Research on Target Recognition and Algorithm Application Based on Machine Vision

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Abstract: The assessment of low altitude airspace safety capacity has long been a challenge for air traffic control departments. Based on this, the study introduces the theory of average mutual information, a powerful mathematical tool, and creatively establishes a flight collision risk coupling model. This model not only considers the influence of a single risk factor, but also deeply explores the interaction and coupling effects between different risk factors, revealing how risks are intertwined and amplified within the system, providing a more accurate perspective for risk prevention and control. Based on this, this article proposes a new solution approach. A low altitude airspace security capacity model based on risk level standards was constructed by combining the previous risk assessment model with the characteristics of airspace usage.

Keywords: Machine vision; algorithms; models

I. Introduction

Low altitude ground target recognition and risk analysis based on machine vision have profound research significance in the context of rapid technological development today. The research in this field is not only related to aviation safety, intelligent transportation, drone applications, and other aspects, but also has an important impact on the sustainable development of society and public safety. The following is a detailed explanation of its research significance.

Firstly, from the perspective of aviation safety, low altitude ground target recognition is a crucial step in ensuring flight safety. In complex low altitude environments, aircraft face various potential risks, such as collisions with ground targets such as buildings, power lines, and trees. Through machine vision technology, aircraft can obtain and recognize these targets in real time, take corresponding obstacle avoidance measures, and reduce the occurrence of accidents. This is crucial for improving the autonomy and safety of aircraft.

Secondly, there is an urgent need for low altitude ground target recognition technology in the field of intelligent transportation. With the acceleration of urbanization and the increasing severity of traffic congestion, intelligent transportation systems need to more efficiently and accurately identify and process various traffic information. Low altitude ground target recognition technology can provide real-time traffic information for intelligent transportation systems, such as vehicle density, road conditions, etc., thereby helping traffic management departments formulate more reasonable traffic planning and management measures. In addition, this technology can also be used in the perception and decision-making system of autonomous vehicles, improving the safety and reliability of autonomous driving.

In terms of risk analysis, low altitude ground target recognition technology is also of great significance. By identifying and classifying ground targets, the level of risk that aircraft may face during flight can be evaluated. This is crucial for developing targeted safety measures and emergency plans. In summary, low altitude ground target recognition and risk analysis technology based on machine vision has broad application prospects and profound research significance. Therefore, we should strengthen research efforts in this field and promote continuous innovation and application of related technologies.

1. Detection in images

Target recognition is the process of detecting the presence of a known target in an input image and locating the target from the image. The accuracy of target recognition directly affects the accuracy of subsequent target tracking. If the target recognition is incorrect from the beginning, the subsequent tracking process will also be meaningless. The commonly used image target recognition methods currently include color based image matching, edge based image matching, and point based image matching. The first two methods mainly rely on global features for image matching, which have the advantages of convenient operation and high matching efficiency, but the matching accuracy is relatively low. The latter method matches images based on local features, which has advantages such as high accuracy and good stability.

Image features are information of interest extracted from an image, used to represent the most basic attributes or features of an image. They can be natural features that human vision can recognize, or some manually defined statistical features. Generally, there are two classification methods: global features and local features. Global features reflect the overall image, and the extraction process of such features covers all pixels in the entire image. Common global features include color features, edge features, and texture features. Local features refer to features that only appear locally, which can effectively describe the details in an image and remain stable even when the target is partially occluded. It can be seen that using local features such as corners to replace the entire image can reduce computational complexity without affecting the acquisition of image information. The commonly used local features include SURF features and SIFT features. Good local features should have the following characteristics:

(1) Repeatability means that the same target should have as many features as possible in different images, without being affected by factors such as rotation, blur, and lighting.

(2) Efficiency, the time complexity of feature detection algorithms should be as low as possible to meet real-time requirements.

(3) Locality, features should be local in order to solve the problem of partially occluded targets.

(4) Uniqueness means that the features of different objects in the same image can be distinguished from each other.

II. Color image processing

In order to reduce the impact of lighting changes on image matching, the hue components in the HSV color space are usually used to construct histograms. Setting q={q (u)} u=1.2. m is the histogram model obtained by statistically analyzing the target image R, that is:

$$\begin{cases} q(u) = \dfrac{1}{N} \sum\limits_{(x,y)\in R} \delta[c(f_R(x,y)) - u] \\ \sum\limits_{u=1}^{m} q(u) = 1 \end{cases}$$

In the formula, m is the total number of components in the histogram, “is the index value of the histogram, fR (x, y) is the image function of the target image R, c is the quantization function, δ is the Kronecker δ function, and N is the total number of pixels in image R. This section mainly focuses on the research of ground target recognition algorithms, and proposes a method of combining local and global features to identify targets in response to the shortcomings of using a single image feature for recognition.

III. Color histogram feature matching

The use of color histogram feature matching method for target recognition mainly relies on the rotation and scaling invariance of the color histogram features, and generates a reverse projection map through the color histogram to identify the location of the target. When there are interference objects in the scene with the same color as the target, using a single color tone feature cannot accurately locate the problem. A weighted fusion method is adopted to further reduce the impact of interference sources and preliminarily locate the suspected area of the target by combining edge direction histogram features and color histogram features in the reverse projection.

In the in-depth exploration of the optimization process of target recognition and tracking technology, we first need to recognize that in complex and ever-changing practical environments, relying solely on a single image feature often cannot ensure accurate recognition and tracking of target objects. Especially in the presence of interfering objects with similar colors to the target, traditional methods based on color histograms may face serious challenges. To overcome this challenge, researchers have proposed various innovative solutions.

Firstly, the combination of color histograms and edge direction histograms provides us with a new approach. Color histograms can capture the distribution information of colors in an image, while edge direction histograms can reflect the direction and shape information of edges in the image. By weighting and fusing these two features, we can obtain a more comprehensive and robust representation of the target features. This fusion feature can not only reduce the interference of similar colored objects in the background, but also to some extent cope with changes in the shape of the target.

Secondly, the introduction of SURF feature extraction technology further improves the accuracy of target recognition. SURF feature is an improved version of Scale Invariant Feature Transform (SIFT), which has higher computational efficiency and better robustness. By extracting SURF features within the suspected area of the initially located target and matching them with the pre stored target template, we can achieve precise localization of the target. This method based on local features can effectively address challenges such as lighting changes, perspective changes, and partial occlusion.

Finally, in response to the shortcomings of traditional CamShift tracking algorithms, we propose an improved method that utilizes color and edge features for weighting. The CamShift algorithm is a color histogram based object tracking algorithm, but it is prone to failure when facing objects with the same color background or similar shapes. By introducing edge features and weighting them for fusion, we can improve the sensitivity of the algorithm to the shape and contour of the target, thereby achieving stable tracking of the target.

In summary, by combining color histograms, edge direction histograms, and SURF feature extraction techniques, as well as improving the CamShift tracking algorithm, we can construct a more robust, accurate, and real-time target recognition and tracking system. Such a system can not only cope with complex and ever-changing environmental challenges, but also provide strong technical support for various practical application scenarios. With the continuous development of technology, we have reason to believe that future target recognition and tracking technologies will become more mature and perfect.

IV. Color histogram feature matching and target recognition

Color histogram is a commonly used image feature that counts the frequency of different colors appearing in an image. It has rotation and scaling invariance. By calculating the color histogram of the target object and generating a backprojection map, it is possible to quickly locate areas in the image that are similar in color to the target. By weighted fusion of color histogram features and edge direction histogram features, a more robust target feature representation can be obtained. Specifically, the weights of the two features can be adjusted according to the needs of actual application scenarios. When generating a reverse projection image, considering both color and edge features can further reduce the influence of interference sources and preliminarily locate the suspected area of the target.

CamShift (Continuously Adaptive Mean Shift) algorithm is an object tracking algorithm based on color histograms. It uses color histograms to generate a backprojection image and iteratively searches for the centroid of the target area through the Mean Shift algorithm, thereby achieving target tracking. However, traditional CamShift algorithms are prone to tracking loss when the target color is similar to the background color or the target shape changes.

To address this issue, researchers have proposed that color and edge features can be considered simultaneously when calculating the backprojection image, resulting in a more robust target representation. In the process of iteratively searching for the target centroid, these two features can also be used for weighted fusion to improve the robustness and accuracy of the algorithm. The improved CamShift algorithm can effectively compensate for the shortcomings of traditional algorithms and can stably and accurately track ground targets in the same colored background and in the presence of similar shaped objects.

V. Summary and Outlook

This article introduces a target recognition method based on color histogram feature matching and an improved CamShift tracking algorithm. By combining color features and edge features, preliminary and precise localization of targets can be achieved. Meanwhile, the improved CamShift algorithm can stably and accurately track targets in complex environments. Future research can be expanded from the following aspects: firstly, exploring more image feature fusion methods to improve the robustness and accuracy of algorithms; The second is to study target recognition and tracking methods based on deep learning to cope with more complex scenarios and challenges; The third is to study algorithms with better real-time performance to meet the needs of practical applications.

The airborne vision system target recognition and tracking algorithm studied in this article solves the problem of ground target recognition and tracking in complex scenes, laying a theoretical and methodological foundation for unmanned aerial vehicle automatic target tracking and airborne vision measurement. The main research content and achievements of the paper are summarized as follows:

1.Aiming at the problem of ground target recognition and tracking in complex scenes, a unmanned aerial vehicle (UAV) airborne visual detection platform was constructed, and a target recognition and tracking algorithm based on airborne vision was proposed to achieve stable recognition and tracking of ground targets with both cameras and targets in a fast moving state.

2. We studied the visual image processing methods for drones, using two online processing methods: onboard embedded system processing and wireless transmission system to transmit images back to the ground for processing, which enhanced the reliability and processing capability of the system.

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