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Research on Data Fusion Algorithm of Intelligent Building Based on Internet of Things Technology

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Abstract

In an era of sustained economic growth and rising living standards, the demand for housing continues to increase significantly, driving the development of the construction industry and the inevitable transformation of architectural digitization as a prevailing trend. This circumstance has generated limitless economic opportunities across various construction-related sectors, including building materials, technology, and related services. Simultaneously, the evolving Internet of Things (IoT) technology has paved the way for the digitization of buildings, revolutionizing the entire process of architectural design, construction, and management. Architectural digitization enables real-time monitoring, in-depth data analysis, and the optimization of building efficiencies, encompassing energy management, temperature control, and lighting systems. In the current landscape, architectural digitization has given rise to smart buildings that can effectively control nearly all aspects, from temperature and lighting to security systems and comfort. Furthermore, IoT technology has facilitated addressing sustainability challenges by enabling more efficient and sustainable energy management—an essential aspect of the journey toward environmentally friendly buildings. Nevertheless, on the path to fully interconnected digital buildings, there are challenges that must be addressed, such as data security and user privacy, both of which require special attention. Looking forward, research directions include the development of more sophisticated digital integration algorithms, enhanced data security, and the integration of artificial intelligence into building management. The future of architectural digitization holds great promise, with the potential to create more efficient, secure, and environmentally friendly buildings. To achieve these goals, it is essential to strengthen cross-sector collaboration, receive government support, and emphasize research and innovation in the field of architectural digitization.

Keywords: Building Data, Internet of Things, Data Fusion

1. Introduction

Architecture, a multifaceted discipline, extends beyond being a mere dwelling place; it constitutes the very fabric of our existence, providing environments in which we not only reside but also work, create, and cultivate our lives. In this ever-evolving landscape of human civilization, the demand for innovative housing construction has catalyzed a transformative era in the architectural domain. Within this epoch, a profound shift towards the digitization of architectural processes and environments has taken center stage, redefining our approach to designing, constructing, and inhabiting spaces.

The driving force behind this paradigm shift is the relentless march of technological progress, particularly the Internet of Things (IoT). The IoT, with its network of interconnected sensors, devices, and systems, has become an invaluable tool in architectural design and construction. Through digitization, we can replicate and simulate real building scenarios, harnessing the power of data to make more informed and strategic decisions. This not only streamlines the construction process but also enables architects and builders to optimize their designs and structures for efficiency, sustainability, and functionality.

The implications of this digitization are profound, touching every aspect of our built environment. From smart homes that seamlessly integrate technology for enhanced comfort and security to sustainable structures that maximize energy efficiency, architectural digitization is reshaping the very essence of how we conceive, build, and interact with our surroundings. It promises a future where buildings are not static entities but dynamic, responsive ecosystems that adapt to our needs and preferences.

However, as with any transformative endeavor, there are challenges to overcome. Ensuring data security, protecting individual privacy, and addressing the ethical implications of a digitized built environment are vital considerations. Moreover, fostering interdisciplinary collaboration between architects, engineers, data scientists, and policymakers is essential to fully unlock the potential of architectural digitization.

As we delve deeper into this exploration of architectural digitization, we embark on a journey to understand its intricacies, potentials, and limitations. This journey is not just about the buildings we create but also about the profound impact these creations have on our lives, our communities, and our planet. It is a journey that seeks to harmonize the art and science of architecture with the boundless possibilities offered by the digital age. Together, we shall navigate this uncharted territory and shape a future where architecture transcends the mere physical to become a conduit for the realization of our aspirations and the enhancement of our collective well-being.

2. The Concept of Building Data

2.1. Definition and Components of Building Data

Building digitization refers to the huge number and variety of sensors placed in building components. It integrates data at the end and establishes the Internet between the prefabricated components and the prefabricated components. This network is also suitable for the prefabricated components and the building sub-database. The Internet of Things system or other data transmission network between the building sub-database and the central database is the data integration channel. The central database is the data integration system of the data integration terminal. It collects and stores all collectible data in a large number of buildings. Finally, computer technology organizes and analyzes these data. Therefore, building data is composed of four elements: data source (data integration tip), data integration channel (contained in the building sub-database), central database, and data sorting and analysis system [1,2].

2.2. The Difference Between Building Data and Building Intelligence

Number of data collected by building digitization:These data are larger and more diverse. Smart buildings start from the needs of people and collect a small amount of data on specific aspects. Building digitization is to collect all kinds of data as much as possible [3,4].

Central database for building data: The level of the central database is higher. The level of the intelligent building is equivalent to the building sub-database in the building digitization. Therefore, the databases of each intelligent building are separate from each other, and there is no higher-level database to integrate and collect the data of each database. Data collected by building digitization is more versatile.The use of data is wider, and the value of data is played more thoroughly. The specific data in the smart building is only used for a specific purpose. This specific purpose is set by the designer. After the data meets the needs of the purpose, the other value of the data is wasted [5,6].

2.3. The Source of Ideas for Building Data

The source of ideas for building digitalization is the emerging big data theory. This refers to the method of using all data instead of random analysis (sampling survey), and advocates "quantifying everything". This kind of thinking advocates extracting data from all possible places. It quantifies everything and uses all data to predict human behavior and other events. This approach will produce huge commercial, scientific research and public management values. Its theoretical relationship has been discussed in detail in big data theory. Big data theory is the essence of applying big data ideas to buildings. This is to transform buildings into data collection devices, and then through data integration, they will eventually become a new source of huge amounts of data,as shown in figure 1.

Figure 1. Model fusion

3. Research Direction and Related Research Status of Building Data

There are four elements of building data: the first is the data integration tip, the second is the data integration channel, then the data integration terminal, and the final data collation and analysis system [7,8]. People study how to initially realize and continuously optimize these four elements in actual production and life. This is the research direction of building data. Data integration tips refer to many different types of sensors installed in building components. The placement of sensors in the field of intelligent buildings has a certain research foundation. People are committed to researching the deployment of sensors in buildings to achieve the goal of collecting the largest and most diverse data possible, and on this premise, the most economical and rationalized purpose.

4. Models and Algorithms for IoT Data Fusion

The research of data fusion has been going on for a long time, it mainly collects object information through automation technology, and through corresponding processing means, finally obtains the characteristic information needed for decision-making. The definition of data fusion from the military perspective is that data fusion is a multi-faceted and multi-level processing process. Its main function is to detect and analyze data from different sources, so as to obtain a more accurate estimate of identity and state, so as to make a scientific view of the battlefield situation. Accurate evaluation. In industrial applications, data fusion improves the sensor's anti-interference ability, and the accuracy of information is improved. Data fusion plays an important role in many fields [9,10].

4.1. Types of Data Fusion

Data fusion can be divided into three levels: data level, feature level, and decision level.

Data-level fusion analysis: Data-level fusion is the most basic fusion. It directly fusions on the basis of raw data and processes unprocessed sensor data. The data layer fusion processing usually adopts a centralized fusion system. Because data fusion only performs numerical processing on sensor data, this method has the characteristics of high accuracy and low data loss. However, the amount of data it faces is huge, so the amount of calculation for data fusion is relatively large, and the real-time performance is not good. At the same time, the measurement interference of the sensor will be brought into the fusion calculation. Therefore, the system must be equipped with a filtering function, and the sensor has a higher requirement for anti-interference ability [11,12].

Feature-level fusion analysis: The level of feature-level fusion is relatively high. First, the features of sensor information are extracted, and then the extracted feature information is processed and analyzed. Feature-level fusion enables information compression and improves the real-time performance of data processing. The extracted feature values provide data information required for decision analysis. However, some potentially useful information may be ignored, which will affect the fusion performance to a certain extent. Centralized and distributed are common fusion systems for feature-level fusion. Feature fusion includes two types of fusion of target state and target characteristics. Among them, target state fusion is widely used in tracking multi-sensor tracking, and target feature fusion is widely used in pattern recognition [13,14].

Decision-level fusion analysis: Decision-level fusion is a higher-level fusion, which uses multiple sensors to monitor the same target. This method completes the preliminary analysis of the feature information extraction and identification of sensor data, as well as judgment, etc. locally. Decision- level fusion uses correlation processing to achieve data fusion at the decision-making level, and obtain the final judgment result. Decision-level fusion loses a lot of data, but it saves a lot of system resources. This method requires only a small amount of communication and has strong real-time performance.

4.2. Architecture of IoT Data Fusion

The heterogeneity of data determines the need to establish a corresponding organizational model in the data processing process of the Internet of Things. The important ones are central, distributed, point-to- point, and hybrid centralized. The central organization has high data analysis efficiency, but its storage capacity is poor. It is suitable for occasions with small data volume and high timeliness requirements. Distributed organization system can increase the storage capacity of the system by increasing the number of nodes, but the decentralized data storage leads to longer processing time, so this type is suitable for systems with low timeliness and large data volume. The point-to-point organizational structure is simple, and the mixed type is both accepted and affirmed by the majority of faculty and staff. At present, the active accounts of the mailbox system are more than 70%, and the active accounts of the WeChat enterprise account are more than 50%. Compared with the previous ones, the new system greatly improves user satisfaction and office efficiency [15,16].

4.3. The Basic Model of IoT Data Fusion

Information ring fusion model: As shown in figure 2.The intelligence loop fusion model equates data fusion with intelligence analysis and processing, which is divided into two parts: information processing and fusion. UK intelligence ring is a typical intelligence ring model, and it regards fusion as a ring structure, which includes four stages of collection, sorting, evaluation, and distribution. The acquisition phase uses sensors and analysis systems to collect corresponding information. It merges, simplifies and compresses the collected information in the collation phase, which prepares for further fusion. The evaluation stage is the key to the fusion model. This stage is responsible for analyzing the information of the previous stage and transferring the results to the next stage. Finally, it guides the models in the acquisition phase. The distribution stage sends the result of the fusion data to users. This stage is used to make decisions or revise the fusion process. Informational data processing uses multiple intelligence principles such as central control, system development, timeliness, and information objectivity. This processing method can adjust the model in time to ensure the normal operation of the information source when the customer needs change, and it can continuously evaluate and analyze the collection and analysis of information, thereby continuously revising the model. These features ensure the confidentiality of the system, but its applications are relatively limited [17,18].

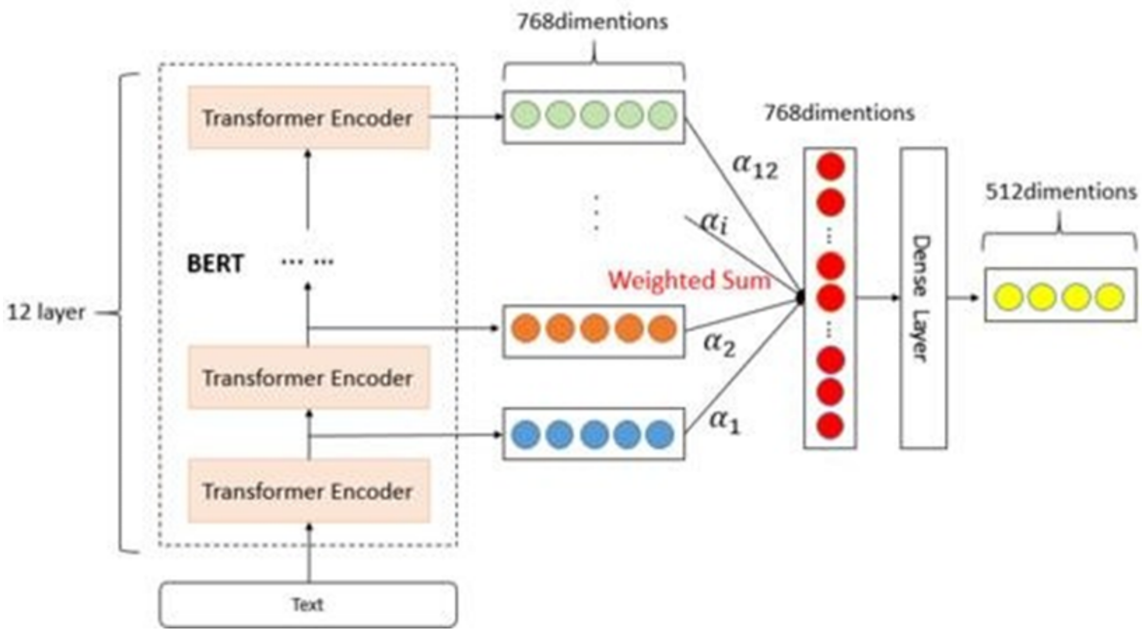

Figure 2. Model fusion

JDL fusion model: Strengthening the communication and communication of system management, theoretical research, system design, and system evaluation are the important goals of the model, which can ensure the smooth and efficient operation of the integrated system's overall design, system development, and system operation. The model is mainly composed of data sources, initial data processing, target estimation, situation estimation, threat estimation, process estimation, database and human-computer interaction interface. System sensor information is the main source of data, and the data initial processing module performs operations such as deviation correction, coordinate unification, and standardization on the collected data. Target evaluation first performs a preliminary analysis of the processed object, and then it will further match the associated sensor monitoring data to determine the physical characteristics and identity information of the object. In order to provide information support, situation assessment will evaluate and estimate the relationship and changes of the processing objects. It will estimate the comprehensive target and environmental conditions based on the superior situation, and obtain potential threats to the target environment. The process is estimated to have European configuration sensors and resources, and it will also collect and process information to improve the performance of system data fusion. The database provides the system with data processing support such as storage, recall, and retrieval. There is a systematic operation interface in the human-computer interaction interface [19,20].

The Boyd ring includes four phases: Boyd's ring includes four stages: observation stage, adjustment stage, decision-making stage and execution stage. The observation phase is responsible for monitoring the target object and collecting information; the adjustment phase mainly identifies the target object and processes the collected information; the decision-making phase formulates response strategies based on the analysis results of the adjustment phase; the implementation phase provides a fusion strategy during the implementation phase and the observation phase. Boyd control fusion model is based on data flow, and its stages form a closed loop. In this cycle, the data will be gradually simplified during the operation of the model. The overall structure of the model is relatively simple, and it has strong timeliness, but there are many related problems of data fusion at each stage, and the connection between each stage is ignored in the data fusion process.

5. Conclusion

Architecture stands as an essential cornerstone of urban landscapes, deeply interwoven with the fabric of people's daily lives and professional endeavors. Its significance transcends mere physical structures, as it encompasses the very essence of human existence within these constructed environments. However, in the wake of the rapid evolution of the Internet of Things (IoT), the conventional paradigms of building design and construction are undergoing a profound transformation. This paradigm shift towards building digitization heralds a new era, one where the convergence of cutting-edge technology and architectural ingenuity holds the promise of revolutionizing our urban spaces and the way we interact with them.

The concept of building digitization is poised to revolutionize the conventional construction processes and models that have long been the norm. In doing so, it ushers in a future where our physical environments are no longer static entities but dynamic hubs of data and connectivity. By harnessing the power of artificial intelligence, building digitization empowers us to analyze vast troves of data in a manner that was previously inconceivable. This comprehensive data analysis extends beyond mere numerical insights; it offers profound insights into human behavior, preferences, and needs, which are pivotal in shaping the architecture of tomorrow.

One of the most compelling aspects of building digitization lies in its capacity to elevate the residential living experience. By delving into the intricacies of data fusion, a hallmark of the IoT, this transformative approach merges disparate streams of information into a cohesive whole. This synergy enables architects, designers, and urban planners to fine-tune their creations with unparalleled precision, aligning them with the ever-evolving demands and aspirations of residents. Each individual living within a digitized building becomes a vital data point, contributing to a continuous feedback loop that refines and optimizes the entire system.

The synthesis of building data within a digitized framework not only enhances the efficacy of the structures themselves but also fosters a sense of interconnectedness and efficiency that transcends the traditional boundaries of architecture. With each passing day, this fusion of technology and design is propelling us further towards a future where our built environments seamlessly adapt to our evolving needs, promoting sustainability, comfort, and innovation in equal measure. As we stand on the cusp of this architectural revolution, it becomes abundantly clear that building digitization is not merely a technological endeavor; it is a testament to our collective vision for a smarter, more harmonious urban future.

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