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Analysis on the Application of Image Processing in UAV and Autopilot

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Abstract: The purpose of this paper is to analyze the application of image processing in UAV and autopilot. UAV and autonomous driving technology are important development directions in the field of intelligent transportation and agricultural production, and image processing, as one of the core technologies supporting its perception and decision-making, plays a vital role. For UAV, in agricultural plant protection and natural disaster monitoring, the rapid evaluation and identification of farmland growth status and disaster situation can be realized through image processing technology, which provides important support for crop production and rescue work. For the automatic driving system, image processing technology can detect and track the road environment, traffic signs and pedestrians, and improve the driving safety and comfort of vehicles. However, image processing technology also faces some challenges in application, such as complex environmental conditions and real-time requirements. In the future, through the improvement of sensor technology, algorithm optimization and data sharing, the application of image processing technology in UAV and autonomous driving will be continuously improved, bringing more innovation and development opportunities for intelligent transportation and agricultural production.

Keywords: UAV; Image Processing; Autopilot.

1. Introduction

With the continuous development of science and technology, UAV and autonomous driving technology have become the focus of attention in today's society. The wide application of UAV covers military reconnaissance, disaster monitoring, agricultural plant protection and many other fields [1-3]; Autopilot technology is regarded as an important development direction of transportation in the future, which will bring unprecedented convenience and safety to people's travel. In these two fields, image processing technology plays a vital role.

Image processing technology is an important branch of digital image processing, which aims to obtain the information contained in the image and make corresponding decisions through a series of operations such as image acquisition, processing, analysis and recognition [4]. In UAV and autonomous driving, image processing technology can not only improve the perception ability of the system, but also realize intelligent decision-making, thus achieving more efficient, safe and intelligent operation [5].

The purpose of this paper is to deeply discuss and analyze the application of image processing technology in UAV and autopilot. Firstly, the basic principles and common methods of image processing technology will be introduced, including image acquisition and sensor technology, image preprocessing, feature extraction and description, target detection and recognition, etc. Then, it will focus on the specific application of image processing technology in UAV and autonomous driving, and discuss its role and effect in visual navigation, target recognition and intelligent decision-making. Finally, the importance and development prospect of image processing technology in UAV and autonomous driving field will be demonstrated through case study and future prospect. Through the research of this paper, we will fully understand the application of image processing technology in UAV and autopilot, and provide theoretical support and technical guidance for further promoting the development of these two fields.

2. Overview of Image Processing Technology

Image processing technology is an important part of digital image processing, which covers many aspects such as image acquisition, transmission, storage, processing, analysis and recognition. In the field of UAV and autopilot, image processing technology is widely and deeply applied, which provides important support for the perception, decision-making and execution of the system [6-7].

Image acquisition is the first step of image processing, and the key lies in selecting appropriate sensors and acquisition equipment. In UAV and autopilot, common image sensors include camera, infrared sensor, radar and lidar. These sensors can acquire image data with different bands and resolutions, and provide rich information sources for subsequent processing. Image preprocessing is to improve image quality, reduce noise, enhance image features and accurately correct image geometry [8]. Common image preprocessing operations include image filtering, enhancement, geometric correction, color space conversion, etc. These operations can make the image clearer and more accurate, which is beneficial to subsequent feature extraction and target recognition.

Feature extraction is a key step in image processing, which involves extracting effective information that can describe the image content from the image. Common features include edges, corners, textures, etc. These features can be used to describe the structure and shape in the image, providing a basis for subsequent target detection and recognition [9]. Target detection and recognition is an important task in image processing, which involves detecting interested targets from images and classifying them. In UAV and autonomous driving,

common targets include pedestrians, vehicles, traffic signs, etc. Through target detection and recognition, the system can realize the perception and understanding of the surrounding environment.

Image classification is to divide images into different categories, while semantic segmentation is to assign each pixel in an image to a corresponding semantic category. These two tasks are of great significance in UAV and autopilot, which can help the system accurately understand and identify the objects and scenes in the image and provide support for intelligent decision-making.

In recent years, deep learning technology has achieved great success in the field of image processing and has become one of the important methods of image processing. Through the deep learning model, end-to-end image processing and recognition can be realized, which greatly improves the performance and robustness of the system. In UAV and autonomous driving, deep learning technology has been widely used in target detection, target tracking, semantic segmentation and other tasks, and has achieved remarkable results.

3. Application of Image Processing in UAV and Autopilot

3.1. Application of Image Processing in UAV

The application field of UAV is increasingly extensive, and image processing technology plays a vital role in it. By processing and analyzing the image data collected by UAV, the functions of flight path planning, target detection and recognition, environment perception and obstacle avoidance can be realized, thus improving the flight safety and task execution efficiency of UAV.

In the flight process of UAV, visual navigation is the key to ensure its safe flight. Through image processing technology, real-time monitoring and identification of the surrounding environment of UAV can be realized, obstacles, terrain and buildings can be identified, and the flight path can be adjusted according to the identification results to avoid collisions and accidents [10]. In addition, the image data can be used for 3D modeling and map construction to provide more accurate navigation information.

UAV often needs to track and identify specific targets when performing tasks, such as vehicles, people or animals. Through image processing technology, real-time tracking and identification of the target can be realized, and information such as the position, speed and state of the target can be provided, so that more accurate and efficient task execution can be realized. This technology has important application value in military reconnaissance, disaster monitoring and search and rescue.

Image processing technology can also realize real-time processing and feedback of image data during task execution. By analyzing and identifying the image data, we can find the abnormal situation in the task execution in time, and take corresponding measures to adjust and deal with it, so as to ensure the smooth completion of the task. In addition, real-time environmental information can be provided through image data, which can provide reference for decision-making and improve the efficiency and accuracy of task execution.

3.2. Application of Image Processing in Automatic Driving

Automatic driving technology depends on the perception and understanding of the surrounding environment of the vehicle, and image processing technology is one of the important means to achieve this goal. By processing and analyzing the image data collected by the vehicle-mounted camera, we can recognize and understand the road conditions, traffic signs, pedestrians and vehicles, so as to realize the intelligent driving and safe driving of vehicles.

Self-driving vehicles get the image data of the surrounding environment through the on-board camera, and then use image processing technology to process and analyze these data to realize the perception and understanding of the environment. By identifying road markings, traffic lights, traffic signs and other information, vehicles can accurately grasp the driving direction and traffic rules to ensure safe driving. Traffic sign is an important sign of road traffic management, which is very important for the safe driving of self-driving vehicles. Through image processing technology, real-time detection and recognition of traffic signs can be realized, including speed limit signs, prohibition signs, warning signs and so on. After the traffic signs are recognized, the vehicle can adjust its speed and direction according to the signs to ensure that it conforms to the traffic rules. Lane line is an important reference line to guide vehicle driving, and vehicle tracking is an important means to keep the vehicle driving in the lane. Through image processing technology, real-time detection and tracking of lane lines can be realized, and vehicles can keep running stably in the lane. At the same time, it can also track and identify the surrounding vehicles and avoid collisions and traffic accidents.

Image processing technology can also provide important support for intelligent decision-making of autonomous vehicles. By analyzing and identifying the image data, vehicles can find out the changes of road conditions and traffic conditions in time, and take corresponding measures to adjust and deal with them to ensure driving safety. In addition, the image data can also provide reference for vehicle path planning and behavior decision-making, and improve the accuracy and efficiency of driving.

4. Case Study

This section will introduce several typical cases to show the concrete application and effect of image processing technology in UAV and autopilot.

UAV has become an important plant protection tool in agricultural production. By loading high-resolution cameras and multispectral sensors, UAV can obtain image data of farmland, and monitor and identify crop growth and diseases and insect pests through image processing technology. Taking an agricultural company in the United States as an example, they used UAV and image processing technology to realize rapid inspection and accurate application of pesticides to a large area of farmland, which effectively improved the yield and quality of crops (Figure 1).

Tesla's Autopilot system Autopilot is one of the most advanced autopilot technologies on the market. Autopilot uses sensors such as on-board camera and radar to obtain images and data of the surrounding environment of the vehicle, and then carries out image processing and pattern recognition through deep learning algorithm to realize the detection and tracking of lane lines, other vehicles and pedestrians (Figure 2). By training and optimizing the actual driving data of millions of kilometers, Autopilot can realize automatic driving on the expressway, and greatly improve the safety and comfort of driving.

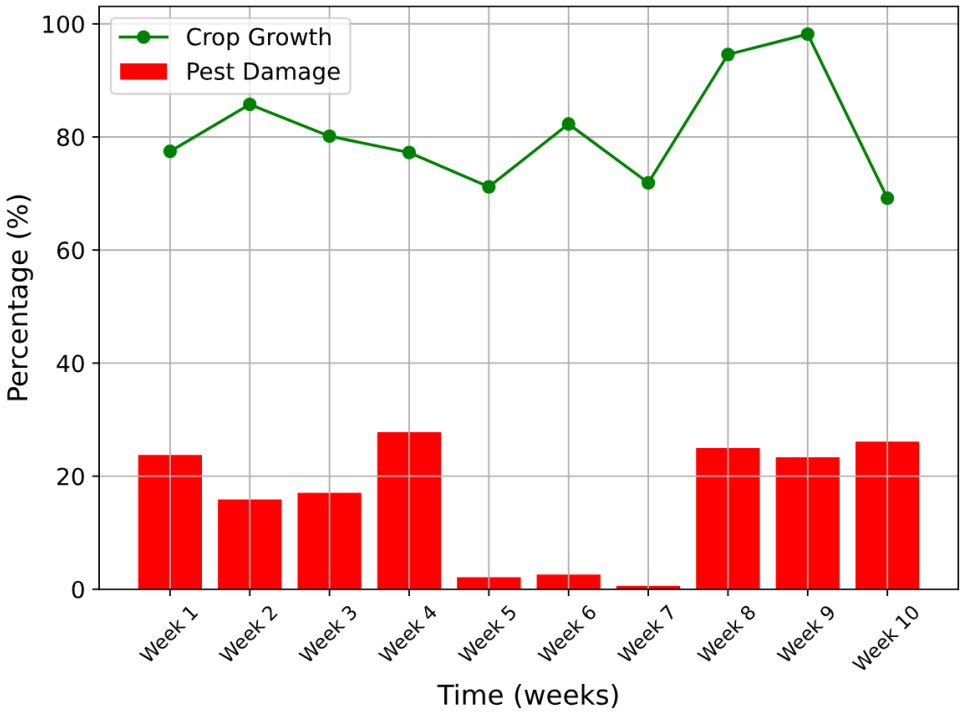

Figure 1. Crop growth and pest monitoring

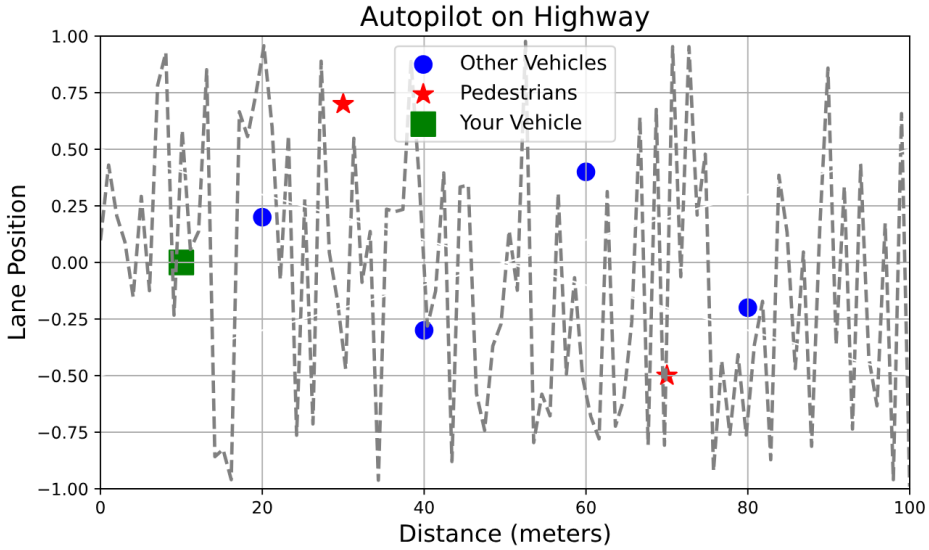

Figure 2. Expressway automatic driving

UAV plays an important role in natural disaster monitoring and rescue. For example, after natural disasters such as earthquake, flood and forest fire, UAV can obtain the image data of the affected area through aerial photography and infrared photography, and realize the rapid assessment and identification of the disaster situation through image processing technology. Taking a mountainous area in a province of China as an example, the UAV team used image processing technology to monitor and evaluate the landslide disaster, which provided an important reference for the rescue and reconstruction work in the disaster area (Figure 3).

In the field of UAV and autonomous driving, the application of image processing technology provides important support for system perception and decision-making, but it also faces some challenges and limitations. Through the previous case study, we can see that image processing technology plays an important role in UAV and autonomous driving, which provides rich information for the perception and understanding of the system. In the field of UAV, image processing technology can realize the monitoring and identification of farmland, natural disasters and other scenes, and provide important support for agricultural production and rescue work; In the field of automatic driving, image processing technology can realize the detection and tracking of road environment, traffic signs and pedestrians, and improve the driving safety and comfort of vehicles.

However, the application of image processing technology in UAV and autopilot also faces some challenges and limitations. For example, in the field of UAV, complex environment and weather conditions may affect the image quality and recognition effect; In the field of autonomous driving, real-time and accuracy are required, and problems such as sensor error and complexity of image processing algorithm need to be overcome.

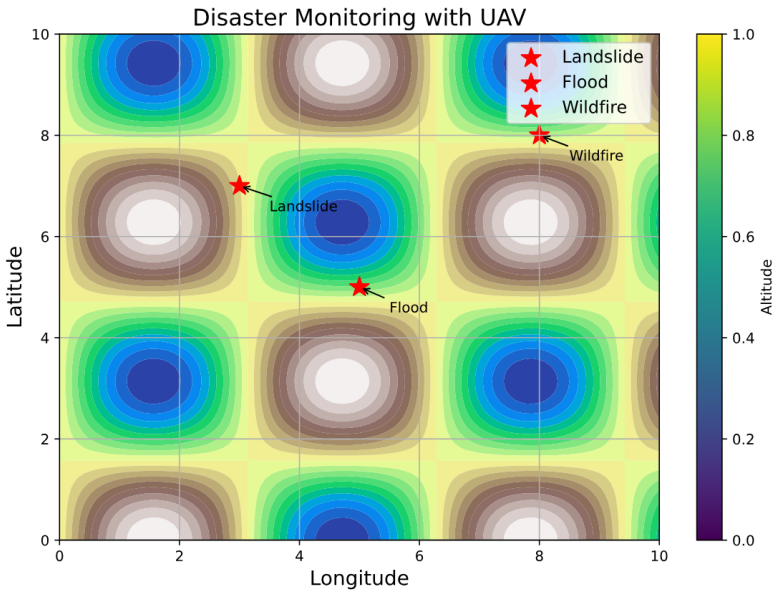

Figure 3. UAV disaster monitoring

In the future, we can further improve the application effect of image processing technology in UAV and autopilot through the following aspects:

Improvement of sensor technology. Develop more advanced sensor technology to improve the resolution and accuracy of images to adapt to complex environmental conditions and scene requirements.

Algorithm optimization and deep learning. Further optimize the image processing algorithm, combined with deep learning and other technologies, improve the accuracy and robustness of target detection and recognition, and realize more intelligent perception and decision-making.

Data sharing and collaboration. Strengthen the data sharing and cooperation mechanism, establish a more perfect data set and labeling system, and provide more abundant and reliable data support for the research and application of image processing technology.

5. Conclusion

To sum up, the image processing technology in the field of UAV and autonomous driving plays an important role, which provides important support for the perception and decision-making of the system, but it also faces some challenges and limitations. First of all, in the field of UAV, image processing technology can realize the monitoring and identification of farmland, natural disasters and other scenes, and provide important support for agricultural production and rescue work. In the field of automatic driving, image processing technology can realize the detection and tracking of road environment, traffic signs and pedestrians, and improve the driving safety and comfort of vehicles. Secondly, the application of image processing technology in UAV and autopilot also faces some challenges and limitations. For example, complex environmental and weather conditions may affect the image quality and recognition effect; Real-time and accuracy are required, and problems such as sensor error and algorithm complexity need to be overcome. Finally, in the future, the application effect of image processing technology in UAV and autopilot can be further improved through continuous efforts in sensor technology improvement, algorithm optimization and deep learning. At the same time, strengthen the data sharing and cooperation mechanism, establish a more perfect data set and labeling system, and provide more abundant and reliable data support for the research and application of image processing technology.

References

[1] Liu, D., Pu, G. , & Wu, X. (2022). Quaternion-based improved cuckoo algorithm for colour uav image edge detection. IET image processing, 2022(3), 16.

[2] Aljehani, M. , & Inoue, M. (2019). Performance evaluation of multi-uav system in post-disaster application: validated by hitl simulator. IEEE Access, 2019(99), 1-1.

[3] Jiwen, L. (2019). Application of uav photogrammetry and 3d modeling in mine geological environment monitoring. ACTA GEOLOGICA SINICA (English edition), 93(2), 437-438.

[4] Zhou, H, Peng, J. , Liao, C. , & Li, J. (2020). Application of deep learning model based on image definition in real-time digital image fusion. Journal of Real-Time Image Processing, 17(3),99.

[5] Barbosa, B. D. S., Gabriel Araújo e Silva Ferraz, Santos, L. M. D. , Santana, L. S. , & Conti, L. (2021). Application of rgb images obtained by uav in coffee farming. Remote Sensing, 13(12), 2397.

[6] Tsouros, D. C., Bibi, S. , & Sarigiannidis, P. G. (2019). A review on uav-based applications for precision agriculture. Information (Switzerland), 10(11), 349.

[7] Feito, F. R. (2020). Multispectral mapping on 3d models and multi-temporal monitoring for individual characterization of olive trees. Remote Sensing, 2020(07), 12.

[8] Horstrand, P, Guerra, R. , Rodriguez, A. , Diaz, M. , & Lopez, J. F. (2019). A uav platform based on a hyperspectral sensor for image capturing and on-board processing. IEEE Access, 2019 (99), 1-1.

[9] Wang, L. , & Li, J. (2021). Fast blur detection algorithm for uav crack image sets. Journal of computing in civil engineering, 2021(6), 35.

[10] Shi, Q. , Zhang, J. , & Yang, M. (2021). Curvature adaptive control based path following for automatic driving vehicles in private area. Journal of Shanghai Jiaotong University (Science), 26(5), 690-698.