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Overview of Aircraft Target Detection Methods based on Remote Sensing Images

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Abstract

Aviation safety has been a focus of attention for the past ten years. Knowing the location of the aircraft will undoubtedly make people more at ease. Accurate and rapid detection of various aircraft targets in a complex environment is a key issue, and it is also the basis for ensuring the safety of aircraft navigation, protecting territorial security and strengthening airspace resource management. Image data for aircraft inspection can be obtained through infrared imaging technology, SAR radar and satellite remote sensing. In recent years, many breakthrough achievements have been made in target detection technology. We divide aircraft target recognition into different processing methods for research. Through the research of aircraft target detection technology based on traditional image processing and aircraft target detection technology based on deep learning, the existing aircraft target detection methods are summarized and analyzed, and the two types of recognition methods are compared and analyzed. Finally, the main difficulties and research directions of aircraft target detection technology are discussed, and the future development trend of this field is prospected.

Keywords

Aircraft Detection; Remote Sensing Image; Image Processing; Deep Learning.

1. Introduction

Aircraft target detection in remote sensing images has important research significance no matter in the military or in the civil field. Especially in the military field, you can quickly and accurately understand the enemy on the battlefield. It can be seen from the remote sensing images that it is more convenient to obtain target detection information of docking aircraft at military and civil aviation airports, and the geographic location of the aircraft is of critical safety significance. The number and distribution of landing sites can provide powerful information support for future combat decisions and play a key role in the victory of the war. High-resolution optical remote sensing images can often provide massive amounts of spatial information, and are accompanied by easily recognizable features of spatial structure and texture information. After processing, they can accurately identify some remote sensing targets such as ships, airplanes, fuel tanks, and vehicles.

Because the aircraft is sailing at high altitudes, the aircraft targets in the remote sensing images are easily interfered by factors such as clouds, seasonal weather, light intensity, shadows, occlusion, etc., which will seriously affect the structure and texture information of the internal details of the target, and bring a huge impact to the detection target challenge. Therefore, there is an urgent need to improve the processing speed and accuracy of detection algorithms, and quickly and accurately estimating the number of enemy aircraft is an important technology for modern warfare battlefield situation analysis. The application in civil aviation is mainly to find missing flights, which can greatly reduce the loss of plane crashes. On the basis of summarizing the research status of aircraft target detection in remote sensing images, we discussed the classification of detection methods in detail. On the basis of classification, the common methods of aircraft target detection and the problems existing

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in samples and data sets are explained. The key technical difficulties of aircraft target detection are analyzed in detail, and the development trend of aircraft target detection in high-resolution remote sensing images is prospected. Under the needs of the world economy, military, and society, the detection of aircraft targets in various environments will be further strengthened. While using new technologies, for example, deep learning research on aircraft target detection should also develop detection methods based on traditional image processing technologies. Through the combination of a variety of methods to better deal with various tests may encounter problems. Large format and high resolution remote sensing images will produce a great storage space, which makes the processing speed become another bottleneck affecting the application scenarios with high real-time requirements. At present, the research methods of aircraft target detection can be roughly divided into two categories: one is the aircraft detection method based on traditional image processing technology, which performs target detection through the process of image segmentation, feature extraction and classifier classification; the other is based on Deep learning technology, using algorithms such as convolutional neural networks for aircraft detection, has become a research hotspot. Traditional image processing methods are widely used and mature, but due to excessive reliance on manual feature extraction, they have strong generalization capabilities. Although the method based on deep learning has good performance in recognition accuracy and real-time performance, it relies too much on high-quality data and has relatively weak response to some edge detection. It can be seen that efficient and accurate aircraft target detection algorithms in remote sensing images have important research significance.

2. Aircraft target detection process

Image processing technology is the core area of aircraft target detection research. The existing methods of acquiring aircraft target images and aircraft target detection processes can accurately identify aircraft targets from complex environments are mainly divided into two categories: based on tradition the image processing target detection technology and the target detection technology based on artificial intelligence and deep learning have similar processing procedures. After comparison, a flow chart of aircraft target detection is drawn, as shown in Figure 1.

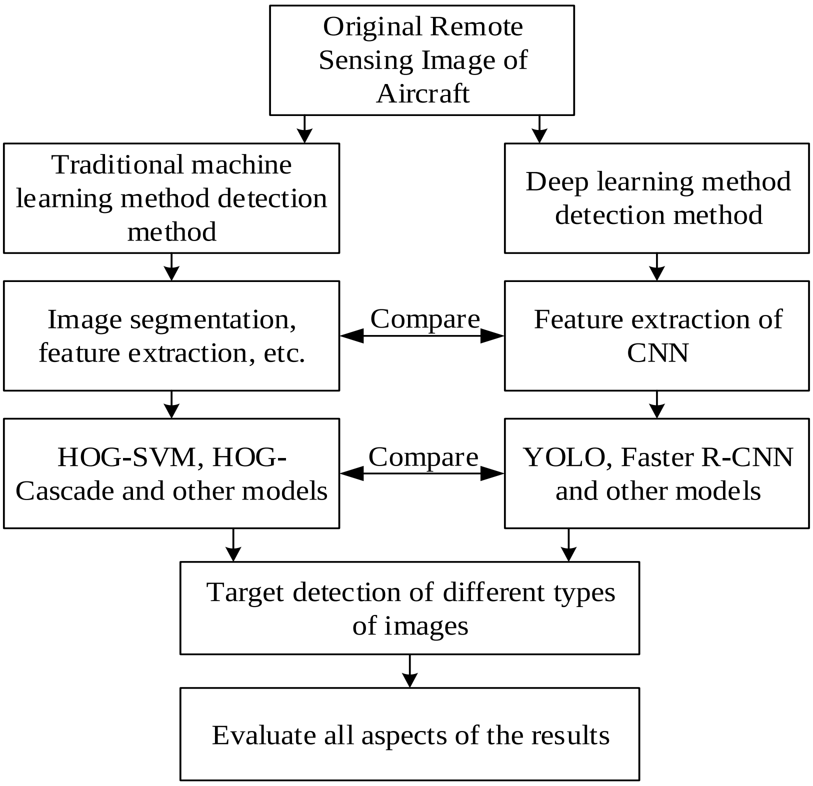

Fig. 1 Flow chart of aircraft target detection

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In deep learning methods, the main models are Convolutional Neural Network (CNN), deep Belief Network (DBN), YOLO Neural Network, etc. [1] By extracting the depth features of the image, the deep neural network is used to realize the layer-by-layer transmission of the feature image, so as to reasonably optimize the target position and accurately predict the target position [2]. The traditional image processing methods mainly include general image processing methods such as edge detection. When using it to detect aircraft targets, the original remote sensing image is preprocessed and image segmented and combined with color features to extract the edge features of the candidate area. And texture features, and use classification, clustering and other target recognition. We will compare and analyze each aspect of the two methods one by one.

Both the aircraft target detection method based on ordinary image processing technology and the aircraft target detection method based on deep learning need to preprocess the original image to eliminate noise caused by external interference factors such as atmospheric environment and signal transmission. The difference in feature extraction methods is One of the important differences between the two methods. Traditional image processing methods are used to detect aircraft targets. Histogram of Gradients (HOG) scale and invariant feature transformation are usually used to detect aircraft targets. SIFT, LBP and other feature extraction algorithms provide clear feature vectors for further detection of aircraft targets [3]. Deep learning methods use convolutional neural networks and other methods to extract features [4]. In contrast, traditional feature extraction methods are less robust in terms of image resolution, aircraft target shape, and sample lighting effects. And rely on prior knowledge. The feature extraction of encapsulated features is carried out by deep learning neural network, which is less affected by subjective factors, and more accurate aircraft target features can be obtained. In order to detect the effect, rely on the prior knowledge classification and target detection of the feature extraction process. Due to the weak characteristics and robustness of the operator, and the detection process mostly uses the pixel search exhaustive method, it is faced with complex processing target detection results. It is poor and has good accuracy for deep target detection and learning in a complex environment.

3. Aircraft target detection

3.1 Method based on traditional machine learning

Firstly, through filtering, denoising, segmentation, feature extraction, machine learning, pattern recognition, target recognition and other methods to preprocess the image set, using the characteristics of the data to obtain the target position image, so as to achieve the detection of aircraft targets. Traditional radar image target detection technology has also achieved some research results. For example, Guo et al. combined an aircraft target detection algorithm based on Canny operator edge detection and convolutional neural network. Through operations such as aircraft edge detection and bounding box preprocessing, the location range of potential aircraft targets in the airport can be determined [5]. Based on high-frequency radar signals, Dzvonkovskaya et al. used the threshold signal processing method of curve regression analysis and the constant false alarm rate (CFAR) detection algorithm to identify and track aircraft targets, thereby avoiding external noise, radio frequency interference and the impact on aircraft [6]. Zhao et al. proposed a new Pyramid Attention Expansion Network (PAEN) [7]. In order to reduce the imbalance of aircraft characteristics, experiments with mixed SAR aircraft data sets have proved the effectiveness of this method for aircraft detection. Pan et al. used a peak extraction method based on local maximum detection of 8 neighborhood pixels to extract the peak feature points of the target and template [8]. Then calculate the azimuth angle of the target, set the confidence interval to reduce the template library that needs to be matched; finally calculate the matching cost function of the peak point set of the target image and the peak point set of the template image. When the matching cost function takes the minimum value, it indicates that the target matches the corresponding template image. Zhang et al. propose to perform registration based on image features [9], which remain unchanged as the reference information of the two images. This method selects reference points that represent certain features in

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the image, extracts the features of the image, and then uses these features to calculate the spatial transformation parameters.

SVM technology is a technology widely used in traditional aircraft target detection methods, and has attracted the attention of domestic and foreign scholars in related fields in the aviation field. Ma et al. gave an automatic recognition method of aircraft targets based on support vector machines [10]; using Touzi edge extraction, the geometric features of the target shape parameters were obtained, and 16 feature vectors such as Hu invariant moments were used as the training samples of SVM. The aircraft target recognition model is trained to complete the automatic recognition of aircraft targets; the test results show that the algorithm can recognize aircraft targets of different scales and degrees of ambiguity up to 99%; the algorithm reduces the sample training time and improves the recognition accuracy It also reduces the complexity of the algorithm, has the characteristics of high recognition degree and fast recognition speed, and can be used for rapid recognition of aircraft targets. Zhu et al. proposed a new aircraft recognition method based on combined invariants [11]. For images of different aircraft types, three types of invariants, Hu moment, affine moment and normalized Fourier descriptor (NFD), are extracted for feature-level fusion. Aiming at the problem of a large range of combined invariants, four normalization methods are proposed, combined with support vector machines (SVM) to improve the classification performance of the aircraft recognition system. Simulation experiments show that extracting the combined invariant features of the aircraft, using traditional neural network or SVM to construct the classifier, the classification performance is better than the same classifier of single category invariant, and the classification performance of SVM is better than that of traditional neural network. Zhan et al. used a neural network-based image edge detection method [12]. The method first extracts the boundary candidate image based on the gray extreme value of the neighborhood, and then uses the binary pattern of the boundary candidate pixels and their neighborhood pixels as the sample set, and enters the edge Detect the neural network for training. Extract the contour feature vector with RST invariance and input it into the support vector machine for training and recognition. A comparative experiment was carried out between the support vector machine and the traditional artificial neural network algorithm. The experiment shows that the aircraft image recognition algorithm based on the support vector machine has better performance. Based on the advantages of rough set and support vector machine algorithm, Ma et al. designed a support vector machine pattern recognition classifier based on rough set and decision directed acyclic graph, analyzed the classification performance, and achieved good results effect [13].

3.2 Method based on deep learning

For aircraft target detection, target area selection and target feature extraction are affected by method efficiency and noise such as deformation, background, and illumination, and it is difficult to quickly and accurately identify the target aircraft. Deep learning is widely used in the field of graphics research. Multi-layer artificial neural networks can better describe image features, and can achieve significant results for aircraft target detection under complex conditions. In recent years, research on aircraft target detection based on deep learning has become more and more abundant, mainly based on regional recommendations and regression methods. For example: Li et al. proposed a SAR image aircraft detection algorithm based on improved Faster R-CNN. A SAR image aircraft data set (SAD) was produced [14], using Faster R-CNN as the detection framework, and using the improved k-means algorithm to design a more reasonable a priori anchor box to adapt to the shape characteristics of the aircraft target; drawing on the idea of the inception module, Design multiple convolution kernels of different sizes to expand the width of the network and enhance the expression of shallow features; at the same time, the ROI Align unit proposed in the Mask R-CNN algorithm is introduced to eliminate the mapping deviation between the feature map and the original image. Li et al. proposed a detection method that includes two types of deep neural networks: Fully Convolutional Neural Network (FCN) and Convolutional Neural Network (CNN) [15]. Cluster the FCN segmentation map by density clustering to obtain the adaptive candidate area of each target; use the VGG-16 network to extract the high-level features and results of the candidate area to obtain the detection frame; propose a new

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detection frame suppression algorithm to prevent overlap, the false detection frame is suppressed. Wu et al. proposed a combination of BING method and CNN to detect aircraft targets [16]. However, the average detection time (or test time) for testing images using this method is about 6.414 s. Cao et al. used RCNN for aircraft detection, which has a greater improvement over the previous algorithm, but it is not as good as Faster R-CNN in terms of accuracy and speed [17]. YOLO and its improved version are also commonly used techniques in aircraft target recognition. The core idea of YOLO is to use the entire image as the input of the deep learning network. Based on the grid segmentation of the target image, it is determined and detected that the center coordinates are located in the grid of the target, and the bounding box position coordinates and confidence are evaluated in the grid. Calculate the final screening to get the optimal border. For example: Zheng et al. used the K-means algorithm to perform clustering analysis on the data set, drawing on the idea of the Densely Connected Convolutional Networks (DenseNet) [18], and replacing the two residual network modules in the YOLO V3 network with two dense network modules, which was improved into one Dense-YOLO deep convolutional neural network structure. Test and analyze high-quality remote sensing images and low-quality remote sensing images such as overexposure and cloud occlusion. The experimental results show that the application of the newly improved deep convolutional neural network has improved effects on both images. The YOLO algorithm is simple and easy to implement, but when there are multiple small targets in the division result, problems such as missed detection are prone to occur [19]. Therefore, some researchers proposed YOLOv2 [20], YOLOv3 and other models on the basis of YOLO, which improved the target detection ability and improved the performance in small target recognition and detection [21].

3.3 Comparative analysis

Remote sensing image aircraft target detection can be regarded as a classification problem. Since the development of machine learning technology, there have been many powerful feature representation methods and classifiers with excellent performance. Traditional machine learning methods mainly use the following steps to achieve target detection: construction of training data sets, region extraction, feature design and extraction, feature processing, similarity measurement selection, classifier design, training and detection, combined with SVM and other algorithms. It has a good recognition effect and can meet the requirements of most situations in terms of accuracy. Comparing traditional chart detection methods and deep learning target detection methods, we get: The aircraft target detection method based on deep learning benefits from the powerful feature expression capabilities of neural networks such as CNN, and can extract higher-level semantic features of aircraft targets in complex scenes. The aircraft detection performance is excellent, which is significantly improved compared to traditional methods, but it is more dependent on training data. The detection performance is poor for the large aspect ratio and densely arranged aircraft group. Deep learning target detection methods have more advantages than traditional target detection methods in detecting aircraft targets in complex environments. This is currently one of the most attractive research directions in this field. The demand for data volume is large, and the requirements for hardware facilities are high. To sum up, both traditional machine learning and artificial intelligence deep learning algorithms have their shining points. We have consulted a large number of literatures and counted the percentage of commonly used algorithms in aircraft target detection algorithms, as shown in Figure 2.

4. Analysis of main algorithms for target detection

4.1 Based on YOLO model

YOLO algorithm mainly analyzes the target detection framework as a spatial regression problem. A single neural network can obtain predictions of bounding boxes and category probabilities from the complete image through a single operation. First adjust the image size, then send the image to the convolutional network, and finally process the network prediction results to get the detected target. The specific operation method is to implicitly divide the entire image into S × S grids, and predict which grid the center of the object appears in. The basic network model of the YOLO algorithm

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network structure is GoogLeNet, but its inclusion module is not used. Instead, 1×1 and 3×3 convolutional layers are used alternately, with a total of 24 convolutional layers and 2 fully connected layers. The convolutional layer extracts features, and the fully connected layer predicts category and box position regression [22]. The YOLO algorithm has a global understanding of the image, the background false detection rate is low, and the model's generalization ability is strong. The detection speed has been increased to the real-time level, but there is still a gap compared with Faster RCNN. Since each grid only predicts two bounding boxes, the number of objects predicted by the model is limited. The detection accuracy of small targets and dense targets is low, and the generalization ability of targets with large scale changes is weak [23].

4.2 Based on SSD model

The SSD algorithm abstracts the solving space of the target detection problem into a set of detection boxes with a preset ratio (aspect ratio), and predicts the classification label and offset in each detection box to better frame the target. In order to be able to deal with targets of different sizes, the prediction results of multiple feature maps of different sizes are combined for a picture to be able to detect objects at different scales. The SSD algorithm uses the basic network structure of VGG16, uses the previous five layers, and then uses the Astrous algorithm to convert the sixth and seventh fully connected layers into two convolutional layers [24], and then adds three additional convolutional layers and an average pooling layer. The feature maps of different levels are respectively used for the offset of the default frame and the prediction of different category scores, and finally the final detection result is obtained through non-maximum suppression.

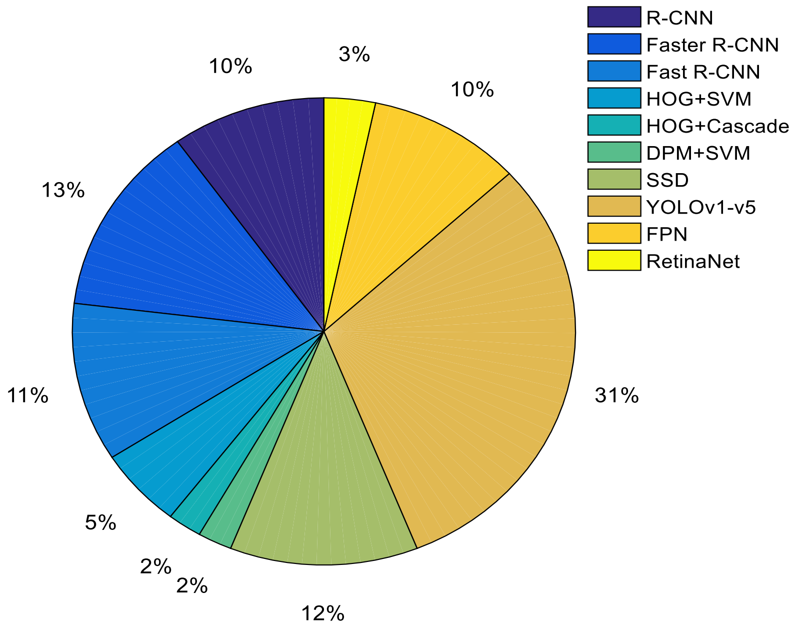

Fig. 2 Percentage of algorithms applied to aircraft target detection

4.3 Based on Faster R-CNN model

Faster-RCNN is a type of classification-based target detection algorithm, and it is one of the current popular detection frameworks. Compared with YOLO algorithm, it has obvious advantages in accuracy [25]. The algorithm uses VGG16 as the basic feature extraction network, and adds convolutional layer, pooling layer and other structures on this basis to obtain feature maps. Then generate more accurate candidate regions through the RPN network, and finally use ROI pooling to judge the feature map and the output results of the RPN network. The core idea of Faster-RCNN is to generate a number of candidate regions through pre-established anchor frame styles, and then perform subsequent operations such as judgment. The training image gets the feature map through

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the VGG16 network, and the original image is convolved several times to get the feature map. Each pixel on the feature map corresponds to a certain area on the original image. In order to capture all the targets to be detected, the 1-to-1 mapping form does not meet the requirements. The following expansions are made to the receptive field area mapped on the original image: add the area aspect ratio form, a total of 3 types, respectively: 1: 1, 1: 2, 2: 1 [26]; add the area size form, a total of 3 types, respectively for: 512, 256, 128. Therefore, each pixel on the feature map corresponds to 9 candidate regions in the original image. This greatly improves the accuracy of recognition.

4.4 Based on HOG+SVM model

When HOG+SVM is used for remote sensing image detection, the main idea of collecting HOG features is to analyze the image. The appearance and shape of local targets can be shaved, or the direction distribution of edge density is a good description. We have a very good description of each image. The pixel collects the histogram of the mound or edge direction, and the image features can be described according to the information of the histogram. OpenCV provides a method to calculate HOG feature and provides it to SVM for classification based on the collected HOG feature vector [27]. Support vector machine (SVM) is a simple classifier which can be transformed into aircraft and non-aircraft classification problems in aircraft detection. Support vector machine based on grid is used in OpenCV. Positive and negative samples were collected. Then the SVM classifier is used to train the aircraft detection model.

5. Detection methods of different types of images

5.1 Detection method based on optical remote sensing satellite image

Compared with infrared and SAR images, the aircraft images obtained by satellite remote sensing satellites are clear and intuitive, and the shooting range is wider. When using satellite images to detect aircraft targets, there will be some noises in the images, such as cloud noise, salt and pepper noise, band noise and so on. These noises are influenced by internal and external factors such as weather conditions, light and sensor characteristics. In addition, non-target objects such as clouds, birds and buildings around the airport may appear in the images due to the satellite's large range. Therefore, filtering is needed in the process of image preprocessing. The most basic method of cloud processing is to use wavelet transform to denoise. On this basis, there are also some enhancement algorithms, such as Atrous convolution-based enhancement algorithm and non-sharp masking algorithm. Median filtering and other methods can be used for salt and pepper noise. For noise such as birds, the gray threshold method based on texture information is mostly used. When using optical satellite images to detect specific aircraft targets, it is necessary to carry out predictive detection, generation of candidate target area (ROI) and other processes, and finally use CFAR and other algorithms to detect targets.

5.2 Detection method based on SAR image

Compared with infrared images, SAR images have richer texture information and image contours, and can present more target area details. SAR image is a reflection of the scattering characteristics of radar waves by aircraft objects, and its imaging mechanism has additive and multiplicative noise. Therefore, denoising is also a key problem that needs to be solved based on SAR detection methods. Since dry speckle noise is the main noise in SAR images, the denoising method can adopt filtering denoising, wavelet threshold denoising and Contourlet transform denoising [28]. These denoising methods are mainly to suppress image background clutter and maintain image edges and texture details. The SAR image has richer background information, so it is necessary to deal with factors such as content and noise effectively when performing image segmentation. In addition to the basic edge and space-based image segmentation algorithms, existing algorithms that can be used for SAR image segmentation include Markov-based segmentation algorithms, threshold-based segmentation algorithms, and multi-scale geometric analysis segmentation algorithms [29]. Among them, the threshold segmentation method is simple and easy to implement, but is limited by speckle noise, target size, target background and other factors, and its application range is limited; Markov-based

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methods rely on the relationship between pixels and surrounding pixels; based on multi-scale geometric analysis, the segmentation method can be applied to complex and multi-target image segmentation, and is more suitable for aircraft detection. The target detection of SAR aircraft images mainly emphasizes high detection rate and low false alarm rate. The constant false alarm rate algorithm achieves target detection by comparing the gray level of pixels with the threshold value in a certain area, and is a more commonly used method of aircraft target detection based on SAR images [30]. This method draws the clutter distribution model curve according to the atmospheric clutter data, and obtains the target pixel segmentation value according to the false alarm rate, and then obtains the target with high gray value in the image according to the threshold value. There are also some other methods that have achieved good detection results, such as aircraft target detection methods based on saliency detection.

5.3 Detection method based on infrared image

Infrared aircraft images are obtained by detecting the infrared radiation of the target. Based on the imaging principle and the characteristics of detection equipment, infrared imaging noise is inevitable, and infrared aircraft image has the characteristics of strong background clutter uncertainty and impulse noise, due to the many sources of infrared imaging noise, the signal of the aircraft itself is easy to be masked by various background noise. In addition, because infrared detection equipment is one of the main sources of noise, the corresponding image signal-to-noise ratio is low, which brings great difficulty to aircraft target detection. Therefore, infrared image denoising and other preprocessing is the key of aircraft target detection technology based on infrared image, through image denoising and preprocessing, the influence of noise on infrared image is reduced, which provides an accurate basis for subsequent image processing. In view of the characteristics of infrared image noise, the commonly used denoising methods include median filtering and pseudo-median filtering, wavelet threshold denoising, image sharpening, histogram averaging, etc. Among them, using histogram mean and other spatial domain methods has the advantages of simple algorithm and fast calculation speed, but it will lead to a certain degree of image blurring. Wavelet threshold denoising has a good denoising effect on the Gaussian noise in the infrared image, and can retain the image features well. It is suitable for processing infrared images of various sizes and resolutions. However, due to the threshold method, it is difficult to choose an appropriate threshold. For infrared image segmentation, according to the nature of the gray image of the infrared image and the need for denoising processing, the edge detection process of the aircraft infrared image may be very fuzzy, therefore, the image segmentation algorithm needs to be able to deal with the characteristics of the infrared image. At present, commonly used infrared aircraft image segmentation methods include the image segmentation algorithm based on edge detection, the image segmentation algorithm based on maximum entropy and the image segmentation algorithm based on clustering [31]. The traditional edge operator method uses the maximum value of the gradient and the zero-crossing value of the second derivative to determine the edge of the image. Although it is simple and feasible, its anti-interference and location performance is poor, at present, some new edge detection techniques are gradually applied in the process of image extraction. Edge detection methods based on mathematical morphology include edge detection based on multi-scale morphology and edge detection based on partial differential equation morphology. The edge detection method based on neural network adopts the neighborhood gray extremum to filter the image and adopts BP neural network to learn. On the basis of effective data preprocessing and image segmentation, corresponding detection can be designed [32].

6. Conclusion and Prospect

Aircraft target detection in optical remote sensing image has important research meaning and practical application value. A large number of achievements in this field have emerged in recent years.But there is still a big challenge in the actual application, mainly reflected in: 1) the current study are mostly based on high resolution images, the target can be clearly seen in the image plane, and actually

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the rainy weather is complex, there is a lot of cloud cover, etc., this is also where optical satellite imagery weak potential, makes obscured goal targets. However, in the case of thin cloud, mist and partial occlusion, the target can still be detected by the improved algorithm. 2) Most of the research before the eye pursues precision while neglecting the speed. In practical application, the detection speed is very important. However, it is difficult to achieve real-time aircraft target detection at present. Based on the analysis and summary of the advantages and disadvantages of the existing aircraft target detection methods, this paper identifies the following key development directions for future aircraft target detection:

6.1 Stealth aircraft target detection

With the progress of science and technology and the growth of national economy, stealth fighter has been gradually developed rapidly and widely used in the military field. At present, there is still a lack of systematic research on the detection of stealth aircraft dynamic targets. How to identify stealth aircraft accurately and quickly is an urgent problem to be solved to ensure aviation safety.In addition, for national security, stealth aircraft targets are not easy to be detected by radar and other remote sensing technology means, so the detection of such targets is of great practical significance for airspace territorial security, resource protection and so on. How to use infrared or remote sensing technology to obtain the target data of stealth aircraft is a significant research content in this research direction. Due to the small number of target samples of stealth aircraft and the difficulty of data annotation, which method to select for target detection needs to be further studied in the aspects of feature processing and deep learning structure design.

6.2 Combining traditional algorithms with deep learning algorithms

At present, the existing methods can be based on different types of remote sensing image plane target detection, but the method based on traditional image processing or deep learning still exist some shortcomings in accuracy, only the two types of algorithm fusion and complement each other, each other can be on the premise of guarantee the high accuracy successfully applied to the actual needs of unmanned test platform, Perfecting knowledge transfer in application fields. The development of remote sensing technology

At present, the image types that can be applied to aircraft target detection include red image, SAR image, optical remote sensing satellite image and other forms. With the development of remote sensing technology, the imaging resolution of remote sensing image is getting higher and higher, and the image content features are getting richer and richer. How to improve the efficiency of various processes such as preprocessing, feature extraction, classification and recognition based on the rich features of data by existing methods is also a problem to be studied in the future.

6.3 More effective combination of aircraft target detection and identification technology

With the increase of China's economic development and national defense security needs, effective detection and identification of the number and type of aircraft in a specific airspace has important economic and security significance. At present, although there are many detection and recognition research methods, how to carry out more accurate and real-time detection and recognition based on various remote sensing images, and how to ensure the effectiveness of detection and recognition under complex environment are the key issues worthy of attention.

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