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Enhancing Forest Fire Detection Accuracy of UAV Remote Sensing Technoloy Using Retinex Theory Algorithm

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ABSTRACT

This paper focuses on the application of UAV remote sensing technology in forest fire monitoring based on Retinex theory algorithm. This paper expounds the principle and development of Retinex theory algorithm, and introduces the principle and advantages of UAV remote sensing technology. The application status of UAV remote sensing technology in forest fire monitoring is analyzed, and the problem of image definition reduction caused by illumination and smoke is pointed out. This paper discusses the role of Retinex theory algorithm in improving image quality, and enumerates practical cases to analyze its effect and verify the practicability and feasibility of the algorithm in forest fire monitoring, in order to provide more accurate and efficient technical support for forest fire monitoring.

KEYWORDS

Retinex theory algorithm; UAV remote sensing technology; Forest fire monitoring; Image enhancement

1. INTRODUCTION

The application of UAV remote sensing technology based on Retinex theory algorithm in forest fire monitoring is an important direction of technological innovation in the field of forest disaster prevention and extinguishing [1]. With the influence of global climate change and human activities, forest fires occur frequently and become more and more serious. Traditional monitoring methods are often caused by uncertain factors such as terrain, environment and manpower, and it is difficult to realize accurate identification and rapid treatment of fires. UAV remote sensing technology has gradually become the core tool of forest fire monitoring by virtue of its strong flexibility, wide coverage and real-time data transmission [2]. However, the images obtained by UAV in complex environment, such as haze, uneven illumination, smoke interference and so on, often have problems such as color vector truth and low contrast, which directly affect the accuracy of fire recognition. Under this background, Retinex theory algorithm provides key technical support for UAV image quality by enhancing image color balance and detail restoration ability.

2. RETINEX THEORY ALGORITHM PRINCIPLE AND DEVELOPMENT

2.1. Fundamental

Retinex theory is an image enhancement algorithm which simulates the color constancy of human visual system. Its core idea is to eliminate the influence of uneven illumination by separating the

illumination component and the object reflection component in the image, and restore the object's own characteristics and color details [3].

Retinex algorithms can be implemented in a variety of ways, including single-scale Retinex (SSR), multi-scale Retinex(MSR), and MSR with Color Restoration(MSRCR) [4]. Single-scale Retinex is mainly used to solve simple illumination phenomenon but easy to produce halo effect; multi-scale Retinex mainly balances global illumination and local details;MSR with Color Restoration solves color vector problem by introducing color restoration factor.

The key technology of Retinex theory algorithm lies in the effect of Gaussian filter, which extracts low-frequency information of illumination through Gaussian kernel with different standard deviation, retains overall illumination to a great extent, and retains local contrast in a small range.

2.2. Development History

Since the Retinex theory was proposed, researchers have developed a theoretical algorithm system modeled after the human visual system. Single Scale Retinex algorithm (SSR) is the most basic algorithm. It obtains the illumination image by Gaussian filtering the original image, and then compares and separates the illumination image from the original image to obtain the reflection image. Multi-scale weighted average Retinex algorithm (MSR) is based on SSR and uses several different scale parameters, and then weights the final results, which can compress the dynamic range of the image while ensuring the authenticity of the image. Multi-scale Retinex algorithm with color recovery (MSRCR) is based on MSR and adds color recovery function to further improve the color quality of images.

3. PRINCIPLES AND ADVANTAGES OF UAV REMOTE SENSING TECHNOLOGY

3.1. Technical Principle

UAV remote sensing technology is an advanced technology combining UAV platform and remote sensing sensor. Its principle mainly involves UAV platform, remote sensing sensor, data transmission and processing.

UAV platform can follow preset course and flight altitude. Through the flight control system, the UAV can accurately control the flight attitude, speed and position to ensure the stability and accuracy of remote sensing data acquisition. Remote sensing sensors acquire images of objects by collecting radiation information in visible and near-infrared bands of electromagnetic spectrum reflected or emitted by objects. Different objects have different reflection and absorption characteristics for different wavelengths of light. Data transmission means that the data collected by the remote sensing sensor is transmitted to the ground control station in real time through wireless communication link during the flight of the UAV, or stored in the storage device on the UAV, and extracted and processed after the flight.

3.2. Technological Superiority

Compared with traditional forest fire monitoring methods, UAV remote sensing technology has many advantages. For example, UAV can be deployed rapidly according to mission requirements, can fly at low altitude in complex terrain and areas, obtain high-resolution images, and is not limited by ground traffic and geographical conditions, and can adjust flight route and altitude at any time; It can carry a variety of sensors, such as optical cameras, infrared cameras, etc., which can obtain high-resolution images when flying at low altitude, clearly present details of ground objects, and meet the requirements of high-precision remote sensing monitoring; Data can be transmitted to the ground

control station in real time, so that operators can control the status of the monitoring area in time, and quickly adjust the task plan when problems are found to obtain the required information. At the same time, UAV remote sensing technology also has the advantages of low cost and low safety risk.

4. CURRENT APPLICATIONS OF UNMANNED AERIAL VEHICLE REMOTE SENSING TECHNOLOGY IN FOREST FIRE MONITORING

At present, UAV remote sensing technology is widely used in forest fire monitoring and plays an important role. UAVs can be equipped with visible light cameras, infrared cameras, multi-spectral cameras and lidar and other sensors to monitor forest areas in real time to detect fire hazards and disasters in time. Through preprocessing, feature extraction and classification of collected data, key information such as fire location, combustion area and spread speed can be extracted. On the contrary, in practical applications, UAV remote sensing technology still faces many challenges. For example, a large amount of smoke is often generated at the scene of a fire, which interferes with the flight and image acquisition of drones, resulting in reduced image clarity, etc.

5. APPLICATION OF RETINEX THEORY ALGORITHM IN FOREST FIRE MONITORING BASED ON UAV REMOTE SENSING

5.1. Image Enhancement

Retinex theory algorithm plays an important role in image enhancement in UAV remote sensing forest fire monitoring. Because the UAV will be affected by lighting, smoke and other factors when acquiring images, the contrast of images will be reduced and the details will be blurred. Retinex algorithm can enhance the reflection component of image by removing the influence of illumination component, so as to improve the contrast and sharpness of image. By enhancing the image of fire scene, the information of fire source and fire spreading direction can be displayed more clearly, which plays an important role in finding fire hidden danger and accurately judging fire development trend [5].

5.2. Fire Identification and Monitoring

Retinex theory algorithm has important applications in fire recognition and monitoring of UAV remote sensing forest fire monitoring. Retinex algorithm can effectively suppress the influence of uneven illumination [6]. By processing the remote sensing images acquired by UAV, the boundary of fire area is clearer, which is conducive to fire identification. After Retinex algorithm processing, the red characteristics of the flame will be more prominent, which is convenient to use these characteristics to identify and locate the fire and eliminate the interference of other color objects. At the same time, combined with the real-time flight of UAV, Retinex algorithm can process remote sensing images in real time during the flight of UAV, quickly discover potential fire points, grasp the development of fire in time, and provide favorable help for fire fighting.

6. ACTUAL CASE ANALYSIS

6.1. Example Background

Forests are vital in ecosystems to conserve water and soil and maintain the balance of species diversity. However, forest fires occur frequently. Affected by climate warming and other factors, their frequency and scale continue to increase. Nowadays, traditional forest fire monitoring methods cannot meet the current environment. In order to grasp the fire situation in time, UAV equipped with visible light camera and infrared thermal imaging camera is used to monitor the fire scene. However,

due to the large smoke and uneven illumination, the image quality is low, which brings difficulties to fire detection.

6.2. Application Process

In order to improve the image quality, Retinex theory algorithm is used to enhance the image. Firstly, according to Retinex theory, the image is decomposed into reflection component and illumination component. By suppressing the influence of illumination component, illumination compensation is performed on the image to eliminate the image brightness difference caused by uneven illumination, so that the fire area and background in the forest scene are more prominent in brightness. Then, adjust the color information of the image, enhance the contrast between the fire area and the surrounding environment in color, highlight the red characteristics of the flame, and suppress the interference of other colors to make the fire area more conspicuous. Finally, the high frequency detail information of the image is enhanced [7].

6.3. Effect Appraisal

After Retinex algorithm processing, the remote sensing image quality is significantly improved, making the forest background more uniform, and the color and texture of the fire area more prominent, so that the monitoring personnel can more clearly identify the fire position and range. At the same time, by enhancing the contrast between fire and background, fire features can be extracted more accurately, and misjudgment and missed judgment can be reduced.

7. CONCLUSION AND PROSPECT

7.1. Conclusion

Retinex theory algorithm effectively solves the problems of uneven illumination and shadow occlusion in UAV remote sensing images. By removing illumination interference, the contrast between forest fire area and background environment is significantly improved, and key features such as flame and smoke are more prominent. In practical application, the fire monitoring system based on Retinex theory algorithm and UAV remote sensing technology realizes real-time monitoring of forest fire, greatly shortens the fire response time, and provides favorable support for forest fire control decision-making and processing.

7.2. Outlook

Retinex algorithm can be further studied and improved in the future, such as combining deep learning algorithm to optimize parameters to adapt to more complex scenes and different resolutions of UAV remote sensing images. At the same time, explore and research other new image enhancement algorithms to continuously improve image quality and fire feature extraction effect to make the algorithm and monitoring system more perfect, and provide more scientific and effective technical support for forest fire prevention and suppression.

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