DOI: 10.26599/IJCS.2022.9100001 International Journal of Crowd

Digital Selves based Intelligent Construction Framework

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ABSTRACT

Construction is the pillar industry of Chinese national economy, but the profit rate has continued to decline in recent years. The conventional job-centric construction information system cannot meet the requirements for safety, quality and efficiency. In order to solve the above problems, a digital selves based intelligent construction framework has been proposed which is centred on workers, equipment and sites. It changes the conventional job-centered construction information system and realizes efficient coordination of information among various departments and stages. Applying the digital selves based intelligent construction framework to the case has been proved to be a good solution to the problem of information sharing. Meanwhile, the authenticity and reliability of the information have been ensured. The system has improved management efficiency and information systematization for all participants. It has enabled companies and workers to have a more comprehensive understanding of themselves and to make timely and effective strategies against hazards. In addition, the system has effectively raised the level of digitalization, automation and intelligence of construction, making governance more accurate and more effective.

KEYWORDS

Digital Selves, Intelligent Construction, Digital Governance, Digital Empowerment, Multidimensional Measurement Model

As the pillar industry of China, construction is an important part of the national economy. With the deepening of reform and opening up and the sustained development of the national economy, construction has also been growing rapidly. As shown in statistics of the National Bureau of Statistics, in the past 10 years, the total production value of the construction in China has shown a trend of increasing year by year. It grew from 11.6 trillion yuan in 2011 to 26.4 trillion in 2020, an increase of 126.64%. Along with the continuous growth of the total production value of the construction, the number of construction enterprises in China also shows a trend of increasing year by year. The number of construction enterprises grew from 72,000 in 2011 to 117,000 in 2020, an increase of 61.9%. Therefore, judging from the total production value of the construction and the number of enterprises, Chinese construction has achieved sustained and stable development in recent years. However, the total profits of construction enterprises have declined, and the profit rate of production value has fallen for six years. In 2022, the national construction enterprises achieved a profit of 836.9 billion yuan, 10.18 billion yuan less than the previous year, a decline of 1.2%. The growth rate was 1.47 percentage points lower than the previous year[1].

Meanwhile, the conventional construction is highlighted as a labor-intensive industry[2] And there are problems such as low overall productivity[3], serious on-site resource consumption, prominent construction environment pollution[4] low quality of workers, and defects in the quality and safety of construction projects[5]. Under the background of new infrastructure, the need to implement digital technology in the construction is becoming increasingly urgent.

Existing construction information systems also have problems. First, data among different systems cannot be connected, shared and coordinated with each other. This leads to duplication, inconsistency and errors and makes it difficult to effectively integrate industrial resources[6]. As a result, it affects the efficiency and quality of all aspects of the project like design, construction, and management. Moreover, most construction systems are job-centric, overemphasizing individual responsibilities and positions, and ignoring the characteristics of the construction itself. Construction is a highly complex and comprehensive operation involving design, construction, supervision, material supply, equipment use and other aspects, which requires strong cooperation and coordination among various departments. In this situation, the job-centric structure tends to lead to a lack of effective communication and collaboration among various departments[7], resulting in problems and mistakes. The digital selves based intelligent construction framework proposed in this paper can effectively solve the above two problems.

Previous research has shown that BIM in the construction industry emphasises the building itself by creating and managing a 3D model of a building project through digital modelling techniques[8][9]. This includes building information on geometry, structure, materials and spatial layout. BIM can provide a more intuitive and accurate view of the building design and construction process, improving project efficiency and quality. However, the value of BIM is far more than just the building itself; it's also about the information and data it contains. By creating

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rich information models, BIM can support a variety of building-related decisions and operations. This information can include attributes of building elements, performance parameters, construction details, material costs, construction schedules, equipment maintenance needs, and more. By combining this information with building modelling, a more comprehensive and integrated building lifecycle management can be achieved.

Therefore, this paper prefers to focus on the information of the building and proposes an intelligent construction framework based on digital selves. The Digital self, as articulated in this context, is a dynamic representation of an individual, system, or entity within the intelligent construction landscape. Formulated through the analysis of data sourced from the Smart Site Standard, the digital self encapsulates a comprehensive view of various facets, including behaviors, interactions, and key attributes relevant to the entity under consideration. The calculation process involves leveraging the Smart Site Standard to quantify and interpret diverse data points, contributing to the construction of a detailed, real-time digital profile. Digital selves serve as an evolving, data-driven reflection of the entity's characteristics, activities, and engagement within the intelligent construction. By capturing the intricacies of the entity's digital footprint, the digital self facilitates informed decision-making, adaptive responses, and optimized performance within the dynamic context of intelligent construction practices.

This paper introduces a pioneering framework for intelligent construction anchored in the innovative concept of digital selves, comprising digital empowerment, digital governance, digital talent, and digital economy. A distinctive contribution of this research is the modeling of digital selves, representing a significant advancement in the field. Specifically, my contribution lies in crafting a robust and effective model for digital selves, providing a foundation for information sharing within the proposed framework. The application of digital selves is a key highlight, showcasing the practical implementation in information sharing across the intelligent construction. Notably, this study extends beyond theoretical propositions by integrating the digital selves based intelligent construction framework into a real-world case study. Through this practical application, the paper underscores the profound impact of digital selves, demonstrating the feasibility and tangible benefits of the proposed framework in enhancing the efficiency and functionality of intelligent construction.

This paper is constructed as follows: The first section delineates the current state of the construction industry and the research objectives. The second section provides a comprehensive review of semantic modeling, summarizing the advantages of this study compared to previous research. The third section elaborates on the intelligent construction framework based on digital selves. The fourth section applies the research in a case study. The fifth section discusses the strengths of this study. The sixth section serves as the concluding part of this research.

1 Related Work

Semantic modeling, as a foundational aspect of knowledge representation, aims to structure information in a way that facilitates both human and machine comprehension[10]. At the core of this approach are technologies such as RDF[11] (Resource Description Framework) and OWL[12] (Web Ontology Language), providing a standardized means to express relationships and meanings. Understanding the intricacies of these technologies is paramount, as they enable the creation of interconnected webs of information, forming the basis for the structured representation of digital entities.

Semantic modeling involves the structured representation of knowledge to enable machine understanding. It provides a formal framework for expressing relationships and meanings within a given domain. Semantic modeling has been applied to represent human-related information, offering a structured approach to capturing the complexities of personal identity[13].

In the context of personalization, semantic modeling enriches user experiences by leveraging rich contextual information. The use of ontologies facilitates the representation of user preferences, behaviors, and interactions in a standardized format. For instance, the use of the Web Ontology Language (OWL) allows for the expression of complex relationships and dependencies, enabling personalized content recommendations, adaptive interfaces, and context-aware services. Research by Wang[14] demonstrates the practical implementation of semantic modeling for user-centric personalization in web environments.

Beyond personalization, semantic modeling finds applications in contextual environments, such as smart homes and intelligent construction. Ontologies like the Building Information Model (BIM) standard enable the representation of building structures, systems, and worker behaviors in a semantic format. This semantic representation supports applications ranging from energy efficiency assessments to the optimization of indoor environmental quality.

Johansen[15] proposed an automated performance assessment framework for addressing safety issues on construction sites. The foundation of this study lies in an architectural safety ontology specifically focused on falls from heights. The research extends this ontology, presenting a comprehensive approach. Additionally, the study introduces a standardized format that facilitates the assessment of accuracy and reliability metrics based on relevant standards. However, it is crucial to note that the steps of this study would have to implemented in a scheduled construction situation

Harter and others[16]similarly applied a lifecycle assessment method to existing building stock, using relevant standards as input parameters. The results of the study indicate a multidimensional assessment space among these parameters. The objective is to verify the achievement of climate goals and make informed decisions regarding the implementation of climate-neutral measures.

In the realm of new energy vehicles, Liu[17] addressed the dynamic assessment issue by constructing a two-tiered dimensional framework for policy analysis based on the PMC index model. Using text mining and ontology semantic methods, a dictionary for mining new energy vehicle policies was established. Text mining techniques were then employed to assign values and conduct dynamic assessments for the PMC index model. This study holds practical value for optimizing policies to facilitate the high-quality development of the new energy vehicle industry.

In conclusion, the exploration of semantic modelling within the context of intelligent construction systems has unveiled a landscape of significant advancements and promising avenues for research. The reviewed literature has provided valuable insights into the integration of semantic technologies to enhance the understanding, representation, and utilization of digital selves in the realm of intelligent construction.

The emphasis on semantic interoperability and data integration across diverse objects has emerged as a common thread in the article. By adopting semantic models, researchers aim to bridge the gap between various data sources, facilitating seamless communication and collaboration between smart devices, sensors, and workers within the construction.

2 Architecture of intelligent construction supervision platform

The overall architecture of intelligent construction supervision platform based on digital selves can be divided into intelligent sensing system, construction digital infrastructure, business panels and intelligent construction index publishing system. The architecture of the intelligent construction supervision platform is shown in Figure 1.

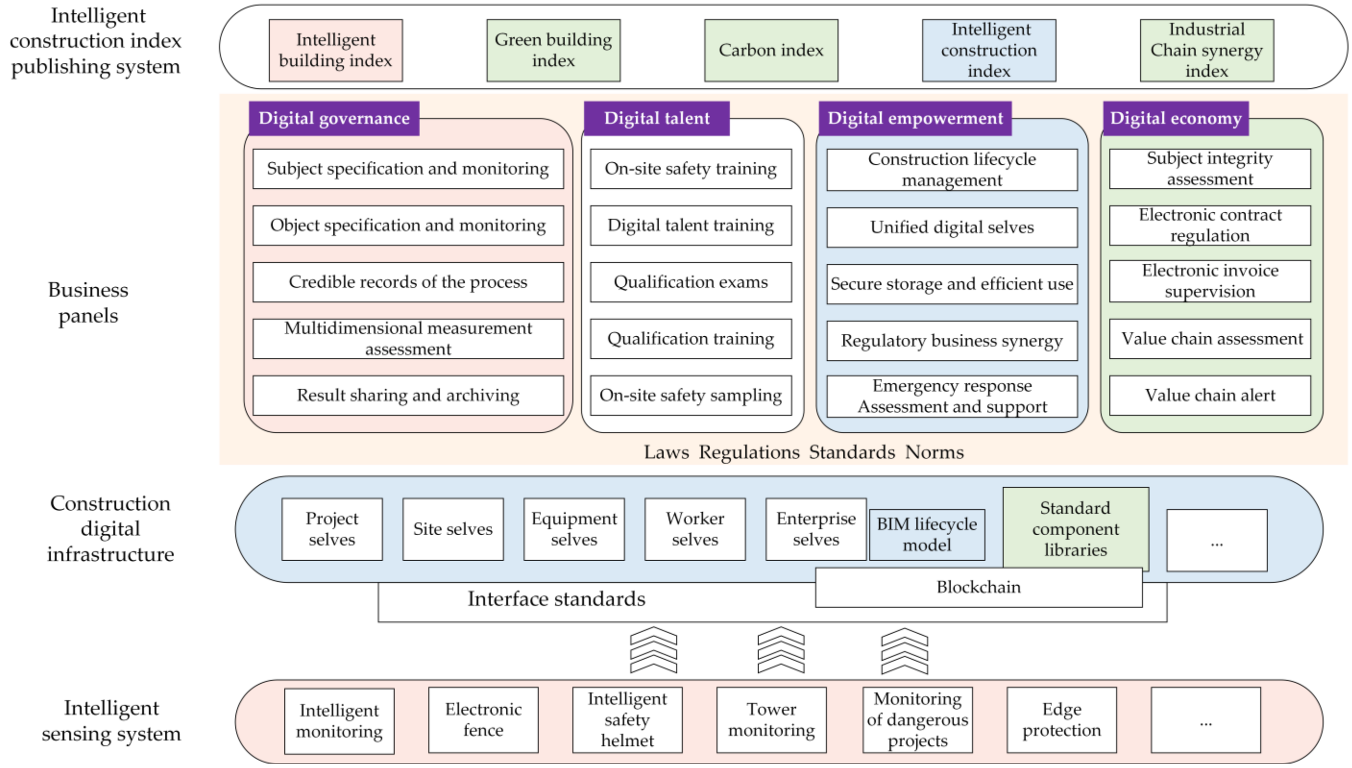


Fig.1 The architecture of intelligent construction based digital selves

1.The intelligent sensing system provides all-weather, real-time standardized monitoring and credible recording of sites and related information. Intelligent construction indexes such as standardization, civilization and safety are then released according to a multi-dimensional measurement model and ultimately achieve precise governance.

2. At the same time, the intelligent sensing system completes project selves, worker selves, equipment selves, enterprise selves and site selves for the construction digital infrastructure through standard data interfaces. Each of the selves and the meaning of each index are as follows:

①The project selves include safety index, information integrity index (time), safety production standardization index, information integrity index (space), personnel management index, assembly index, quality index and green civilization index. Safety index is an indicator to assess safety level of a project, which contains various risks and threat factors. It is used to assess the degree of risks the project faced and the effectiveness of security measures. Safety index can be used to assess and monitor the status of a project and help managers identify and solve safety problems timely to improve the safety level. The information integrity index (time) usually considers data integrity, data timeliness, data backup and recovery, and reflects the integrity and timeliness of data in the project information system. Safety production standardization index can reflect the specification degree and standardization level of safety production management, thus the index can be used to evaluate and monitor the improvement of safety production management level and enhance it. Information integrity index (spatial) which reflects the integrity and the spatial safety of data in the project information system, usually includes data integrity, data access control, data backup and recovery, and data transmission security, and it can be used to assess and monitor the security status of the project information system, help managers identify and solve security problems timely, and improve the security assurance level of the project information system. Personnel management index is an indicator used to measure the capability and effectiveness of management teams in managing and coordinating the human resources of a project, having a critical impact on the implementation and success of a project. Assembly index reflecting the proportion and the level of adoption of assembly technology is an indicator to assess the degree of implementation of assembly technology in a project, and is used to improve the construction quality and efficiency. Quality index is an indicator to assess the quality level of products, works or services, reflecting the quality level of a project and the degree of meeting customer needs, thus it helps to improve the satisfaction of customers and competitiveness. Green civilization index is an indicator used to measure the projects' contribution to environmental protection and sustainable development in the process, including energy saving and emission reduction, environmental protection, resource utilization and sustainable development, which can improve the social image and reputation of a project. The project self is shown in Figure 2.

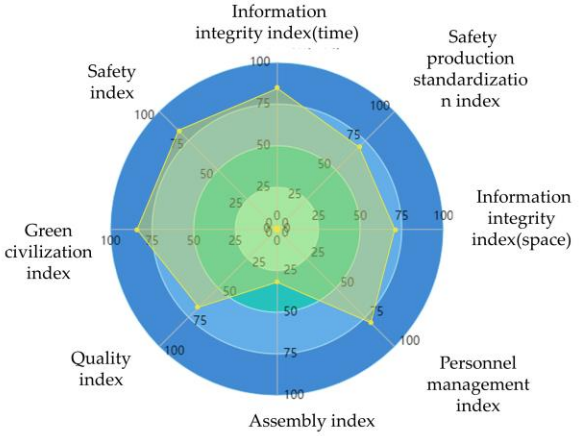


Fig. 2 The project self

②The worker selves include information integrity index, credit evaluation index, professional skill index and safety awareness index. Information integrity index refers to the assessment of the degree and quality of protection measures for workers' personal information, which reflects the security and confidentiality of workers' personal information and can be used to assess and monitor the situation of protection. What is ultimately achieved is to help managers identify and solve safety problems in a timely manner, guarantee the safety and confidentiality of workers' personal information, and improve the overall safety level of the construction. The credit of workers provides better efficiency and quality of service. Credit evaluation index is an indicator to measure the performance and credit of workers in the process of work, reflecting their ability and level of performance and credit, as well as the degree of attention workers pay to work attitude and work ethics. Workers with a high credit evaluation index can not only improve their own professional quality and competitiveness, but also provide better efficiency and service quality for enterprises. Professional skill index is an indicator to assess the level of professional skills of workers in construction, which helps to improve the quality and efficiency of projects. Safety awareness index is designed to assess the degree of awareness and importance workers attach to safety issues. Its meaning is to measure whether workers can fully recognize the importance of safety issues at work, whether they can actively take preventive measures, and whether they can reasonably cope with unexpected risks and risk factors. A higher safety awareness index means that workers are more concerned about safety issues and are more able to take self-protection and preventive measures to reduce the occurrence of accidental injuries. The worker self is shown in Figure 3.

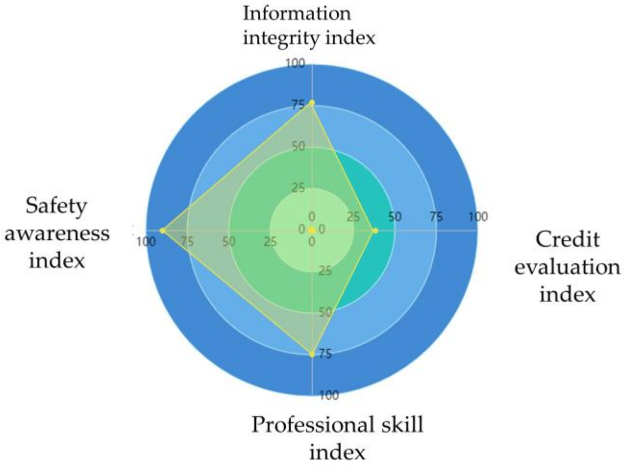


Fig. 3 The worker self

③The equipment selves include information integrity index, health index, operation and maintenance index, operation index and safety index. Information integrity index that is used to assess the completeness and accuracy of equipment information reflects the emphasis placed by managers on management and maintenance of equipment information. Equipment with a high information integrity index not only increase the life and efficiency, but also improve the security and service quality. Health index refers to aspects such as intactness rate, breakdown rate and maintenance situation, which reflects the status and health of an equipment. High health index not only helps to improve the life and efficiency, but also can improve the safety and stability of an equipment. The operation and maintenance index including cost, efficiency and quality of operation and maintenance ,contributes to improving the service life and efficiency. Operating index is a measure of complexity and ease of operation. A higher operating index means that the equipment is easier to use and vice versa. The operating index of an equipment can be assessed by user surveys, user experience tests and so on. In the design and deployment of products, it is very important to raise the operating index, considering the user experience and ease of operation. Safety index for measuring safety performance and safety management level of an equipment reflects the situation of safety measures, safety management and accident handling. The level of safety index also directly affects the safety and stability, and is related to the effectiveness and service life. The equipment self is shown in Figure 4.

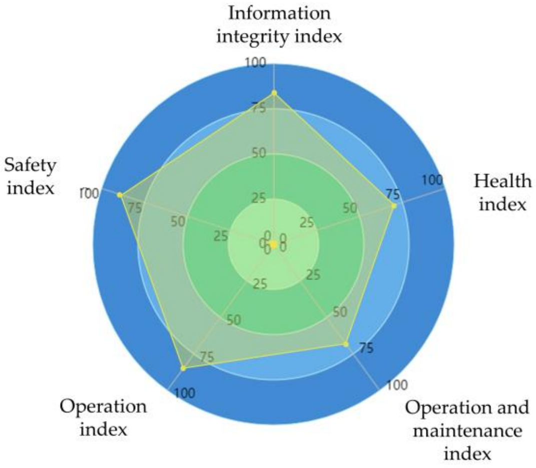


Fig. 4 The equipment self

④The enterprise selves include safety production index, information integrity index, production quality index, management standard index and credit evaluation index. Safety production index for measuring the quality and effect of safety production work in an enterprise reflects management level of safety production work, improvement of safety production facilities, implementation of safety education and training, construction of safety production culture and management of safety accidents. The level of safety production index also directly affects the quality of an enterprise's safety production work and is related to the productivity and sustainable development of an enterprise. The information integrity index of an enterprise is used to measure the completeness and accuracy of information disclosure. The level of information integrity index directly affects the credibility and visibility of an enterprise and is related to the reputation and long-term development of an enterprise. The production quality index of an enterprise that is used to measure the quality level of products and projects, reflects production technology level, quality management level, project quality and product quality of an enterprises. The management standard index reflects the situation of organizational structure, management system, management procedure and management efficiency of an enterprise. At the same time, the level of management standard index is also directly related to economic efficiency and prospect of an enterprise. The credit evaluation index of an enterprise is used to measure situation of credit record, credit history, credit management and credit risk. By evaluating the credit evaluation index, it is possible to understand the credit level and credit risk situation of an enterprise, as well as whether it is necessary to strengthen credit management and credit risk control. At the same time, the level of credit evaluation index is also directly related to market competitiveness and prospect of an enterprise, and affects reputation and trust of customers. The enterprise self is shown in Figure 5.

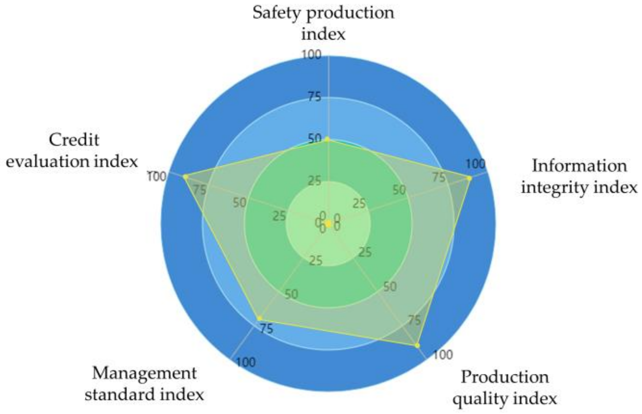


Fig. 5 The enterprise self

⑤Site selves include project progress, quality index and compliance index. Equipment at site collects and calculates date to get an indicator that reflects progress of a project namely project progress. Project progress enables enterprises and governments to keep abreast of project completion and adjust plans in a timely manner to increase project progress and efficiency. At the same time, it is also used to compare with the plan to assess the gap between actual progress and planned progress, so that timely measures can be taken to adjust. The quality index of site selves is defined to assess quality of construction, environmental hygiene, safety and labor protection of workers at site. These indicators assist managers in getting a comprehensive understanding of a site, identifying problems in time, taking measures to upgrade the quality and safety of a project, and ensuring the smooth progress. The compliance index of site selves refers to indicators to assess whether the site complies with relevant laws, regulations and standards. These indicators enable managers to have a comprehensive understanding of the compliance situation of a site, identify problems in time, take measures to improve them and ensure the legal and compliant operation of a site. The site self is shown in Figure 6.

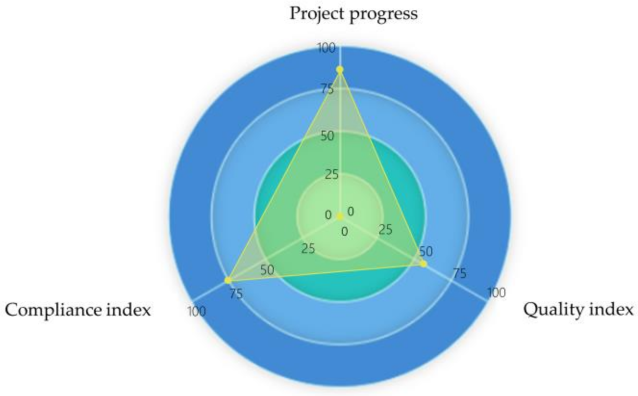


Fig. 6 The site self

3. Access to the business panels according to laws, regulations, standards, and norms. The business panels include the digital governance panel, digital talent panel, digital empowerment panel and digital economy panel.

①The intelligent construction supervision sub-section of digital governance panel reflects the quality and safety hazards in the construction process dynamically and timely through the intelligent sensing system. Management discipline and risk controllability are quantified through the multidimensional measurement model guided by laws, regulations, standards, and norms. The multidimensional measurement model is used to monitor the intelligent sensing system in real time to lead the precise governance, and then the standardization of management and the controllability of risk are realized. The schematic diagram of the digital governance panel is shown in Figure 7.

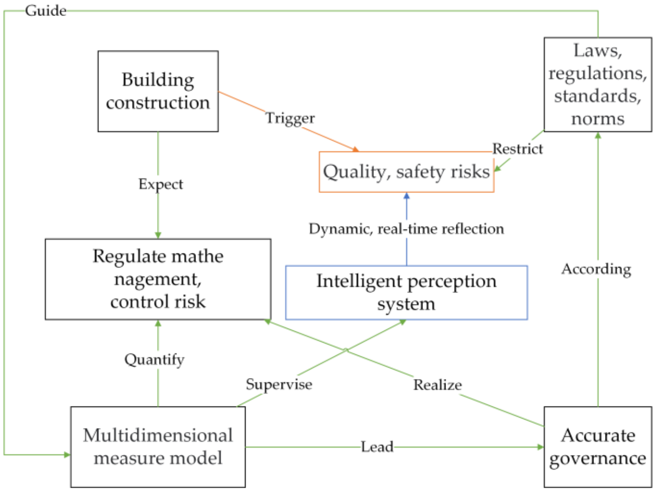


Fig. 7 **The schematic diagram of the digital governance panel**

② The digital talent panel aims at the situation of insufficient professionals to quantify standardization of management and operation by unified digital selves. One of the site management systems based on laws, regulations, standards, norms achieve the normality of management and operation through the monitoring of professionals. In response to the situation that risk awareness still needs to be strengthened, risk awareness is quantified through dynamic, real-time evaluation of the digital selves by multidimensional measurement model. The on-site training and sampling system counts the results into the credit evaluation system of unified digital self to strengthen the risk awareness of construction. The schematic diagram of the digital talent panel is shown in Figure 8.

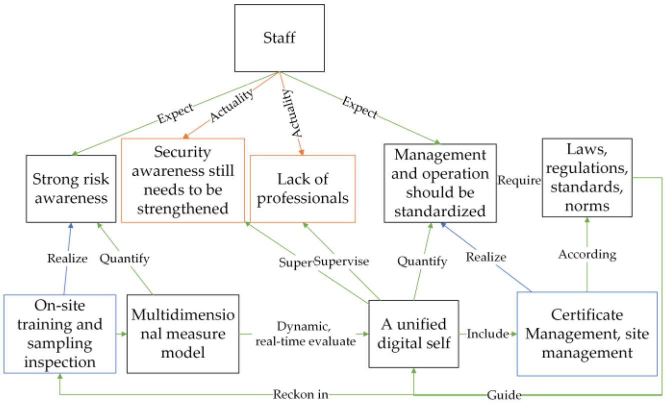


Fig. 8 **The schematic diagram of the digital talent panel**

③The digital empowerment panel breaks down data barriers in government service system through construction digital infrastructure. The efficiency and rapid response capability of collaboration is quantified through multidimensional measurement model guided by laws, regulations, standards, and norms. The multidimensional measurement model monitors the construction digital infrastructure in real time to generate governance capacity, thus achieving the purpose of efficient collaboration and rapid response. The schematic diagram of the digital empowerment panel is shown in Figure 9.

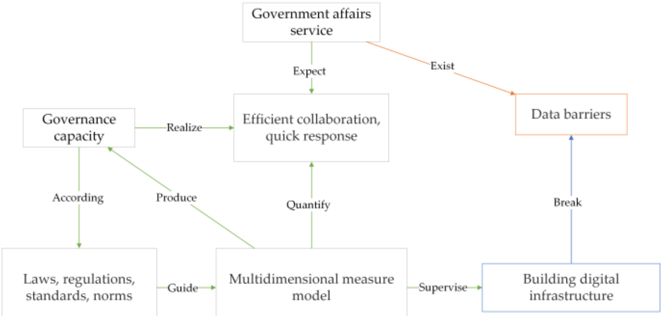


Fig. 9 **The schematic diagram of the digital empowerment panel**

④The digital economy panel achieves subject clarity through a basic information model of the object and standard component libraries. Through the support of subject's digital selves for subject's credit evaluation systems, basic information model of subject and object, electronic contract specification management system, and electronic invoice specification management system are established based on laws, regulations, standards and norms to achieve the effect of regulating transactions. The multidimensional measurement model quantifies the health of industrial ecology and guides value chain prediction and early warning system for the purpose of promoting the healthy development of the industrial ecology. The schematic diagram of the digital economy panel is shown in Figure 10.

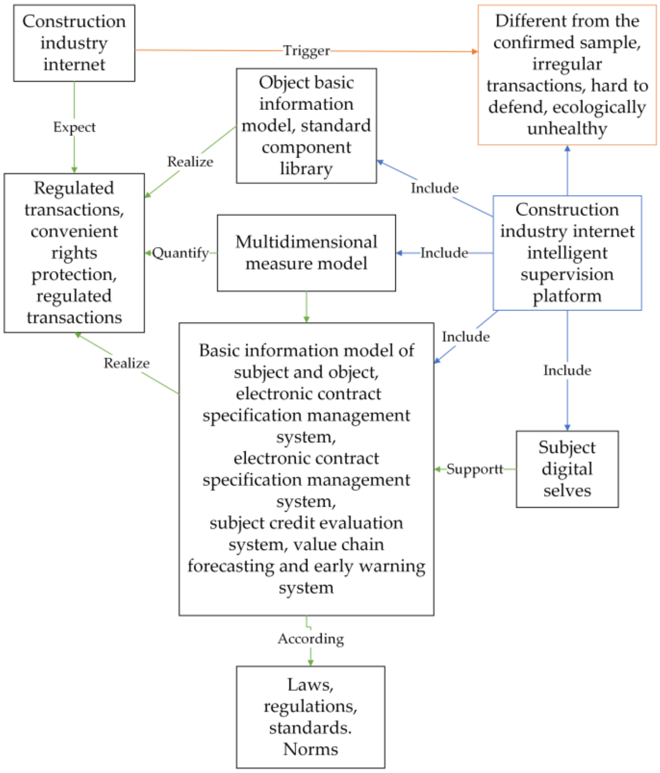


Fig. 10 **The schematic diagram of the digital economy panel**

4. Business panels combine multidimensional measurement model to support the release of intelligent building, intelligent construction, industry chain synergy, green building, and carbon indices by the intelligent construction index publishing system.

2.1 Multidimensional Measurement Model

In intelligent construction, the multidimensional measurement model provides big data analysis and modeling of workers and equipment in the process to establish digital selves that can be displayed, quantified, compared, and evaluated.

The multidimensional measurement system consists of intelligent sensing subsystem, data collection and trusted transmission subsystem, measurement generation and analysis subsystem, assessment index dynamic generation subsystem, index enhancement recommendation subsystem and automatic generation and submission of assessment documents subsystem. Intelligent sensing subsystem is accessed to real-time sensor systems associated with the assessment to achieve all-weather, real-time supervision. The data collection and trusted transmission subsystem collects data from relevant sensors timely and retains critical data in a trusted manner based on blockchain technology. The measure generation and analysis subsystem converts the data that is collected into values based on the multidimensional measure model, and performs intelligent analysis and collation to provide warning risk points for precise governance. The assessment index dynamic generation subsystem generates values of standardization, civilization and safety in real time based on the comprehensive measurement values after analysis to guide the focus of governance. Based on the results of evaluation, the index enhancement recommendation subsystem intelligently distinguishes the most effective means of modification and expected effect of the improvement for builders to improve the construction. The automatic generation and submission of assessment documents subsystem automatically generates submission information for monitoring requirements based on generated and recorded data, which improves the efficiency of submission and the credibility of submission information. The multidimensional measurement model is shown in Figure 11.

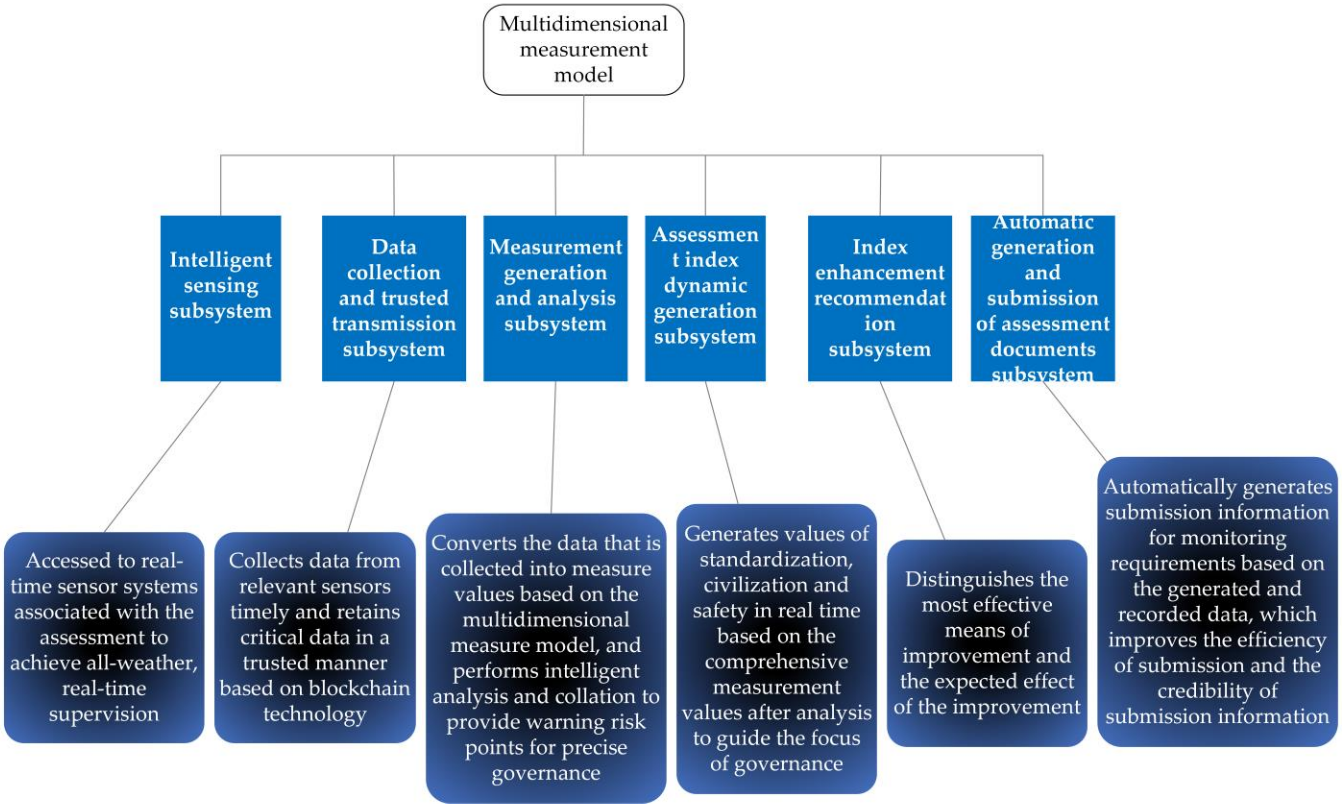


Fig. 11 The multidimensional measurement model

3 Research and data methodology

Smart construction technology evaluation focuses on the construction process and site, with indicators covering safety management, quality management, green and civilized construction, personnel management, progress management and so on. Each category of indicators should be scored based on factors such as location coverage, time coverage, and recognition rate. The scores are then calculated according to specified weights to obtain a percentage.

Determining the variables for each dimension of the digital selves involves a meticulous process based on statistical data. Taking safety management within each self as an example, the identification of variables is grounded in the notification of production safety accidents in housing and municipal engineering nationwide, provided by the General Office of the Ministry of Housing and Urban-Rural Development in 2018. The incidents and their respective proportions are detailed as follows: falls from heights accounted for 52.2% of the total; object impacts constituted 15.2%; injuries from lifting operations contributed to 7.5%; collapses represented 7.3%; mechanical injuries were at 5.9%; and incidents such as electric shocks, fires, and other types accounted for 11.9% of the total. In this section, based on the mentioned incident types, the key processes and areas prone to accidents on construction sites are sequentially included in the monitoring scope according to their proportional occurrence, aiming to ensure safety in production.

Safety management, quality management, green and civilized construction, and personnel management should be calculated using the following formula:

$$ConstructioncontentScore = \sum_{i=1}^{n}(A \times B \times C \times D)$$

A means Location Coverage. It refers to the percentage of established points in the construction plan that have been completed during the construction process and on-site.

B means Time Coverage. It indicates the percentage of monitoring time after the activation of protective equipment during effective construction time.

C means Recognition Rate. It represents the inherent accuracy of target recognition by protective equipment.

D means Construction Content Weight. The definition and determination of these weights depend on the specific priorities or significance assigned to each construction content aspect within the evaluation framework. The Construction Content Weight is a coefficient that reflects the relative importance or contribution of that specific aspect to the overall evaluation. These weights are typically determined through expert judgment, stakeholder consensus, or a systematic analysis of the impact of each construction content on the desired outcomes.

The progress management score formula is:

$$ProcessManagementScore = \frac{X}{x} \times \frac{Y}{x} \times 100\%$$

X means Accurate Reporting Nodes. Y means Timely Reporting Nodes and x means Total Nodes.

The accuracy of reporting engineering nodes and the timeliness of their reporting are assessed on-site by experts based on the actual conditions at the construction site.

4 Case Study

A city applies the digital selves based intelligent construction framework in the intelligent construction supervision platform. After constructing site selves, worker selves, enterprise selves, project selves and equipment selves, the real-time status of the object is reflected through indexes.

Intelligent construction supervision platform of a city takes B/S architecture for each functional module to provide various services required for system operation. The front end is developed with H5+CSS+JS, uses VUE framework and is supported by various popular components so that it can be compatible with various browsers. The back end is designed in JAVA and uses Spring MVC + Spring + Mybatits framework. In addition, it adopts Anolis OS 8.6 domestic operating system, supports SM2, SM3 and other domestic encryption algorithms, and uses Mysql database and Redis middleware. The whole system is based on HTTP protocol, uses RESTful design style and development method, and uses Spring Security + JWT to ensure system security.

Governments and enterprises can access government side and enterprise side by entering their account and password respectively. The government side can query data and provide real-time supervision of safety production, quality management, design and review, credit enforcement, dust detection and epidemic prevention. Digital selves collect data related to construction through sensors, cameras and other devices and display them on the government side. At the same time problems can be detected and warned in time. In addition, digital selves analyze data sets in construction area, such as the movement of people, vehicles and energy consumption in area, and provide support for governments to formulate management policies. In terms of green construction, digital selves monitor the environment of construction area such as air quality, noise, water quality and so on to provide data of environmental protection for governments. The government side interface is shown in Figure 12. After logging into the enterprise side, enterprises can make inquiries on enterprise information and project information. Simultaneously, real-time supervision of safety production, quality management and credit enforcement of projects is also possible. The digital selves collect data through sensors, cameras and other devices and display them on the enterprise side. During the construction, digital selves provide enterprises with support of monitoring and management, which makes it easy for them to discover quality problems in time and promote construction efficiency and quality. The enterprise side interface is shown in Figure 13. Governments and enterprises view specific information about enterprises, workers, equipment, projects and sites, as well as the corresponding digital selves in the index center. Take the equipment self as an example, the equipment self in the system is shown in Figure 14.

Fig. 12 The government side interface

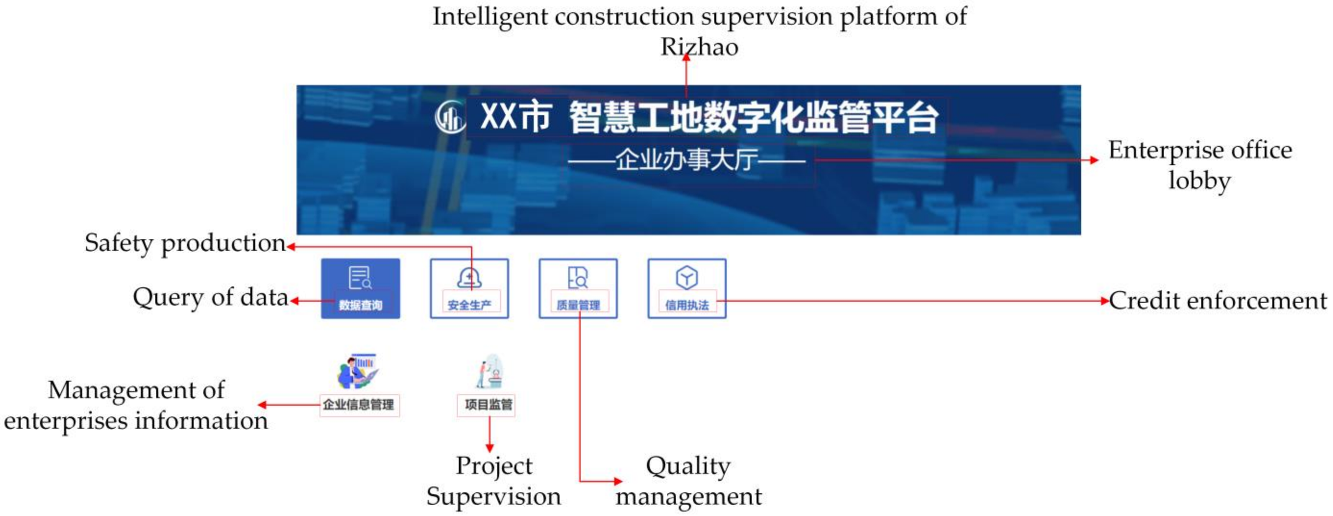
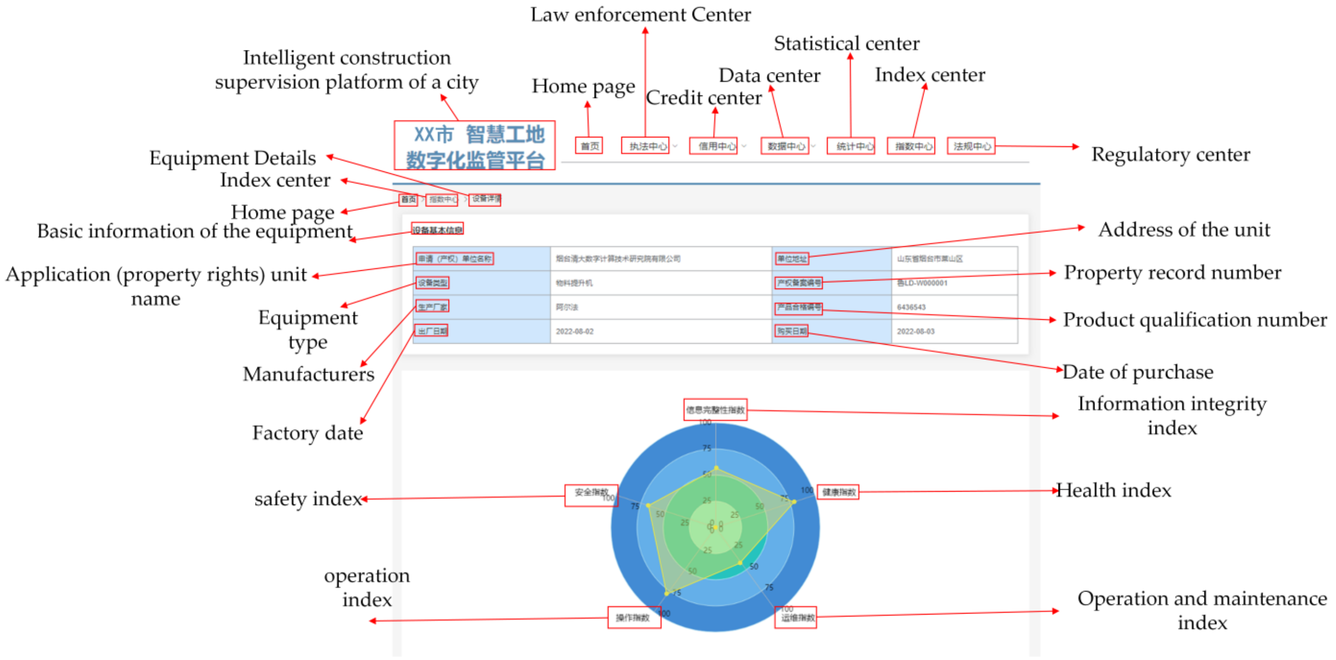


Fig. 13 The enterprise side interface



申请（产权）单位名称	烟台清大数字计算技术研究院有限公司	单位地址	山东省烟台市莱山区
设备类型	物料提升机	产权备案编号	鲁LD-W000001
生产厂家	阿尔法	产品合格编号	6436543
出厂日期	2022-08-02	购买日期	2022-08-03

Fig. 14 The equipment self in the system

In an intelligent site supervision platform of a city, the data can be displayed in real time through a large intelligent screen. First, the site self reflects the actual state of the site through real-time monitoring and recording of images and data from the site camera. The large intelligent screen collects, integrates and displays the real-time data of the site, and presents it to managers in an intuitive way. Secondly, the large intelligent screen not only displays the site self, but also combines other data sources for display such as project progress, personnel management, safety management, etc. Through the comprehensive display by large intelligent screen, managers have a more comprehensive and systematic understanding of the actual situation of the project, so that problems can be found, and measures can be implemented in time. In addition, the large intelligent screen analyzes data of projects deeply through big data analysis, artificial intelligence, and other technical means, so as to provide managers with more precise decision support. The large intelligent screen is shown in Figure 15.

In this case, the digital selves in the index centre analyses data of projects, companies, workers, sites, and equipment in multiple dimensions. The multidimensional measurement model combines the indicators of each subject for assessment, providing comprehensive and multi-perspective data analysis results. In addition, multidimensional measurement models can capture the correlations and interactions between different indicators. By linking and analysing multiple dimensions, it is possible to reveal dependencies and impacts between indicators. In addition to this, the multidimensional measurement model is flexible and scalable and can be customised and adapted to the needs of the regulatory platform.

The integration of multidimensional measurement models with semantic modeling represents a synergy between structured representation and quantitative analysis. Understanding how these approaches can complement each other is crucial for creating a comprehensive understanding of digital selves. By leveraging the strengths of both semantic and measurement models, researchers can move beyond isolated representations, capturing the dynamic and multifaceted nature of digital entities.

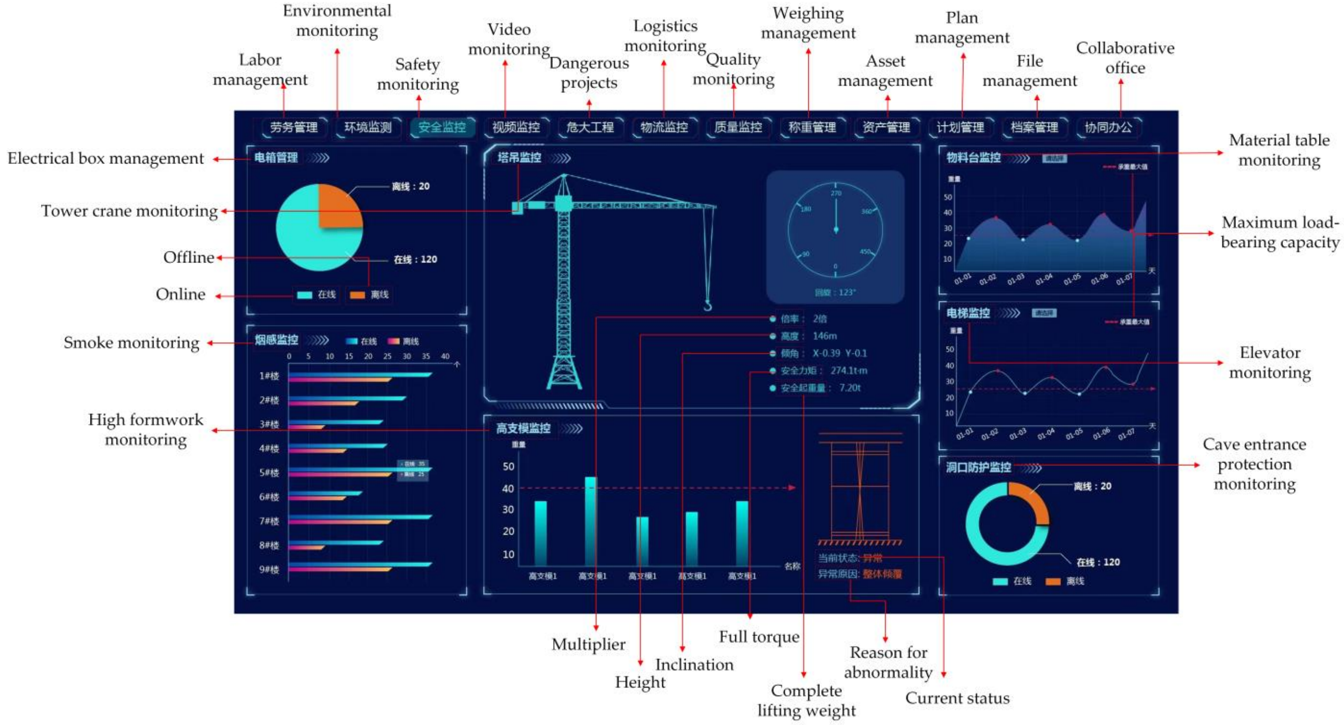


Fig. 15 The large intelligent screen

5 Discussion

The findings of this study in developing an intelligent construction based on digital selves present a significant contribution to the existing literature on intelligent environments, semantic modelling, and digital technologies in construction and housing.

Our incorporation of semantic modelling techniques aligns with a growing trend in the literature that recognizes the potential of these approaches in enhancing data interoperability and contextual understanding. As highlighted by Wang[18], semantic technologies contribute to more effective knowledge representation.

Our system's departure from conventional information systems by focusing on the site, equipment, and workers represents a significant advancement. This aligns with the evolving discourse on holistic subject-object integration within intelligent environments[19]. By achieving the building intelligence system subject and object simultaneously, our study contributes to a more comprehensive and nuanced understanding of the construction ecosystem.

The emphasis on enabling information circulation across various departments echoes the challenges identified by article[20]regarding information islands in complex projects. Our study builds upon this by not only highlighting the issue but also proposing a practical solution. This aligns with the broader trend emphasized by article[20], who advocates for improved information flow and collaboration as essential elements in smart construction.

In the realm of data management, our system's capability to achieve consistent, reliable, credible, and traceable data adds depth to the literature. Our study contributes by providing a concrete application of ensuring data quality and traceability.

In the context of our study, the proposed intelligent construction framework, rooted in the innovative concept of digital selves, serves as more than a technological advancement; it emerges as a robust business collaboration platform. This platform presents a transformative opportunity for governments and enterprises, offering timely and accurate information for informed decision-making. By leveraging digital selves, the system facilitates seamless collaboration between various stakeholders involved in intelligent construction. This collaborative approach not only streamlines communication but also enhances the efficiency and accuracy of supervision processes.

In contextualizing our findings, it's evident that our study adds value to the literature by not only identifying challenges but providing practical solutions rooted in the integration of digital selves. This approach contributes to the ongoing evolution of intelligent construction systems and aligns with the growing emphasis on collaborative decision-making platforms.

6 Conclusion

Our research has underscored the transformative potential of semantic modeling in advancing the capabilities of digital selves within intelligent construction. By focusing on the application of semantic modeling, we have demonstrated the feasibility of enhancing information integration, fostering collaboration, and improving decision-making processes in the context of intelligent construction. The development of a digital selves based intelligent construction framework marks a noteworthy contribution, providing a practical foundation for the evolving field.

Despite the progress made, it is crucial to acknowledge that challenges persist within the domain of semantic modeling for intelligent construction. Standardization, scalability, and the dynamic nature of construction site present ongoing hurdles that necessitate attention.

The outlook for digital selves and intelligent construction is one of transformative potential. As these technologies continue to evolve, their integration is expected to improve efficiency, and contribute to a safer and more interconnected industry. Continued research, collaboration, and adaptation to emerging technologies will be crucial in realizing the full benefits of digital selves in the construction landscape.

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