An Analysis of the State of Art of the Metaverse and Its Disruptive Impact on Services

Andrea Cigliano[1], Francesca Fallucchi[1,2] and Marco Gerardi[1]

[1]Department of Engineering Science, Guglielmo Marconi University, 00193 Rome, Italy
[2]Leibniz Institute for Educational Media, Georg Eckert Institute, 38118 Brunswick, Germany

Abstract

The metaverse is a virtual environment where individuals may connect with one another, partake in a variety of activities, and access digital content. It coexists with the real world and it has the potential to significantly affect daily life as well as a variety of services and applications as it develops. To understand the importance of the impacts of the metaverse in today's society, just think of the disruptive technologies that enable it: Artificial Intelligence (AI), Extended Reality (ER), IoT, Digital Twin (DT) and Blockchain/NFT all with assistance with the availability of large, rich and structured/unstructured dataset and advanced computational models. Metaverse is cadidated (and not only) to redefine everyday life, designing activities and services/products provisioning towards increasing efficiencies, money saving and quality performance, with a big impact in everyone and helping the design and testing of next generation of internet. However, there still remain not only technical and interoperability issues but above all ethical, human, social, and cultural concerns as to the metaverse's influence upon its prospective scope in reconstructing the quality of urban life. This paper undertakes an upper-level scientific literature review of the area of the metaverse from a broader perspective. Further, it maps the some services and the relative requirements for declinate the enabling technologies of the metaverse, and explores their contributions.

Keywords

Metaverse, DT: Digital Twin, ER: Extended Reality, VR: Virtual Reality, Blockchain, Nft, Quantum Computing, IOT, LLM: Large Language Model, NLP: Natural Language Model, GenI: Generative Artificial Intelligence, DH: Digital Humanity, AI: Artificial Intelligence

1. Introduction

Recent investments and disinvestments by big tech and some large companies in the metaverse have been seen as a vital sign that the internet will transform and take on a new dimension. After the Covid-19 pandemic, people have to stay at home and perform many activities in digital environments, which has accelerated the digitalization process. The recent energy crisis has accelerated the process of developing alternative energy sources or more sustainable distribution and consumption [1, 2, 3, 4]. The new internet design is planned to be developed to support a permanent digital world where thousands and millions of people can act simultaneously and switch between different platforms. However, problems such as the management of energy resources and equipment products that will support the necessary infrastructure need to be overcome. In this context, this paper intends to give is the state of the art of the development of the metaverse, with particular regard to the technologies used and the academic publications carried out in the research areas related to Metaverse, Energy and Smart Cities. As a first step is a brief conceptualization and definition of the Metaverse. Basically it is a combination of the prefix "meta" (meaning beyond) and the suffix "verso" (short for Universe), if we wanted to define it, it is a composite world with a coherent value system and an independent economic system linked to the world physicist. The term metaverse was first created by Neal Stephenson in his science fiction novel Snow Crash in 1992. Herrman and Browning define it as "a fully realized digital world that exists beyond the analog one we live in" [5]; Morgado explained it as "a plethora of interconnected world" [6]. Meta Platforms, Inc. Bosworth and Clegg (2021) describe it most simply: "The metaverse is a set of virtual spaces where you can create and explore with other people who are not in the same physical space as you" [7]. Putting the various definitions as a common factor, metaverse means a collective, persistent and interactive parallel reality created by synthesizing virtual worlds in which people can use personal avatars to work, play and communicate with each other [8]. For this research we conducted a literature search on a variety of online scientific database sources and analyzed which services in real life could be impacted by the metaverse is treated in the fields of iot, energy, smart cities and other related collateral areas. Every service has requirements in term of QOS (Quality Of Services) [9] . These requirements and relative QOS have enabling technologies associated for the respect of its.

1.1. Contributions

We will describe metaverse current background, which helps us explain why is a hot topic just now, despite having being around for long time. We highlight current overview on scientific pubblications on metaverse. We will further highlight why, this time, the context is radically different from what we experienced in the past: that is, why the upcoming metaverse instances could represent something semantically different from what we have seen in the technology domain until now (an approximated answer: exponential technology growth; unprecedented capabilities in data generation, collection, and analysis; and, convergence of the cyber-physical worlds). Based on the introduced foundational material we develop our vision of the metaverse, highlighting the metaverse-enabling technologies in particular on developing energy and smart city services. Finally, in our discussion we argument the thesis that the exposed threats and the envisaged impacts generated by the development of the metaverse call for an interdisciplinary approach where computer science and engineering are critical.

1.2. Sections

The remainder of the paper is organized as follows. In Section II we revise the method utilized and some background information and related work in the field. In Section III,

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a.cigliano@unimarconi.it (A. Cigliano); f.fallucchi@unimarconi.it (F. Fallucchi); m.gerardi@unimarconi.it (M. Gerardi)

we discuss the current istances on metaverse or more correctly Metaverses, with a specific reference to the many technologies correlated. In Section IV, based on the state of play and the introduced guiding principles, we provide our analysis of what are the most stringent criticalities of the metaverse, also highlighting broad—in scope, depth, and breadth—research directions in energy and smart city. Finally, in Section V we provide our conclusions.

2. Related Works

The services impacted by the metaverse are analyzed and treated in many real-world scenarios such as widely distributed cloud sevices and solutions[10, 11], as well as healthcare [12, 13, 14], gaming [15], education [16, 17, 18], cultural-heritage [19, 20], smart city [21], etc. Technologies involved as metaverse enabler have been largely treated in these domains of services and frameworks are proposed [22, 23]. In these studies, AI [24, 25, 26] is one of main pillar to build the metaverse. The other one is Digital Twin [27, 22], in the metaverse every real single entity, concept, or operation should be involved in the created 3D environment. Thus, a huge amount of various types of data are highly needed in such a system, including Internet of Things (IoT) collected from various locations, devices and in an immersive while being accessible through XR, including augumented reality (AR), virtual reality (VR), and mixed reality (MR) [22]. The technologies that allow human interaction with the metaverse are mainly concentrated on case studies that look at healthcare and gaming [28, 29, 30, 31, 32]. Metaverse perspectives cannot be dissociated from a pervasive technology like AI in fields like education and work [16, 33, 24]. The research works on blockchain technology and the metaverse is certainly the combination that has a high number of research works on the use of cryptocurrencies and NFTs as means of payment and beyond [34, 7, 35, 36, 37, 38, 39], also including specific sectors, e.g. automotive [40].

In this paper draws attention to metaverse state-of-art and contributes to the answer to the research questions of recurring research contexts on metaverse, namely:

- What is the Metaverse, and what are the supporting technologies based on existing papers?
- How Metaverse has been detailed in research along with other keywords?
- Are there constraints in the existing Metaverse research which require further research?

The metaverse aims to be pervasive in everyone's everyday life, but there will be services that will be impacted more than others that will lead to real disruption or "metaverse service disruption" (MSD). Below are some services that will undergo a profound transformation with the growth of the metaverse .

3. Metaverse service disruption

Already nowadays the metaverse is used in many fields, but the services that will be impacted in a disruption will be:

- Games and Virtual Reality: Players can immerse themselves in 3D virtual worlds and interact with other players in real time;
- Training and education: Professionals and students can participate in training and education sessions in virtual environments, similar to a physical classroom;
- Conferences and Meetings: Businesses can host virtual conferences and meetings in metaverse environments, which offer a more immersive experience than a standard video conference;
- Shopping and entertainment: Consumers can explore virtual stores, view and purchase products in 3D, and participate in entertainment events such as concerts and shows;
- Arts and Culture: Visitors can explore virtual museums and galleries, view 3D artwork, and interact with other visitors.

Below a list of Metaverse services and a typology of classification:

4. Metaverse services and implementation requirements

In Table 3 it is reported the requirements of the Metaverse typology.

5. Metaverse architecture and Metaverse-enabling technologies and requirements coverage

Since its first appearance, the concept of Metaverse is still evolving with various descriptions, such as a second life [42], 3D virtual worlds [43], and life-logging [44]. Commonly, the Metaverse is regarded as a fully immersive, hyper spatiotemporal, and self-sustaining virtual shared space blending the ternary physical, human, and digital worlds [45]. Metaverse is recognized as an evolving paradigm of the next-generation Internet and the evolution of Social Media and the next mobile Internet revolutions [45], where users can live as digital natives and experience an alternative life in virtuality. The Metaverse integrates a variety of enabling technologies [47, 34, 48], including the Non-Terrestrial Networks (NTNs) [50]. In particular, digital twin produces a mirror image of the real world, Virtual Reality (VR) and Augmented Reality (AR) provide immersive 3D experience, 5G and beyond offer ultra-high reliable and ultralow latency connections for massive Metaverse devices as wearable. It provides an immersive experience, generates a mirror image of the real world based on Digital Twin technology and Avatars, and builds an economic system based on Blockchain technology. The Metaverse is comparable as a new type of social form, that includes economic systems, cultural systems, and legal systems, which are closely related to reality, but have their own characteristics. Hyper Spatiotemporality refers to the Metaverse, a virtual world parallel to the real world. It breaks the boundaries of time and space and offers users an open, free and immersive experience. The pervasiveness inherent in the Metaverse can be seen in recent sci-fi movies/series such as Avatar(2009, 2022), Ready Player One (2018), The Peripheral (2022) and others. The Metaverse is the tight integration, interaction, and intertwining of the real and virtual worlds that requires the integration of a variety of new technologies to create a novel Internet application and social form. The method

Metaverse related work detailed list		
Year	Publication	Brief description
2022	Y. Wang et al. [41]	A comprehensive survey of the fundamentals, security, and privacy of metaverse. Specifically, an analysis on distributed metaverse architecture and its key characteristics with ternary-world interactions.
2007	J. Sanchez [42]	An Interactive Qualitative analysis of the user experience in Second Life, an online Metaverse, in an undergraduate literature class. A focus group of eighteen students produced a systems model including ten affinities with one primary driver and one primary outcome.
2013	J. D. N. Dionisio et al. [43]	Moving from a set of independent virtual worlds to an integrated network of 3D virtual worlds or Metaverse rests on progress in four areas: immersive realism, ubiquity of access and identity, interoperability, and scalability.
2019	A. Bruun et al. [44]	Research in the wild has emerged in HCI as a way of studying participant experiences in natural environments. Also, lifelogging tools such as physiological sensors have become more feasible for gathering data continuously in the wild.
2021	H. Ning et al. [45]	The development status of Metaverse, from the five perspectives of network infrastructure, management technology, basic common technology, virtual reality object connection, and virtual reality convergence, it introduces the technical framework of Metaverse.
2021	D. Grider et al. [46]	The Metaverse is still emerging, but many key components have started to take shape and are revolutionizing everything from e-commerce to media and entertainment, and even real estate.
2021	L.H. Lee et al. [47]	The first effort to offer a comprehensive framework that examines the latest metaverse development under the dimensions of state-of-the-art technologies and metaverse ecosystems, and illustrates the possibility of the digital 'big bang'.
2022	Q. Yang et al. [34]	Dive into the metaverse by discussing how Blockchain and Artificial Intelligence (AI) fuse with it through investigating the state-of-the-art studies across the metaverse components.
2021	H. Duan et al. [48]	A three-layer metaverse architecture from a macro perspective, containing infrastructure, interaction, and ecosystem.
2022	S. Dhelim et al. [49]	a Fog-Edge hybrid computing architecture for Metaverse applications that leverage an edge-enabled distributed computing paradigm.

Table 1
Metaverse related works list.

Metaverse services		
Service	Typology	Refs
Decentraland	Decentralized Virtual World	https://decentraland.org
Somnium Space	Decentralized Virtual World	http://somniumspace.com
Cryptovoxels	Decentralized Virtual World	http://www.voxels.com
The Sandbox	Decentralized Virtual World	https://www.sandbox.game
Oculus	Virtual Reality/Augmented Reality	https://www.oculus.com
Playstation VR	Virtual Reality/Augmented Reality	https://www.playstation.com/it-it/ps-vr
Magic Leap	Virtual Reality/Augmented Reality	https://www.magicleap.com/en-us
Roblox	Gaming Metaverse	https://www.roblox.com
Fortnite	Gaming Metaverse	https://www.fortnite.com
Meta Horizon	Social VR	https://www.oculus.com/horizon-worlds
Mozilla Hubs	Social VR	https://hubs.mozilla.com
Rec Room	Social VR	https://recroom.com
Spatial	Enterprise Metaverse	https://www.spatial.io
Immersal	Enterprise Metaverse	https://immersal.com
Rumii	Enterprise Metaverse	https://www.dogheadsimulations.com/rumii
Stellantis	Virtual Shopping Experience	https://stellantisvirtual.com
Skodaverse	Virtual Shopping Experience	https://www.skoda-auto.com/world/skodaverse

Table 2
Metaverse Services and Typology of classification.

used will be to analyze the papers and publications on the Metaverse on the Smart Cities and Energy sector with a focus on the technologies used in in particular by focusing everything in the three layers in which the metaverse has been defined in the scientific literature [48](see figure 1).

To make it easier to understand the Metaverse concept from a technological point of view, Figure 2 provides an overview of what the metaverse enablign technologies components.

The Metaverse architecture does not separate the physical world from the virtual world so that it can produce an immersive experience. The infrastructure layer contains the

Metaverse services						
Reqs	Dec. Virt. World	VR / AR	Gaming Met.	Social VR	Ent. Metaverse	V. Shop. Exp.
Massive Access	High	High	High	High	Low	High
Mobility/Coverage	Low	Low	Low	Low	Medium	Low
Payment Systems	High	High	Low	Low	High	Medium

Table 3
Service Type Requirements.

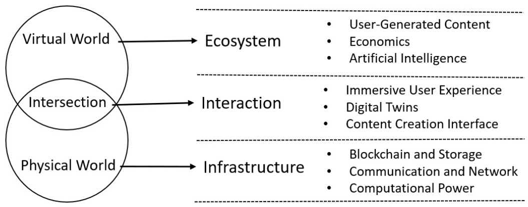

Figure 1: Three-layer Architecture of The Metaverse [48]

basic requirements to support the operation of the virtual world, such as computation, communication, blockchain, and storage. The interaction layer is an essential part of the interaction layer that bridges the physical and virtual worlds. The ecosystem layer can provide a parallel living environment with various services continuously serving all the world's inhabitants. A decentralized economic system must also support the Metaverse ecosystem based on smart contracts. Based on previous studies and literature, we concluded that the most critical technologies to create a Metaverse platform are Blockchain, Virtual/Augmented/Mixed Reality (Extended Reality or XR), Artificial Intelligence, Internet of Things (IoT), Digital Twin.

5.1. Extended Reality

Virtual Reality (VR) is a technology that uses software and hardware to replace one's perspective of the physical world with a digitally created one [51]. The most popular VR applications today employ comprehensive control of a user's senses (especially sight and hearing) to produce a completely immersive experience that immerses the viewer in a completely virtual environment that feels very realistic. AR is a technology that combines the digital and physical worlds. Object identification, plane detection, face recognition, and movement monitoring are just a few of the technologies it employs to distinguish real-world surfaces and objects. Augmented reality could become our primary portal to the Metaverse, as well as our primary interface to digital resources, replacing the present ecology of phones and desktops. Mixed reality is a fusion of augmented and virtual reality that does not take place exclusively in the physical or virtual environment [52]. Mixed reality can be employed in a variety of applications to enrich the Metaverse, including entertainment, military, healthcare, and robot operations [53, 54, 55, 56]. Extended Reality (XR) is an umbrella term that encompasses Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and everything in between.

Within the rapidly-emerging Metaverse, the potential of XR is driving expectations for a slew of previously unimag-

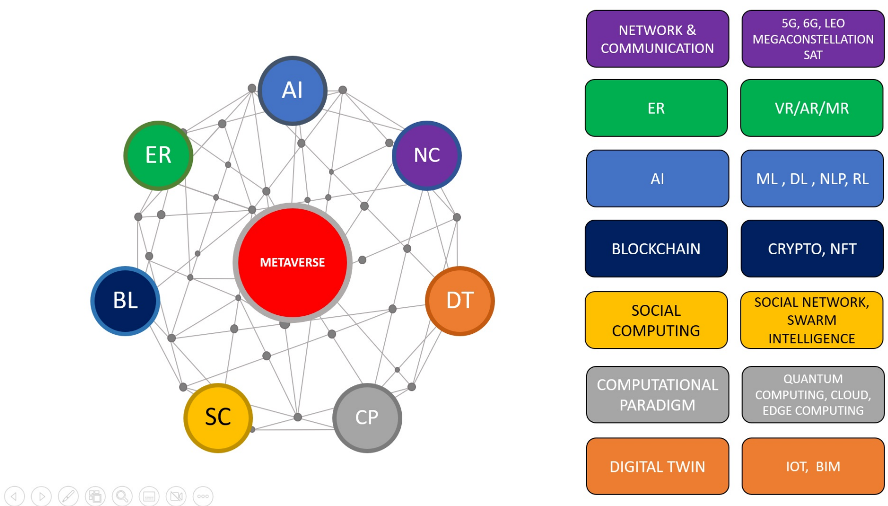

Figure 2: Metaverse enabling technologies

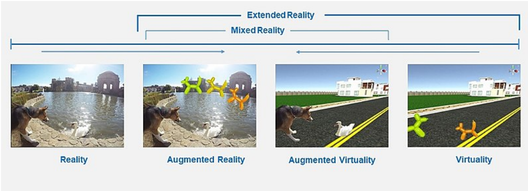

Figure 3: Extended reality scheme based on Paul Milgram's scheme [6]

inable possibilities. When Extended Reality replaces conventional PCs and affects the way we work, play, and connect on a daily basis, human lives will never be the same. People will use the Metaverse's virtual capabilities to apply for jobs, earn a living, meet up with pals, shop, and even get married.

5.2. Generative Artificial Intelligence (GenAI)

The concept of the Metaverse refers to a collective virtual shared space, created by the convergence of virtually enhanced physical and digital reality. It is persistent and provides enhanced immersive experiences. GenAI, particularly Large Language Models (LLMs) and other generative models, play a critical role in this environment by enabling the creation of dynamic content and intelligent interactions. GenAI refers to technologies that can generate new content from existing data. This includes text, images, video, and audio generation. LLMs, generative adversarial networks (GANs), and variational autoencoders (VAEs) are pivotal in crafting personalized and engaging content in the metaverse. This study employs a mixed-methods approach, integrating both qualitative and quantitative research. Data is collected through virtual ethnography in various Metaverse platforms, interviews with developers and users, and analysis of user-generated content within these environments. The study also reviews existing literature on generative AI applications and their implications for virtual worlds. GenAI and in general AI is a research discipline proceeded based on the hypothesis that every aspect of learning can in principle be so precisely described [57]. The state-of-the-art AI studies focus on machine learning, deep learning, and reinforcement learning in the fields including computer vision, decision-making, and natural language process (NLP). Intuitively, the breakthroughs of AI in the real world motivate people to realize Metaverse. For example, machine learning provides technical support for all systems in Metaverse to reach or exceed the level of human's learning. It shall significantly affect the operational efficiency and the intelligence of Metaverse. Intelligent voice services provide technical support, such as voice recognition and communication, for Metaverse users.

5.2.1. Applications of Generative AI in the Metaverse

- Content creation in a Dynamic Environment Design): Generative AI algorithms can create expansive, detailed virtual environments on-the-fly, adapting to user interactions;
- Content creation with Character and Avatar Customization: AI-driven tools enable users to create highly personalized avatars and non-player characters (NPCs) that can interact intelligently with users;
- Interaction and Engagement with Natural Language Processing (NLP): AI-enhanced communication tools allow for real-time language translation and generation of realistic dialogues with NPCs;
- Behavioral AI with enhances the responsiveness of environments and characters to user actions, creating a more immersive experience;
- Accessibility and Inclusivity with Adaptive Interfaces: AI algorithms can adjust the user interface dynamically to accommodate users' physical and cognitive needs.

5.3. Internet of Things (IoT)

The Metaverse gathers data from a variety of Internet of Things (IoT) devices to ensure that it runs efficiently in several applications of the Metaverse such as medicine, education and Smart Cities. The IoT devices will connect the Metaverse through the use of a diverse range of hardware, controllers, and physical items. Connecting to the Metaverse and navigating both physically and virtually is made possible by IoT devices equipped with specialized sensors. The capacity of IoT devices to perform operations in the Metaverse will be critical to the user's ability to operate in the Metaverse. Whether remotely performing large-scale computing tasks, accessing large databases, or providing shared experiences between users, they are inextricably linked to networks and communications. The fifth generation (5G) and the sixth generation (6G) are the communication foundation of the Metaverse. 5G has the advantages of high speed, low delay, ubiquitous network, low power consumption and interconnection of all things, which makes it possible to realize the Metaverse. 6G will break the limitations of time and virtual reality, expand the service objects from humans, machines, and things in the physical world to the "environment" of the virtual world, and realize the cooperation between humans-machines-things-environment by connecting the physical world and the virtual world, providing the network foundation for the Metaverse. In the 5G and 6G network environment, quantum communication ensures the communication security in the Metaverse. Post quantum cryptography is already a reality today, quantum communication provides high security by applying quantum key based on quantum no-cloning theorem and uncertainty principle [43]. Moreover, quantum communication improves the overall security due to the superposition properties of qubits.

5.4. Digital Twin

Digital Twin is a digital reproduction of a real product or component created by the combination of simulations and service metadata [58]. Data from numerous sources are included in the digital representation throughout the product life cycle. These data are constantly restructured and shown in a variety of ways in order to forecast current and future situations in both operational and design settings, therefore improving decision making [59]. Constructing a complex virtual model that is the counterpart or twin of a physical object in the real world is what Digital Twin is all about. It employs simulation, machine learning, and reasoning to aid decision-making and is generated from real-time data. Metaverse will be able to offer remote maintenance workshops for machines that need to be repaired, which might be linked to or mapped onto a real workshop, thanks to digital twin and simulation technologies. Digital twins are an important part of the Metaverse because of their non-artistic qualities.

5.5. Blockchain

Metaverse envisaged scenario that it is closely related is just a parallel world, where the economic ecology is inevitable. The digital assets are the core functions provided by the blockchain, such as the homogenized tokens based on ERC-20 and the non-homogenized tokens based on ERC-721 or ERC-1155. Since the blockchain technology maintain the smooth economic operation of Metaverse, blockchain technology is the soul of the Metaverse. The motivation behind integration of blockchain in the metaverse can be summarized in:

- Ensuring Data Privacy and Security
- Ensuring the Quality of the Data
- Enabling Seamless and Secured Data Sharing
- Enabling Data Interoperability
- Ensuring Data Integrity

There are many use cases of application of blockchain in the metaverse, for example:

- Financial system: Tamper-proof, openness, transparency and decentralization are the four significant features in blockchain. In the Metaverse, millions of transactions happen for goods exchange in a short time, so the security and efficiency of these transactions must be guaranteed. Based on the above-mentioned features, blockchain is a good candidate for the large-scale and scalable economic system construction in the virtual world
- Smart contract deployment: The inherent nature of the blockchain network allows smart contracts to be automated, programmable, open, transparent and verifiable among other remarkable features, thus allowing for onchain trusted interactions without the need for a thirdparty verification platform. If the financial system in the Metaverse is built on top of the blockchain, the characteristics of smart contracts can be used to decentralise the operation of contracts in a programmed, noncustodial, verifiable, traceable and trustworthy manner, thus significantly reducing the harmful behaviours such as rent-seeking, corruption and underhanded operations that may exist in the financial system, and can be widely used in the financial, social and gaming sectors.
- NFTs: The most important feature of NFT is indivision and uniqueness, which make it suitable for identity representation, for example, assets that are exclusive and indivisible and can be freely traded and transferred. In the Metaverse, these virtual assets come with certificates called NFTs that indicate ownership.
- Cryptocurrency: is one of the main applications under the spotlight empowered by blockchain. It also makes blockchain more popular. The trust of a wide range of users supports the value system of cryptocurrencies and drives both the circulation and trading of cryptocurrencies. To date, more than 12.000 virtual currencies have been issued worldwide, and new virtual currencies are still being created every single day. Like the real world builds upon fiat currencies, the Metaverse inevitably needs cryptocurrencies, which deliver value during their circulation, payment, and currency of settlement. In detail, blockchain systems have implemented a series of operations for cryptocurrencies, such as creation, recording, and trading. Traditionally, Bitcoin [35] adopts the UTXO (Unspent Transaction Outputs) transaction model to trace the usages of this cryptocurrency, while Ethereum [36] records the balance of each account address, which can be queried directly through the Ethereum dataset tools (e.g. Etherscan). Both UTXO and Ethereum adopt the Proof of Work (PoW) consensus. Miners mint coins by generating new blocks. However, there is a cost for them to generate blocks. In such PoW consensus, miners mine blocks by calculating a hash puzzle, which consumes a giant amount of electricity. For Ethereum 2.0, miners under the PoS (Proof of Stake) consensus mechanism mine blocks by electing, which depends on the coin age of miners [37]. Using blockchain technologies, there are multiple ways to deal with cryptocurrency exchanges. The vast majority of cryptocurrency exchanges occur in centralized exchanges such as OKEx and AOFEX. The advantages of the centralized exchanges include low-latency transactions, simple interfaces and a certain level of security. However, the centralized exchanges also experience scandals such as price manipulation by insiders taking advantage of information asymmetries. Other cryptocurrency exchanges occur in decentralized exchanges, where smart contracts or other peer-to-peer network execute transactions automatically [38]. In some cases, the smart contracts, e.g., IDex and Paradex, maintain continuouslimited order books offchain, a counterparty of the order or the exchange itself performs order matching and submits order pairs to the smart contract for processing. In other cases, such as Uniswap and Bancor, the smart contract performs as a counterparty and trade with its user directly. It is easy to foresee that metaverse built by different corporations will coexist in the near future. Thus, various cryptocurrencies used in those smaller metaverses need to be exchanged like fiat currencies in the physical world. We envision that multiple cryptocurrencies will also coexist in future Metaverse. The Metaverse users will naturally need to exchange different cryptocurrencies.

6. Results and discussion

The Metaverse, designed as a simulation of the natural world, covers all areas related to humans and society and offers a suitable working platform for researchers in all fields, from health to sports, from education to art. This the research deals with the scientific aspect of the Metaverse studies and examines academic studies in Energy and Smart Cities and in other research keywords connected from a technological and related domain point of view. Most of the studies in the literature have explained the concept of the Metaverse. The implemented applications observed, are mainly at the prototype level. However, these studies, which make significant contributions to the literature in terms of design and editing, have a high potential to be realized when sufficient technical infrastructure is provided. The AR/VR technologies, digital twins, and Blockchain applications, which are components of the Metaverse, have been actively used for a while. Furthermore, technological developments that allow the purchase and sale of non-Fungible Token (NFT)-based artworks, souvenirs, and lands, which have been very popular lately, show that the promised universe is one step closer. However, for this fictional universe to be fully realized, 5G technology needs to come into play, AR/VR hardware and content should become widespread, and the use of peer2peer technologies should increase. When the Metaverse is brought to life as it was designed, it will be possible to perform many daily activities such as working, traveling, shopping, going to school, having fun by creating a 3d avatar in a digital universe. Any change users make in the Metaverse will be permanently visible to almost everyone, thus providing users with greater identity and continuity of experience. The Metaverse becoming a reality will support and transform existing research topics and reveal new research areas. In addition, this digital universe will be a big data source with the data it will produce. Therefore, it will also provide a suitable working platform for big data, data science, and artificial intelligence researchers. With the development of the technological infrastructure and the interest of researchers in this field, it is expected that the number of scientific studies in the area will increase, and richer content will emerge soon. All these developments herald an exciting future. An open Metaverse, this is one of the challenging issues that will determine, in my view, its success or not. In this context, the key word is interoperability. Not only does the so-called Metaverse still not exist in the forms in which the marketing of certain companies wants to sell it. But not even a single Metaverse is the digital twin of the physical world. Rather, there are several platforms on the market, each with its own rules of engagement and its specificities. Meta itself has realized that isolation is not convenient. In his latest presentation to the market, Zuckerberg insisted not only on the legs of the Horizon avatars, but also on collaborations with other companies, such as Microsoft, Adobe and Zoom. A sign that if the Facebook founder really wants to make the project with which he hopes to inject new life into a company afflicted by the decline in advertising revenues, by the compromised public image and by a social competition that he cannot keep up with, it is time to come to terms [49]. Different from the physical world, the digital creation in the virtual world might be unlimited. The identity of digital objects determines value instead of the undifferentiated labor in the conventional economy. In the field of digital creation, it is necessary to develop authoring tools to enable the users to produce original content easily and gain rewards efficiently at a low cost. Those tools could improve the enthusiasm of content producers of the Metaverse. The marginal benefits will increase in the Metaverse instead of diminishing marginal benefits of production in the physical world. The difference in marginal benefits between the physical world and the virtual world demands a value conversion mechanism to bridge their gap. In future Metaverse, people prefer to turn to their virtual cabinet to select a digital outfit, while companies begin to hype the virtual skins, virtual clothing, and even virtual estates with a high price which will block a large portion of players to join in the Metaverse. Hence, it is necessary to propose particular governance mechanisms under the cooperation of worldwide companies. Furthermore, how to establish a digital currency system that enables the currency exchange between the Metaverse and the physical world remains an open issue. In addition, the transaction volume and frequency that occurred in the Metaverse will become extremely much higher than happened in the physical world. Thus, how to support such high-volume and high-frequency transactions remains a challenging problem in the future Metaverse. Another issue related to future Metaverse might be the inflation caused by massive cryptocurrency supplements in a decentralized economy system built upon blockchain and AI technologies.

7. Conclusions

The analysis carried out on the research publications using a sample of the universe searched through the online metadata sites of the research works for certain keywords, it emerged that the metaverse it is already having an impact on certain categories of services and will be increasingly disruptive. The services involved will be increasingly pervasive as the technologies enabling the metaverse are pervasive. The research area relating to the metaverse and quantum computing deserves a separate discussion, which deserves a separate discussion as the latter is a rapidly growing and maturing technological area. The challenges facing us in the metaverse are enormous in the short to medium term. According to the current trend, it seems that metaverse will be the future from multiple perspectives and offers limitless possibilities from many frontiers. Enabling technologies such as Blockchain, GenAI, XR, Digital Twin will be instrumental in realizing the true potential of the Metaverse. There is a huge research prospect in these areas.

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