cyberspace.	[51, 52]
28.	To put it simply, the Metaverse is the internet's next evolutionary step, allowing users to have a two-way conversation with their surroundings.	[53]
29.	The Metaverse is a huge ecosystem application powered by technologies like AI, the IoT, Big Data, and Extended Reality (XR), and it embodies the concept of a "parallel virtual world" where alternative lifestyles in unreal cities may be experienced.	[54]
30.	The Metaverse is an online realm that allows users to affect their physical surroundings.	[53]
31.	The Metaverse may be thought of as an expansion of the Internet which enables users to engage in conversation with one another and the world around them. This is accomplished via the use of many different kinds of technology, such as virtual reality as well as augmented reality.	-
32.	The spread of digital twins into other domains, such as people and society, is what the Metaverse is all about.	[55]
33.	A Metaverse is a world that exists in parallel with the physical world.	[55]

B. METAVERSE PROPERTIES AND FEATURES

Selected properties retrieved from the reviewed articles will be listed. A number of Metaverse's properties and features will be graphically represented and shown in Figure 2.

These Metaverse's definitions have been containing various categories highlighting essential points one of which is that the Metaverse considers virtual and actual places where goods could be shared and be applicable for sale. Other thing that the Metaverse has considered is that physical and digital

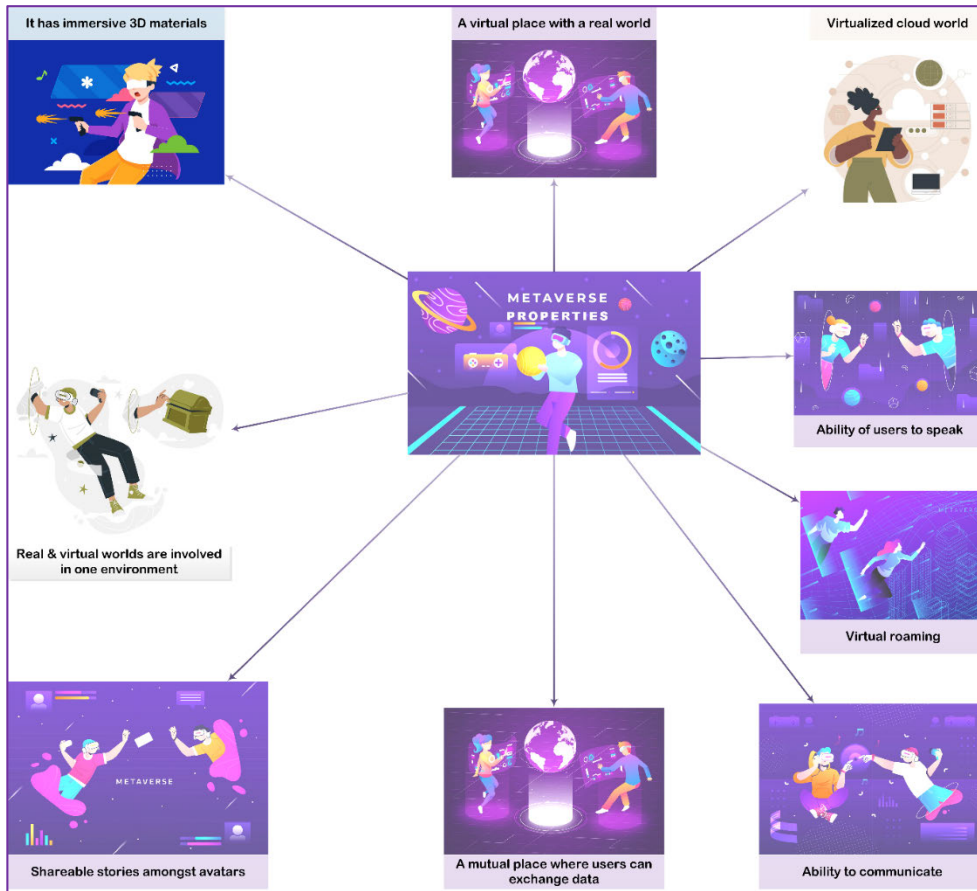


FIGURE 2. A graphical list of Metaverse properties and features. Images used in this graphical representation are licensed. Design is done by authors.

realities are able to meet. One of the important and essential points considered through this variety of Metaverse's definitions is the user's experience and environment where such a 3D world of objects can produce a 3D network of virtual spaces where users can do a wide variety of activities such as socializing, connecting, learning, working, shopping, playing, and many more.

IV. METAVERSE ARCHITECTURE

A. OVERVIEW

This section is dedicated to provide a comprehensive outline on Metaverse architecture. In order to discuss the architecture of Metaverse, it is of importance to discuss about core components of which Metaverse consists. A comparison between these components is also provided.

B. VIRTUAL REALITY (VR), AUGMENTED REALITY (AR), AND MIXED REALITY (MR)

Metaverse could be encompassed three main components, which are VR, AR, and MR [56]. To simplify the conception of these three components, a comparison between VR, AR, and MR is provided in Table 2 aiming to define, in a simple way, the conception of Metaverse.

C. HOW TO SIMPLY DIFFERENTIATE BETWEEN VR AND AR?

It is easy to say that when there are one or more computer-generated object(s) in front of you, i.e., inside your real place, and all the other objects (items) are real, then this is an AR. But, if you find yourself inside an environment that includes items or objects that do not belong to your real place or your current environment, that means, you are in a VR. This is mentioned in a comparative way as provided in Table 3. To clarify this in a graphical representation, that is shown in Figure 3.

D. A METAVERSE PYRAMID-SHAPED ARCHITECTURE

It is useful to mention that the architecture includes four main components, which are: VR, AR, (MR: it is a subset of AR), and XR. Both VR and AR are considered amongst the most basic simulated and interactive experience(s) for the Metaverse. These components are represented and shown in Figure 4.

V. METHOD

A. KEYWORDS-BASED ARTICLES SELECTION CRITERIA

A number of keywords in addition to the "Metaverse" have been used in this research to extract articles from the digital

TABLE 2. A comparison between VR, AR, and MR.

VR	AR	MR
You are in an entirely virtual, simulated environment or world.	One or more digital overlay / virtual items are brought to your real place that you can see.	It is as AR but MR enables placement of 3D objects; $MR \subseteq AR$.
You are an object inside a virtual environment.	Selected objects are placed into your real place or environment.	Same as AR.
You as a whole participate (freely) in the virtual environment.	You are directed to do an action or guided to perform a task.	3D objects can interact with your surrounded environment or their environment like in Pokémon items moving around.
It adds you to a virtual environment (universe).	It adds to a real universe (real environment) a group of objects created by computer.	It adds to a real universe (real environment) a group of 3D objects created by computer.

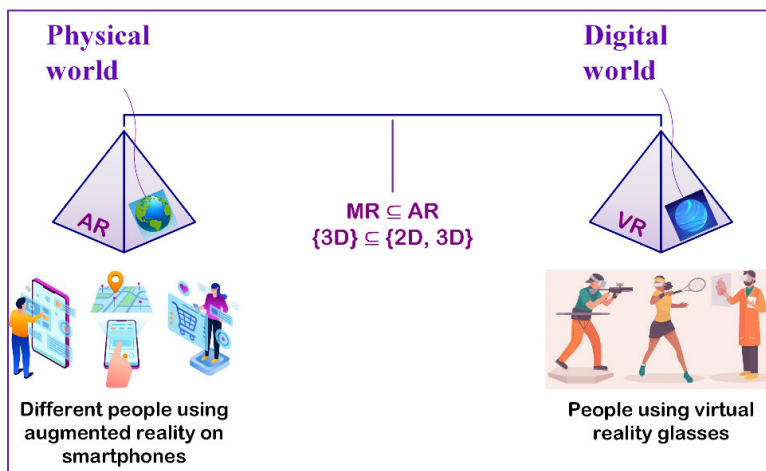


FIGURE 3. AR versus VR experience. AR is in a physical world with added virtual objects, while VR is in digital world. MR is the environment defined as a subset of AR. The conception of this illustration has been extracted from [57], [58] and an article on Microsoft website.² [1] The four attached icons (images) are licensed. Design is done by authors.

TABLE 3. How to easily differentiate between VR and AR.

VR	AR
All items or objects are not placed in your real current place.	One virtual item is placed inside your real place / environment.
Items that you could see or feel are not real.	Items around you are real unless one or few more but not all.
You are free of moves.	You could be asked to do something.

libraries (DLs). Selected keywords have a relationship with the title of the manuscript that aims to include a number of Metaverse’s applications. Those keywords used are highlighted in Figure 5.

B. MULTI KEYWORDS-BASED FILTER CRITERION FOR ARTICLES’ EXTRACTION PROCEDURE FROM DIGITAL LIBRARIES (DLs)

A selection procedure of keywords may be obtained by the implementation of the method shown in Figure 5. Consider the terms “Metaverse”, “applications”, “education”, “privacy”, and “social” among others. On the other hand, the keyword may need to be altered in a different way to provide a more precise result based on the search-in DLs that was used to look for the associated publication. Additional varied

¹<https://docs.microsoft.com/en-us/windows/mixed-reality/discover/mixed-reality>

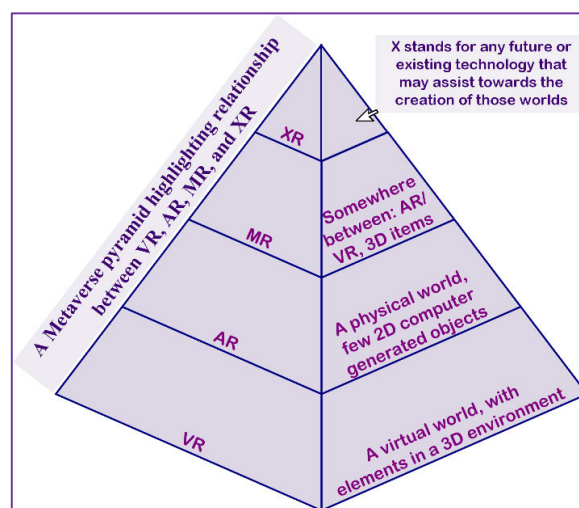


FIGURE 4. A Metaverse pyramid architecture.

keywords have been included in Table 4 to demonstrate how a more specific term may be used to get the associated research article.

C. APPLIED PRISMA 2020

In this article, the PRISMA 2020 statement and its flow diagram have been applied [58]. Related statistics and results have been shown in Figure 6. Further steps and procedures

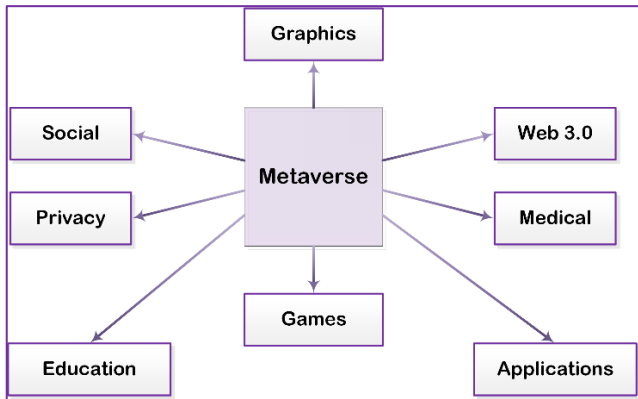


FIGURE 5. A list of keywords used to extract articles from the digital libraries.

TABLE 4. A multi keywords-based criterion for reviewed articles' extraction procedure from DLs.

In-title of article	Filter criterion	In-abstract of article
Metaverse	AND	Applications
Metaverse	AND	Education
Metaverse	AND	Gaming
Metaverse	AND	Games
Metaverse	AND	Medical
Metaverse	AND	Privacy
Metaverse	AND/ OR	Metaverse security

applied to extract papers from the literature review will be mentioned and highlighted as follows:

1) FILTRATION STEPS

a: FIRST STEP

The search is applied to four DLs. In this step, the following keywords have been applied: "metaverse" OR "Metaverse AND applications" OR "Metaverse AND medical" OR "Metaverse and privacy" OR "Metaverse and Web 3.0" OR "Metaverse AND social" OR "Metaverse AND education" OR "Metaverse AND games" OR "Metaverse AND graphics" OR "virtual reality" OR "augmented reality".

Additionally, each extracted article will be initially screened, if its scope and keywords are amongst the above keywords, the related article will be taken. In this step, there were 260 articles obtained.

b: SECOND STEP

It considered the occurrence of similarity in results and thus it has applied a removal process of redundant papers. Either, a similarity in titles has been found, it is considered duplicated papers and thus the paper will be removed. In this step, 242 articles/ papers have been obtained.

c: THIRD STEP

In this step, another filtration criterion has been applied which includes a sum of pre-defined conditions such as newspapers, demonstrations, extended abstracts, posters, and survey papers. After these exclusion criteria have been applied, the obtained articles have been equal to 66.

TABLE 5. Applied Articles' collection criteria.

Indexing service	Scopus OR WOS
Publisher	IEEE, Elsevier, MDPI, and Springer Nature
Database names	IEEE Xplore, ScienceDirect, MDPI, and Nature
Search period	15 th May 2022 to 27 th May 2022
Article date	2008 to 2022
Type of papers collected	Conference proceedings & Journals
Scope of a candidate article	Metaverse, Metaverse applications, social Metaverse, interactive Metaverse, and Metaverse privacy
Metaverse related issue	<ul style="list-style-type: none"> • Applications such as education, medical, games. • Social Metaverse considering privacy, security, contents, emotional signs by avatars • Metaverse interaction such as 3D graphics, Metaverse design, and interactive contents
Paper selection	NOT a newspaper, demonstration, poster, and extended abstract.

2) INCLUSION AND EXCLUSION CRITERIA STRATEGY

This review article has selected a number of indexing services. Furthermore, four publishers have been considered which are IEEE, Elsevier, MDPI, and Nature. Additional criteria which have been considered are provided in Table 5.

VI. FINDINGS

The topics and concerns of the reviewed papers are classified accordingly. Papers that have concerned certain topics which are related are placed in a class. There have been several classes created. They are four main classes, namely: Metaverse applications, Metaverse concerns, Metaverse and privacy, and Metaverse graphics. The results of this analysis are discussed as follows:

A. METAVERSE BASED APPLICATIONS

1) EXHIBITION CONTENT METAVERSE APPLICATIONS

There are a wide number of applications that can be designed with the help of Metaverse. It is mentioned that the ways in which museums display their collections are undergoing profound changes nowadays. Smart glass techniques use a range of digital platforms to present exhibition material in ways that enable people to fully comprehend the items which are on show [59]. This is done while maintaining a focus on improving the museum experience for guests. On the other hand, the large bulk of these approaches only involve the transmission of information in a unidirectional fashion. Use of illumination that differed significantly between actual and virtual places, along with the absence of contact with tourists visiting, has rendered museums unsuitable for use as experience venues. The paper proposes a strategy for deploying content services for the museum experiences of visitors. The presented approach introduces a service idea to give users the opportunity to experience a virtual world through establishing a connection between a beacon that is physically located in an actual area, such as an exhibition room, and a head mounted display [60]. Additionally, the

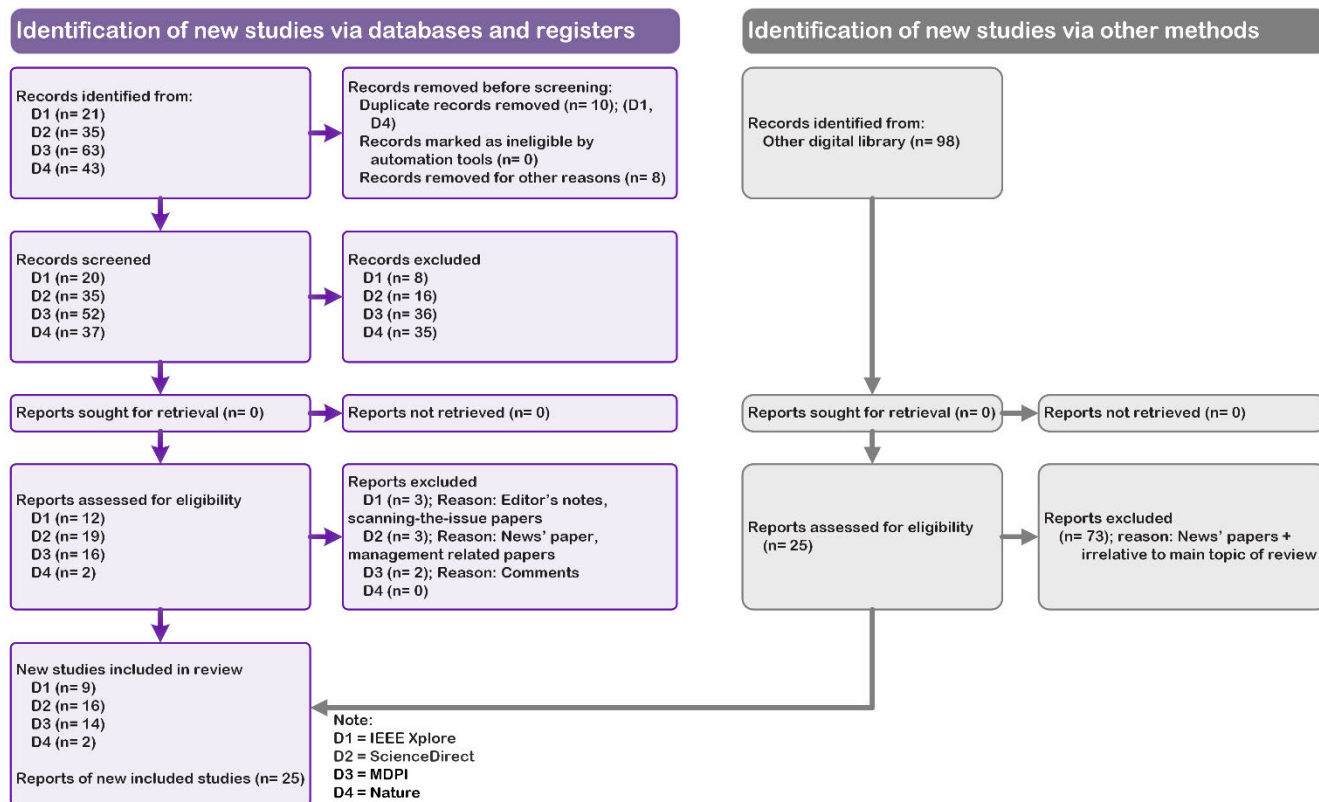


FIGURE 6. PRISMA 2020 applied for this systematic review.

service presents the attributes of artifacts together with tales about those items in order to diversity the user experience. This is done by including a storytelling element. This service has been designed to enhance the museum experiences that visitors have both online and in-person more meaningful. In the end, this article provides the exhibition content that was thus developed as Metaverse exhibition content [60]. This content was created by combining augmented reality with a virtual environment in an efficient manner [61].

2) EDUCATION METAVERSE APPLICATIONS

Speech communications must be cognizant of contextual in order to communicate with virtual objects in the 3D world of Metaverses [62]. A study suggests use of such Metaverse for Boeing-737 airplane maintenance education using historical documents, 3D simulations [63], and aviation maintenance expertise. Central nervous system is a situationally speech interpretation module that may be used to browse and manage processes in the Metaverse. This module has applied AI blend neural networks and classical symbolic reasoning, to interpret users' queries and respond to them based on contextual and airplane information. The performance of the presented application has demonstrated successful outcomes regarding capacity to ability to consider speech demands of non-native accent. Instead of purchasing costly actual planes, the presented Metaverse based application for training and education substitutes them with virtual ones that could be quickly

modified. It also serves as a field expert to educate maintenance of airplanes, providing practical assistance [64], [65].

Another example is provided in [66]. It considers the eye movement or frequency of flickers of the eye. An eye movement system has been developed for avatars in order to support a simulated problem-based learning class held in Metaverse. It established a connection between their flickering of an eye habit and an emotional reaction to a variety of issues which they were prompted to speak on behalf of people who used their product. Three students from a college have participated in the experiment, during which they addressed a straightforward and a challenging issue, respectively. The teachers suggested arithmetic tasks to be assigned to them in order to work on online. Every session lasted for a total of ten minutes. Utilizing specialized application, the frequency of flickers of eye that were captured for every individual participant was kept track of while they were in session. Following the conclusion of their learning lessons, the participants were given surveys to complete. After that, an analysis of the findings was carried out. All of the findings indicated that the challenging issue could cause participants' sentiments to become unsteady, which might lead to an increase in the frequency of flickers of eye. When instructors used this approach, they were better able to examine the replies of their pupils, which led to improved results from virtual problem-based learning class [6,], [67].

In the field of medicine, researchers have suggested defining the Metaverse as Medical IoT (MIoT), which

may be assisted by the use of both AR as well as VR glasses [68], [69]. In the field of Metaverse, a number of panelists from a variety of fields, including medicine and information technology, conducted research and reviewed published materials to determine whether or not there is widespread agreement among experts about the MIoT. By deploying a Metaverse platform, which is made of AR as well as VR glasses and the MIoT systems, and combined with the techniques of holographic architecture, holographic emulation, VR integrating and interconnectivity, it is possible to realize the three fundamental functions of MIoT, which are: comprehensive observation, reliable transmission, as well as smart processing.

In other words, it is able to perform medical education, scientific popularization, consulting, assessed care and prognosis, medical trials, and even complete medical treatment in the Metaverse by interacting with online and offline cloud specialists and endpoint physicians. This will be possible via the use of cloud computing. The connection between virtual and actual cloud specialists and endpoint customers, including endpoint physicians, clients, as well as their close relatives, might also enable many types of medical services. Some examples of these services include illness control [70], health-care [71], medical tests [72], diagnosis of illnesses, therapy [73], first aid, outpatient presence, consulting, and so on. In addition, it is important to emphasize that safety is a precondition for use of Metaverse in medicine, as well as a dependable safety structure is the cornerstone for ensuring the regular functioning of the Metaverse [5].

The purpose of [74] is to present and explain an educational system for assessing equipment in a virtualized environment, as well as to highlight the value of the system for ongoing research cooperation. Now that we are living in Society 5.0, the solutions to our day-to-day difficulties would come from the IoT via the cooperation of individuals across national boundaries. It is necessary for the writers to work together across a variety of geographically separated companies and nationalities. There is a need to set up an educational system for evaluating gadgets so that we might be prepared for scenarios like this. This will eventually lead to the creation of a sharing system that people can really use. The article has provided an explanation of the notion that has been offered for such a system of education in Metaverse. In addition to that, the relevance of the systems has been presented [74].

Utilizing Metaverse allowed for the delivery of a blended education consisting of both e-learning and hands-on engagement. The subject of radiation, education about nuclear safety, as well as education concerning subjects (science, technology, engineering, and mathematics), was brought up. There were six participants total, all of them were in the fifth and sixth grades at the primary school. They listened to the lecture via their participation in the Metaverse environment (Second Life) [75], [79]. And after that, the experimental work with radiation have been conducted in actual situations, led and supervised by the instructor in Second Life, and assisted by the instructor in actual situations. Obtained results

of the survey that was provided to every participant after the experimental work demonstrated very obviously that the proposal fulfilled with the initial aims excellently, both from the standpoint of science, technology, engineering, and mathematics as well as nuclear safety education(s) at preliminary phase (pre secondary) stages. This was shown very clearly by the results of the survey. Researchers came to the conclusion that the blended learning approach was successful for science, technology, engineering, and mathematics education to a large degree [80].

3) SECURITY APPLICATIONS

In conjunction to parallel intelligence, a secure digital twins technology is needed for a Metaverse in order for it to be able to expand on its own [81], [82]. A Metaverse is a world that exists in parallel with the physical world. The application of Blockchain technology to other domains does not concurrently need all of the fundamental components. The irreversible qualities of Blockchain will be extracted presenting a safe dimensional digital storage approach. This approach can assure digital mapping process security of IoT. The presented approach of multi-dimensional hash geocoding has addressed several of the issues associated with multiscale geographic data processing, enabling distinct index of multi-dimensional information and preventing loss of data due to decrease in data dimensionality, all while boosting information retrieval efficiency and aiding the adoption of digital twins in the Metaverse [55].

4) MEDICAL APPLICATIONS

Patients and doctors in cardiovascular care have traditionally relied on face-to-face contact as a foundational element of their interaction [83], [84]. This one-of-a-kind relationship has been called into question as a result among the latest pandemic, which has resulted in increased dangers to the standard of clinical services and also has further distanced them from medical personnel. Because of this current paradigm, there has been a dramatic escalation in the adoption of novel technology throughout every area of day-to-day life, including social interactions, entertainment, and healthcare services. On this unparalleled world health environment, telehealth, AR, as well as VR have flourished, exploring different frontiers in cardiology which is more than previously linking it to technology developments, in order to provide optimum quality of care to patients [83].

Lately, there is now a surge in growing importance in the most technology advancements known as Metaverse [85]. This scientific advance promises an innovative technological reality that is prepared to introduce about evolution in a variety of facets of our life, besides the healthcare [71].

The current pandemic spurred an escalation in the adoption of telehealth by cardiovascular as well as encouraged the flowering of technical innovations, like Metaverse, that is an innovative interactive blend of virtual spaces that integrates AR as well as VR [86], [87]. This article is a theoretical phrase for the integration of Metaverse by cardiology.

It encompasses limitless potential with obstacles in which it contains and provides new perspectives to illness learning, preventing disease, and disease diagnostics. Several uses may be found for it, the most notable of which are the improvement of medical visualizations, the facilitation of cardiovascular treatments, as well as the reformulation of the delivery of medical learning [72], [88]. The employment of NFT as a secure asset for patient records looks to be a possible option, despite the fact that hurdles are anticipated in several addition to security, technological, and legal [83].

5) METAVERSE GAMES (MVG)

Online role-playing games are now played by millions of individuals from all over the world [89]. In these games, huge number of participants engage to each other in a virtualized environment, either via the use of actual physical personalities or increasingly frequently, thru the creation of altogether fresh virtual IDs that are in no way connected to the actual names of those players [90], [91]. The percentage of subscribers is increasing at a pace that is considered to be non-linear, so it is likely that we could be on the cutting edge of new innovation that is likely to be just as momentous as the WWW. The commercial possibilities and problems presented by a virtual environment like Second Life has been addressed [92]. The consequent effects have been investigated for corporate socially responsible, with a particular emphasis on those that are connected to ethics and policies [93].

Utilizing the affordance theory as a foundation, a conceptualization of multimodality actualization for Metaverse games in relation to the affordances of bodily experiences provided by users has been presented. How the affordances of players in MVGs impact the experience for individuals could be explored by investigating how abilities are perceived and exercised in an expanded context [94]. The main goal is on the abilities of MVGs players. Significant affordances have been identified and dual nature of affordance in Metaverse based on a mixed technique of experimental work have been defined.

A player's perceptual impressions of emotional abilities are brought to life via the combination of a heuristic procedure that is able to select affordances gained from underpinning cues in an immersive manner. With regard to affordance duplexity, it is argued that embodiment of social cues could probably help to explain how users could be able to form and restrict themselves in relation to the Metaverse as well as Metaverse serves as a framework that shapes and constrains individuals' behaviors [94].

When MVGs are designed, designers need to take use of the potential provided by every platform and educate themselves on the abilities of those platforms [90], [95]. It is essential, while making MVGs, not just to create attributes which are immediately experienced, but to uncover opportunities which are hidden. This may be accomplished by creating games that efficiently translate hidden features and functions into real capabilities. The paper has developed an expanded

model of affordances by building a framework specify the mechanism by which attributes could be formed.

MVGs and play-to-earn (PTE) games [96], [97], which contain their own economies, businesses, as well as money (or, cryptocurrencies), such as Metaverse and PTE tokens (PTETs), have emerged as a result of the convergence of blockchain technology with the videogaming world [97], [98]. According to findings obtained, the said crypto niche is best described by (i) positive lengthy playing ability, (ii) lack of excessive joint motion with cryptocurrencies world, and (iii) the absence of significant associations with those non-fungible token attributes [98]. In [98], the research has studied the major aspects of such a crypto niche, which is growing thanks to gamers, traders, and corporations. PTETs as well as Metaverse tokens have favorable long-term overall average, though. The gameplay practice is paid by the tokens players earn when performing their games, and blockchain corporations might invest in this area due to the good profits. When trying to compare such tokens with crypto market, ambiguous findings might be discovered due to market instability. Investors couldn't exceed trading volume indexes using this collection of tokens, but they may unearth fresh "golden eggs" that did. The profits of Metaverse tokens as well as PTETs did not joint-move considerably with CCI30. Investors might vary their bitcoin investments with some of these tokens, as well as blockchain firms could explore new blockchain entertainment initiatives. To sum it up, researchers showed that the good performance of MVTs and PTETs is not supported by the true development of non-fungible token sales as well as investor interest in the absence of substantial relationships between capital appreciation and non-fungible token characteristics.

6) METAVERSE AND WEB 3.0

The amount of money being put into Web 3.0 and the virtual worlds "Metaverse" is rising quickly [99], [100]. Analysts in related industries and media pundits see Web 3.0 and Metaverse as the next great things in their respective fields [100]. These ideas are still in the process of quickly developing, and there is no widespread agreement over what Web 3.0 as well as the Metaverse will ultimately include [101]. In spite of this, these occurrences have lately garnered a lot of attention, and a lot of people have tried their best to figure out how to characterize them.

B. METAVERSE CONCERNS

The use of AR and VR headsets, which enable the hardware view and communicate with it, is considered by many people in the industry to be a progression of the Internet [35], [102], [103]. In contrast to standard web pages, the creation of personalized 3D information and surroundings for a virtual world may be an exceedingly time-consuming and expensive endeavor. In light of this, research into procedurally generated material is essential to enable the effective synthesis of high-quality audiovisual Metaverse's contents. When developing a completely decentralized Metaverse, one

of the primary concerns that has to be addressed is the need for individuals to download appropriate surroundings on demand as they travel between various worlds. It is essential for the multimedia community to do more research on effective methods for the networking, storing, and reduction of multimedia data if digital worlds are to continue to be freely accessible to others [35].

1) FROM 2D TO 3D IMMERSIVE IMPLEMENTATION

Works on designing and implementing immersive 3D experiences, generate procedural contents, can involve large amounts integration of multimedia contents such as 3D models, 2D images, as well as 360 video [104]. To overcome this problem, one solution that has been tried involves the manual development of 3D assets in the form of little building blocks that may be rearranged in different ways to create new things. These technologies do not provide for control over through the environment at a finer granular level, and they still need the construction of assets in three dimensions [105]. More recently, AI-based solutions have shown themselves to be a powerful tool for 3D solution to generate procedural contents, despite the fact that they are still in its early stages and development. The development of NeRFs is considered one of the AI industry's major accomplishments that has helped reduce the demand for such equipment [105]. NeRFs enable novel-view synthesis to be performed using just a predetermined group of input photos. There were several other iterations established, all of which enable rapid training, compressing for low-latency view [106], and do away with the need for camera specifications [107].

The Metaverse can be conceptualized as a 3D virtual world that contains avatars, digital objects, and operational economies [100]. In this world, technology plays a role that is more comprehensive than that of a separate or distinct instrument. One approach to comprehending the Metaverse is to think of it as a virtual world. Both the real and the digital worlds are merging into one another as the Metaverse expands. Organizations and individuals have the ability to relocate to the Metaverse, where people could be able to conduct business, interact with one another, play games, create things, and engage in financial transactions, including the purchase of real estate and the construction of buildings using cryptocurrency, just as they would in the "real" world [100].

An organization's corporate brand is comprised of the customers' perceptions of the characteristics and quality of either the organization's goods or provided services, in addition to the sentimental feelings that consumers have for the brand. It has become more crucial to influence customers inside Metaverse to establish a greater association and a better link with a firm and the goods or provided services it offers by using cryptocurrencies, non-fungible tokens, avatars, and immersing games experiences. These customers are constructing their online personas inside the Metaverse as well as on sites, that have really served as a haven for the society [100].

C. METAVERSE AND PRIVACY

1) WHY DOES PRIVACY IN METAVERSE MATTER?

Many see the Metaverse as a social microcosmos where relatively average individuals may relax and improve their (complicated) social skills. Because of this, it provides a rich setting in which to observe and analyze legal and social developments [108].

Since then, a huge portion of sensitive information probably will be shared amongst users (avatars). As a result, it is possible for adversarial parties to learn very sensitive information about a person via such monitoring, including credit card numbers, social security numbers, the name of the person's mother, medical records, bank account details, and so on [36].

Thus, the privacy of Metaverse is being highly paid attention since it is considered one of the most crucial and sensitive issues in the Metaverse world due to its high concerns to many users and developers. It has been considered by many research studies, for example [109], [119]. The manner in which we engage with the material world around us is undergoing a sea change as a direct result of recent developments in technology. Because of this, our digital prints and marks as well as digital bread crumbs are being followed, and they have the potential to expose the current locations we are in, age, preferred shopping, friends, preferred movies, and many more. In addition, this type of tracking could lead to aggressive entities gaining access to top secret information about oneself [120], [121], including credit card details [122], social protection identification digits [123], the name of one's mother's maiden name, someone health records, and information about someone bank account [124], [125] and among other things. This data is put at risk in a variety of ways that are all connected in some manner, and social engineering is one of them. In addition, cameras that are linked to the Internet make it possible for individuals, businesses, and government institutions to record both living and nonliving things within a certain geographical region. These recordings might be kept in remote data storage facilities, accessed by humans, or evaluated by computers for a variety of reasons, depending on the situation [126].

2) MONITORING AND SURVEILLANCE IN METAVERSE ENVIRONMENT

Surveillance cameras, for example, may collect and analyze data in a variety of ways, allowing for inferences about activity and position as well as data aggregation and pattern recognition [54], [127]. In many facets of life, we are, to a significant extent, the subject of surveillance as well as sensing [54]. This would include at home (for example, smart grid electricity monitors, Wi-Fi), while travelling (for example, Google Maps and fitness devices), in public spaces (for example, public security cameras as well as sensing devices, storefront cameras, video cameras), and at work (firm's firewalls, company email, and Internet usage monitoring). Our privacy might well be compromised in ways that we are not conscious

of since, in several instances, we are just not conscious that the recordings and analytics are taking place [109]. As a result, the private data may be at risk in ways that we did not expect [36], [119].

3) CONFUSION-BASED PRIVACY IN A SOCIAL METAVERSE ENVIRONMENT

One of the mechanisms proposed to maintain the privacy goal within the social Metaverse is called confusion by creating a haze of copies. This conception is represented and illustrated in Figure 7. It is interesting technique and is briefly described as follows. A complicated Metaverse will, in due course, give people strong reasons to desire to mislead neighboring avatars in the viewable zone [36]. These reasons will become available over time. It is possible that there will be moments when the sheer aggravation caused by certain avatars, such as malevolent individuals or bots, the sheer quantity of watching avatars, and the danger of harassing or stalking if such an avatar just is pursuing you around, basically documenting your trip is going to make obfuscation techniques desirable. This is despite the fact that socializing with many other avatars will continue to be a primary source of enjoyment in any social Metaverse. The following is a potential circumstance that calls for investigation: You are now in a section of the Metaverse that is designed to seem like a shopping center. Here, a wide variety of digital and physical goods are sold at a variety of different stores. Even since every business may keep a record of purchases you have done, you may want to keep other avatars that you really do neither recognize or trust from seeing movements you do as you go from one store to the next [119].

There is another mechanism which depends on creating private copies [109]. An alternative offers the customer with a really private place in which monitoring is impossible [128]. The approach proposed seeks to mislead any avatars or bots that are conducting monitoring on the person. Producing a private copy is the topic of discussion for this particular section, which is part of a larger category of privacy-protecting strategies. According to these ideas, the person will have the ability to submit a request in order to have a private copy from some portion of the virtual environment made for the user's temporary and entire usage. Other persons and avatars might continue to utilize the main fabric component of the Metaverse without being adversely impacted by the activities of the person who is doing those in the produced private copy since the relevant piece of the Metaverse inside the primary fabric remains in place in parallel. Take for instance a consumer that is interested in having a personal experience while doing their online purchasing. The person has the ability to make a request for a private copy from a whole virtual shop or even just a section of a digital store, such as a certain department. For instance, the shop might offer private things that the customer would prefer neither to buy for in public, such as virtual undergarments or social activities, for instance [36].

D. METAVERSE GRAPHICS

Since the graphics design is one of the key pillars in the Metaverse it affects the interaction between avatars and other objects [8]. Hence it is a matter for both building good interaction between avatars and sub-Metaverses as well as creation highly nice environment of Metaverse's objects. There are some research studies focusing on enhancing graphical construction of Metaverse. At the moment, the Metaverse evolution is in its initial phases, so there is no architecture for the visual building or investigation of the Metaverse [129]. This is due to the fact that the virtual world (Metaverse) is still day-by-day developing. In this study, a framework is presented describing how Metaverse can be developed in terms of graphics, interactivity, and visual imaging. The paper has discussed a number of several types of visual components that make up the Metaverse as well as its related graphics. An interaction method has been proposed utilizing user actions, feedback, and different sensory channels. Within the framework of the visual building and investigation of the Metaverse, the paper has discussed current possible uses as well as future prospects [40].

VII. ANALYSIS AND DISCUSSION

Analysis of reviewed articles according to a number of criteria can include:

- topics concerned by the reviewed articles,
- a comparison between reviewed articles in terms of issue, objective, method, advantages, and weaknesses
- topics covered by the analyzed articles
- average citation(s) according to the topic based on the annual citation(s) number of each article,
- frequency of citations of the reviewed articles,
- publication date.

A. DISTRIBUTION OF REVIEWED ARTICLES ACCORDING TO METAVERSE TOPIC AND APPLICATION

In this analysis, the distribution of reviewed articles according to the topic or application addressed by the article is considered. Obtained results of this analysis are shown in Figure 8.

Figure 8 shows that topics covered and concerned by the reviewed articles vary. It shows that the highest portion of interest by articles goes to the Metaverse education applications. Those articles have applied Metaverse for the purpose of education and training for different fields and research areas that can teach participants or students or give them training related the interested topics.

B. A COMPARISON BETWEEN A NUMBER OF SELECTED PAPERS REVIEWED IN THIS ARTICLE IN TERMS OF ISSUE, OBJECTIVE, METHOD, ADVANTAGES, AND WEAKNESSES

In this type of analysis, the reviewed papers are analyzed and compared in terms of the issue that the paper is going to consider and address, paper's objective, the method applied/used by the proposed system, advantages of the proposed mechanism or system, and a few of weaknesses points that have

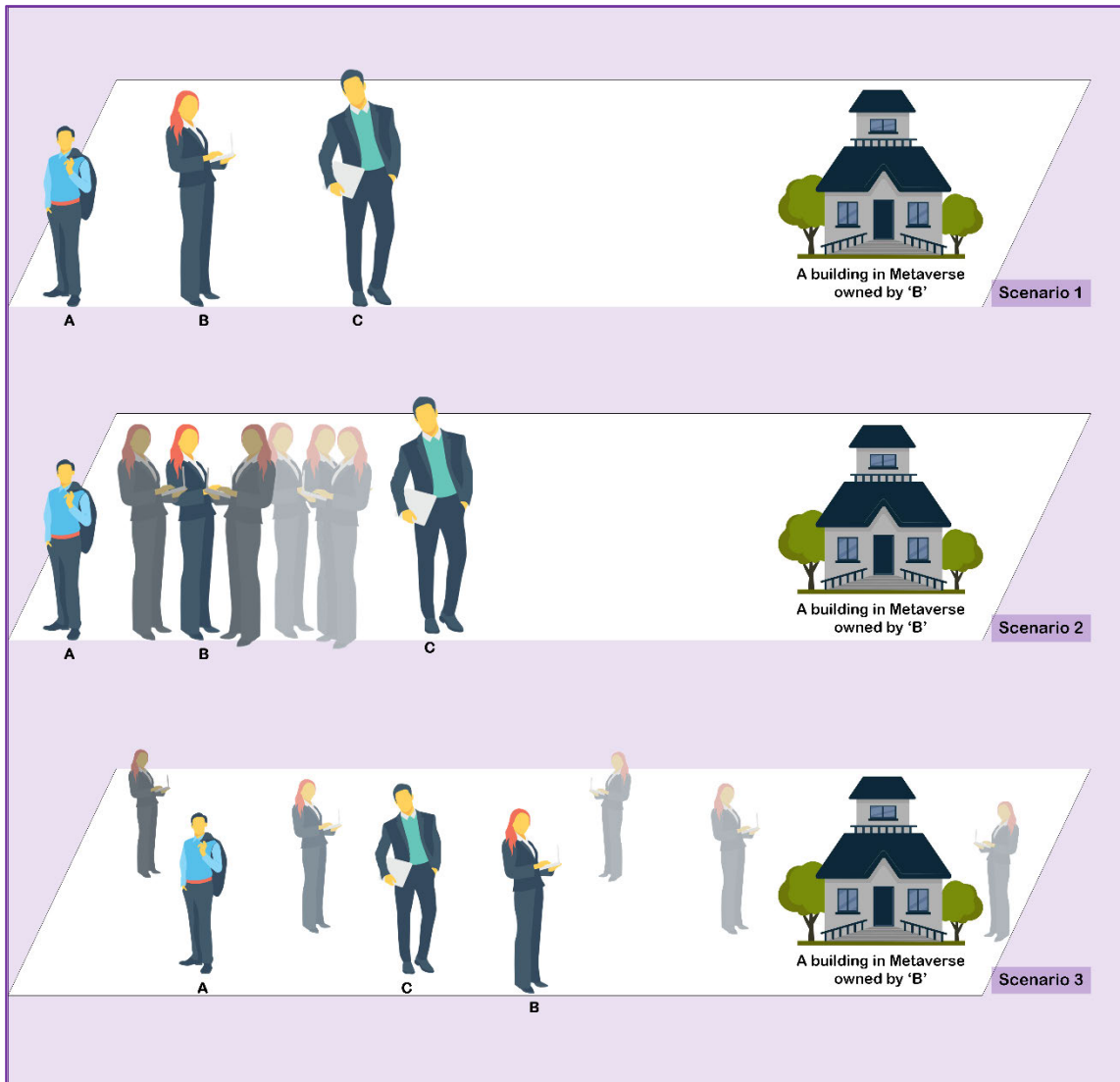


FIGURE 7. A graphical representation of the multi copies privacy conception applied by Metaverse's avatars. According to Figure 7, the provided paradigm is shown in a more straightforward manner. This scenario is divided in three scenarios. Scenario 1 depicts a stylized image of the Metaverse in which our protagonist (avatar B) is located close to her digital residence. The avatar 'B' is surrounded by two other avatars that are quite close to her, but she would want to have more solitude from them. The 'B' selects, configures, and activates the "haze of copies" privacy plan, which can be seen in the center of Scenario 2 inside Figure 7. Scenario 3 shows that the strategy is carried out. During this period, the actual 'B' avatar is able to avoid being discovered by A and C. The unexpected appearance of a collection of avatars that are almost similar to the one being used by the user may, from the perspective of an observer located inside the Metaverse (that could be, for example, avatar A in Figure 7), result in bewilderment. The fact that the group includes the member B, whose goal it is to continue with her activity without being harassed, is quite important. A number of this conception's parts are derived from [36]. Images used in this graphical representation are licensed. Design is done by authors.

been reported. The analyzed results of this comparison will be provided in Table 6.

C. ANALYSIS OF PAPERS ACCORDING TO THE TOPIC COVERED BY THE ANALYZED ARTICLE, YEAR OF PUBLISHING, AND CITATION FREQUENCY

This analysis aims to highlight the productivity of the topic related to the Metaverse by showing the citation index of the related papers. That indicates that the researchers are focusing or paying attention more to those papers that have higher

citation frequency compared to others. The obtained results are provided in Table 7.

In this analysis shown in Table 7, the period is calculated using the formula in Eq. (1):

$$Period = 2023 - \text{Year of paper's publishing} \quad (1)$$

This calculates the period in years belonging to age of paper.

Additionally, the productivity value is obtained using Eq. (2):

$$P_{paper} = \frac{citation}{period} \quad (2)$$

TABLE 6. A comparison between analyzed papers according to issue, method, and advantages criteria.

Ref.	Issue	Objective	Method	Advantage	Weakness
[64]	It suggests the use of the Metaverse for aviation maintenance education and training on Boeing-737, complete with legacy manuals, 3D models, 3D simulators, and expertise of aircraft maintenance.	To navigate and control the operating flow in the Metaverse, which is governed by maintenance manuals and must be rigorously obeyed.	It makes use of a form of AI known as Neuro-Symbolic, which brings together neural networks and the more conventional symbolic thinking.	<ul style="list-style-type: none"> • It was able to comprehend the users' inquiries and provide responses based on the surrounding context and aircraft-specific information. • Averaged accuracy is 94.7%. • One component of this entails the formation of a virtual community of the next generation to be known as the aircraft maintenance Metaverse. 	<ul style="list-style-type: none"> • Expression error percentage = 7.5% • It cannot discriminate fragments in aircraft maintenance data.
[130]	Social value of Generation Z	To categorize the research that has been done on the social impact of the Metaverse.	It does this by breaking down the ideas and fundamental procedures that are required to materialize the Metaverse into three distinct parts.	Research in the fields of movies, video games, and academic studies are taken into consideration, including Ready Player One, Roblox, and Facebook.	It covers the social Metaverse and social influence.
[34]	In its current iteration, is it possible for the Metaversi to facilitate the sharing of a friends list, an avatar, or any in-game experience?	to begin the process of creating the Metaverse with regard to the gameplay experience.	Simulation and	<ul style="list-style-type: none"> • A historical introduction is provided about the Metaverse, visual simulation, and the comparison of VR to visual worlds. • In addition to this, it has offered a conventional framework for playing online games at a high level. 	-
[36]	This analysis illustrates the fact that our digital footprint and digital breadcrumbs are trackable and have the potential to reveal not only our identity but also our location, age, interests in shopping, friends, favorite movies, and a great deal more information.	To explain how a fight over privacy is currently poised to take place on the stage.	A survey paper	Along with a summary of the scholarly work that has been done in this domain, it offers some examples relating to the Metaverse.	It only considered the social side of Metaverse.
[100]	These ideas are still in the process of quickly developing, and there is no widespread agreement over what Web 3.0 and the Metaverse will ultimately entail. In spite of this, these occurrences have recently garnered a lot of attention, and a lot of people have tried quite a few different ways to characterize them.	The effects of these advancements on the brand and product strategies employed by corporations are the primary subject of this article.	The Metaverse can be conceptualized as a 3D virtual environment that contains avatars, digital objects, and operational economics. In this universe, technology plays a role that is more comprehensive than that of a separate or unique instrument.	It has been suggested that Web 3.0 and the Metaverse have given significant marketing and branding incentives to companies, particularly among younger clients, to strengthen their brand image.	The Web 3.0 and its associated development have only been covered in this paper.
[61]	New display methods utilize a variety of digital technologies to present exhibition content in ways that allow visitors to better comprehend the artefacts that are on display. This is done while maintaining a focus on improving the museum experience for visitors. On the other	In order to tackle the issue of information being delivered in only one direction, the author of this article proposes a strategy to implement content services for the experiences of museum visitors.	This research lays the groundwork for the idea of a service that connects users to a virtual world through the use of a beacon that is physically located somewhere in the globe.	<ul style="list-style-type: none"> • Additionally, the service presents the features of artefacts along with stories about those items in order to diversity the user experience. This is accomplished by incorporating a storytelling element. 	It requires a fast Internet speed since the graphics requirement. This would cause an issue with non-sophisticated display devices.

TABLE 6. (Continued.) A comparison between analyzed papers according to issue, method, and advantages criteria.

	<p>hand, the vast majority of these methods only involve the transmission of information in a unidirectional fashion. The use of lighting that clearly differentiates between actual and virtual places, combined with the lack of interaction with museum visitors, has rendered museums unsuitable for use as experience spaces.</p>			<ul style="list-style-type: none"> • The design of the service will create relevant museum experiences both online and in-person at the institution. • It describes the exhibition content that was produced in this way as Metaverse exhibition content. This content was produced by employing an efficient combination of augmented reality and a virtual world. 	
[55]	<p>The Metaverse and its expansion of Digital Twins.</p>	<p>To suggest a method for the secure storing of multidimensional data in order to guarantee the safety of the digital operations that make up IoT.</p>	<p>In order to prevent the loss of information, a method known as non-mutagenic multidimensional hash geocoding has been developed.</p>	<p>It has increased the effectiveness of information retrieval and made it easier to create the Metaverse by using spatial Digital Twins based on the work that was proposed.</p>	<ul style="list-style-type: none"> • There has not been any usage of examples taken from actual geographical data in the process of building scenes for virtual reality. • There is not a high level of efficiency in the indexing of spatial data. • It is necessary to strengthen the trustworthiness of the simulated Virtual Reality settings.
[83]	<p>The current outbreak accelerated cardiovascular health’s use of telemedicine and spurred the development of innovative technologies like as the Metaverse, a revolutionary interacting combination of digital universes that combines AR and VR.</p>	<p>To reshape the current medical educations and to increase the security of assets for patient’s records.</p>	<p>The CardioVerse is a speculative phrase describing cardiovascular medicine’s embrace of the Metaverse, including both its limitless potential and obstacles, and introducing new aspects to disease teaching.</p>	<p>The proposed method has some features such as making use of non-fungible tokens as a security asset, security-related and regulatory elements.</p>	<p>It doesn’t cover other aspects and fields for Metaverse’s education purposes.</p>
[66]	<p>In the Metaverse’s lesson, the topic of eye blinking as a behavioral indicator of an emotional reaction to stimuli as avatars is being addressed.</p>	<p>The eye blinking mechanism in Metaverse will be used to evaluate students’ learning styles.</p>	<p>Using specialized software, the amount of eye blinks has been counted for each individual user, which included a number of students acting as users. After then, the pupils provided their responses to the questionnaires.</p>	<p>When instructors used this approach, they were better able to examine the replies of their pupils, which led to improved results of problem-based learning conducted virtually inside the context of the Metaverse.</p>	<p>The outcome and results obtained are based on a few numbers of students (users).</p>
[5]	<p>Making a definition of the Metaverse in medicine as the MIoT that can be accessed using VR glasses.</p>	<p>In the Metaverse, it is our intention to provide medical education, scientific popularization, consultation, grading treatment and diagnostics clinical research, as well as complete medical care.</p>	<p>In this study, a multi-disciplinary group of medical professionals and information technology specialists from all over the world analyzed published articles on the subject of expert consensus on the MIoT, making reference to research findings in the field of Metaverse technology.</p>	<ul style="list-style-type: none"> • The availability of contact amongst real and virtual cloud specialists and terminal users, including physicians, patients, and relatives. This might also make it easier to provide many medical services, such as illness prevention, healthcare, physical examinations, diagnosis and treatment of illnesses, rehabilitation, chronic diseases management, in-home care, first aid, outpatient attending, and consultations. 	<p>A very highly secured proposed system is needed since the MIoT requires a strong secured platform due to the presence of sensitive and private data in the patients’ health records.</p>

TABLE 6. (Continued.) A comparison between analyzed papers according to issue, method, and advantages criteria.

				<ul style="list-style-type: none"> • The security of the medical Metaverse’s platform. 	
[93]	Online role-playing games and players interacting with one another in a virtual world.	In this article, the commercial possibilities and problems presented by a virtual environment like Second Life will be addressed. Additionally, the consequent implications for corporate social responsibility, with a particular emphasis on those that are connected to ethics and policies will be investigated.		This will aid in the process of identifying relevant research issues that need to be addressed in a methodical manner.	Some questions are open and not yet answered in regarding to the Second Life e.g., This will aid in the process of identifying relevant research issues that require to be addressed in a methodical manner. Who makes the decisions on how much money to invest in a virtual space? Is the actual user hiding behind the avatar, or does the avatar represent the real user, and which one is mostly expressed?
[40]	The Metaverse does not yet have a structure that can guide the visual building of its components or its investigation of those components.	a paradigm is proposed that provides a concise summary of how graphics, interaction, and visualization approaches promote the visually constructed Metaverse and user-centric exploration.	Through the use of two distinct graphical production processes in a pipeline as well as three distinct types of visual components that come together to form the Metaverse. A taxonomy of interaction technologies based on interaction tasks, user actions, feedback, and different sensory channels is also provided, as is a taxonomy of visualization approaches that help user awareness.	It has the potential to pave the way for more investigation into the fields of graphics, interaction, and visualization in the Metaverse.	Potential applications are overviewed. It lacks to give real samples for actual applications and scenarios.
[98]	The Metaverse and play-to-earn games	To investigate the functioning and behavior of 174 different tokens.	It has evaluated a number of features that are associated with the Metaverse, such as the fact that it has a good performance in the long term, I the lack of strong co-movements with the bitcoin market, and (iii) the appearance of bubbles.	It has shown that there is a new niche in the cryptocurrency market.	<ul style="list-style-type: none"> • Results are empirical. It is necessary to conduct an investigation of both NFT and IGO behavior in relation to market segmentation.
[80]	Utilizing Metaverse allowed for the delivery of a blended education consisting of e-learning and hands-on engagement.	The aim was to analyze results obtained from data collection procedure done with a schools’ students and teachers in regarding to the topic of radioactivity, nuclear safety education and STEM education using the Metaverse.	A questionnaire	Researchers have come to the conclusion that the blended learning approach was successful for STEM education to a large degree.	Participants are few and results are of simplicity.

where

- P_{paper} is the productivity being calculated for a certain number
- *citation* is the total number of citation that paper has during all years
- *period* is how many years this paper has since it was first published until the year ‘2023’.

The citation has been retrieved from The Google Scholar Citations metrics service on between 20th and 23rd October 2022.

D. ANALYSIS OF REVIEWED ARTICLES HIGHLIGHTING AVERAGE CITATION(S) ACCORDING TO THE TOPIC BASED ON THE ANNUAL CITATION(S) NUMBER OF EACH ARTICLE

In this analysis, productivity of papers based on the number of citations based on the annual citation basis for the whole articles that fit in the related topic, refer to Table 7.

This analysis calculates the productivity of the topic. How such a metaverse’s topic is more productive than other topics based on an accumulative citation of those papers that belong to the related topic?

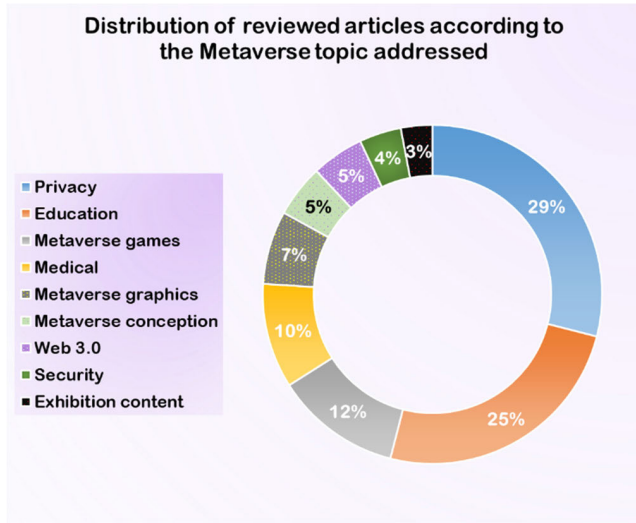


FIGURE 8. Distribution of reviewed articles according to Metaverse topic.

TABLE 7. Distribution of papers according to citation frequencies.

Ref.	Topic	Year	Citation	Period	Productivity
[64]	Education & medical apps	2021	26	2	13
[130]	Social	2022	180	1	180
[34]	Games & graphics	2022	15	1	15
[36]	Social	2018	52	5	10.4
[100]	Games & graphics	2022	3	1	3
[61]	Games & graphics	2017	104	6	17.33
[83]	Education & medical apps	2022	26	1	26
[66]	Education & medical apps	2015	30	8	3.75
[5]	Education & medical apps	2022	17	1	17
[93]	Games & graphics	2008	180	15	12
[40]	Games & graphics	2022	28	1	28
[98]	Games & graphics	2022	23	1	23
[80]	Education & medical apps	2014	33	9	3.67

The calculated average results are provided in Table 8. To calculate the productivity of the topic, Eq. (3) is used:

$$P_{topic} = \sum_{n=1}^m \frac{P_{paper}}{\#paper} \quad (3)$$

where

- P_{topic} is the productivity of such a topic
- P_{paper} is the productivity of such a paper
- $\#paper$ is the total number of those papers that belong to one topic
- n is a counter starting with a value '1' representing the topic no. 1
- m is the maximum number that n will reach, representing the total number of topics which is 3 in our case, which has been designed as per Table 8.

TABLE 8. Average citation(s) according to topic based on annual citation.

Topic	Productivity
Education and medical apps	12.68
Social	95.2
Games and graphics	16.39

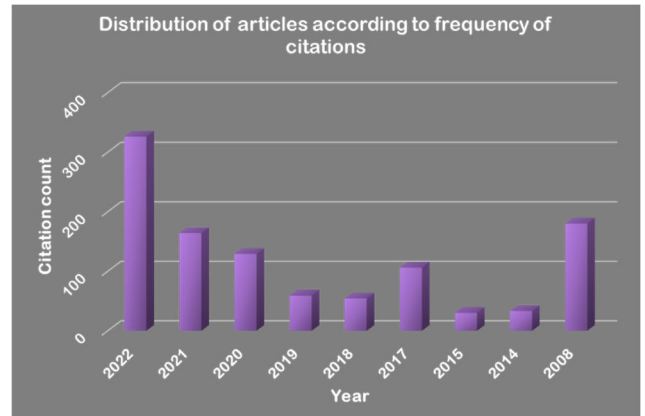


FIGURE 9. Distribution of articles according to citations frequency.

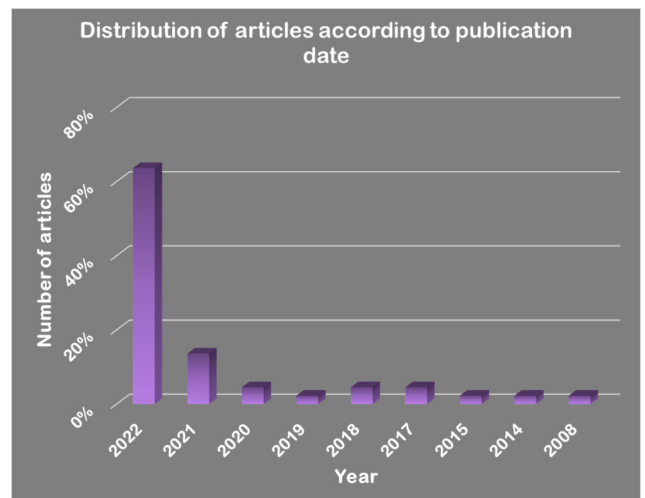


FIGURE 10. Distribution of articles according to publication date.

It is shown in Table 8, that the most productive topic is the social Metaverse with an average number of citation(s) reach 95.2. The social Metaverse is being paid attention more than others due to that it also implicates the privacy issue. That indicates that one of the most important issues related to the Metaverse is the privacy of society and social contents and behaviors when there is such interaction or contact using with emotion-based avatars.

E. DISTRIBUTION OF ARTICLES ACCORDING TO CITATIONS FREQUENCY PER YEAR

Distribution of articles according to frequency of citations per year has been provided and shown in Figure 9.

As shown in Figure 9, it is highlighted that those papers published in 2008 have the highest number of citations. However, those articles recently published in 2022 have a quite good number of citations. This indicates that the number of

researches and papers related to the Metaverse field of study is being obviously increased.

F. DISTRIBUTION OF ARTICLES ACCORDING TO PUBLICATION DATE

Distribution of articles according to the publication date has been provided and shown in Figure 10.

It is obviously seen that most reviewed papers have been published in the year 2022 is higher than 65 per cent. It is noteworthy that recently there has been a clear interest by researchers and designers regarding the development of the Metaverse.

VIII. CONCLUSION

This part is going to give a conclusion of this review. This section has been divided into five sub-sections mentioned as follows:

- The first sub-section is dedicated to provide a list of challenges and concerns in the research done on the Metaverse during the period mentioned in the Method section.
- The second sub-section is going to provide a conclusion on the future trends and directions related to the Metaverse.
- The third sub-section is going to provide and present a suggested framework that points out a number of potential solutions to their corresponding limitations, that have been faced by researchers and reported in the reviewed articles.
- The fourth sub-section is going to provide a summary of the whole sections of this review paper.
- The fifth sub-section lists a number of limitations related to this review for future research works

A. CHALLENGES AND CONCERNS

1) A LIST OF CHALLENGES ACCORDING TO TOPICS

Listed and highlighted in Table 9 are a number of challenges according to the theme.

2) OTHER REPORTED CHALLENGES IN LITERATURE REVIEWED

1. In the Metaverse, all new users are not linked, and if you spend all of your time creating your virtual identity on one site, you may wind yourself friendless and stuck in the current MySpace or Friendster. This is one of the main issues [34].
2. The effective production and development of 3D immersing material, as well as the efficient transmission of multimedia information, are among the key obstacles that must be overcome before the construction of a full-fledged Metaverse can take place [35].
3. Despite all of the offered approaches and mechanisms, virtual reality related and augmented reality related platforms, including device makers, systems,

TABLE 9. A number of challenges faced by the Metaverse according to a selected theme.

Theme/ topic	Description of a challenge
Welcome to the Metaverse	<ul style="list-style-type: none"> • Since new users are not connected, thus if you spend all your time on one site, you may end up friendless.
Design and development of Metaverse-related material and devices	<ul style="list-style-type: none"> • The development of 3D immersive content and the transmission of multimedia information are important challenges to building a full-fledged Metaverse. • Virtual and augmented reality platforms, including device manufacturers, systems, paradigms, and protocols, must create complete privacy protections for all Metaverse stakeholders. Privacy techniques are fair and easy. • AR uses lightweight devices for short sessions, whereas VR needs heavy, expensive technology. Some gear combines AR and VR, moving between them as required. This technique is more expensive and bulkier than a single-model device, but it allows for more AR and VR applications. Despite their tremendous potential, holograms are never extensively used in the Metaverse.
Privacy issue	<ul style="list-style-type: none"> • Users entering the Metaverse’s large virtual worlds risk having their privacy invaded in a variety of ways, including other platform customers listening in on their interactions. • Although the Metaverse shows potential, security and privacy hinder its progress. Metaverse cybersecurity vulnerabilities and privacy breaches include the following: the management of enormous data streams, user profiling, unfair AI findings, and the privacy of physical infrastructures and individuals. Hacking and viruses are further hazards. • Since the Metaverse is based on the latest technology and processes, the Metaverse may also inherit the dangers and inherent defects that are present in those technologies and methods. New Metaverse-related approaches have been connected to illicit use of wearables or cloud-based storage, theft of digital currency, and exploitation of AI to produce fake news. • Because of the necessity for users to be singled out in the Metaverse, it’s possible that VR goggles or headsets might be used to spy on their owners without their knowledge.
Metaverse’s interactive environment	<ul style="list-style-type: none"> • Expertise in real-time interactivity in the Metaverse brings with it not only the expressive joys of a flawlessly fluid virtual environment, but also challenges in the secure merging of enormous private user data for interacting entities and avatars.
Social Metaverse	<ul style="list-style-type: none"> • People with perfect reputations in the real world have committed crimes online anonymously in the Metaverse. Due of its comment and freedom, the Metaverse has its own rules and laws. Younger Metaverse members have diverse viewpoints on social

TABLE 9. (Continued.) A number of challenges faced by the Metaverse according to a selected theme.

<p>members have diverse viewpoints on social concerns. Instead of thinking of the Metaverse as a physical place, it must be built with a vision and ethical understanding.</p> <ul style="list-style-type: none"> • Second, there are likely to be substantial methodological difficulties when doing research in a virtual world like Second Life. Who precisely are researchers talking to when they conduct interviews with, say, business owners or subscribers? Avatars, or the genuine persons hidden behind avatars? To rephrase, do subscribers seem to be responding to the current back-and-forth between these two elements? Has that conduct altered, and if so, how so in terms of attitude? What is the far-reaching impact on our culture and community, and will new social orientations emerge as a consequence of that behavior? The above increases the difficulty of a must-take job concerning a basic component of online role-playing games. • Games like Second Life exist online, but they are better understood as complex societies than simple games. Issues raised earlier don't reveal their full significance until much later, when it's possible to start exploring for workable solutions.
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paradigms, and protocols, must establish comprehensive privacy mechanisms for all parties that belong to the Metaverse. Currently proposed privacy mechanisms are very fair and simple [110].

4. When users enter the Metaverse's huge virtual worlds, they run the risk of having their privacy violated in a number of different ways, including having other platform customers listen in on their conversations [131].
5. Despite the fact that the Metaverse is showing signs of promise, the primary challenges that impede its continued growth are those pertaining to security and privacy. The organization of huge data streams, prevalent user profiling events, unfair results of AI, and the privacy of physical infrastructures as well as humans are just some of the cybersecurity threats and privacy violations that could occur in the Metaverse. Other potential dangers include hacking and viruses [109].
 - a. To begin, since the Metaverse incorporates a wide range of the most recent technologies and methods that are developed on them as its base, the Metaverse may also inherit the dangers and inherent defects that are present in those technologies and methods. New techniques have already been linked to a number of situations, including the unauthorized use of wearables or cloud-based storage, the theft of digital currencies, and the misuse of AI to manufacture false news.
 - b. Second, because of the intertwining of multiple technologies, the consequences of current risks

might be intensified and grow more serious in virtual worlds. At the same time, new threats that do not exist in physical or cyberspace environments can develop, including such virtual following and virtual espionage. In specifically, the private details included in the Metaverse might have been more granular or unprecedentedly pervasive in order to construct a digital duplicate of the actual world. This opens up new vistas for offenses using personal big data. For instance, in order to construct a virtual scene utilizing AI methods, customers will invariably be required to don wearable AR/VR devices that come equipped with in-built sensors. These sensors will be used to thoroughly collect wave patterns of users' brain, facial gestures, eye tracking, hand motions, as well as other biometric characteristics and attributes, in addition to the external environment [36].

- c. Additionally, since individuals in the Metaverse need to be individually recognized, it implies such headsets, VR glasses may be used to monitor users' actual whereabouts in an unauthorized manner [132].
 - d. Last but not least, hackers may utilize vulnerabilities in systems and hijacked equipment as entrances to breach physical security and key assets like energy systems, high-speed train systems through advanced persistent assaults [133].
6. Despite this, many of the currently available security countermeasures are insufficient and cannot be adapted to the many uses of the Metaverse. In particular, the inherent properties of the Metaverse, like sense of immersion, extreme spatiotemporality, resilience, compatibility, as well as growth may provide a number of issues for the effective protection of these rights [109], [134].
 - a. The real-time truly interactive expertise in the Metaverse helps bring with it not only the expressive delights of the perfectly smooth virtual world, but also difficulties in the protected fusion of huge private user's data for interacting entities and avatars [135].
 - b. The incorporation of the tripartite universe adds to the extreme spatiotemporality that exists inside the Metaverse, that significantly amplifies the difficulties of confidence management and the degree to which it is complicated. As the line between the actual world and the online environment continues to dissolve, the Metaverse might enable distinguishing among both reality and fiction, like with the case of deep fake incidents, much more difficult, particularly for the sake of legislation and forensic analysis.
 - c. The virtual universes that make up the large-scale Metaverse might have quite different hardware

implementations, networking technology, and applications, that creates significant compatibility challenges.

7. AR makes use of lightweight devices, which are appropriate for brief encounters, while VR often requires very hefty and costly hardware for extended sessions. Some methods combine the benefits of AR as well as VR into a single piece of gear, switching between AR / VR as needed. When compared to a gadget that only comes in one model, this approach is more costly and cumbersome, but it does provide the benefit of employing AR and VR in a variety of different ways. Holograms, on the other hand, are never a widely used technology in the Metaverse despite their considerable potential [130].
8. Because Metaverse gathers data on user activity that is much more specific than user interactions and web history, privacy becomes key challenges which must be addressed. Two-factor verification for avatars is very necessary, as is the safety of data that has been communicated. In addition, measures taken in the name of surveillance as a result of the dramatic increase in user numbers (such as improper chat room monitoring, censoring, and follow-up review) show that in the real world, organizations that perform the same function as the government and the police are required. There have been incidents in which persons with impeccable reputations in the actual universe have committed criminal acts in the Metaverse because they were able to do it anonymously online. Because of its comment and various degrees of freedom, the Metaverse has its own set of standards and regulations that are distinct from those of actual universe. The majority of Metaverse members are members of the younger age, who have a wide range of perspectives on numerous societal issues. Rather than conceiving of the Metaverse as an actual location, it is required to construct a Metaverse that can accommodate a variety of avatars and has a vision as well as an ethical awareness [130].
9. If you're doing research in a virtual environment like Second Life, you may confront significant methodological hurdles. Whenever researchers conducted interviews with entrepreneurs or subscribers, for instance, who exactly are they speaking with: avatars or the actual people who are hiding behind avatars? To put it another way, has the dialogue that is now taking place between these two factors had an effect on the behavior of subscribers? Has that behavior changed, and if so, in what manner, in term of attitude; what is the all-inclusive influence on our culture and community; and will we see the formation of new social directions as a result of this behavior? The aforementioned raises concerns and questions increase the complexity of the must-be-taken task about one of the core components of online role-playing games. These online role-playing games, such as Second Life, shouldn't always be seen

as games but rather as societies that include a great deal of complexities. The whole relevance of the difficulties that were mentioned before doesn't become apparent until much later, at which point it is feasible to begin looking for viable answers [93], [136].

B. FUTURE TRENDS AND DIRECTIONS

1) AN OVERVIEW

In this subsection, the most important and urgent trends that need to be well managed will be briefly discussed.

There is a clear future direction and concern towards the security matter. Despite all the offered techniques, platforms associated to VR and AR, such as hardware manufacturers, systems, and structures, must build a solid privacy strategy across all Metaverse-compliant aspects. In the case of Metaverse systems, the current state of security measures may be insufficient and limiting. Even more so, the immersive nature of the Metaverse, its emphasis on sustainable growth, and its emphasis on incorporation might make it challenging to implement adequate security measures.

Another direction in the future is the education matter. Exploiting Metaverse for education is important in the near future and for long periods due to the characteristics a Metaverse system or application may provide and add to this field. We present a few instances of Metaverse uses. To use the Metaverse for such reasons, 3D model designs must be improved. Current and future development focuses on Metaverse-based education.

The educational system idea for sharing analytical equipment among far-flung places and enterprises has been investigated. Metaverse was used to create a web-based educational platform for operating analytical equipment. Remote designers need the system to cooperate on research initiatives. Researchers have created a strategy and are preparing for experiments. The next level includes creating analytical tools using Metaverse to fulfill requirements and virtual training. By comparing virtualized and physical environment(s) training with a given instrument, researchers may examine the virtual training system's impact on instrument understanding in real life. This will help us choose the best training.

One of the most important future direction is the medical matter. Despite this, people are aware that internet advertising promotes unhealthy habits and dangerous products. Authorities and policymakers are pushing to prohibit marketing for dangerous items and behaviors on Metaverse, especially alcohol and cigarette ads. All contribute to noncommunicable diseases. The Metaverse platform may promote oral health, healthy habits, and general wellbeing, and defend health equity. For medical education, scientific popularity, consultation, diagnostic testing, clinical research, and total healthcare in the Metaverse, a cloud terminal system may allow experts and terminal doctors from virtual and real clouds to interact.

Future game research may examine a few things in light of Metaverse. Metaverses and MMORPGs have advanced in recent years. All evidence points to it growing in popularity

in the future years and being as essential as the Internet in the long term. This is to highlight possible social and ethical repercussions, which need more examination and present a variety of issues. Who decides how much to spend online? Who's behind the character (avatar)? Does the avatar reflect the real customer?

Another example related to games and graphics of Metaverse is that, creating a realistic simulation of a digitized world is a concern of Metaverse researchers. These studies focus on how to aesthetically build the Metaverse with fluid item and avatar interaction. Visual and graphics design may need to be upgraded to create more realistic Metaverse designs as technology and the physical cosmos develop rapidly. More detailed modeling methods are needed to accurately depict a character's face characteristics (i.e., an avatar) and clothes and fabrics.

2) DETAILED TRENDS EXTRACTED FROM THE REVIEWED PAPERS

This subsection is going to outline a number of important trends that are linked to research and advances that will take place in the future about the Metaverse. They are classified into seven categories discussed as follows:

3) TRENDS IN WEB 3.0

Web 3.0 and Metaverse have introduced significant new marketing and branding options for businesses, particularly those looking to improve their image in the eyes of younger clients. A great number of businesses are working toward the goal of gaining a first competitive edge in the Metaverse. It is essential to do so in order to maintain one's relevance among new generations of customers, to build brand recognition among these consumers, and to eventually lure these people into the shops. As a result, the Metaverse has developed into an essential channel for brand activations, making it possible for businesses to run campaigns, plan events, and engage in various types of interactions with customers. Additionally, it is being utilized as a route for communication and advertising, in addition to has been used as a medium for the sale of both physical and digital goods [100].

4) TRENDS IN SECURITY AND HARDWARE OF METAVERSE

In spite of all of the presented approaches that have been presented thus far, it is still needed for such platforms that are related to virtual reality and augmented reality, such as hardware vendors, systems, and structures, to establish coherent strong privacy approaches across all elements that comply to the Metaverse [110]. In the so near future, privacy mechanisms are of importance to be developed.

With the first observations into the crypto niche, researchers make a contribution to the body of literature on the subject of cryptocurrencies. A novel crypto bubble seems to be forming, as seen by a surge in initial coin offerings and the extraordinary profitability of several currencies. Because of this, experts and politicians alike could perhaps keep studying how this particular market sector behaves [98].

Minimizing the strain of interaction of users is another effective and desirable matter for Metaverse-interested researchers. The evolution of sensing devices and gadgets is what will determine the wide range of user interactions. The numerous kinds of activity inputs that may be gathered by a variety of devices are able to satisfy the criteria of a wide variety of immersed interaction kinds. As was indicated before, there are a variety of tools available to customers that have been meant to assist to exploring the Metaverse, interacting with its inhabitants, as well as making changes to its contents. Participants are able to employ interaction via phonation and tactile streams, in addition to using the body gestures, like look, movement, or head movement. Users may also take action just by thinking about doing so, which entails utilizing brainwaves like an electroencephalogram. Several constraints are there to be considered and addressed. Because various designers utilize multiple construction mechanisms, user interactions' types that may be taken generally would be restricted. Despite this, the actions that can be taken by users are nevertheless distinct from actual interactions that take place in actual universe. Individuals are expected to be familiar with various devices in order to be able to recall particular procedures that have been created by a variety of designers, researchers, and systems [137].

Current security solutions may be ineffectual and inflexible with respect to Metaverse systems. Especially, the Metaverse's features, such as sense of immersion, super spatio-temporality, sustainable development, as well as integration may make it hard to provide security in an acceptable manner.

- A distributed Metaverse structure, which is self-sustaining and enduring, is required in order to eliminate the only failure problem and domination by a few strong units. However, achieving clear agreement across vast units in a Metaverse that is time-dependent is very difficult.
- To ensure quick service permission, conformance internal audit as well as responsibility regulation in end-to-end mitigation and multi data source integration, the Metaverse's openness and expandability show that users will be able to freely move between sub-Metaverses under such a variety of action sequences and interaction modes simultaneously [138].

5) TRENDS IN EDUCATION

Exploiting the Metaverse for the purposes of education is of bright importance in the so near future and for so long periods to the offered features that such a Metaverse system or application can give and contribute to this area. We provide few examples currently applied the Metaverse for such purposes. However, there is an obvious need to enhance 3D models' designs in order to effectively utilize the Metaverse to work better with such purposes. The development and enhancement in current times and in the future focus on Metaverse-based education needs.

- In today's modern times, businesses are moving toward interactive and web-based solutions where the

Metaverse is one of them. The aim is to interact socially in digital worlds. Having a Metaverse for the purposes of teaching and practicing massive elements, including flight operations, could provide an effective cost for aerospace universities to have teaching on virtual aircraft rather than training on expensive hardware resources. Therefore, the creation of 3D models may give many features to maintenance's training and education, e.g., imparting information about aviation maintenance and a common area for cooperation, with the assistance of smart glasses and other components of virtual reality's ecosystem [64].

Throughout the course of this investigation, the educational system concept for sharing of analytical equipment across far-flung locations and several companies has been dissected. The primary concentration was on Metaverse in order to realize our goal of developing an online instructional platform for operating various analytical equipment over the WWW. It is necessary to have the system in order to enable distant designers to collaborate on research projects together. Researchers have developed the plan, and at this point researchers are making preparations for such experimental tests. The subsequent stage of this process will include the creation of certain analytical instruments via the use of Metaverse meet the standards set and the execution of the virtual training. Researchers will be able to analyze virtual training system's influence on the comprehension of the instrument's use in the actual life if the combination of virtualized and physical environment(s) training with a specific instrument will be compared. This will allow us to determine which kind of training is more beneficial [74].

6) TRENDS IN HEALTH AND MEDICAL MATTERS

Despite this, humans are conscious of online ads is a big worldwide industry that encourages unhealthy behaviors as well as the consumption of harmful items. On account of this, authorities and regulators are being pushed to establish restricted laws for ads of harmful products and behaviors on the Metaverse platform, particularly ads for alcoholic drinks and tobacco products. All of them are important contributors to the development of non-communicable illnesses. It is anticipated that the fundamental principles of the Metaverse platform would include the promotion of dental health, healthy lifestyles, and overall wellness, in addition to the protection of health equality [53], [139].

In order to accomplish medical education, scientific rising popularity, consulting, assessed diagnostic testing, clinical research, and complete healthcare in the Metaverse, the implementation of a cloud terminal system might make it possible for experts as well as terminal physicians, from virtual and actual cloud, to engage with one another [5].

7) TRENDS IN GAMES AND GRAPHICS OF METAVERSE

In regard to games' researches' future in the presence of the Metaverse, there are few points that can be considered for future works.

- Metaverses and their embodiment in massively multi-player online role-playing games have evolved and developed over the last several years. Only just getting started on a massive transformation that should undoubtedly be as important in the long run as the Internet, and all signs point to it gaining enormous traction in the coming years. This is to bring to light a number of potential social and ethical ramifications, which call for more investigation and raise a wide range of problems. Who, for instance, determines how much money should be spent inside a digital space? Is the actual person hiding in behind the character (avatar), or does the avatar represent the real customer, and which one is mostly expressed?
- Events which actually happen in Second Life are frequently analogous to events that are carried out in actual life. This is because there is neither predetermined objective for customers to work toward in Second Life; rather, they are free to pursue anything they choose to be of personal interest. As a consequence of this, one may anticipate that the ethical packages would have been equivalent in the majority of instances. This line of reasoning might also be applied to the morals of users, given that the majority of the transactions conducted are modeled after real-world exchanges and that the money used in-game is related to currency used in the actual world. Second Life contains set of group rules; however, these rules are more of a collection of suggestions for conduct than they should be an effort to establish a human or corporate performance structure [93].
- The creation of the Metaverses however has opened up a wealth of opportunities for study that spans several disciplines and academic boundaries. In further study, it will be necessary to take into account a number of the issues and concerns that have been expressed. One of these concerns is the fact that many users have already started new enterprises. These enterprises are a combination of real-world organizations and online or (meta) businesses. A few of prosperous businesspeople in virtual-world now have a big yearly wage making a lot of growth recently. For instance, some builders have amassed a personal fortune far into the millions of United States dollars thanks only to the money they have made just inside Second Life. These virtual collections have added landed interests that seems to be comparable to dozens of square kilometers of land, 'cash' ownership through many million Linden dollars, a large number of shopping centers, retail chains, and many other in other Second Life major corporations, and they've already founded one's own brand names. Then it also brings up important questions about public policy, such as whether or not taxes should be levied on such revenue. If that is the case, how could this be made mandatory? In-game cash or actual money from the actual life?

In regard to graphical and visual concerns for Metaverse, there are a number of points and issues considered by researchers in this area. Summarized are few related issues in this matter.

- Creating a real lifelike simulation of a virtualized environment is one of the most addressed issues and concerns by researchers involved in Metaverse. These research studies concern how the Metaverse could visually be built with a smooth interaction of objects and avatars inside the virtual environment. Visual and graphics design may have to be progressively improved in order to find ways to produce more realistic designs to the Metaverse, since technological advancement may keep happening as well as the physical universe will change with time at a breakneck speed. For instance, more precise modeling techniques are required in order to achieve a very good accuracy in the character's facial features (i.e., an avatar) as well as the reality of their clothing as well as textiles. Such great quality in regard to the reality is also mirrored in the development of simulations needed by Metaverse, where users probably observe lively as well as interactive sceneries and avatar(s), but many things in the reality could not indeed depend fully on hand design and need some automation. reviewed literature has shown that the approaches which have adopted the deep learning-based methods could probably lead to assist to enhance the 3D built and designed creation. As a result, simulations and designs with very good accuracy, the process of automation, and the building of interactive VR animations is an area that requires more investigation and it will be a considerable issue in the so near future that needs to be very well addressed [40].
- Taking into account the creative potential of humans is a very useful and supportive tool towards constructing a visual Metaverse environment. People from the actual life may serve as both the motivation and the basis for many different things found in the Metaverse. The Metaverse's building needs to include the incorporation of manual intervention from users, that is necessary to be accomplished with the assistance of visual and graphic-based processes. Besides, the Metaverse may one day permit the reconstruction of a large number of a human's 3D objects, including as their homes, automobiles, and other belongings. Because of this, there must be an increased need for simulations that are graphics or clips captured by handheld devices. Additionally, several 2D artifacts, such as photos, videos, pieces of art, or graphical representations that have been designed by humans, could indeed be converted into the Metaverse to be integrated with 3D objects aiming to facilitate successful immersive environments [40].

8) TRENDS IN USER-ORIENTED SERVICE

There are few researchers considering the monitor of eye movement and blinks. By enhancing these systems and

applications, the Metaverse-participated users will get much more benefits and therefore the interaction with the sub-Metaverse will lead to advanced levels in terms of education, training, medical based monitoring, person's emotion and feeling, humans' desires, and many others [66].

According to [66], the study has demonstrated that instructors, within the Metaverse environment, are able to examine their participants' attitudes in order to attain greater levels of success with virtual problem-based learning when they apply a method called flickering of the eye.

When it comes to user consciousness or awareness in the Metaverse, associating visuals with user demands might be of great relevance. When it comes to creating a user-based consciousness experience, the most difficult task is figuring out how to logically relate graphics to demands of users. Key expressions are of such difficulty. Firstly, in order to construct a tactic helped by information or automated suggestions with the assistance of machine learning techniques, the user's behavioral data such as clicks and flickering of eyes may be required whenever the person might want such information. Secondly, an experimental examination of the interactive systems is required in order to determine if the pre-set layout of such imagery interacts with the perception of many other stuffs and whether or not its existence interacts with the perception of those stuff. Finally, the player or non-player characters have the option of controlling the manner in which they react with visuals. Robotic systems, for instance, are able to provide players with suggestions, communicate with people, and engage with participants in order to assist subscribers in perceiving the Metaverse world as well as representations. Robotic systems, for instance, are able to provide players with suggestions, communicate with people, and engage with participants in order to assist subscribers in perceiving the Metaverse world as well as representations [35], [140].

Improving communication and cooperation within the visualization field is another window of research in the area of Metaverse in the term of user awareness. Metaverse users may benefit from its social qualities, which allow people to interact with one other in a more efficient manner. Thoughts and ideas from the user's perspective must be shared with others. There are occasions when this broadcast is restricted to joint thoughts together with phonation. To further facilitate cooperation, other forms of communication and perceptual pathways have to be investigated. It is vital to note that avatars could be able to play an important function that enables coworkers to quickly and intuitively understand what the client needs to tell, exactly like in the actual life. This is something that should be noted for future research works [40].

9) OTHER TRENDS FOR FUTURE DEVELOPMENT

Limitations and constraints found in [94] could provide potential for more research.

- One important future study is that, the responses have been extracted using self-selected suitable random

samples, which makes it difficult to generalize the findings. In spite of the fact that the experimental nature of the research made this restriction unavoidable, the self-reported structure of the experimental work may necessarily be constrained when it comes to understanding emotion and presence, both are very concepts.

- Another subsequent investigation is described as follows; data may be collected from a more generalized setting. In addition, the potential implications of demographic characteristics have not been taken into consideration.
- Personal characteristics of users could have an impact on the amount of time spent playing MVGs as well as their overall popularity and adoption. Those parameters should be included in further studies, with a larger and bigger number in term of samples’ size must be used in conjunction with any time-series analyses that are conducted.

Similarly, the consequences of stimulation on the people who participated in such an experimental work should be taken into consideration.

- The degree to which respondents are familiar with AR and have had previous experience with it may have an impact on their perceptions as well as their ability to enjoy MVGs. The participants in [94] included both seasoned veterans and fresh faces to the field. It’s possible that the affordability of various tiers of interactions will vary.
- A further future research direction can focus on the effort of relationship exploration and understanding amongst Metaverse experience. It may be possible to investigate the connections that exist between the peculiarities or characteristics of individual users and their interactions playing MVGs. In this research, there were not a lot of studies on the influence of user attributes on the experience of playing MVGs.
- Future study should analyze the co-evolution of user characteristics as well as interactions, to evaluate the Metaverse duality very closely for further evaluation. Further investigation is needed into the interplay of numerous aspects in the realization of MR capabilities.

A number of considerable issues and key points related to the future trends have been summarized and highlighted in Table 10.

C. A SUGGESTED FRAMEWORK

In this section, a number of potential solutions that might contribute to build-up and provide an attempt in the direction of solving a number of limitations will be discussed.

One of the biggest limitations faced by the Metaverse is the issue of sending reliable high-quality visual information over the Internet. For this, a potential solution is to test and check the speed of the Internet and connectivity devices, if they have good speed of connectivity, the Metaverse has the ability to send the heavily-prepared information; otherwise,

TABLE 10. A list of trends and their corresponding needed improvement in the future.

Trend	Considerable issues for future improvement
Web 3.0	<ul style="list-style-type: none"> • brand recognition • brand activations • interactions with customers
Security	to establish coherent strong privacy approaches <ul style="list-style-type: none"> • hardware vendors • systems • structures
Education	<ul style="list-style-type: none"> • there is a need to enhance 3D models’ designs • to provide interactive and web-based solutions
Health	<ul style="list-style-type: none"> • regulators need to establish restricted laws for ads of harmful products and behaviors on Metaverse • fundamental principles of Metaverse include promotion of dental health and healthy lifestyles.
Games and graphics	<ul style="list-style-type: none"> • a smooth interaction of objects and avatars • visual and graphics design may have to be progressively improved. • find ways to produce more realistic designs • achieve a very good accuracy in the character’s facial features (i.e., an avatar) and reality of their clothing and textiles
User-oriented service	<ul style="list-style-type: none"> • improve the monitor of eye movement and blinks for to enhance Metaverse-participated users’ interaction with sub-Metaverse • when it comes to creating a user-based consciousness experience, the most difficult task is figuring out how to logically relate graphics to demands of users • improving communication and cooperation within the visualization field • it is important to note that avatars could be able to play an important function that enables co-workers to quickly and intuitively understand what the client needs to tell, exactly like in the actual life.

the Metaverse platform will go to the other plan which is sending medium-quality visual information. This solution is needed to adaptively manage this matter.

Another limitation is that the graphics of Metaverse is still in its simple level. There is a lot of paid attention towards enhancing this matter. The issue when graphics is enhanced the speed of transferring such information might be affected where that requires a sophisticated platform in terms of hardware and software requirements that process related heavy-information. If the internet connection is slow that will increase the problem to a worsen level. For this, one of the solutions is to have three levels of graphics information to meet the design of the hardware used.

In regard to the servers that host densely-populated virtual worlds, the image processing techniques will be indeed one of the potential alternative solutions with the help of other techniques and methods such as compression and encryption schemes. For example, the image could be compressed. If there are a sequence of multi-frame images, encryption and compression for the purpose of storage is considered one of the solutions for this concern.

Further limitations and solutions are graphically depicted in Figure 11.

D. CONCLUSION

This section is dedicated to provide an overview of the most important points and findings out discussed in this article's sections. This section is provided in two sub-section first of which provides a summarized map on topics and issues that have been reviewed and covered in this review second of which provides a summary on selected remarks concluded from the reviewed articles and history of the Metaverse since so early. One of the main contributions is that this review has suggested a framework providing solutions to a number of issues and concerns that have been paid much attention by researchers. Besides, an interesting graphical representation depicting the concluded remarks has been attached at the end of this section to give a more clarification on some highlighted points that might be useful to readers and researchers interested in the Metaverse development.

1) GENERAL CONCLUSION

This article has reviewed a number of Metaverse related articles published recently. Since the topic is lately being considered and taken care of by researchers from different fields of study and research areas, the number of articles found in DLs is not so many. However, this article has attempted to cover a wide range of issues where the scope of this review research has been open. Noticed in this article are different and several topics that have been discussed and reviewed. Besides, in order to cover different angles, a number of topics and issues have been surveyed. This article has covered a history summary telling us the story of Metaverse development. Definitions and properties of the Metaverse have been also mentioned and extracted from the reviewed literature. To give readers and interested people in Metaverse development further details, the Metaverse's architecture has been mentioned taking into consideration its components which are VR, AR (including MR). For this review, PRISMA 2020 statement has been applied for systematic reviews. A number of issues have been highlighted in the literature section such as Metaverse privacy, Metaverse applications including medical, education, security and few others. Metaverse games as well as graphics have been reviewed. This review has been supported by an analysis regarding the reviewed articles considering several criteria such as publication's date, journals' statistics, and topics addressed by each of the reviewed articles. In regard to the challenges faced by researchers, developers, policymakers of Metaverse, numerous concerns and issues have been remarked and discussed in detail. The future trends and directions that will shape the future of Metaverse and its applications have also discussed in great detail. Finally, a number of important and interesting points of Metaverse have been concluded discussing important topics such as Metaverse privacy, energy consumption, cost of Metaverse associated products, graphics design enhancement, and few others.

A graphical representation summarizing remarks extracted from the reviewed articles have been added.

2) OTHER CONCLUDED REMARKS

Important and very useful notes have been extracted after spending quite a bit of time to review literature related to the Metaverse that have been published in top-tier journals. Listed and discussed are a number of those remarks learned. A graphical representation has been provided to summarize up few concluded remarks, as shown in Figure 12.

1. There are lots to do in this research area. Many developments and enhancement(s) are required from researchers, designers, developers, programmers, and policy-makers towards coming up with regularly updated performance in regard to the Metaverse.
2. It is also concluded that the privacy issue is one of the most important concerns for all in-Metaverse participants. There is a need to enhance and propose many solutions aiming to bring Metaverse's individuals and users feels so comfortable and satisfied when they are inside the Metaverse world.
3. The graphics matter is one of the biggest challenging issues faced by the Metaverse's developers. Graphics currently are obviously poor with low quality. That is not encouraging many users and participants to be involved in such an environment. So, there is a need to enhance the quality of graphics as a required task by Metaverse designers and other researchers interested in this research development.
4. Increasing the quality of graphics and images will require sophisticated associated devices. If that has been addressed and solved. Another issue will be rising which is the cost of products and other related services such as the need for a high speed of Internet connection. This will open the window for utilizing the 5G technology networks; which will affect other related devices. This topic should be taken care of by designers and researchers interested in Metaverse development.
5. The issue of energy consumption will be a matter and concern in case a lot of social connections – as the Metaverse focuses on the social connection in an immersive way – will be occurring in the digital world.
6. One of the interesting fiction issues that can be handled by the Metaverse in the future is that. Can you imagine that you would be able to meet your favorable person who had been on the physical world tens of years ago or maybe few hundred years ago!

E. LIMITATIONS

This sub-section lists a number of limitations of the current review for future research works, which are as follows:

- This review has considered a specific range of period during which the reviewed articles have been published.
- A number of analyzed articles might be few since the time spent during this article's time, there have been

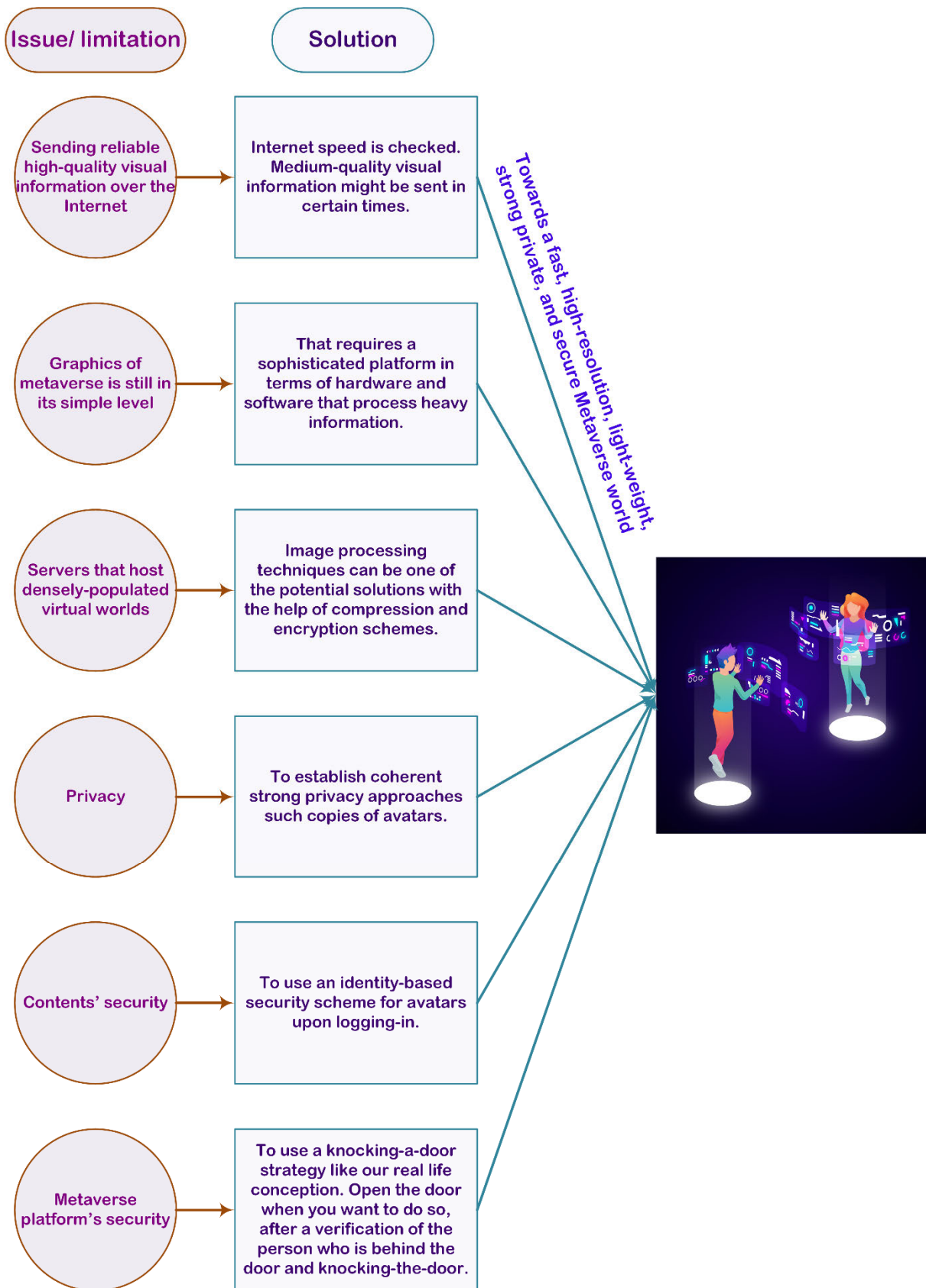


FIGURE 11. Issues and their corresponding solutions - a suggested framework towards a high-resolution, light-weight, strong private, and secure Metaverse. Every limitation has its suggested solution aiming to achieve such a Metaverse’s feature. An image is licensed.



FIGURE 12. Metaverse's future. Images used in this graphical representation are licensed. Design is done by authors.

papers published but not considered since the criterion of search period has been set to a specific period of time.

- Future researchers might include the new papers and articles that have been published.
- It has covered a selected number of topics to be discussed in this review which have been mentioned above.

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