From Tradition to Modern—Developments and Future Trends in Engineering Surveying and Mapping

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Keywords: Surveying and Mapping, Big Data Analytics, Artificial Intelligence, Development.

Abstract: Engineering surveying and mapping have always been an essential part of construction engineering; with the development of The Times, engineering surveying and mapping began to change from the traditional way to the direction of digital and intelligent. This paper uses the case study method and literature analysis method to discuss the application of unmanned aerial vehicle (UAV) remote sensing, building information modeling (BIM), and geographic information system (GIS) in the current field of engineering surveying and mapping and analyses the advantages of these technologies in terms of surveying and mapping accuracy, project management efficiency, and use cost, such as high precision, high efficiency, and able to demonstrate the construction process concretely. This shows the importance of artificial intelligence and big data in developing engineering mapping. Based on the literature reading on cutting-edge technologies and the development status of existing surveying and mapping technology, this paper believes that the future development of engineering surveying and mapping should continue to use big data analytics and artificial intelligence. Continue to expand the utilization rate of BIM GIS and other similar technologies, so that the entire engineering surveying and mapping industry can move forward to a more efficient and accurate goal.

1 INTRODUCTION

Surveying and mapping is a basic work in construction engineering, including many links such as project planning and design, construction safety management, and project status detection. Engineering surveying and mapping can provide accurate three-dimensional data, providing a reference for decision-making in the construction process and ensuring production safety. Therefore, surveying and mapping is an indispensable part of modern engineering.

The traditional engineering surveying and mapping methods mainly rely on manual measurements, such as total station, mirror, tape, and other optical and mechanical measuring instruments. These methods are limited by terrain, vegetation, weather, and other factors, and the mapping process is long, labor-intensive, and lacks safety, although, with the development of the industry, accuracy and efficiency have improved, but still lag behind the growing demand.

So, to seek change, since the 1990s, with the development of aerospace and computer technology, methods such as remote sensing (RS) and Global Positioning systems (GPS) have emerged, which have gradually transformed engineering surveying and mapping from manual methods to digital methods. Digital mapping technology has the characteristics of high accuracy, easy transportation and storage of equipment, and quickness. Now, with the wide application of emerging technologies such as building information modeling (BIM) and unmanned aerial vehicle (UAV) surveying and mapping, engineering surveying and mapping methods are developing towards higher intelligence and automation.

This era is the era of rapid growth of computing power, but also the era of continuous growth of urban population; how to face the social development and intelligent transformation trend is the opportunity faced by engineering surveying and mapping. This paper will explore this issue in depth, introduce UAV remote sensing surveying technology, building information modeling (BIM), geographic information system (GIS), and the application of these

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Zhang, S.
From Tradition to Modern—Developments and Future Trends in Engineering Surveying and Mapping.
DOI: 10.5220/0013326200004558

In *Proceedings of the 1st International Conference on Modern Logistics and Supply Chain Management (MLSCM 2024)*, pages 243-247
ISBN: 978-989-758-738-2

technologies in the field of engineering surveying and mapping, explore how these technologies promote the transformation of engineering surveying and mapping to intelligence.

2 DEVELOPMENT STATUS OF ENGINEERING SURVEYING AND MAPPING TECHNOLOGY

In recent years, with the continuous innovation of engineering surveying and mapping technology, engineering surveying and mapping technology is no longer only applied in engineering projects; it has begun to be used in a wider range of related industries, while the emergence and application of new technologies have also brought new tools to the engineering surveying and mapping industry, such as UAV platform, light detection and ranging (LiDAR), BIM system, GIS system.

In terms of urban planning and smart city construction, the city 3D modeling and building data provided by engineering surveying and mapping technology provide planners with more comprehensive information, and the use of relevant BIM and GIS software equipped with this information helps planners make better planning decisions.

In civil engineering surveying and mapping, the unmanned aerial vehicle platform equipped with LiDAR has been widely used. The unmanned aerial vehicle platform can easily reach the height that manpower cannot reach, then survey the more dangerous terrain, and generate 3D point cloud images through the data scanned by the LiDAR sensor, which is more efficient and safe than the traditional surveying and mapping methods.

This paper will discuss the development status of UAV remote sensing, BIM, and GIS in engineering surveying and mapping, evaluate the current application scenarios and advantages of these technologies, analyze the current limitations and shortcomings of these technologies, and put forward some improvement suggestions conducive to the industry's development.

2.1 Development of UAV Remote Sensing Mapping Technology in the Field of Engineering Mapping

Remote sensing refers to the technique of capturing information at a distance (remotely) by specific instruments (sensors) (Pajares, 2015). The continuous development of commercial UAVs enables them to carry more weight, last longer, and carry more advanced sensor systems, which provides opportunities for the use of remote sensing technology on UAV platforms.

The UAV equipped with a remote sensing system can scan and process a wide range of terrain data in the air. Moreover, the UAV has a built-in GPS, and the user can complete the mapping task of the specified area by writing the flight path of the UAV. During the use period, the operator only needs to control the data remotely to ensure the correct data transmission and flight path.

In the UAV remote sensing surveying and mapping technology, the UAV using a LiDAR sensor is a typical example. The survey area is scanned by the carried LiDAR sensor. After the scanning is completed, the collected data is digitally processed by software. As a result, three-dimensional topographic maps are generated, and LiDAR does not require much light, so mapping tasks can be carried out normally even at night when there is no light (He, 2020).

UAV remote sensing surveying and mapping technology has many advantages over traditional surveying and mapping technology. For surveying and mapping engineering, the effective implementation of itself is carried out through effective cooperation between various departments (Zuo, 2022). The most obvious advantage of UAVs is their flexibility. Compared with the large amount of equipment required for traditional surveying and mapping, the UAV itself is small in size and light in weight, and the preparation before the mapping is not complicated, and the scanning work can be started immediately. In the surveying and mapping process, some terrain will be more complicated, and the surrounding environment will make it difficult to install surveying and mapping instruments, which will also pose a threat to the safety of surveying and mapping workers. The application of UAV remote sensing technology can replace manual surveying and mapping work in dangerous and narrow areas, and only workers need to remotely control in safe areas, and the security of the surveying and mapping process can be guaranteed. In the process of construction and mapping, emergencies caused by weather changes and emergencies occurring in the construction process often need to understand the site situation and make effective decisions quickly. At this time, UAV remote sensing mapping technology can be quickly deployed to analyze the area and help decision-makers understand the site situation so as to reduce losses and casualties the first time.

Compared with traditional mapping methods, the UAV operating system is relatively simple, requiring only a few days of training and practice, and users can master the basic operation. Because traditional surveying and mapping methods often require a longer period of learning and practice, the advantages of drone technology are more obvious on the learning curve. UAVs can scan a large area of terrain in a short time and turn it into a digital three-dimensional image. The scanning results are more accurate, and the surveying and mapping tasks can be completed more efficiently.

Although commercial UAVs have high flexibility, the use of UAVs is still affected by environmental factors, such as wind speed, temperature vegetation density, etc. Environmental effects need to be considered in the process of use. For example, the flight stability of UAVs will be greatly affected by strong winds and heavy rains. In less harsh environments, UAVs can normally complete flight tasks, such as in cloudy weather or when the ambient wind speed is less than 6, UAVs can still carry out aerial photography detection (Zuo, 2022).

2.2 Application of BIM in Urban Planning

BIM is a representation process that creates and provides, in all respects, a multi-dimensional view of the building data throughout the life cycle of the building (Borkowski, 2023). Therefore, this means that BIM technology not only includes digital 3D models, It also includes the design process, material allocation, construction arrangement and other contents of the entire construction project, and is a tool that can integrate all aspects of a construction project. It can act as a public knowledge resource about object information and lay a reliable foundation for decision-making throughout its life cycle from the very beginning (Dixit, 2021).

After building a 3D model through BIM and importing the environmental and meteorological data of the city, the daylight interval, air flow and temperature changes caused by sunlight inside the building can be visually seen through the simulation software, which enables designers to find the problems and defects in architectural design faster and modify the defective design.

The amount of engineering material planning in construction is huge and complex, and manual planning is often prone to poor planning, resulting in material loss or waste and delay of the construction period. The BIM system can provide the basic data of the construction of the building and clearly show the required materials and the construction side can make a more accurate material plan, thereby reducing the waste of materials and time.

Compared with the traditional CAD 3D model, the advantage of BIM is that it can add a timeline based on the 3D model to simulate the construction progress of the entire construction cycle, which can not only make decisions compared with the actual construction progress but also allow investors to clearly understand the progress of the entire project so that the communication between the construction side and the owner becomes more direct and simple.

Although BIM is of great significance to building planning, at present, there are still many problems that need to be solved in the wide application of BIM. In a construction project, "stakeholders" are the decisive factor for the success of the project (Xu, 2023). However, in the construction project in which BIM participates, it is different from traditional stakeholders. For example, developers of BIM applications can charge high software royalties and make profits from them (Rezwan, 2022). It can be seen that the stakeholder structure of projects using BIM will also change, and this uncertainty will lead many developers to give up using BIM technology.

2.3 Application of Geographic Information System （GIS）

A geographic information system is a computer-aided system for the collection, storage, management, and analysis of the representation of geographic reference data (Rezwan, 2022). It can collect all kinds of terrain data and integrate it into one system, and relative to BIM, it features such as 3D component editing, terrain modelling and geospatial analysis that BIM lacks, and these functions are now major requirements in the construction industry, so GIS plays a key role in building planning. GIS can monitor geographical space, which can help in the planning of building safety programs. Engineers can understand the environmental conditions, site topography, temperature distribution, etc., through a GIS system to plan the possible risks. For example, by understanding the terrain conditions near the construction project, they can know the areas where landslides may occur. Plan escape routes and emergency plans.

At the same time, GIS can make up for the shortcomings of BIM in terrain rendering. In actual design, GIS is responsible for large-scale planning of buildings, and BIM is responsible for small-scale design inside and around buildings, which can better improve design efficiency.

3 DEVELOPMENT TREND OF ENGINEERING SURVEYING AND MAPPING

With the progress of computer science, engineering surveying and mapping gradually began to intelligent transformation, which is the general trend, although the accuracy of surveying and mapping is getting higher and higher, modern technology is still not mature, although the UAV remote sensing surveying and mapping technology can be quickly and efficiently deployed and work, but still can not be used in special weather conditions, and the endurance time is not high; Although the development of BIM and GIS can make building design and management more efficient, and security monitoring can be guaranteed, they are still in the initial stage. Coupled with the changes in stakeholders and old-fashioned ideas, they are faced with many obstacles and cannot be widely implemented. Besides, BIM and GIS systems can save costs for project expenditure. However, more work is needed to implement the design in the early stage, and the number of workers who have the relevant knowledge is also smaller, which leads to more expenses.

Future engineering surveying and mapping is developing towards digitalisation, intelligence and big data analysis. With the improvement of computer computing power in recent years, the addition of machine learning, artificial intelligence and other technologies can replace users to complete some basic operations, such as autonomous UAV navigation (Lu, 2018). This technology can ensure that the UAV moves along a given route in a complex dynamic environment, using AI's visual analysis to determine the running path and avoid roadblocks (Trzeciak, 2023); For example, the use of AI to merge time-synchronized and spatially registered images and LiDAR scans into higher resolution dense scans, then gradually reconstructed, which can retain useful 3D point data, eliminate noise, and make 3D modeling clearer (Zhu, 2021).

The amount of data generated by engineering surveying and mapping is very large, and the sources of the data are mixed. Therefore, combining big data analysis and cloud computing technology can more effectively store, manage and analyse the surveying and mapping data, and realise the real-time sharing and presentation of data. By introducing neural networks to fuse full-wave LiDAR and polar-interferometric SAR data information, users can predict a wide range of forest information.

4 CONCLUSION

This paper discusses the current development status of engineering surveying and mapping technology and mainly studies the use of UAV remote sensing surveying and mapping technology, BIM systems and GIS systems in the current industry. The research found that although the UAV remote sensing mapping technology has been widely used in the mapping process, the UAV platform still has the problems of insufficient endurance and low stability, and the efficiency of the data processing method collected by the sensor is still not fast enough. BIM system plays a significant role in improving construction efficiency and reducing costs, but it is not widely used at present due to the old-fashioned thinking of the industry. GIS systems can help engineers better understand terrain data and environmental information, but its obstacle is that the information source is complex, and the data is large and difficult to process and integrate. In the future, with the addition of big data and artificial intelligence, all kinds of information obtained from surveying and mapping will be more closely linked, and the engineering surveying and mapping industry will liberate complicated human labour and develop in a more intelligent direction.

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