

# Application Research of UAV-based Remote Sensing Technology in Land Surveying

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**Abstract:** *With the rapid development of UAV (Unmanned Aerial Vehicle) technology, UAV-based remote sensing technology has been widely applied in the field of land surveying. This paper explores the current status and development trends of UAV-based remote sensing technology in land surveying through systematic literature review and empirical research. Firstly, the basic principles and characteristics of UAV remote sensing technology are introduced, followed by an in-depth analysis of its advantages in land surveying, including high resolution, flexibility, cost-effectiveness, etc. Based on this, specific applications of UAV remote sensing technology in land use classification, terrain measurement, environmental monitoring, etc., are studied, and the problems and challenges therein are analyzed. Finally, the future development direction of UAV remote sensing technology in land surveying is prospected, aiming to provide reference for relevant research and practice.*

**Keywords:** *UAV, Remote Sensing Technology, Land Surveying, High Resolution, Environmental Monitoring*

## 1. Introduction

Land surveying is an important basic work for the management and planning of land and resources, which is of great significance for guaranteeing the national economic and social development. Traditional land surveying methods face problems such as long data acquisition cycle, high cost, and low spatial resolution. With the continuous maturity of UAV technology, UAV remote sensing technology has gradually become a research hotspot in the field of land surveying. UAVs have advantages such as high flexibility, relatively low cost, and the ability to acquire high-resolution data, bringing new development opportunities for land surveying. This paper aims to comprehensively explore the current status and trends of UAV remote sensing technology in land surveying through the study of its applications, providing reference and guidance for practical work in the field of land surveying.

## 2. Basics of UAV Remote Sensing Technology

### 2.1 Overview of UAV Remote Sensing Technology

UAV remote sensing technology, as an emerging means of geographic information acquisition, plays an increasingly important role in land surveying. This technology, based on UAV platforms, efficiently collects surface information by carrying various sensors. <sup>[1]</sup> Throughout its evolution, the widespread use of sensors such as multispectral, hyperspectral, and LiDAR enables UAV remote sensing technology to be widely applied in fields such as land resource management, environmental monitoring, and urban planning.

#### 2.1.1 Development History

UAV remote sensing technology originated from military applications, initially used for battlefield reconnaissance and intelligence gathering. However, with technological advancements and cost reductions, this technology has gradually been applied to civilian fields, with land surveying being an important aspect, providing a new pathway for data acquisition. Meanwhile, its application scope has expanded to various sectors including agriculture, forestry, environmental protection, etc., providing efficient and economical geospatial information solutions for different industries.

### **2.1.2 Diversity of Sensors**

The core of UAV remote sensing technology lies in the integration of various sensors to acquire different types of surface information. Among them, multispectral sensors capture information in different bands, providing multispectral data for land use classification, making surface features clearer. Hyperspectral sensors further refine the spectral range, providing more detailed spectral information, facilitating more accurate classification and analysis of land cover. LiDAR sensors emphasize precise 3D terrain information acquisition, achieving highly detailed surface model generation by measuring the reflection time of laser pulses, providing important support for terrain measurement.<sup>[2]</sup>

### **2.1.3 Wide Application Fields**

UAV remote sensing technology finds wide applications in various fields such as land resource management, environmental monitoring, urban planning, etc. In terms of land resource management, high-resolution images captured by UAVs enable land use classification, vegetation monitoring, etc., providing important references for agricultural production and land planning. In environmental monitoring, UAVs can monitor atmospheric pollution, water quality, etc., providing real-time data for environmental protection. In urban planning, UAV remote sensing technology provides high-precision geographic information for urban construction, supporting planning decisions and improving the efficiency of urban management.

### **2.1.4 Evolving Classification Methods**

The classification methods of UAV remote sensing technology are also evolving. Multispectral remote sensing technology captures information in different bands, providing diverse data for land use classification; hyperspectral further refines the spectral range, offering richer spectral information for finer classification. LiDAR, through emphasizing precise 3D terrain information acquisition, provides highly accurate data for terrain measurement.<sup>[3]</sup>

In conclusion, with the development of UAV remote sensing technology, its role in land surveying will become increasingly prominent. Its diverse sensors and evolving classification methods make it an indispensable tool in fields such as land resource management, environmental monitoring, etc., providing new pathways to enhance data collection efficiency and information quality.<sup>[4]</sup>

## **2.2 Advantages of Drones in Land Surveying**

Drones, as advanced tools for geographic information collection, demonstrate numerous advantages in the field of land surveying, making them a highly favored technological means. These advantages are primarily manifested in high-resolution data acquisition, flexibility, expanded coverage range, and cost-effectiveness.

### **2.2.1 High-Resolution Data Acquisition**

Firstly, the high-resolution data acquisition capability of drones provides more detailed and accurate surface information for land surveying. By carrying advanced sensors such as multispectral, hyperspectral, and LiDAR, drones can obtain high-precision images and three-dimensional terrain information of the surface. This provides robust support for fine-grained land use classification, resource management, etc.<sup>[5]</sup> High-resolution data not only enables clear identification of surface features but also helps in capturing and analyzing subtle changes in land features more accurately, thereby enhancing the quality and resolution of land surveying data.<sup>[6]</sup>

### **2.2.2 Flexibility**

Secondly, the flexibility of drones is a significant advantage in land surveying. Drones can easily execute tasks, especially in complex and hard-to-reach terrains such as forests and mountainous areas. Compared to traditional manned aircraft, drones exhibit greater maneuverability and can adapt flexibly to different terrains and weather conditions, thereby expanding the coverage range of land surveying. This flexibility helps improve the comprehensiveness and accuracy of data collection, particularly in-depth research on specific areas.

### **2.2.3 Expanded Coverage Range**

In addition to flexibility, the application of drones has also expanded the coverage range of land surveying. Traditional aircraft may be restricted by complex terrains or hard-to-reach areas, while drones can overcome these obstacles, execute tasks, and obtain the required data. This is particularly significant for studying regions with complex terrains such as high mountains, deep valleys, or forested

areas. The application of drones enables these areas to be included in the scope of land surveying, providing more comprehensive information for scientific research and resource management.<sup>[7]</sup>

#### **2.2.4 Cost-effectiveness**

Finally, drones have a cost advantage compared to traditional manned aircraft. This advantage reduces the overall investment in land surveying and improves the economic efficiency of surveying. Since drones can be operated from the ground, the cost of manned pilots is reduced, and their relatively small size and weight reduce transportation and maintenance costs. This makes drones a more economical and practical tool for land surveying, suitable for land surveying projects of various scales.

In conclusion, drones offer significant advantages in land surveying, providing more efficient and comprehensive solutions for the field through high-resolution data acquisition, flexibility, expanded coverage range, and cost-effectiveness. These characteristics drive the advancement and development of land surveying technology.

### **3. Application of UAV Remote Sensing Technology in Land Use Classification**

#### **3.1 Overview of Land Use Classification**

As one of the core tasks in the field of land surveying, land use classification aims to identify and delineate land surface cover in different areas. Through in-depth research on land use classification, we can gain a more comprehensive understanding of the distribution and utilization of land resources, providing important support for scientifically planning land use.<sup>[8]</sup>

The basic concept of land use classification involves the process of classifying land surface cover and dividing land into different functional areas such as farmland, urban areas, forests, etc. This classification not only facilitates the scientific and rational utilization of land resources but also provides basic data for environmental protection, resource management, etc. Traditional classification methods are mainly based on manual interpretation, but with the rapid development of remote sensing technology, especially the widespread application of UAV remote sensing technology, data-driven land use classification methods have gradually become a research hotspot.

With the development of the social economy and the diversification of land use patterns, traditional classification methods have gradually revealed limitations. Therefore, it becomes particularly important to study land use classification with the help of advanced remote sensing technology, especially UAV remote sensing technology. With its high resolution and high flexibility, UAV remote sensing technology provides new ideas and tools for land use classification.

By carrying multi-spectral, infrared sensors, etc., UAVs can obtain rich information about the land surface, including vegetation cover, land types, etc. These high-resolution data provide more detailed and accurate information for land use classification. Compared with traditional manual interpretation, UAV remote sensing technology greatly improves the accuracy and efficiency of classification.

In the evolution of land use classification methods, data-driven methods have become an important trend. The application of UAV remote sensing data makes it possible to use machine learning, deep learning-based land use classification methods. This method identifies and classifies different land types in images through training algorithms, with high automation and accuracy.

Overall, research on land use classification has made significant progress under the impetus of UAV remote sensing technology. Emerging classification methods provide new avenues for better understanding land use and planning land resources rationally. In the future, with continuous technological innovation, the application of UAV remote sensing technology in the field of land use classification will continue to expand, providing stronger support for sustainable land management and planning.

#### **3.2 Specific Applications of UAV Remote Sensing Technology in Land Use Classification**

##### **3.2.1 Methods**

UAV remote sensing technology primarily utilizes high-resolution optical and infrared sensors, as well as LiDAR technology, to capture rich information of the Earth's surface. Through image processing and feature extraction of this information, automatic identification of different land use types is achieved. Optical sensors provide high-resolution images of the Earth's surface, while infrared

sensors capture physiological characteristics of vegetation. The combination of these sensors effectively distinguishes different land cover types. LiDAR technology, by measuring the reflection time of laser pulses, provides highly detailed terrain information, offering comprehensive data support for land use classification.

### **3.2.2 Algorithms**

In terms of algorithms, deep learning technology has emerged prominently in UAV remote sensing image processing. Particularly, convolutional neural networks (CNNs) and other deep learning models exhibit excellent performance in land use classification, better coping with complex land cover conditions. These algorithms, through learning from large volumes of annotated data, can identify and classify different land use types in images, providing highly accurate tools for land use classification.

### **3.2.3 Practical Cases**

Many studies have successfully applied UAV remote sensing technology to land use classification. By combining high-resolution images with advanced classification algorithms, researchers can accurately determine different land use types such as urban areas, farmland, wetlands, etc. In urban planning, UAV remote sensing technology can rapidly obtain information on urban construction land and green space distribution, providing scientific basis for urban development. In ecological conservation, UAV technology can assist in monitoring wetland boundaries and vegetation cover, providing critical information for wetland ecosystem protection and restoration.

In summary, the application of UAV remote sensing technology in land use classification provides advanced means for the field of land surveying. Through high-resolution image acquisition and advanced deep learning algorithms, UAV remote sensing technology brings higher accuracy and efficiency to land use classification, providing reliable data support for urban planning, ecological conservation, and other fields. In the future, with continuous technological innovation, the application of UAV remote sensing technology in land use classification will further expand, providing stronger technical support for sustainable land management and planning.

## **4. Application of UAV Remote Sensing Technology in Land Use Planning**

### **4.1 Application of Multispectral Sensors**

UAVs equipped with multispectral sensors play a crucial role in land use planning. These sensors possess multispectral sensing capabilities, capturing the spectral reflection of the Earth's surface across different bands. Through the analysis of these multispectral data, highly accurate classification of land cover has been achieved.

Multispectral sensors cover visible and infrared bands, with each band corresponding to different surface features. Through spectral feature analysis, different types of land cover such as farmland, urban areas, and forests can be distinguished. This provides decision-makers in land planning with detailed and comprehensive land use information, enabling them to formulate precise planning and management strategies.

The application of multispectral data allows UAVs to acquire richer information about land features. For example, in farmland classification, multispectral data not only distinguishes different vegetation types but also provides information about vegetation health. This has practical implications for agricultural management, disaster monitoring, and other aspects.

### **4.2 Advancements with Hyperspectral Sensors**

Hyperspectral sensors, as a further breakthrough in UAV remote sensing technology, provide more detailed and precise data for land use planning. Hyperspectral data contain additional bands, enabling finer identification of surface features. The use of hyperspectral data demonstrates unique advantages in land classification.

Hyperspectral sensors can distinguish even subtle spectral differences on the Earth's surface, further enhancing the accuracy of land cover classification. For instance, in urban area classification, hyperspectral data can identify different materials of buildings, such as glass, metal, concrete, providing more precise information for urban planning.

Through the utilization of hyperspectral sensors, UAVs can comprehensively understand and

capture micro-level features of the land surface. This provides decision-makers in land planning with a more comprehensive and accurate land information foundation, enabling them to make more scientifically informed planning and management decisions. The use of hyperspectral data not only improves the accuracy of land cover classification but also provides more sophisticated technical support for future land resource management. This allows managers to accurately understand land reserves and provide scientific basis for planning urban development and municipal construction, as well as classifying industrial zones, commercial areas, office areas, and more.

In land use planning, the combined application of multispectral and hyperspectral sensors provides decision-makers with powerful tools, enabling them to better understand land use conditions and formulate targeted plans. The application of this advanced technology brings a more comprehensive and in-depth information foundation for urban planning and resource management, driving the development of land use planning field.

#### ***4.3 Land Change Monitoring Using Multi-temporal UAV Data***

The monitoring of land changes using multi-temporal UAV data is a crucial application in the field of land surveying. By comparing UAV remote sensing data from different time periods, we can comprehensively understand the spatiotemporal evolution of land, providing strong support for studies in urban planning, agricultural development, and natural resource management.

This monitoring method fully utilizes the advantages of high-resolution imagery data captured by UAVs. Over time, changes occur in land use and cover, such as urban expansion, changes in agricultural land area, and evolution of natural ecosystems. Comparative analysis of multi-temporal UAV data can reveal trends in these changes, providing accurate and reliable data for formulating scientific land planning.

Understanding the spatiotemporal evolution of land is crucial for scientific decision-making in land use planning. Through multi-temporal UAV data, researchers and decision-makers can observe changes in land over different time periods, identifying potential development trends. This comparative analysis provides more accurate basis for future land planning, enabling decision-makers to better predict urban development directions, adjust agricultural strategies, and effectively manage natural resources.

Overall, land change monitoring using multi-temporal UAV data not only provides high-quality spatiotemporal information but also offers strong support for land planning and management decisions. The application of this advanced technology will continue to bring new breakthroughs in the field of land surveying in the future, promoting sustainable urban development and the scientific utilization of land resources.

#### ***4.4 Spatiotemporal Data Analysis in Land Planning***

Spatiotemporal data analysis is a key capability of UAV remote sensing technology in land surveying. By conducting spatiotemporal analysis on multi-temporal UAV data, decision-makers can gain deep insights into the trends of land changes and predict future land use patterns. This capability provides scientific basis for formulating rational land planning and management measures.

Spatiotemporal data analysis enables decision-makers to observe the periodicity and trends of land use changes. For example, it can analyze the speed and direction of urban expansion, understand the patterns of changes in agricultural land use, and the evolution process of natural resources. By understanding these trends, decision-makers can more accurately predict the future development direction of land use and adjust land planning strategies accordingly.

Spatiotemporal data analysis also supports sustainable urban development. By understanding the impact of land changes on the environment, decision-makers can formulate more environmentally friendly and sustainable land planning policies. This helps achieve balanced urban development while ensuring the protection of the natural environment.

In summary, land change monitoring using multi-temporal UAV data and spatiotemporal data analysis provide depth and breadth of information for land planning and management. The continuous development of UAV remote sensing technology will further enhance its role in the field of land surveying, bringing more advanced technical means for future land information acquisition and application. This will contribute to the development of land use planning and urban management towards a more scientific and sustainable direction.

## 5. Conclusion

Through the study of the application of UAV remote sensing technology in land surveying, this paper summarized the advantages and specific applications of UAV remote sensing technology in land surveying. At the same time, it analyzed the potential problems that may be encountered in practical applications. In the future, there is still much room for development of UAV remote sensing technology in the field of land surveying. Further technological research is needed to address practical challenges and promote its widespread application in land surveying.

## References

- [1] Wu, Changcheng. *Application of UAV Remote Sensing Surveying Technology in Surveying and Mapping [J]. Engineering Construction and Design, 2023(23): 142-144.*
- [2] Shi, Shun. *Exploration on the Application of UAV Remote Sensing Technology in Surveying Engineering Measurement [J]. Industrial Science and Technology Innovation, 2023, 5(03): 97-99.*
- [3] Wang, Dongmei. *Application of UAV Remote Sensing Technology in Civil Engineering Project Construction [J]. Journal of Changchun Normal University, 2023, 42(10): 107-111.*
- [4] Liang, Xu. *Research on the Application of UAV Remote Sensing Surveying Technology in Engineering Surveying [J]. Engineering Technology Research, 2022, 7(20): 14-16.*
- [5] Jiang, Xinlin. *Application of UAV Aerial Remote Sensing Technology in Land Survey[J]. Technology and Market, 2023, 30(06): 98-100.*
- [6] Zhang, Songjing. *Research on the Application of UAV Aerial Remote Sensing Technology in Land Surveying Boundary Delineation [J]. China Housing Facilities, 2023(06): 113-115.*
- [7] Wan, Xiang. *Application of UAV Remote Sensing Technology in Rural Land Monitoring[J]. Enterprise Science and Technology Development, 2023(06): 84-86+90.*
- [8] Li, Chaoxu. *Application of UAV Remote Sensing Images in Land Right Confirmation Surveying[J]. Beijing Surveying and Mapping, 2023, 37(05): 751-755.*