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The Construction Industry Has Injected New Blood Digitalization Creates the Future of the Industry

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ABSTRACT
As the world's largest industry, the construction industry accounts for 13% of the global GDP, but in recent years, the overall construction industry has not developed significantly. With the continuous development of the digital age, many other industries have made adjustments to adapt to Industry 4.0. However, due to the huge body of the construction industry, every key player's changes in this industry will affect the entire industry's ecological chain. The construction industry is a necessary industry for human life, and it will always be in a key position for human development. This is why many people will still be optimistic about this industry and strive to promote the development of this industry when the development of this construction industry is difficult. Physical digital technology, cloud sharing services, and online analysis platforms will all have a huge boost to the construction industry. The data completes the digital system, which brings more advanced technology, and then highlights the high efficiency and high quality in all aspects. This may be the development prospect of the construction industry. In this work, the new technologies in the construction industry and digital construction development are the main direction.

Keywords: *Industry 4.0, Robotics, Human exoskeleton, drone, 3D printing, City Intelligent Model, GIS and Blockchain.*

1. INTRODUCTION

New technologies developed with great speed in the past few decades. Nowadays, the digital revolution is pushing forward all aspects of life at an ever-faster pace, including the construction industries. The construction industry, and its broader ecosystem, buildings, infrastructure, and industrial structures that are the foundation of our economies and are essential to our daily lives. However, the complexity of construction has led to its slow industrial evolution, so in some developing countries the construction industry continues to follow traditional labor-intensive industry practices. Thus, some businesses are still stuck between the old order and craft-based processes and the modern computer-driven existence. In that case, construction could transform into a technology-driven industry through the adoption of ideas and technologies of Industry 4.0.

Recently, several studies have treated the development of a few cutting-edge technologies of the construction industry. The SmarTech Publishing study estimated the market at 40 billion dollars by 2027. On the other hand, the building and architecture sector alone accounts for 3.2% of the global 3D printing market, and this number is expected to grow by 2030. Canvas, a San Francisco-based construction robotics company that focuses on drywall installation, announced today that it has raised a $24 million Series B. The round is led by Menlo Ventures, and will be used to expand the startup's fleet of robots and develop new applications for its technology.

In the contemporary construction industry, those new technologies have played a significant role in promoting the development of the construction industry. They have changed the production, transportation and design of the traditional construction industry. Our contribution in this article aims at introducing some cutting-edge technology that has an important impact on the evolution of the construction industry, including 3D printing, robotics, drones, exoskeletons, City Intelligent Model (CIM), Geographic Information System (GIS), etc. The study builds on the findings of previous research studies and shows current information. This paper is divided into three main parts. In the first part, we'll introduce the

latest development of robotics, drones and exoskeletons technology and their application in the construction industry. Then we'll introduce the City Intelligent Model (CIM) and its development status and application prospect in the industry. Finally, the last part of this paper presents the GIS technology's latest development and how it can be improved in the future.

2. ROBOTICS IN CONSTRUCTION

Industry 4.0 has become a hot topic at the moment, and the era of the Internet of Everything has arrived. Industry 4.0 is a stage of the industrial revolution associated with the development of digital technologies [1]. Many industries have undergone major changes and have injected new operational cores. The world has once again entered a stage of rapid development. The global construction industry has been affected by the world's urban population rising by 200,000 people per day [2]. However, the construction industry has not adapted to the development of this era as quickly as other industries, because its nature and scale are different from other industries. A 2015 McKinsey Global Institute (MGI) analysis found that the construction industry was among the least digitized industries in the total economy across assets, usage, and labor [3]. The digitalization of the construction industry is difficult to quickly take shape because the industry covers a wide range, the steps are cumbersome, require a lot of manpower and the project cycle is long, which causes many uncontrollable factors. A 2016 McKinsey analysis found that construction projects typically take 20 percent longer to finish than scheduled and are up to 80 percent over budget, frequently resulting in litigation [3]. And let the construction industry be well integrated with digitalization and adapt to the addition of new technologies to make the construction industry more efficient, improve quality and safer. At present, the development of robotics technology can gradually accelerate the development of the construction industry. The development of robotic systems can bring more benefits:

- Reduce manual errors:

  By transmitting the calibrated data to the machine, the operation of the machine is very precise, which greatly reduces the error of manual operation. And many machines come with sensors and measuring tools, such machines can be proofread and operated in real time.

- Reduce costs in the construction process:

  When the construction industry uses a lot of robotics, the industry's reliance on labor will decrease. Moreover, the service life of the robot system and each working time can be much longer than that of a human, which reduces a lot of labor costs and reduces the working cycle. This will be a direct result of the ability to easily meet the project deadlines and to complete tasks on time and with no need for repairs [4].

- Make construction workers safer:

  This is the obvious thing. If a lot of work does not need to be done in person, then people do not need to stay in a dangerous area. And workers do not need to work, which also greatly reduces the harm to the body caused by work.

- Increase industry profits:

  Since the robotics technologies can reduce the cost in the construction process, this naturally increases the profit in the industry. That's a very important fact for construction which is an industry that normally faces big challenges in captivating the attention of the younger workforce [4].

"One of the proposed classifications, developed to characterize the Construction 4.0 concept, is based on two pillars: the digitalization of the construction industry and the industrialization of construction processes" [5][6]. Therefore, the development of robotics is based on these two points. Now, many emerging companies have begun to develop digital construction technology, and many physical digital work machines have appeared.

2.1. Automated construction machinery

Through the survey, there are many automated machines that can be seen on the market, and they have different work scenarios just like people. The machinery developed by BUILT ROBOTICS is mainly used outdoors. They are large-scale work machines, such as excavators and bulldozers. But the excavators and bulldozers they developed are unmanned, and can perform precise work in the set working area through the sensors and radar on the machine. In addition, in order to ensure construction safety, the sensors on the machine can sense whether there are people, animals or obstacles in front of the machine. If there are people, animals or obstacles in front of the machine, the machine will perform emergency braking and stop working, and then send a notification to the manager through the application on the mobile device. What's more, managers can also set working hours and view work progress on applications on mobile devices. CANVAS, a construction robot company from San Francisco. The interior decoration robot they developed has been used in many construction projects, such as the renovation of San Francisco International Airport Terminal 1 and the Wayne and Gladys Valley Center for Vision of the University of California, San Francisco. "Here, teamwork is essential: humans direct the physical situation and programming of the robot, which in turn applies most of the finishing

automatically. This can shorten the drywall finishing from seven days to two while helping workers avoid musculoskeletal injuries exacerbated by the finishing process" [7].

2.2. Human exoskeleton

The human exoskeleton can be said to be the future of physical labor. "According to a recent survey by the Associated General Contractors of America (AGC)，the report detailed the industry's disinclination to invest in technology this year: when asked whether they would adopt new technologies in 2021, the majority of respondents said that they would not" [7]. Therefore, the comprehensive digitalization of the construction industry will take a long time. At this time, it is necessary to strengthen the efficiency and safety of the work on the existing basis. Ekso, a bionic manufacturing company from California, will bring answers to the construction industry. The exoskeleton they are currently researching is suitable for medical aids and construction. In terms of construction, exoskeleton can make workers more labor-saving and reduce the chance of workers being injured. Among their products, there is a very thin and light style EKSO EVO, which has better comfort and heat dissipation function. At the same time, it has a good support function for the user and does not need to rely on electricity. It uses a spring system in the robotic arm, which can provide 5-15 pounds of power assistance on each arm.

Figure 1: EKSO EVO exoskeleton

The current challenge of this technology is that the cost is too high, and it is difficult for construction companies to buy in bulk.

2.3. Construction Drone

Drone is a technology with a wide range of commercial uses. After data import or artificial intelligence algorithms, Drones can complete tasks according to the instructions given. In the construction field, drones are currently mainly responsible for monitoring sites and facilities, scanning construction terrain and providing visual data. FLYGUYS is a company that provides professional construction drone services. As you can see on their website, they can provide many kinds of services, such as Land Mapping, Ground Quality Assessments, Construction Bid Packages, and Project Management & Monitoring. They have a very high-end technology that can be used in many scenarios, called LiDAR. LiDAR (light detection and ranging) is a remote sensing method of examining the surface of the earth. By operating drones equipped with LiDAR sensors, it measures the light's reflection and range from the earth's surface across millions of beams [8]. When this technology is placed on a drone, it can collect all kinds of information on the ground, including the area of the land, the height of the ground, and the density of buildings or plants on the ground. This information can very well help construction companies in modeling and design.

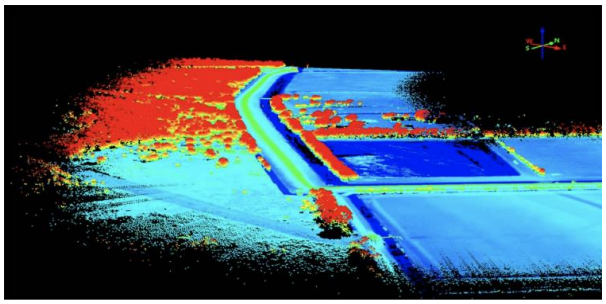

Figure 2: Ground layer collection by LiDAR drone

2.4. 3D Print

3D printing technology has actually appeared in front of people many years ago, but there are still many obstacles to good use in the construction industry. At present, not all building materials can be used for 3D printing, and the size of the parts required for construction is also different, and the printing equipment required may also be different, which will result in high cost of 3D printing. Moreover, there are currently no complete regulations and laws on the use of 3D printing technology in construction, so until these rules are not complete, 3D printing technology will not be used flexibly in the construction industry. Of course, 3D printing technology also has many benefits. Using 3D printing technology to build a house is much faster than traditional construction, and it may only take a few days to build a house, greatly improving the construction efficiency. And it can also create a better ecological environment. Worldwide construction waste currently totals more than 1 billion tons each year, and according to Construction Dive, this number is expected to double by 2025 [9]. 3D printing technology can accurately control the amount of materials used, which greatly reduces the generation of construction waste.

Figure 3: BAM opens Europe's first concrete printing centre in the Netherlands

3. CITY INTELLIGENT MODEL

The concept of CIM originated from the campus intelligent model of the 2010 shanghai world expo, whose application was extended to the area of a whole city or its districts [10]. The concept of the CIM was derived from it by combining the demands of urban planning, construction, and management. At that time, 256 pavilions in Shanghai World Expo Park were submitted to the office of the chief planner, the design schemes of different countries and the different software adopted by them cannot be unified [11]. So one of the professors of Tongji university suggested the idea that the city should be regarded as a living body, which was called the city being. It should be Perceptible, judgmental, responsive and learnable.

The city intelligent model aims at predicting the future events, using intelligent models to assist decision making, Strengthening the interaction between people and urban information. It's not simply an information management platform, but a huge database which can intelligently allocate the resources in key decision-making fields such as architecture, municipal administration and transportation through the integrated calculation of urban data such as hydrogeology, climate environment, construction projects and municipal engineering.

The city intelligent model is not just BIM+GIS+IOT, it's an organic combination of several technologies [12]. Building information modeling is just a cell of the CIM. Massive BIM models can be embedded in one CIM model, creating a model much closer to the real world [13]. The 3 dimensional GIS technology and internet of things provide dynamic city data. With the development of 5g, the runtime environment of the intelligent model can be much stabler.

Here's an outline of how CIM functions. Different from BIM modeling, the core technology of CIM is the big database and artificial intelligence algorithm, which is much more accurate and efficient.

Since 2010, there have been four generations of the CIM technology. At the very beginning, CIM was built to forecast the distribution of people flow in Shanghai World Expo, and optimize the layout of major venues in the park. The second version of CIM technology was built to function as a city brain. Taking the mayor's decision-making and command as the goal, it realizes the monitoring and early warning and auxiliary decision-making for the key information of urban development. In the third version, a large scale of intelligent models was introduced, which boosted the rapid development of CIM. More data can be calculated in the model and more accurate forecasts can be made. The latest version introduced the Urban vagus nervous system and was applied in Qingdao Sino German future city. The CIM 4.0 is connected to the city's big data bank, real time monitoring of urban external environments such as sunshine and wind intensity, and automatically solves city safety problems such as emergencies. It is of great help to the planning of urban architecture.

With the development of artificial intelligence technology, the next generation of urban space operation platforms driven by AI technology will inevitably appear.

3.1. GIS and Blockchain

The GIS, which is the Geographic Information System, has become a strong support of the construction industry in the past years. With the newly developed internet technologies, GIS is going to play a more and more important role in the industry's Informatization. GIS is essentially a geographic information collection and comprehensive application system, and the precise operation of its system is inseparable from the rich geographic data contained in its different databases. On the basis of these geographic data, engineers can use software to simulate the actual situation that may occur in any facility or building in real life. Engineers can use the functions of the software to implement analysis and simulation of terrain, geology, airspace characteristics, ocean currents or rivers and even wind direction. These different geographical factors constitute the basic prerequisites for the safety of a building or facility and the feasibility of a project [14].

As a technology that is not yet fully mature, GIS already has many advanced computer technologies. These very complicated programs combine to form a very comprehensive computing system. Many people understand that when they think of geographic information, they are nothing more than mountains, rivers, or stones and minerals. In fact, they are not. This cognitive limitation also limits the potential possibilities of geography. In fact, maps, zoning, etc. are the foundations of geography. All information depends on these foundations to establish connections. The principle for establishing this connection is-everything affects other things, but it has a greater impact on things that are close [15]. Location affects the natural environment and the human environment, which in turn affects human activities. So the subject of geography itself, although it sounds like a subject, but its content involves sociology

(urbanization, population, housing, race), politics (international relations), environmental science (utilization and protection of water resources, wildlife protection). Even medical and legal. And GIS is the overall planning and utilization of all this comprehensive information. The most important function that GIS can achieve is data entry and analysis. GIS has many different public or private databases, they may come from the government, NGO, or other engineers, and the quality of these data is often not uniform. Engineers using GIS must be able to filter out the available data before using the GIS database. At this time, programming skills also become very important. Engineers who are proficient in using GIS can use GIS software to visualize the data they want to analyze. And this is also an important direction that GIS is now focusing on development. Using a map as a blueprint, GIS can read text and table content in the form of non-pictures, and enter these content into the GIS database. This pushes the utilization efficiency of GIS to a new level. The form that can transform data allows people to think about problems in more directions and dimensions when analyzing data. The concepts that can only be established by formulas and numbers in the past can be displayed in GIS software through visualization, and these Data can also be brought in and used as part of a complete data simulation. And this involves an important reform direction of GIS, which is the automation of data analysis and simulation. With the blessing of programming technology, more and more engineers rely on Python to establish an automated information data analysis process. Operators do not need too much manual intervention to know some problems they want to explore. This progress has greatly improved the design efficiency of the construction industry. The problems that previously required a large number of formulas and complex calculations have been able to be semi-automated through software programming.

The combination of GIS and blockchain technology has also played a very important role in the progress of the construction industry in the new era. "Blockchain" may no longer be an unfamiliar term for many people, but the role of blockchain in the industry has just been revealed [16]. The integrated application of blockchain and GIS is still in the initial stage of research, and we have been able to see its importance in the future from the existing information. As mentioned above, GIS has different databases, and the quality of these databases is often uneven, which causes some difficulties in the selection and utilization of data. Engineers often need more time to filter or collect data by themselves. This greatly reduces the efficiency of the project. At this time, the combination of blockchain and GIS database perfectly solves this problem. By applying the blockchain technology to the GIS database, the main advantage lies in the immutability of the GIS data. This immutability, combined with the revision and proofreading of the data by all parties, further strengthens the authenticity, validity and usability of the data. In addition, the application of this new technology has also promoted the unification of industry standards. When more and more databases are associated with the same blockchain, they must run under the same algorithm. The birth of this standardization has also strengthened the efficiency of automated data analysis programs from the side. Engineers do not have to modify the data every time to reach the usable standard. The data under the same protocol adopts a consistent storage method, and this protocol also has a tendency to be extended to automatic analysis algorithms. Once a new industry standard is finally born from this , The degree of automation will be greatly improved in the construction industry [17].

4. CONCLUSION

Nowadays, more and more technologies are emerging with the rise of the Internet. Although the construction industry is not at the forefront of new technologies, the construction industry is also catching up. New technologies are helping the construction industry to advance in a more efficient, safer way and at a more unified pace. Industrial technologies such as 3D printing and wearable exoskeleton are fundamentally changing the way the entire industry works through a new production method. With the advancement of these industrial technologies, software technology and information technology such as CIM and GIS are also synchronized. There is no doubt that in the near future, these newly developed technologies will play more and more important roles in the building industry, and they will bring a more efficient and more advanced industry to the whole world to help build a better and brighter future for all human beings.

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