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Review

Metaverse and machine readable standards: Basic concepts, key technologies, and application scenarios

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Abstract: Standards are important in facilitating the development of new technologies in the Metaverse scene, and machine readable standards are a new form of standards centered on machine reading, execution, and understanding. Therefore, the study of machine readable standards is of great significance to promote the development of Metaverse technology and disciplines. At present, there is no research on the fusion of machine readable standards and Metaverse home and abroad, and there is no research on the research value, key technologies, difficult challenges and application scenarios of machine readable standards under the perspective of Metaverse. Challenges and potential opportunities for the application of machine readable standards are also discussed. Finally, the application scenarios of machine readable standard in the Metaverse field are proposed, including four scenarios: resource retrieval, knowledge question and answer, personalized knowledge push and virtual digital human.

Keywords: Metaverse; machine readable standards; basic concepts; key technologies; application scenarios

1. Introduction

At present, standardization organizations and institutions at home and abroad play a very important role in writing standards, approving standards, standard promotion and dissemination, standardization scientific research, etc. However, the current paper document form is difficult to meet the cross-country, cross-region, cross-industry, cross-department, cross-technology, cross-domain integration and innovative application under the digital era. It is urgent to break the traditional manual interactive low-efficiency reading, writing and application mode. It is necessary to develop a new computer-based reading mode, that is, the machine can read the standard document, understand the standard terms, implement the standard parameter requirements, and independently determine the standardized process, so as to quickly find standards, quickly modify the standard format, quickly obtain standard indicators, and even achieve the standard data correlation and dynamic content update functions.

Therefore, this paper explores the basic concepts of machine readable standard and Metaverse based on the synergistic perspective of Metaverse and machine readable standard, analyzes the correlation between them, studies the machine readable standard and the related technologies of Metaverse, focuses on the research value and significance of machine readable standard to Metaverse, analyzes the application challenge and potential of machine readable standard, and forecasts the application scenarios of machine readable standard, so as to provide technical support and reference for the development of Metaverse.

2. Recent research advances in Metaverse and machine readable standards

At present, there is no consensus on the basic concept and connotation of the Metaverse the world. This paper summarizes and sorts out the basic concept of the Metaverse. See **Table 1** for the basic concept of the Metaverse.

Table 1. Concepts of Metaverse and machine readable standards.

Basic concept	Description	Literature basis
Metaverse	The Metaverse is a virtual world connected and created through science and technology, mapped and interacted with the real world, and has a digital living space of a novel social system.	[1]
	The Metaverse is a world composed of countless interconnected virtual communities where people can meet, work, and entertainment through virtual reality devices (e.g., headphones and eyes), smartphone applications, and other devices.	[2]
	The Metaverse is a virtual world that connects everyone. Everyone has a virtual identity and can do anything desired. The Metaverse has eight characteristics: identity, friends, immersion, low latency, diversity, anywhere, economy, and civilization.	[3]
	The Metaverse is the next-generation Internet application and social form generated by integrating multiple new technologies. It realizes space-time expansion based on expanded reality technology and digital twin, human-machine fusion based on AI and Internet of Things for virtual people, natural people and robots, and economic value-added based on blockchain, Web3.0, digital collections/NFT, etc.	[4]
	The Metaverse is a collective virtual shared space composed of virtual augmented physical reality and physical persistent virtual space, including the sum of all virtual worlds, augmented reality, and the Internet.	[5]
	The Metaverse is a new comprehensive technology concept, based on immersive Internet technology, Internet of Things technology, interactive technology, electronic game technology, artificial intelligence technology, Web 3 Digital collections/Non-FengibleToken, 5G/6G, blockchain technology, digital twin technology, etc. to build a virtual world mapping the real physical world. In this virtual world, users can use their virtual entities to interact and complete the corresponding tasks in the real world.	[6]
	Metaverse is essentially a generalized cyberspace. On the basis of covering physical space, social space, cyberspace and thinking space, it integrates multiple digital technologies, integrates networks, hardware and software equipment and users into a virtual reality system, and forms a virtual world that maps to and is independent of the real world.	[7]
Machine Readable Standards	SMART standards are a new digital form standard oriented to machine (such as computer, robot and automation system equipment) to read, identify, execute, analyze and apply.	[8]
	SMART standards are new forms of standards that can be read, executed, and resolved by machines without human intervention.	[9]
	SMART standards refer to standard document oriented, using computer technologies such as big data, natural language understanding and knowledge atlas to transform common paper document standard or PDF form standard into computer recognizable, readable, understandable and executable data form standard, so as to realize standard transferring in data form (formula, model, algorithm, code, etc.) to various business systems for application.	[10]

1) In this study, the definition of the Metaverse is that it is not an independent emerging technology, but a technical aggregate integrating various cutting-edge technologies such as big data, cloud computing, the Internet of Things, mobile Internet, artificial intelligence, blockchain, virtual reality, digital currency, security encryption, privacy protection, computer interface, etc. The Metaverse has the ability to map real world things into the virtual world, and to create things in the virtual world. Finally, it realizes the friendly interaction between real and virtual world, in order to break through the interaction barriers between virtual world and real world.

2) The definition of machine readable standard in this study refers to a new standard form that can be identified, read, understood, implemented and applied by

the machine. It no longer emphasizes the presentation in paper text form, but uses the embedded data transmission, storage, management, analysis, evaluation and other links in code or knowledge form (including data, models, programs, software tools, etc.).

3. Machine readable standards and Metaverse related techniques

3.1. Metaverse related techniques

As shown in **Figure 1**, there are different technical supports for realizing the six demands (vision, hearing, smell, taste, touch and consciousness) of the eye, ear, nose, tongue, body and brain in the era of the Metaverse. The essence of the Metaverse is the comprehensive application of various technologies. This paper considers that the core technologies mainly involve the following 7 technologies:

1) Network and computing technology, it can realize high-speed communication, ubiquitous connection and resource sharing between virtual world and real world.

2) IOT technology, it can realize data transmission between terminal equipment and virtual world.

3) Human-computer interaction technology and extended reality technology (including VR, AR, MR, XR, etc.), it can provide immersive experience for users.

4) Electronic game technology, it can help build virtual world scenes and dialogues, improve the intelligent level of virtual world.

5) Blockchain technology, it can help build a safe and reliable economic system in the virtual world.

6) Digital twin technology, it can help create a mirror image of the real world.

7) Large model related technologies, it can help improve virtual resource computing, analysis and optimal configuration capabilities.

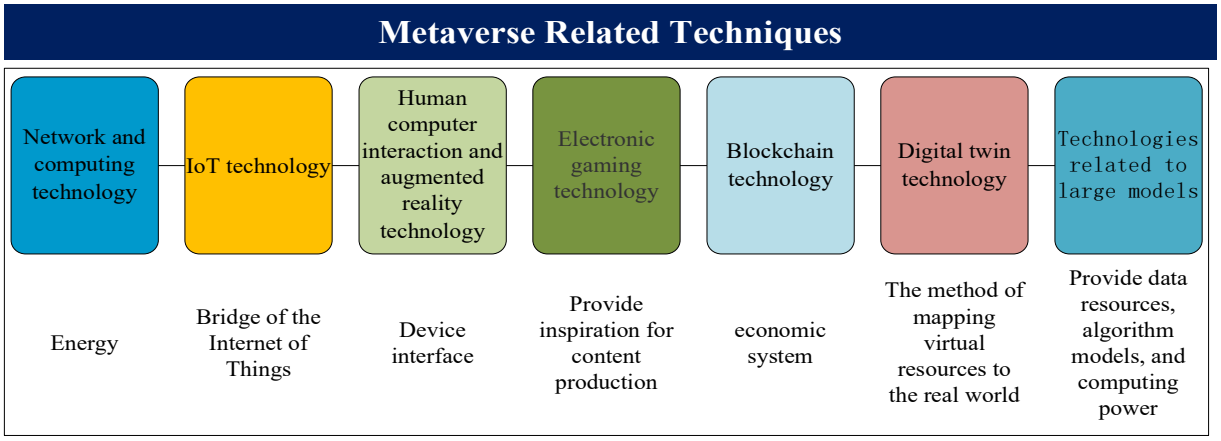


Figure 1. Metaverse related techniques.

3.2. Machine readable standards related techniques

As shown in **Figure 2**, the relevant technologies of the machine readable standards include 7 aspects:

1) Image and text recognition technology refers to the technology of scanning paper standard or PDF format text data, analyzing and processing image files, and

acquiring text content, picture content, table content and other information.

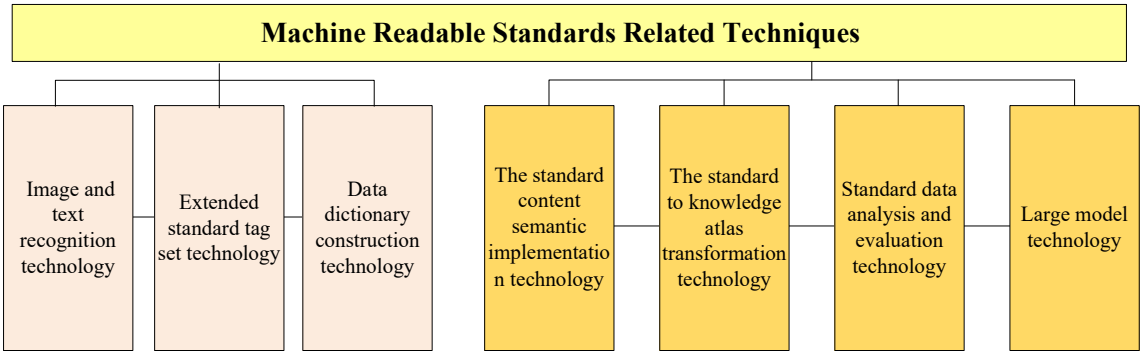


Figure 2. Machine readable standards related techniques.

2) Extended standard tag set technology refers to the technology that digitalizes the standard, manages the tag of its data elements, and identifies the data elements.

3) Data dictionary construction technology refers to the set of information describing data and the set of definitions for all data elements used in the system. It accurately and strictly defines each system-related data element and organizes them in a dictionary order, so that users and analysts have a common understanding of all input, output, storage components and intermediate calculations.

4) The standard content semantic implementation technology refers to describing and managing the logic, technology and other elements in the minimum standard information unit through the semantic information model, restructuring the correlation between the minimum standard information units and giving semantics. Finally, the knowledge and information in the standard are digitalized through the semantic information model, and the mapping or fusion between different types of information models is realized.

5) The standard to knowledge atlas transformation technology refers to the technology that combines the theories and methods of applied mathematics, graphics, information visualization technology, information science and other disciplines with metrology citation analysis, co-occurrence analysis and other methods, and uses the visualized atlas to visually display the knowledge resources and their carriers of power standards, excavate, analyze, construct, draw and display the knowledge and their interrelation, so as to realize the multidisciplinary fusion.

6) Standard data analysis and evaluation technology refers to the technology that combines high mathematics, linear algebra, statistics and other disciplinary knowledge, uses big data, cloud computing, block chain and other information technologies to fully exploit the data value of standard information unit, and embeds the standard information unit into the standardization work (standard data analysis, standard data evaluation) for use, so as to achieve standard project establishment and statistical analysis of published data, standard data image display and other effects.

7) Large model technology refers to the construction technology of machine learning model with massive parameters and complex computing structure. It includes language big model, visual big model, multi-mode big model, decision big model, industry vertical big model and other categories. It can quickly identify, read, understand, implement and interpret the contents and knowledge in the standard text,

so as to realize the effect of simulating human perception and thinking about the world.

3.3. Correlation between the Metaverse and machine readable standards

As shown in **Figure 3**, the Metaverse and machine readable standards have three common points:

1) Firstly, both machine readable standards and Metaverse are comprehensive applications of multiple technologies. The Metaverse involves various technologies such as big data, cloud computing, and the Internet of Things. Machine readable standards also involve various technologies such as blockchain, big data, cloud computing, and big models. Therefore, both technologies are essentially a collection of technological applications.

2) Secondly, both machine readable standards and Metaverse can map real-world resources to virtual worlds. The Metaverse is essentially a mapping of the real world, where things in the virtual world correspond one-to-one with the real world. Machine readable standards also involve mapping paper text from the real world to code form text that machines in the virtual world can recognize, read, and understand. Therefore, both can exist simultaneously in the real world and the virtual world.

3) Thirdly, both machine readable standards and the Metaverse can utilize the virtual world to advance the development of the real world. The Metaverse can use virtual worlds for simulation prediction analysis and future development path prediction, and can promote the development of the real world based on the results of virtual world analysis. Machine readable standards can involve combining multiple standard data indicator parameters for simulation calculation and analysis, and can optimize the allocation and integration of resources such as standardized personnel, paper literature, and data indicators in the real world based on simulation calculation results. Therefore, both can counteract the real world through the virtual world.

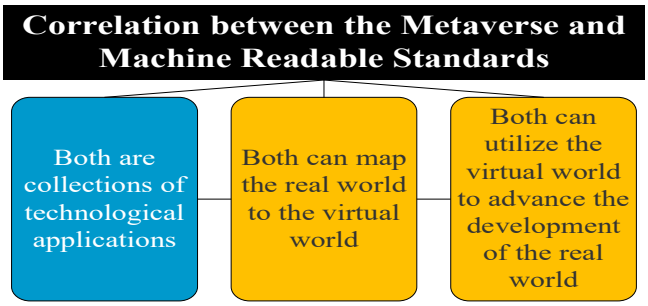


Figure 3. Correlation between the Metaverse and machine readable standards.

4. The significance and value of studying machine readable standards from the perspective of the Metaverse

As shown in **Table 2**, conducting research on machine readable standards from the perspective of the Metaverse not only promotes the development of Metaverse related technologies such as network computing, Internet of Things, digital twins,

artificial intelligence, blockchain, human-computer interaction, and electronic games, but also has the following value and role in the development of Metaverse work:

Table 2. The role of machine readable standards in Metaverse technology elements.

Number	The key technical elements of building the Metaverse	The significance and value of machine readable standards for Metaverse research	Can it play a positive role	Description
1	Network and computing technology	The energy of the Metaverse provides high-speed communication and resource sharing functions for the Metaverse	Yes	Machine readable standards can standardize data formats and improve communication speed
2	IoT technology	The bridge of the Metaverse, achieving ubiquitous connection between the virtual world and the real world	Yes	Machine readable standard specifications for data exchange forms, enhancing the interaction ability of the Internet of Things
3	Human computer interaction and augmented reality technology	The entrance and exit of the Metaverse, providing a device interface to enter the virtual world and providing users with an immersive experience	Yes	Machine readable standards can standardize data exchange formats between different systems, improving data transfer speed between virtual and real worlds
4	Electronic gaming technology	The innovative driving force of the Metaverse provides strong technical support for the content production of the Metaverse	Yes	Machine readable standards can standardize the interaction ability of different game data, improving the efficiency of electronic game content production
5	Blockchain technology	The monetary guarantee of the Metaverse provides technical support for building a safe and reliable economic system in the Metaverse world	Yes	Machine readable standards can standardize the interaction format between data on the blockchain and other data off the chain, improving the efficiency of data transmission on and off the blockchain
6	Digital twin technology	The mapping method of the Metaverse involves digital replication of physical entities, achieving mapping and mutual influence between the Metaverse and the physical world	Yes	Machine readable standards can standardize the data format of mapping real-world resources to virtual resources, improving the efficiency of constructing virtual worlds
7	Technologies related to large models	The innovative technological foundation of the Metaverse, achieving efficient mapping between the virtual world and the real world in the Metaverse	Yes	Machine readable standards can help correlate and integrate a large amount of standard data, enhancing Metaverse related data resources, algorithm models, and computing power

1) Firstly, machine readable standards can improve the query efficiency, writing efficiency, and dissemination speed of Metaverse related standards.

2) Secondly, machine readable standards can promote the integration and application of various new technologies in the Metaverse. Machine readable standards are no longer presented in the form of paper standards, but emphasize a new form of standards that can be read, executed, and interpreted by machines, and advocate for standards to be embedded in various systems in the form of knowledge for application.

3) Thirdly, there are machine readable standards that can break down the barriers between the virtual world and the real world in the Metaverse. Machine readable standards standardize the structured presentation of standards, which can help Metaverse related data flow freely in different business systems, interaction platforms, and business scenarios.

4) Fourthly, machine readable standards can enhance the security of the construction and operation of the Metaverse. Machine readable standards can achieve traceability and tracking of faults during the construction and operation of the Metaverse, quickly identifying which standards, clauses, and specific parameters faults or problems occur.

5. The application challenges and potential opportunities of machine readable standards from the perspective of the Metaverse

Although machine readable standards have many advantages, it is also important to recognize the technical challenges and potential opportunities that exist in their specific applications, as shown in **Table 3**.

Table 3. The application challenges and potential opportunities of machine readable standards.

Number	Application challenges	Primary coverage	Potential opportunities
1	What is the construction method of machine readable standards	How to convert existing paper standards into machine readable standards and how to directly construct incremental machine readable standards	1) Research on the conversion method of stock machine readable standards 2) Research on the construction method of incremental machine readable standards
2	What are the requirements for using machine readable standards	What are the requirements for using machine readable standards in different fields such as electricity, aviation, aerospace, electronics, communication, petroleum, and chemical engineering	1) Study the common requirements of machine readable standards 2) Research the demand for differentiated characteristics of machine readable standards
3	What are the key technologies for establishing machine readable standards	What technologies are needed to solve the problems in the application of machine readable standards in research	1) Research common techniques for machine readable standards 2) Industry specific technologies for researching machine readable standards
4	What are the application scenarios of machine readable standards	What business scenarios are involved in studying machine readable standard applications	1) Research common scenarios of machine readable standards (such as query standards, writing standards) 2) Research industry-specific technologies for machine readable standards (such as electric power inspection scenes and aviation aircraft scenes)
5	What are the digital support platforms and tools for machine readable standards	Tools such as information systems, service platforms, and mini program applications for researching machine readable standards	1) Research standard databases for machine readable standards 2) Study the standard information service system for machine readable standards
6	What are the typical practices of digital support for machine readable standards	Excellent experience in researching machine readable standards, pilot applications, and other practices	1) Technical path for researching machine readable standards 2) Development experience in researching machine readable standards
7	What to do about the copyright issue of machine readable standards	Research on Intellectual Property Issues of Machine readable Standard Data	1) Research international policies 2) Research on Chinese policies
8	What to do about the security and privacy protection of machine readable standards	Research on encryption and decryption technology, privacy protection technology, and blockchain technology for machine readable standard data	1) Research on secure encryption technology 2) Research privacy protection technologies

6. Application scenarios of machine readable standards from the perspective of the Metaverse

As shown in **Table 4**, the application scenarios mainly involve four categories:

resource retrieval, knowledge Q&A, personalized knowledge push, and virtual digital human.

Table 4. Application scenarios of machine readable standards.

Number	Application scenarios	Core building technologies	Primary coverage
1	Retrieve resources	VR, AR, Knowledge graph, natural language understanding, brain computer interface and other technologies	Implement fast indexing, virtual literature search, and visual presentation functions
2	Knowledge Q&A	Identity authentication, security encryption, privacy protection, big language models, and natural language understanding and other technologies	Implement knowledge Q&A and reference consulting services
3	Personalized knowledge push	Cloud computing, edge computing, distributed storage, privacy protection, big data analysis, user preference behavior analysis and other technologies	Realize precise push of personalized resources and user preferred knowledge push
4	Virtual digital human	speech recognition, natural speech understanding, big data analysis, deep learning, machine learning, digital twins, and big language models and other technologies	Realizing anthropomorphic virtual services such as science popularization and content explanation

1) Retrieve resources, the current standard retrieval process has problems such as low retrieval efficiency and inaccurate results. In the future, with the development of technologies related to Metaverse and machine readable standards, fast indexing, virtual literature search, and visual presentation functions can be achieved. For example, in the process of virtual literature search, VR, AR and other access technologies can be used to construct three-dimensional positions and 3D models of all electronic and physical resources, store them in a distributed database, and import them into a retrieval system, allowing users to freely explore the virtual system and search for books or other resources in the virtual world at any time. In terms of visual presentation, brain computer interface technology can be used to preview the 3D model of standard resources according to the theme, keyword, title, content, etc. that appear in the user's mind, and then use cloud computing and edge computing to integrate standard literature resources with databases to achieve unified retrieval and knowledge sharing.

2) Knowledge Q&A, the current standard intelligent Q&A process has problems such as incorrect answers and poor content quality. In the future, with the development of technologies related to the Metaverse and machine readable standards, knowledge Q&A and reference consulting services can be achieved. For example, in the process of character customization, users can become virtual characters in the community (technical experts, managers, readers, etc.), and even freely build their desired height and appearance. In the process of virtual consulting, digital twin technology can be used to build a twin of knowledge Q&A customer service in the virtual consulting agency scene. When users ask questions, holographic projection technology can be used to allow the virtual avatar of customer service to personally visit the users for Q&A services.

3) Personalized knowledge push, the current standard push process has issues such as poor content quality and lack of relevance to user interests. In the future, with the development of technologies related to the Metaverse and machine readable standards, precise analysis of user preferences and characteristics can achieve precise push of personalized resources. For example, in the process of building user profiles, massive data is analyzed and stored through cloud computing, edge computing,

distributed storage and other technologies to build a 3D path map for each user, and based on the analysis of users' historical behavior, users' preferred electronic literature names, electronic literature construction indicators and parameters, physical literature storage locations, etc. are accurately pushed.

4) Virtual digital humans, the current standard virtual service links have problems such as inaccurate speech recognition, unintelligent language understanding, and unsmooth dialogue and communication. In the future, with the development of technologies related to the Metaverse and machine readable standards, we will introduce cartoon characters through the construction of virtual digital humans, build bridges for communication with readers, and achieve virtual services such as anthropomorphic science popularization and content explanation. For example, in the process of speech recognition, deep learning algorithms are used to convert human speech into text for speech recognition, and then the reader's speech problems are understood and analyzed for human real intentions, thereby completing anthropomorphic dialogue communication and correctly answering business questions. In the process of voice communication, technologies such as biological cloning, digital twins, and AI are used to digitally twin real characters, adjusting the appearance, height, speaking speed, tone, and volume of the service object, making the dialogue scene more anthropomorphic.

7. Case study on the implementation of machine readable standards from the perspective of the Metaverse

As shown in **Figure 4**, the implementation method of machine readable standards in the Metaverse scenario includes three steps.

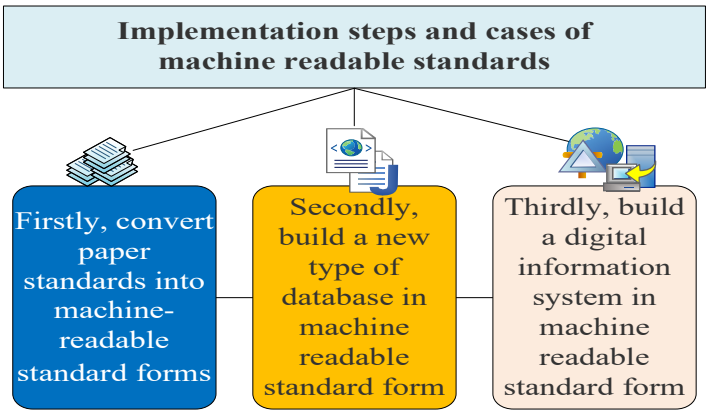


Figure 4. Implementation steps and cases of machine readable standards from the perspective of the Metaverse.

1) Convert paper standards into machine readable standard forms. Firstly, using OCR type text recognition technology to recognize paper standards or PDF documents, converting them from paper standards or PDF format to editable format documents (such as doc, docx format, etc.). Secondly, based on practical application requirements, the editable format documents mentioned above are decomposed into small information units (SIUs) according to their structural composition, technical elements, etc., and then labeled to form different types of standard information units

(such as scope type standard information units, definition type standard information units, and requirement type standard information units). Finally, perform rule mapping, add semantic algorithms and complex information models on the basis of standard information units, and output machine readable standards in structured forms (such as XML and HTML). At this time, the standards can be read, recognized, understood, and executed by the machine.

2) Build a new type of machine readable standard form database, aggregate different machine readable standards into the same database, and form a machine readable standard data resource library.

3) Build a digital information system in machine readable standard form, develop standard information service systems, platforms, and other tools based on the machine readable standard data resource library. The final effect and advantages include four aspects: firstly, the query criteria are more precise, not only querying the entire standard text, but also separately querying a specific chapter, paragraph, sentence, word, or symbol of the standard. Secondly, writing standards is more efficient, and editing software can be used to achieve online collaborative editing by multiple people. Thirdly, the management standards are more comprehensive, achieving standard development management, standard scientific research project management, standardized talent management, and so on. Fourthly, analyzing standards is more convenient, enabling data analysis of standard branches, fields, and key standards, providing decision-making references.

8. Conclusion

This study believes that machine readable standards are a crucial part of building a Metaverse technology system, which will standardize and lead the transmission, storage, management, sharing, and application of Metaverse data. They are of great significance for promoting the comprehensive application of various elements and technologies in the Metaverse, as well as promoting the interaction and integration between the real world and the virtual world. They may become a bridge connecting the virtual world and the real world, affecting the future development direction and implementation effect of the Metaverse. The research conclusions are as follows:

1) The building technologies of the Metaverse include seven types of technologies: networks and computing, the Internet of Things, human-computer interaction and augmented reality, electronic games, blockchain, digital twins, and big models. The key technologies for machine readable standards include image and text recognition, extended standard label sets, data dictionary construction, semantic implementation of standard content, standard to knowledge graph transformation, standard data analysis and evaluation, and big models.

2) The research value and significance of machine readable standards from the perspective of the Metaverse include four aspects: firstly, it can improve the query efficiency, writing efficiency, and dissemination and promotion speed of Metaverse related standards; Secondly, it can promote the integration and application of various new technologies in the Metaverse; Thirdly, it can help break down the interaction barriers between the virtual world and the real world in the Metaverse; Fourthly, it

can enhance the security of the construction and operation of the Metaverse

3) The application challenges and opportunities of machine readable standards from the perspective of the Metaverse include eight aspects: what is the construction method of machine readable standards, what are the requirements for the use of machine readable standards, and what are the key technologies for building machine readable standards.

4) The application scenarios of machine readable standards in the Metaverse perspective include four aspects, specifically referring to resource retrieval, knowledge Q&A, personalized knowledge push, and virtual digital humans.

5) The implementation steps of machine readable standards from the perspective of the Metaverse include three aspects: first, converting paper standards into machine readable standard forms; second, constructing a new database of machine readable standard forms; and third, constructing a digital information system of machine readable standard forms.

Conflict of interest: The author declares no conflict of interest.

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