# Exploring Virtual Discrete Manufacturing Assembly

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**Abstract.** The industrial Meta Universe is the application of the Meta Universe-related technologies in the industrial field. Compared with the consumer Meta Universe, the industrial Meta Universe pays more attention to tackling the exact problems in the actual scene, and its value may be considerably greater than the consumer Meta Universe. The industrial Meta Universe, as a key link in the Meta Universe industry, is a vital application and development of the Meta Universe in the industrial field. In this study, the global perception, twinning modeling, and in-depth simulation of complex industrial scenes are conducted to control the industrial system and production process in a coordinated way and achieve the overall optimization operation. This contributes to the formation of a new production mode of interpersonal collaboration, virtual and real control, and digital integration.

**Keywords:** global awareness; twin modeling; deep simulation.

## 1    Introduction

Currently, there are many practical cases in the industrial Meta Universe, such as the industrial integration of AR intelligent helmets applied by electric power enterprises and the Boeing 777 aircraft designed by Boeing using virtual reality technology [1]. In other words, the further integration of the Meta Universe and the industrial real economy is an inevitable trend, though the industrial Meta Universe is still in its infancy [2]. The pioneer of Meta Universe has started to layout and develop the first race track of Meta Universe with a focus on the development of equipment enabling field. Unlike other new enterprises of Meta Universe, the relevant enterprises emphasize the digital assembly entity enabling, which is employed as the preliminary paving path to building super automation, completing the dual win-win of personalization and automation, and realizing the sustainable development and inherent value of super automation [3]. This can guarantee the standardization and maturity of the Meta Universe industry. The industrial Meta Universe indicates the application of Meta Universe-related technologies in the industrial field. It performs the comprehensive simulation

of R&D design, production and manufacturing, marketing and sales, after-sales service, and other links and scenarios in the virtual space, which will cover the entire chain of industrial production [4-7]. It is a new carrier for the integrated development of the new digital industrial space, the new industrial intelligent Internet of Things system, as well as the digital economy and the real economy [8-9]. The value function of the industrial Meta Universe, in addition to meeting the existing needs of enterprises, will drive new demand, expand enterprise vision, break market boundaries, and derive emerging industries [10].

## 2      Calculus is the basis of the Meta Universe

### 2.1      The preliminary embodiment of the Meta Universe

After the diversification of the definition of the Meta Universe, the industrial branches included in the Meta Universe are becoming more prosperous, while increasing members are entering its ecosystem. Nevertheless, the industry seems to have more consensus on the development of the Meta Universe, the first of which is the infrastructure centered on computing. Concerning computing power, the demand for exclusive computing power for graphics, artificial intelligence, and blockchain required by the Meta Universe may increase exponentially. However, the computing power system built around universal computing power in the early stage has been unable to effectively meet the demand for such computing power, whether in terms of technical capability or economic efficiency. Hence, how to better build a more cost-effective dedicated computing power, make good use of the existing general-purpose basic computing power, and realize the coordinated development of general-purpose computing power and special-purpose computing power is the top priority of the next step in computing power construction. The characteristics of the 5G network provide crucial support for the start of the Meta Universe. The new infrastructure of the computing power network will start from the integration of computing networks and evolve to the integration of computing networks and endogenous services, to satisfy the rapid construction and end-to-end business experience of the Meta Universe business. With the industrial entity as an example, the industrial entity the Meta Universe needs a significantly powerful network, whether it is computing power, bandwidth, or network speed. The network capacity is still insufficient, though China has opened more than 1.7 million 5G networks, accounting for more than 60% of the world's total. Gongti Yuanuniverse and the three major operators build a super public network based on the public network, but superior to the public network performance. Consumers and fans coming to Gongti will enjoy the significantly superior performance of the public communication network. With the improvement of infrastructure capacity, the Meta Universe will surely usher in the moment when more ideals shine into reality. In the future, the Meta Universe will be applied in real economic scenarios such as education, medical care, and government services. It can also promote the development of relevant enterprises and form a virtuous circle through policy support and the promotion of the diversification of application scenarios. The development of the Meta Universe is to achieve the deep integration of the digital economy and the

real economy, rather than "off the real to the virtual", to effectively enable the comprehensive upgrading of the real economy. In this way, all walks of life can find the "second growth curve". At present, the initial manifestation of the Meta Universe is only in the game entertainment industry. With the continuous maturity of technology, the next stage of development of the Meta Universe is to reconstruct the social, consumption, and other aspects of reality in the digital world. In the future, the Meta Universe will become a virtual mapping of the real world (Fig. 1).



**Fig. 1.** The preliminary embodiment of the Meta Universe

## 2.2    The industrial Meta Universe

2020 is the critical point of the virtualization of human society, paving the way for 2021 to become the first year of the Meta universe. The market size of the Meta universe industry in China reached 650 billion yuan this year. Meanwhile, the overall scale of the economic added value of China's industrial Internet core industry reached 652 billion yuan. As a more advanced form of industrial Internet, the global industrial scale will exceed 1.4 trillion yuan in 2030. The realization and landing of the Meta Universe require six supporting technologies: blockchain, interaction technologies, game-related technologies, AI, network and computing technologies, and the Internet of Things. This stage consists of real-time rendering, network transmission, stereoscopic display, human-computer interaction, brain-computer interface, and other software, as well as optoelectronic components. The research of hardware such as graphics chips has become the key frontier technology to promote the rapid development of the Meta Universe. The XR technology, sensor technology, 3D modeling, real-time rendering technology in interactive technology, and data sensing technology in the Internet of Things technology are crucial for the industrial Meta Universe. At present, the industrial Meta Universe needs to solve two major problems: 1) "human-machine-object" perceptual interaction; 2) the core closed-loop of digital and real integration of "design-manufacturing-operation-optimization". (Fig. 2).

**Fig. 2.** The Industrial Meta Universe

## 3    The value and development of the industrial Meta Universe

Given the direction of 3D modeling in assembly technologies, the developed industrial-level 3D engine, as a domestically developed high-performance WebXR graphics engine for industrial design, can provide zero-code, real-time rendering, cross-platform content creation tools, and platform services, face the trend of industrial digital transformation, improve the "design-manufacturing" link in the core closed-loop, gradually add the standard data level in future update iterations, and supplement the "operation optimization" link. Concurrently, the vital application of the XR technology in industrial training and after-sales helps enterprises to manage the needs comprising complex environment simulation operation, remote auxiliary operation, and maintenance, and later plan to improve the field of view, optical display, human-computer interaction, equipment stability and security, and lower hardware costs to adapt to the characteristics of industrial scenes with the direction of the XR interaction technology, VR virtual training, and MR remote cooperation services.

Shandong, a major industrial province in China, has made great efforts to create new advantages in the digital economy, cultivate new driving forces of the industrial universe and promote intelligent assembly. In the production workshop of Boyang Machinery Manufacturing Co., Ltd. located in Anqiu, Shandong Province, through the construction of a 5G smart factory, one person can manage a workshop, and several people can manage a factory. Driven by Boyang Machinery, more than 30 local traditional enterprises such as Lanxiang Environment, Shanshui Cement, and Lufeng Group have launched intelligent technological transformation projects. A group of technologies used in the industrial Meta Universe includes hybrid reality, computing engines, digital twins, AIoT, computer graphics, and blockchain:

### 3.1   Mixed reality

In the long run, VR is not suitable for the industrial Meta Universe, because it emphasizes the experience of the virtual world. AR is based on equipment and production lines in the physical world. MR (Hybrid Reality) can help users go further since it is better at low-latency and complex scenarios such as remote collaboration, real-time equipment diagnosis, and industrial model design. Equal Ocean Intelligence believes that it is necessary to optimize the vision, visual display, and human-computer interaction logic to ensure the stability, security, adaptability, and flexibility of products in industrial MR applications.

### 3.2   Computing engine

Computational power is the basic engine of the industrial Meta Universe, which can satisfy the needs of countless device access with nearly zero latency. However, China's manufacturing industry generally has a small share of computing power and low digital maturity. In the short term, enterprises still rely on inclusive public computing engines. It is an inevitable trend that the computing engine will establish a system combining infrastructure as a service (IAAS), edge devices, and acquisition devices to achieve industrial operation with low latency and low transmission costs.

### 3.3   Digital twins

Digital twinning is a critical carrier of the underlying assets of the future industrial universe. It is an information model in the computer virtual space and is completely equivalent to physical entities. It is primarily used for the whole life cycle construction of industrial objects to lessen the trial and error costs of innovation and accelerate product development, which is expected to build a digital twin of the whole industrial chain and even the industrial economy in the future.

### 3.4   AIoT

AIoT integrates AI (artificial intelligence) and IoT (Internet of Things) technologies, which can transform human, machine, object, law, environment, and other elements in the real-world industry into data resources and support the construction of digital twins. However, its current application is characterized by fragmentation and centralization, and inclusion and coordination will be its future trend.

### 3.5   Computer graphics

Computer Graphics (CG) is the use of computers to study the representation, generation, processing, and display of graphics, mainly including 3D geometric model modeling, rendering, animation, and interactive technology. The 3D model created based on CG technology is an essential part of the industrial metal sphere.

### 3.6 Blockchain

The Basic technology directly affects the production factors in the industrial Meta Universe. Blockchain directly reshapes the production relationship and brings a decentralized cooperation paradigm. In other words, it is conducive to building "trust without trust", effectively curtailing the cost of trust friction among all entities in the whole industrial chain, and promoting the decentralized transaction of data assets.

## 4 Evaluation of assembly application based on the industrial Meta Universe

The application evaluation of the industrial Meta Universe assembly involves three dimensions of analysis: technological capability, business scenario, and application value. It has been revealed that the industrial Meta Universe at this stage can at least optimize human-computer interaction mode and experience, combine IaaS, edge devices, and acquisition devices, build digital twins, and bridge heterogeneous data sources. Additionally, its application value in industrial scenarios is reflected in tangible value (such as financial indicators of return on investment) and intangible value.

### 4.1 Assembly application

The actual service scenario is composed of four parts: 1) Research and development. The industrial Meta Universe is conducive to breaking the time and space constraints, promoting the remote collaboration of R&D and design experts, conducting simulation tests in virtual space, and lowering the cost and risk of trial and error; 2) Manufacturing. The industrial Meta Universe can realize the digital connection and efficient collaboration of all production factors and create a new production system with the ability of agile perception, real-time analysis, independent decision-making, and accurate execution; 3) Operation and maintenance management. The industrial Meta Universe can manage the whole life cycle of equipment, promote the visualization of industry knowledge, reduce the technical threshold, improve human-computer interaction, and assure that all personnel can access the equipment and in-depth information; 4) Sales service. The industrial Meta Universe can completely change the traditional B2B and B2C business models, make C2M (customer-to-manufacturer) a reality, and timely meet the personalized needs of customers. Notably, new changes have appeared in different industries under the industrial Meta Universe. For example, the Industrial Universe has helped the steel and chemical industries build new carbon-based material plants to realize green transformation and carbon neutrality. From design to sales service, it can overcome the pain point of the whole value chain in the clothing industry, involving reducing costs, enhancing production efficiency, and meeting customer needs.

## 4.2    The future of the industrial Meta Universe

It is expected that the Industrial Universe will make breakthroughs in underlying technologies by 2027, achieve leapfrog transformation by 2032, and take shape by 2032. Therefore, the corresponding core challenges will primarily guarantee sufficient computing power to maintain data operation while we effectively supervise and build new application scenarios once the initial complications of data capitalization, universal coverage, and new orders are tackled. Shortly, precise positioning will be performed for the current stage in different scenarios through factory 3D visualization, cross-space multi-person collaboration, big data real-time analysis, intelligent manufacturing, and other methods. In this situation, MR software and hardware enterprises and industrial software enterprises will shine brilliantly. The industrial Meta Universe should be supported by an astronomical hash rate, suggesting that the computing engine will exhibit a trend of diversification and collaborative development. This intelligent progress will also promote super automation since large-scale computing capacity will become the core infrastructure of super automation.

## 4.3    Edge computing and cloud computing

The industrial Meta Universe will bring a lot of computing power. If there is only a terminal or cloud, it is difficult to meet the demand. The devices where the edge is located will become increasingly sensitive, though more and more basic tasks will be entrusted to edge computing in the future. Edge computing is close to the device side, contributes to cloud data collection, and supports big data analysis of cloud applications. Cloud computing also outputs business rules through big data analysis and sends them to the edge for execution and optimization processing. This renders each other more perfect (Fig. 3).
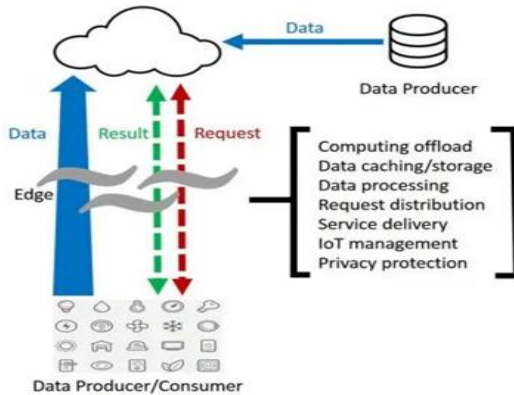


**Fig. 3.** The connection between edge computing and cloud computing

With the emergence of 5G, it is possible to integrate cloud, edge, and end. The biggest advantage of 5G is that it connects the cloud and the edge, allowing the synchronization between the cloud and the edge to be easier (Fig. 4).
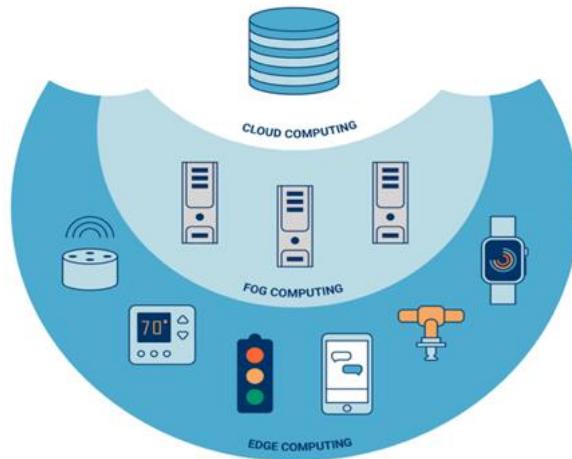
**Fig. 4.** The difference between edge computing and cloud computing

5G can make the end cloud collaboration better, and the end cloud architecture will take on a new look under the 5G architecture (Fig. 5).



**Fig. 5.** Intelligent assembly in the Meta Universe

When the real factory starts construction, many process problems and possible risks have been previewed in the virtual time and also been solved and improved, so that its production line reaches a very optimized state, which farewells to the traditional production mode, realizes the digital monitoring and management of the whole process, improve the production efficiency by 30%, and shortens the R&D cycle by 40%.

## 5    Conclusions

The industrial Meta Universe builds a framework with edge computing and cloud computing. The new generation of AI technology drives the connection of the whole industry chain, all factor chain, and all value chain in the industrial Meta Universe,

which promotes the integration of new information and communication technologies and new industrial technologies, realizes the virtualization and service of the whole system and thus fulfills the smart sharing service of user-centered virtual reality integration. From the perspective of application scenarios, the industrial Meta Universe is the landing and expansion of the Meta Universe in the industrial field, as well as a new carrier for the integrated development of the new industrial digital space, the new industrial intelligent Internet system, and the digital economy and the real economy. With the new integration technology, it realizes the interaction of humans, physical industrial chain, and virtual space in the industrial field, provides intelligent resources and products, and thus enables the development of the real industry.

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