A Review of Research on Light Visual Perception of Unmanned Surface Vehicles

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Abstract. Unmanned surface vehicles have the advantages of maneuverability, concealment, wide activity area and low cost of use. Therefore, they have broad application prospects. This makes unmanned surface vehicles a research hotspot at home and abroad, and the sensing technology is the basis for the unmanned surface vehicles to perform tasks. The perception technology based on optical vision has the advantages of convenient application, relatively low cost, easy data acquisition and large amount of information, and has been widely studied by scholars at home and abroad. This paper mainly discusses the research of optical vision in unmanned surface vehicles from five aspects: Firstly, the water surface image preprocessing based on unmanned surface vehicles, mainly including water surface image defogging enhancement research; second is the use of light vision target detection; the next is the surface target tracking methods. Finally, the light vision research of unmanned surface vehicles is summarized and forecasted.

1. Introduction

An unmanned surface vehicles, referred to as an unmanned surface vessel, is an unmanned surface ship. The unmanned surface vehicles has the ability to perform some tasks independently or completely independently. Compared with other conventional marine equipment, the unmanned surface vehicles have the characteristics of maintenance cost, low energy consumption and long continuous operation time, which can meet the realistic large surface area. Long-term research tasks and engineering project requirements. In addition, unmanned surface vehicles can replace people with complex and dangerous work by carrying different functional modules, such as disaster search and rescue, hydrological information monitoring and collection, marine biological information collection, and regional Chart topographic mapping, marine weather forecasting; adjacent sea defense missions; search, detection and demining of specific waters, combating pirates, counter-terrorism missions, etc.

Unmanned surface vehicles encounter many problems that do not exist on land and in the air. For example, it may encounter severe sea conditions such as heavy fog or heavy water vapor on the surface when performing tasks. These severe working environments have a great impact on the sensors carried by the unmanned surface vehicles and their own movements, and also put forward high
requirements for the environmental awareness of the unmanned surface vehicles[1]. According to the scheduled tasks, the unmanned surface vehicles must be able to sail smoothly in various unknown marine environments, perform environmental detection, surface target detection, target recognition, autonomous obstacle avoidance, and autonomous tasks. The realization of these capabilities is supported by the environmental awareness technology of unmanned surface vehicles.

Compared with other sensing technologies, optical images contain more detailed information on the target area, and the data is easy to obtain and the amount of information is large[2]. At the same time, light vision-based sensing technology makes it easier to effectively identify surface targets. Light vision is the perception technology that is closest to humans to obtain information. Humans obtain more than 80% of information through vision. The optical visual perception technology is beneficial to the effective extraction of navigational vessels, surface floating obstacles, artificial water facilities, island topography and other information during the operation of the unmanned watercraft, which helps them to complete independent planning and self-collision avoidance. The realization of tasks such as environmental monitoring, so as to avoid the collision of the unmanned surface vehicles and the surface target, on the other hand, it can ensure the accuracy of the information of the monitoring target, and improve the intelligent level of the unmanned surface vehicles[3].

2. Study on Defogging and Enhancement of Water Surface Image

The purpose of water surface image preprocessing is to obtain a clear and stable image sequence by processing the original image. The stable and clear image sequence can greatly improve the ability of unmanned light sight avoidance, detection, tracking and recognition. However, sea fog often occurs at sea, and the visibility and contrast of the scene captured by the camera are greatly reduced. The sea fog reduces the visibility of the atmosphere, the image of the optical device is blurred, the resolution is reduced, and the clear image surface feature information cannot be obtained, which seriously affects the extraction of the image information, which brings great difficulty to the image information extraction. Therefore, effectively eliminating the influence of sea fog is a necessary way to improve the availability of image data of unmanned surface vehicles. Therefore, effectively eliminating the influence of sea fog is a necessary way to improve the availability of image data of unmanned surface vehicles. At present, many scholars at home and abroad have done a lot of research on the atomization affecting image quality. There are two main methods[4] recovery methods based on physical models, establishing image degradation models, using existing knowledge to recover scenes; another method It is based on image enhancement and meets subjective requirements by enhancing low-quality contrast to achieve clear objectives.

Based on the dark channel algorithm, Shanghai Maritime University presents a method of dehazing for sea hazy images. It uses the mean shift method and edge detection method of embedding confidence for image segmentation of a sea hazy image, and applies the morphological dilation and erosion operations with binarization to extract regional and non-regional sky area in the hazy image, and finally dehazes the sky area with restricted contrast histogram equalization algorithm, and non-sky area with dark channel prior with guided filtering. Experimental results show that relative to the dark channel priority method, the proposed method does not provide the transition area and the phenomenon of color cast in the sky area, and achieves high performance of haze removal[5].

Another method of defogging is a sea fog dehazing method based on the physical model of atmospheric scattering. Harbin Engineering University uses the atmosphere[6] to solve the problem of video image quality degradation caused by obtaining the sky brightness estimation value, and the frame difference method background extraction method is used to improve the video by calculating the fog distribution map under the same background. Compared with several existing terrestrial dehazing methods, the SSIM of the processed image and the original fog image is smaller than that of Retinex and He. At the same time, the processing algorithm takes 32% less time than the Retinex algorithm and about 48% less than the He algorithm. Based on this, a fast video defogging method based on guided filtering for the unmanned surface vehicles background and target in real-time change state is proposed[7]. In order to improve the video defogging efficiency, the background frame
difference method is combined. This method is applicable to single images and video images under sea fog, and is verified by simulation. 9 is the improved video sea fog processing effect picture. It is proved by experiments that the method can effectively improve the video sea fog removal efficiency, the defogging processing speed can reach 5.2 frames/s, and the video defogging effect is good.

In summary, in the research work of water surface image defogging, the following aspects are worthy of research scholars to carry out the work: First, we must improve the adaptive adjustment ability of the algorithm. The current algorithm does not guarantee that it is suitable for all scenes or images, or that you need to manually adjust the parameters. Secondly, the effect of the defogging algorithm needs to be improved. At present, the image defogging technology still has more or less distortion phenomenon, especially in the processing of dense fog images [8,9]. The complexity of the defogging algorithm still needs to be reduced. The existing defogging algorithm, especially the algorithm with good defogging quality of single image, generally has the problem of excessive time complexity. The ideal dehazing algorithm should be applicable to real-time processing of large images, which requires the defogging algorithm to reduce the time and space complexity while ensuring the quality of the defogging.

3. Research on water surface target detection method
Unmanned surface vehicles mainly undertake tasks such as intelligence gathering, surveillance and reconnaissance, mine clearance, anti-submarine, search and arrest, and hydrographic survey. According to the mission requirements, the unmanned surface vehicles should have the ability to detect and identify the surface target, that is, to obtain the position and motion information of the target. With the unique advantage of light vision, in the close-range detection area of the water surface, light visual perception is easier to obtain the position information of the water surface target and the motion information of the target than other means.

For the problem of direct detection of water surface targets, some researchers have combined the specific characteristics of water surface images for target detection. Harbin Engineering University Wan Lei et al. proposed an automatic detection method for offshore targets based on coastline information for the detection of maritime targets in unconstrained coastal backgrounds, and obtained the target location[10]. The Huff transform is used to perform the voting weighting process to determine the precise position of the coastline. It is proved by experiments that the proposed method can detect the coastline under different tilting states and achieve accurate target positioning. The single frame processing is within 0.2s, with accuracy and accuracy. Rapid. On the basis of this, Zhang Tiedong et al. proposed a weak target detection method based on the visible light sequence image of the sea motion carrier combined with the complex sea-air background image[11]. The Mean-shift segmentation algorithm is used to filter the clustering first. The following figure is the segmentation result. Figure 3 is the automatic detection result of the offshore target based on the coastline information. After that, the largest area area is separated from other areas to binarize the image, and the target extraction is completed. The algorithm has been proved to have good accuracy and real-time performance.
The deep learning has raised the detection method of enriching the surface motion target. The research structure has applied the deep neural network to the practical application of surface motion target detection. Wuhan University of Technology, Xie Wei et al. collected the inland river ship image database to establish a ship single multiple detection (SSD) deep learning framework, and achieved high inland ship detection accuracy by using pre-training model parameters to tune and fine-tune the classification framework. The experimental results show that the recall rate and precision rate of the proposed recognition algorithm can both reach more than 70% under different weather conditions. [12]. The experimental results show that the designed algorithm can successfully output the surface ship detection results, and verify the efficiency and accuracy of the PCANET method by comparing with the CNN algorithm, and prove the superiority of PCANET in feature extraction. Wang Han developed a set of unmanned obstacle detection system based on stereo vision[13]. After field testing, the unmanned obstacle detection system proved to provide stable and satisfactory performance. For high-speed unmanned surface vehicles, the effective range of detection is 20 to 200 meters. Yang Jian, Huazhong Normal University, proposed a monitoring and tracking system based on neural network for water surface targets[14]. The problem of low positioning accuracy of the current CNN-based detection method is solved by using the accurate detection result of segmentation. At the same time, KF is used to track objects of multiple frames to improve efficiency, and the result is smoother than F-R-CNN. And using the improved R-CNN to re-detect the objects in the tracking frame to avoid losing the tracking target, Figure 4 is the specific research process. The experimental results show that the system has the characteristics of high speed, good robustness and high precision. It can locate objects more accurately and stably at the same time, and can be applied to practice in USV.

Figure 3. Automatic detection results of offshore targets based on coastline information

Figure 4. (a) initial detection frame (b) area image (c) segmentation image (d-f) process of superpixel combination in the initial detection frame (g) precise detection frame

4. Surface motion target tracking
The target tracking method can be classified into a generative method and a discriminant method according to whether the observation model is a generative model or a discriminant model. The most popular generation tracking method in previous years is probably sparse coding, and the recent discriminant tracking method has gradually occupied the mainstream position. The discriminant method represented by correlation filtering and deep learning has also achieved satisfactory results [15]. Surface motion target tracking is a task that is full of various challenges, mainly because the surrounding environment of the surface moving target is full of various disturbances and changes frequently, or the shape and size of the moving target itself are diverse in the image sequence. Therefore, accurately identifying and tracking moving targets in a complex water environment becomes a problem with various effects.

Bok-Suk Shin of the Software Research Institute of Hanyang University in Korea developed a real-time visual navigation and remote target detection and tracking system for unmanned surface vehicles for target detection and target tracking of unmanned surface vehicles under severe conditions such as large waves and foggy water. It is the effect of the detection box tracking part of the frame when the
distance is about 200m. According to the test, the target detection and tracking distance of the system is up to 500 meters[16]. In the tracking module of the system, the target tracking matching is performed based on the two-dimensional image of the constraint template, and the specific principle is shown in Figure 5.

Ran Gladstone et al.[17] of the Department of Electrical Engineering at the Technion Institute of Israel also used a monocular camera to estimate and track the target position, and the method takes into account the limitations of the USV in the marine environment, detects the sea level and uses its distance as a reference. The point of contact between the target and the sea surface is detected by finding the maximum stable extreme value region (MSER), and then the horizontal line and the optical characteristics of the camera are used to calculate the distance. The method is tested on multiple marine video lenses, showing that the average absolute error relative to GPS is in the range of 4.8% to 9%, and the overall average error is 7.1%. Figure 6 below shows the original image acquired and the algorithm detects Water antenna and target area. The test has been run for about 0.5-2 seconds per frame, written in MATLAB, running on a standard quad-core Windows PC, and can be ported to USV for practical applications.

Figure 5. shows the results of testing and tracking challenging frames

Figure 6. Template matching for target distance estimation

5. Summary and prospect of unmanned light vision technology

This paper summarizes the research and development of unmanned light perception technology, focusing on image stabilization, surface dehazing enhancement, sea line detection, target position and motion information detection and accurate measurement of target information. The unmanned surface vehicle attitude is greatly affected by waves and other factors, and the six-degree-of-freedom motion is more severe. Therefore, the water surface target detection and tracking technology must first solve the video image stabilization problem, and secondly, further develop the water boundary detection technology, low signal-to-noise ratio and dynamics. Target detection technology under background conditions and accurate measurement of surface target information based on multi-source data correlation and fusion. The unmanned light vision system has obvious advantages compared with other sensing systems. It has been widely used in recent years, but the research on optical vision technology at home and abroad can not make the unmanned surface vehicles truly intelligent. There are many areas that need improvement:

1. A video image-based unmanned surface vehicles sensing system that can be put into practical use should have the characteristics of short processing time, strong adaptability and high reliability.
2. The working environment is more complicated, and the stability requirements of the system are higher than that of unmanned vehicles. Unmanned light visual studies require a clear and complete working process.
3. Drawing on the development experience of unmanned vehicles, the level of intelligent research on unmanned light vision needs to be improved. The main working principle of an unmanned vehicle is based on data processing and behavior prediction after the information is input by the sensor (camera or radar).
4. Enhanced restoration studies of water surface images. It is necessary to establish a water surface image enhancement and recovery system that can satisfy various weather environments, and can adaptively restore images according to the external environment and retain key information of images.
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