Research on Forest Fire Prevention Monitoring and Early Warning Technology Based on UAV Aerial Photography

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Abstract: With the development of science and technology, uav technology plays an important role in many fields, especially in forest fire prevention monitoring and early warning. Based on the UAV aerial photography technology, this study comprehensively uses GIS, remote sensing and pattern recognition to study the forest fire prevention monitoring and early warning technology. Firstly, the forest fire prevention monitoring information acquisition model is established, and the UAV aerial photography and remote sensing images are used to realize the fire source identification and accurately obtain the fire source location. Secondly, according to the characteristics of fire diffusion and the development law of forest fire, the prediction model of forest fire diffusion is established to realize the fire prediction and early warning. Thirdly, the real-time monitoring data received is quickly processed and analyzed, and the optimal rescue route of the ground rescue team is given in time. At the same time, through the analysis of the historical fire source data, the forest fire risk risk assessment model is formed, to provide scientific decision support for the forest management department. The experimental results show that the forest fire prevention monitoring and early warning system combined with UAV aerial photography has achieved remarkable results in fire source identification, fire diffusion prediction and risk assessment, which provides an efficient technical method for forest fire prevention, and is expected to greatly improve the ability of forest fire prevention and fire rescue in China.

Keywords: UAV Aerial Photography; Forest Fire Prevention; Monitoring Early Warning; Fire Source Identification; Risk Assessment

1. Introduction

As technology evolves, drones are becoming increasingly useful in preventing forest fires. In the past, people used manual fire monitoring, the effect is not very good. Now, researchers use drones to improve forest fire monitoring and early warning capabilities. Through drones, geographic information system and other technologies, we can accurately find the location of the fire source, predict the spread of the fire, and give rescue routes. Such methods have achieved remarkable results in experiments, helping to better protect forest resources and the safety of human life and property.

2. Establishment of UAV Aerial Photography and Forest Fire Prevention Monitoring and Early Warning System

The application of uav aerial photography technology in forest fire prevention has wide prospects and significant advantages, and has become an important means of modern forest fire prevention monitoring and early warning[1]. Its application is mainly reflected in fire source monitoring, fire assessment and rescue dispatch.

2.1 Fire Source Monitoring

UAV aerial photography technology can quickly and accurately obtain real-time images of forest fires and help find fire sources in time. Traditional ground monitoring means are limited by terrain and vegetation, so it is often difficult to find fire sources in time[2]. The UAV has the characteristics of strong maneuverability and controllable flight height, which can cover a wide range of areas and obtain high-resolution images. With infrared sensors and high-resolution cameras, the drone can capture fire source images under different lighting conditions, and identify fire sources through image processing technology. This technology not only improves the efficiency of fire source detection, but also provides the precise location of the fire source, providing an important decision-making basis for subsequent fire extinguishing operations.

2.2 Fire Assessment

In fire assessment, an aerial drone technology has also played an irreplaceable role. The UAV can continuously monitor the dynamics of the fire site, and provide detailed data support for the fire assessment by obtaining the fire spread in real time. Using aerial images, combined with geographic information system (GIS) and remote sensing technology, 3 d models of the fire site can be generated to accurately assess the fire site. This process can not only help determine the speed and direction of the fire, but also identify high-risk areas and the potential path of the fire. Through the fire assessment, it can provide scientific decision basis for the command center, formulate effective fire extinguishing strategies, and reduce the loss caused by fire.

2.3 Rescue Dispatch

Aerial photography technology also plays an important role in rescue dispatch[3]. When a fire occurs, ground rescue teams often need to quickly enter the fire site for fire fighting and rescue operations. The complex terrain and thick smoke often hinder the sight of rescue teams, increasing the difficulty of rescue. Drones can fly at high altitude, avoid ground obstacles, obtain clear images of fire sites, and provide real-time fire site information for rescue teams. By analyzing the images sent back by the UAV, the best rescue route can be quickly determined and the allocation of rescue resources can be optimized. Drones can also carry relief supplies and place fire extinguishing agents or supplies in areas inaccessible to improve rescue efficiency.

3. Technology Integration and Optimization

The application of UAV aerial photography technology in forest fire prevention not only depends on the advancement of hardware equipment, but also needs the support of software system. By combining UAV aerial data with GIS, remote sensing and pattern recognition technologies, efficient data processing and analysis can be realized. The real-time image data acquired by the UAV is wirelessly transmitted to the ground control center. After the image processing algorithm for fire source identification and fire evaluation, and then combined with GIS data for spatial analysis, a detailed fire situation map is finally formed. In this process, the application of pattern recognition technology is particularly critical. By training the deep learning model, the accuracy of fire source recognition and fire assessment can be significantly improved[4].

3.1 Outlook

With the continuous development of UAV technology, its application prospect in forest fire prevention will be broader. In the future, with the improvement of uav endurance ability and the progress of sensor technology, the application of uav in forest fire monitoring and early warning will be more efficient. Especially with the support of big data and artificial intelligence technology, the UAV can realize a more intelligent fire monitoring and early warning system. Through the analysis of historical fire data and the construction of fire risk assessment model, it can realize the early warning of fire occurrence and provide more scientific technical support for forest fire prevention.

The application of uav aerial photography technology in forest fire prevention is of great significance, and it has played a significant role in fire source monitoring, fire assessment and rescue dispatching. With the continuous progress of technology, UAV will play a more important role in forest fire prevention, providing strong technical support for the protection of forest resources and ecological environment.

3.2 The Role of GIS Remote Sensing and Pattern Recognition in Forest Fire Prevention

GIS remote sensing and pattern recognition technology play a key role in the establishment of forest fire prevention monitoring and early warning system. These technologies not only improve the accuracy of fire source identification, but also enhance the ability of forest fire spread prediction and risk assessment.

GIS (Geographic Information System) technology is used to integrate and analyze multisource spatial data in forest fire prevention. Through GIS system, the information of forest resources distribution, landform, meteorological conditions and other information can be comprehensively analyzed. This information is essential for understanding the potential risk areas of the fire and the possible diffusion path of the fire[5]. GIS also provides dynamic updates and visualization of spatial data,

allowing monitors to track fires in real time and respond quickly.

Remote sensing technology uses high-resolution images collected by satellites and drones to record and analyze the surface conditions in detail. Through high-altitude photography and infrared imaging, remote sensing technology can quickly and extensively capture surface temperature anomalies and identify potential fire points. It not only provides the precise location of the fire source, but also can monitor the impact range of the fire and assess the intensity of the fire. Combined with multi-frequency band and multi-phase remote sensing data, the environmental changes before and after the fire can be continuously tracked, providing a solid technical foundation for the dynamic detection of fire.

Pattern recognition techniques use machine learning and deep learning algorithms to automatically identify fires and predict the spread trend of fires[6]. Using a large amount of training data, the pattern recognition algorithm can extract the fire source characteristics from the complex remote sensing images and establish the fire transmission model. Pattern recognition not only improves the speed and accuracy of fire source recognition, but also can predict the spread path and development trend of the fire, providing forward-looking early warning information for emergency rescue. The automated processing capacity of this technology greatly reduces the burden of manual analysis and improves the response efficiency of the monitoring system.

The combination of GIS remote sensing and pattern recognition technology makes the forest fire prevention monitoring and early warning system have the ability of efficient information collection, analysis and prediction[7]. The application of these technologies provides a solid technical support for timely and accurate monitoring and response to forest fires, and provides scientific and refined decision support for forest fire prevention and rescue operations.

4. Monitoring Data Processing, Risk Assessment and Decision Support

4.1 Rapid Processing of Monitoring Data and Optimal Rescue Route Planning

The rapid processing of monitoring data and the optimal rescue route planning are the key links in the forest fire prevention monitoring and early warning system. The image and sensor data collected by the UAV need to be processed quickly after the fire occurs, so as to analyze the fire source location, the development state and the impact range of the fire in time, so as to provide scientific decision support for ground rescue.

The rapid processing of monitoring data mainly includes three links: data preprocessing, feature extraction and information fusion. In the data preprocessing stage, image denoising, geometric correction and spectral correction are performed according to the diversity of UAV image and sensor data and their noise interference. This process ensures that the acquired images are of higher quality and accuracy, providing a reliable basis for subsequent analysis. In the process of feature extraction, the automatic identification of fire sources, including abnormal temperature change, the characteristics of smoke and flame. The key to this process is the accurate capture of fire characteristics and to effectively distinguish the interference factors in the environment.

Information fusion technology integrates the data from different sensors to form a comprehensive judgment. This link realizes the complementarity of multi-source information, and improves the accuracy of the location of fire source location.

In the process of rapid fire response, the optimal rescue route planning is also crucial. Based on real-time monitoring data, geographic information system (GIS) technology can enable in-depth analysis of terrain, meteorological conditions and already recorded rescue routes. This process involves the use of a network analysis algorithm to optimize the rescue path to reach the fire source location in the shortest time. The variables included in the model include the road conditions, the running speed of the vehicles, and the environmental delay factors, so as to construct a multi-dimensional decision model.

Therefore, in the process of optimizing the rescue route, advanced algorithms such as genetic algorithm, Dijkstra algorithm or A * algorithm can be used to ensure that the planned route is not only fast but also environmentally adaptable[8]. For example, considering the terrain obstacles, the algorithm is able to autonomously choose the optimal path to avoid the obstacles. This process requires the system to be monitored and updated in real time, and to flexibly adjust rescue routes when new fire

information or road obstacles occur.

By combining the data processing process with the rescue route planning, we strive to achieve an efficient emergency response in the early stage of the fire. It is not only necessary to ensure the rapid identification of fire sources, but also to provide clear and feasible action steps for the rescue teams to improve the overall effectiveness of the rescue operation[9]. The accuracy of data processing and the intelligence of rescue route planning determine the response speed and rescue ability of the forest fire prevention system, and finally ensure that the fire can minimize the loss and protect the ecological environment and people's life safety.

The proposed monitoring data processing and optimal rescue route planning methods provide ideas and practical basis for the development of forest fire monitoring and early warning system. It is expected to continuous optimization and improvement in the practical application in the future to cope with the increasingly severe challenges of forest fire prevention and control.

4.2 Methods and Methods to Provide Scientific Decision Support for Forest Management Departments

In forest fire prevention monitoring and early warning, in order to provide scientific decision support for forest management departments, comprehensively using a variety of technical means and scientific models, flexible and accurate optimization of the allocation of resources and action strategy is the key. Based on uav aerial photography technology, geographic information system (GIS), remote sensing and pattern recognition and other technologies, combined with monitoring data processing and risk assessment, an effective decision support system is formed.

Accurately identifying and locating fire sources is the key first step[10]. Through remote sensing technology, it can not only monitor the fire in the air, determine the direction and rate of the fire development, but also extract the factors affecting the fire, including terrain, vegetation type, meteorological conditions, etc. Combined with the comprehensive processing of multi-source data, real-time dynamic fire monitoring is formed to provide data support for decision-making.

On the basis of fire monitoring, the fire diffusion prediction model can simulate the development trend of fire under different conditions and predict the path and speed of fire spread. The model introduces various parameters affecting the fire diffusion, such as wind power, humidity, temperature, vegetation density, etc., to improve the accuracy and reliability of the model through repeated verification of multiple simulations and historical data. Once the fire source is identified, the potential spread area and time window of the fire line can be predicted through the fire spread prediction model, and the defense line can be deployed in advance to minimize the disaster loss.

For real-time data obtained from UAVs and other monitoring devices, efficient data processing algorithms are used for rapid analysis.dynamically adjust the configuration of ground personnel and equipment according to the real-time change of fire. Implement intelligent rescue route planning, optimize resources and time, and ensure that rescue teams can reach the core area of the fire site the most quickly and safely, and implement effective rescue. The planning of rescue routes relies on the geographic information system (GIS), combined with the real-time data of the fire diffusion model, to provide accurate path guidance for the rescue team.

Through the analysis of historical fire sources data, the formation of fire risk assessment model is also one of the core contents of decision support. Based on the long-term accumulated fire data, the high-risk areas and time period of fire occurrence were extracted, and combined with the current monitoring data for comprehensive evaluation. The risk assessment model can identify and sequence the leading factors affecting the fire risk area through statistical analysis and machine learning methods.

The construction of decision support system not only depends on the establishment of models and the application of technical means, but also needs a set of optimized feedback mechanism. The system feeds back the monitoring data, prediction results and comprehensive evaluation reports to the forest management department in real time to assist the leadership to make effective decisions quickly. The decision support system should be highly interactive and scalable, and can flexibly adapt to different fire scenarios, and continuously optimize and upgrade in the accumulation of experience.

The forest fire prevention monitoring and early

warning system based on uav aerial photography technology has formed a complete monitoring, prediction, evaluation and decision support system through the integrated application of various technical means. From real-time monitoring to risk prediction, from data analysis to intelligent decision-making, it provides a comprehensive technical support for the forest management departments, and effectively improves the ability of forest fire prevention and fire rescue.

5. Conclusion

This study is based on UAV aerial photography technology, through a variety of high-tech means, including GIS, remote sensing technology and pattern recognition, to achieve accurate identification of fire sources, effective prediction of fire spread, and scientific assessment of fire risk, providing a new and efficient method for forest fire prevention. Especially in the study of forest fire monitoring information acquisition model, forest fire diffusion prediction model and forest fire risk assessment model, through the rapid processing of real-time data analysis, can provide the optimal rescue team for ground rescue route, and through the analysis of historical fire data, can also provide scientific decision support. Further studies can improve and optimize the model for various special cases to improve the accuracy and practicability of the system, so as to play a greater role in practical application. At the same time, we can also explore the application of this technology to other fields, such as wildlife protection, water source protection and crop disease and insect pest monitoring, to promote the wide use of advanced technologies such as drones in these fields.

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