

The Application of UAV Remote Sensing Technology in the Construction of Agricultural Water Conservancy Facilities

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Abstract: With the rapid development of UAV technology, its application in the construction of agricultural water conservancy facilities is becoming increasingly widespread. This paper reviews the application of UAV technology in land surveying, soil and water conservation, irrigation system design, and the maintenance and management of agricultural water conservancy facilities, discussing the advantages and challenges brought by UAV technology. UAV technology has improved the efficiency and accuracy of data collection, optimizing the planning and management of agricultural water conservancy facilities. However, the complexity of the technology, operational limitations, legal regulations, and privacy and security issues are major obstacles that need to be overcome in the application of UAV technology. This paper proposes suggestions for future development, including improving the autonomy and durability of UAVs, simplifying data processing procedures, and strengthening legal and regulatory construction. Through these measures, UAV technology is expected to play a greater role in the field of agricultural water resources, contributing to the sustainable development of agricultural production.

Keywords: UAV technology, Agricultural water conservancy facilities, Land surveying, Soil and water conservation, Irrigation system design.

1. Introduction

In the development of agriculture in the 21st century, the construction of water conservancy facilities is a key factor in improving agricultural production efficiency, ensuring food security, and promoting rural economic development. With global climate change and population growth, higher demands have been placed on the management of agricultural water resources. Against this backdrop, UAV remote sensing technology, with its efficiency, economy, and precision, has become an indispensable tool in the construction of agricultural water conservancy facilities [1-3].

Unmanned Aerial Vehicles (UAVs), as an emerging remote sensing platform, have attracted widespread attention in the agricultural field [4]. UAVs not only provide high-resolution image data but can also cover large areas of land in a short time, demonstrating great potential in the planning, construction, and management of agricultural water conservancy facilities [5]. UAV remote sensing technology can monitor the condition of farmland in real-time, assess the effectiveness of irrigation systems, and provide rapid responses in the event of disasters, thus ensuring the continuity and stability of agricultural production [6]. Overall, UAV technology offers a rapid, economical, and efficient solution for the construction of agricultural water conservancy facilities. Its high flexibility and real-time data processing capabilities give it a clear advantage in modern agricultural management. As technology advances, the application of UAVs in the agricultural sector is expected to become more widespread, potentially becoming an important tool for the future construction and management of agricultural water conservancy facilities.

However, despite the broad prospects for the application of UAV technology in the construction of agricultural water conservancy facilities, current research is not deep enough, and there are some technical and managerial challenges in

practical applications. For example, how to process and analyze a large amount of UAV image data, ensure the safety and compliance of UAV flights, and effectively integrate UAV technology with existing agricultural water conservancy management systems are issues that need further exploration and resolution. This paper aims to review the current status of UAV remote sensing technology applications in the construction of agricultural water conservancy facilities, discuss its specific applications in land surveying, soil and water conservation, irrigation system design, and facility maintenance and management, and analyze the challenges faced and future development directions. Through in-depth analysis of these contents, it is expected to provide theoretical support and practical guidance for the further application of UAV technology in the construction of agricultural water conservancy facilities.

2. The Application of UAV Technology in Agricultural Water Conservancy Facility Surveying

In modern agricultural management, precise land surveying is the foundation for ensuring the effective planning and construction of water conservancy facilities. Although traditional land surveying methods are reliable, they are often inefficient and costly. With the development of UAV technology, its application in the surveying of agricultural water conservancy facilities has begun to receive attention [7, 8].

2.1. Basic Principles and Technical Features of UAV Aerial Surveying

UAV aerial surveying uses cameras or other sensors mounted on UAVs to take photos and collect data from the air. This method is characterized by its simplicity of operation, rapid data acquisition, wide coverage, and relatively low cost.

UAVs can complete large-scale land surveying work in a short time, providing high-resolution image data that is crucial for the planning and construction of water conservancy facilities.

2.2. Advantages of UAVs in Surveying Agricultural Water Conservancy Facilities

The advantages of UAVs in surveying agricultural water conservancy facilities are mainly reflected in the following aspects: high efficiency, as UAVs can be quickly deployed and cover large areas of farmland in a short time, significantly improving the efficiency of surveying work. High precision, as UAVs provide high-resolution images that can reveal details of the land surface, helping to plan water conservancy facilities more accurately. Flexibility, as UAVs can fly in various terrains and weather conditions, especially suitable for complex or inaccessible areas. Real-time data transmission allows engineers and decision-makers to obtain up-to-date land information promptly [9-11].

2.3. Case Studies and Effectiveness Evaluation

A project in Hunan Province: This project used UAV aerial photography to obtain image data after land consolidation, used PixelGrid software for aerial triangulation encryption, produced orthophoto maps, and conducted accuracy evaluation. Field verification showed high accuracy in land classification, with a fast and accurate classification process [12].

The application of built-in RTK UAV aerial photography technology in land consolidation project mapping and auxiliary planning design: A land consolidation project area in a county in Jiangxi Province used built-in RTK UAV aerial photography technology for mapping and auxiliary planning design, achieving an orthophoto resolution of 0.033 m, a planimetric coordinate error of 0.051 m, and a digital elevation model (DEM) elevation error of 0.070 m, meeting the accuracy requirements for land consolidation project mapping [13].

These cases demonstrate the widespread application and significant advantages of UAV technology in land consolidation, especially in improving work efficiency, precision, and quality. The successful application of UAV technology also provides new ideas and technical support for land consolidation work, helping to promote the development of this field.

3. The Application of UAV Imagery in Soil and Water Conservation

3.1. UAV Image Data Acquisition and Processing Methods

High-resolution cameras mounted on UAVs can capture detailed images of farmland, which, after professional software processing, can generate high-precision maps for soil and water conservation analysis. These maps can display key information such as erosion areas, vegetation coverage, and water flow direction.

First, it is necessary to arrange the UAV's flight route reasonably according to the task requirements. During the UAV's mission, the ground control system manages its flight route, while the airborne control system controls the imaging system inside the UAV to complete the shooting based on pre-imported data. Before processing the images, it is necessary to detect the distortion difference and internal orientation elements of the digital camera, as these factors can

significantly affect the imaging effect. Then, the images are color-corrected to ensure consistency in color, brightness, and texture. Image matching is an important step in processing remote sensing image data. Feature-based image matching methods are commonly used, and computer algorithms are used to quickly extract feature points accurately using operators such as Harris. Aerial triangulation within a regional network is beneficial for obtaining the accuracy values of check points and control points, understanding the overall data accuracy obtained from remote sensing operations, and improving the accuracy of ground control points when necessary. Generating orthoimages requires processing images using matching points and orientation data, obtaining the actual digital elevation model (DEM) of the test area through human-computer interaction, and accurately generating the orthoimages. After generating the orthoimages, a certain number of ground control points need to be extracted, comparing the coordinates on the screen with the measured coordinates, discovering errors, and ultimately determining the actual accuracy of the orthoimages [14, 15].

Software such as Pix4Dmapper is used for the automated processing of UAV data, including aerial triangulation calculations, adjustment calculations, orthorectification, and automatic mosaicking and calibration techniques, achieving rapid stitching and calibration of UAV data.

3.2. Application in Monitoring and Assessing Soil Erosion

UAV technology can quickly conduct multiple flights over farmland, monitoring changes in the land surface. By comparing images from different time points, researchers can assess the degree and speed of soil erosion, taking timely measures for prevention and control. After completing soil and water conservation projects, UAVs can be used to evaluate the effectiveness of the projects [16-18]. For example, by analyzing vegetation recovery and soil erosion changes, it can be determined whether the project has achieved the expected results.

In a soil and water conservation project in California, USA, UAVs were used to monitor vegetation coverage and soil erosion. High-resolution images collected by UAVs allowed project managers to assess the effectiveness of soil and water conservation measures in real-time. A project in Spain utilized UAV technology to monitor agricultural land to evaluate the effectiveness of soil and water conservation measures. UAV technology provided a way to overcome the influence of complex terrain factors, allowing for accurate and efficient data acquisition. Similarly, in land consolidation and soil and water conservation projects in Brazil, UAV technology was widely applied for project monitoring. Data provided by UAVs were used to assess the effectiveness of land consolidation efforts and the implementation of soil and water conservation measures.

4. Innovative Applications of UAV Technology in Irrigation System Design

The design of irrigation systems is a key link in ensuring the effectiveness of agricultural water conservancy facilities. Traditional irrigation system design methods rely on ground surveys and manual calculations, but the introduction of UAV technology has brought revolutionary changes to this process (Figure 1).

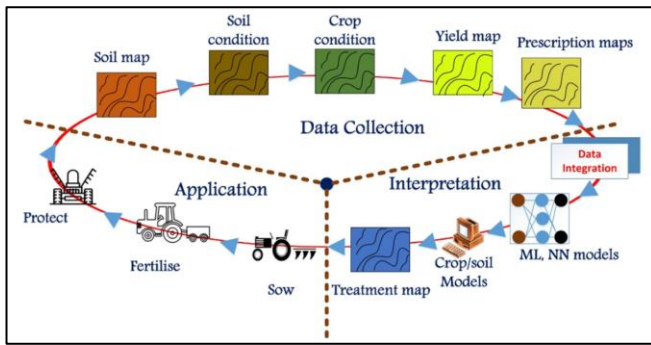


Figure 1. Application of UAV technology in agricultural field [19]

Sensors mounted on UAVs can provide high-resolution data on terrain, soil types, and crop growth conditions. These data are crucial for the design of irrigation systems because they can help designers calculate water flow and distribution more accurately. UAV technology, by providing real-time ground data, makes the design of irrigation systems more precise and efficient. Designers can use UAV data for fine water resource management and allocation, thus optimizing irrigation effects. For example, UAV data can be used to automatically identify and divide irrigation areas, ensuring the rational allocation of water resources. UAVs can quickly detect faults in irrigation systems, such as pipeline leaks or blockages, and carry out timely repairs.

In a project in the Netherlands, UAVs were used to monitor crop growth conditions and soil moisture to design the optimal irrigation scheme. UAV technology played an important role in water resource management in California, helping farmers optimize irrigation systems by monitoring soil moisture and crop water requirements.

These cases show that the application of UAV technology in irrigation system design can significantly improve the efficiency of water resource utilization and crop yield. The application of UAV technology not only improves the quality of irrigation system design but also reduces the waste of water resources.

5. Problems and Deficiencies in Application

Despite the great potential and advantages of UAV technology in the application of agricultural water conservancy facilities, there are also some problems and deficiencies in actual operation. These issues may affect the efficiency and reliability of UAV technology, limiting its widespread application in the field of agricultural water conservancy.

At the technical and operational level, the complexity of UAV data processing and analysis requires operators to have professional software and technical knowledge, increasing the technical threshold of the project. In addition, the limited flight time and battery life of UAVs restrict their ability to continuously monitor large areas of farmland. Adverse weather conditions, such as strong winds and snow, may also limit UAV flights and data collection [20].

Legal and regulatory restrictions are also a challenge in the application of UAV technology. In many countries and regions, UAV flights require strict permits and are subject to airspace restrictions, which may affect the application of UAVs in certain areas [21, 22]. Privacy and data security issues are also important factors to consider in the application of UAV technology, especially in densely populated areas.

In response to these issues and challenges, future

development suggestions include improving the autonomy and durability of UAVs to expand their application range in agricultural water conservancy facilities. At the same time, developing more user-friendly data processing software, simplifying the data analysis process, and reducing the technical threshold. In addition, establishing reasonable laws and regulations to balance technological development and social ethics, ensuring the healthy development of UAV technology. Finally, encouraging interdisciplinary cooperation in the fields of agricultural science, remote sensing technology, and UAV engineering to jointly promote the application of UAV technology in agricultural water conservancy facilities.

6. Conclusion

This paper reviews the application of UAV technology in the construction of agricultural water conservancy facilities, discussing its specific roles in land surveying, soil and water conservation, irrigation system design, and facility maintenance and management. UAV technology, with its high efficiency, precision, and flexibility, provides a new perspective and method for the planning and management of agricultural water conservancy facilities.

By analyzing case studies of UAV technology applications, we find that UAVs not only improve work efficiency and reduce costs but also provide more detailed and accurate data support. These advantages make the application prospects of UAV technology in the field of agricultural water conservancy broad.

However, the application of UAV technology also faces challenges in technology and operation, legal and regulatory restrictions. These issues need to be resolved through technological innovation, the perfection of legal regulations, and interdisciplinary cooperation. Future research should focus on improving the autonomy and durability of UAVs, optimizing data processing procedures, and strengthening legal and regulatory construction.

Overall, UAV technology has shown great potential in the construction of agricultural water conservancy facilities. With continuous technological progress and the perfection of related regulations, UAV technology is expected to play an even more important role in the field of agricultural water resources, contributing to the sustainable development of agricultural production.

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