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Review

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 stabilization research and defogging enhancement research; two water boundary detection; It is the use of light vision target detection; the fourth is the surface target tracking method. Finally, the light vision research of unmanned surface vehicles is summarized and forecasted.

Keywords: unmanned surface vehicles; optical visual perception; image stabilization; defogging; target detection; target tracking

1. Introduction

An unmanned surface vehicles, referred to as an unmanned surface vessel, is an unmanned surface ship. In 2007, the US Navy released the first Naval Unmanned surface vehicles Master Plan, which defined the unmanned surface vehicles as a kind of floating surface when it was still, and almost continuously contacted with the water during exercise, and Unmanned aerial vehicles with different automatic control capabilities [1]. And the demand for this technical field in the document is: "Further increase the regional coverage and improve the water surface. The ability to detect, classify, and identify targets, as well as tracking techniques, to improve sensors for detecting chemical, biological, nuclear, radiological, and explosion threats [2]. 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 [3]. According

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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.

For the environmental sensing technology of unmanned surface vehicles, it mainly includes sensing technologies such as light vision, radar, infrared and underwater sound. 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.[4] .

This paper mainly discusses the research of unmanned light visual perception technology from five aspects: one is the water surface image preprocessing based on the unmanned surface vehicles; the second is the sea boundary line detection method; the third is the water surface moving target detection method; the fourth is the water surface motion Target tracking method.

2. Water surface image preprocessing based on surface unmanned vehicles

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. Unmanned surface vehicles are affected by irregular wind and waves during the navigation process, resulting in irregular swaying of the hull posture, causing shaking, vibration and distortion of the images taken by the mounted camera [5], resulting in video images captured by the visual system. Severe degradation, affecting the performance of the unmanned visual system, will have a great impact on the ability of the unmanned surface vehicles to detect, track and identify. Therefore, research on the stabilization technique of various sports has a strong practical significance [6]. At the same time, clear scene information is also one of the powerful guarantees for realizing the function of the unmanned visual system. 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.

2.1 Stabilization method for irregular shaking of unmanned surface vehicles

The unmanned surface vehicles are affected by the working environment, and there are wave interference and self-vibration. The working effect of the sensing system is affected by the attitude change or vibration of the carrier at different moments, and the obtained image information is unstable and fuzzy. Such unstable images can cause fatigue to the observer, which leads to misjudgment and missed judgment; for the target automatic identification system, the detection target position is larger, errors, false alarms and false alarms. Therefore, in the unmanned surface vehicles carrier, the image stabilization of the camera system is a very important problem, especially in the long-focus, high-resolution unmanned surface vehicles monitoring and tracking system. There are three commonly used image stabilization methods, namely active image stabilization, passive image stabilization and electronic image stabilization. Active stabilization is a stable camera system

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with a gyro-stabilized platform. The gyro-stabilized platform mainly attenuates low-frequency vibration. Passive stabilization uses a vibration damping device to isolate the vibration of the carrier and suppress the effects of high frequency vibration on the camera. Active image stabilization and passive image stabilization can be used together to achieve a wide range of image stabilization. However, the high-precision gyro-stabilized platform is not only complicated in structure, large in size, expensive, and consumes a large amount of power, but also cannot be used due to volume limitations on an unmanned surface vehicle platform. Therefore, the most widely used is electronic image stabilization technology to achieve the stability of television images [7,8].

According to the imaging characteristics in the sea environment, based on the inter-frame compensation method, the National University of Defense Technology designed an electronic image stabilization algorithm based on the characteristics of water antennas [9]. The algorithm first extracts the features of the water antenna, and then uses the linear parameters of the water antenna to calculate the motion deviation between the image and the reference image, and then obtains the interframe compensation. Finally, the image motion is stabilized by the image shift compensation technique. According to the sea environment and lighting conditions, the experimental data is divided into three categories, the average time for processing each typical sea-sky image is 39ms, the image affected by the weather is 41ms, and the time of the sea-sky image with obstacles is 52ms, which meets the requirements of 60ms in engineering. And the image output by the algorithm can stabilize the water antenna within one pixel. Figure 1 is an effect diagram of an electronic image stabilization algorithm based on the characteristics of a water antenna. On this basis, Beijing Institute of Technology uses feature points extracted from successive frames to estimate motion parameters for image stabilization. Motion compensation is achieved by converting the current frame to a reference frame, the reference of which depends on the different compensation methods. The experimental results show that the stability rate reaches 25 frames per second with a tracking window size of 1×12×128 pixels.

For the video image jitter problem of high-speed unmanned surface vehicles in the process of video acquisition, Harbin Engineering University uses the scale-invariant feature transform algorithm to extract feature points in video images [10] using affine models to solve motion parameters, and using Kalman filter to video The normal scanning in the image is filtered, and finally the image compensation is performed by the adjacent frame compensation method to realize the image stabilization processing of the high-speed unmanned surface vehicles. The algorithm uses the video collected by the high-speed surface remote control boat for comparison verification analysis. The results show that the algorithm is effective for the image stabilization of the high-speed unmanned surface vehicles vision system, and can obtain a stable image sequence. Figure 2 two-frame image and its processing effect. However, the algorithm has a poor effect on the large-scale translational motion, and the calculation amount is large, and the real-time performance needs to be improved. Later, according to the various displacement parameters of the obtained image, corresponding compensation is performed to realize electronic image stabilization processing. Firstly, the Kalman filter is used to filter the image. This process removes the normal scan contained in the image, and finally obtains the displacement parameter corresponding to the jitter in the image, and then compensates the image according to the adjacent frame compensation, and finally realizes the electronic image stabilization processing.

Figure 1. Generalized water antenna electronic image stabilization effect

Figure 2. two images and their processing renderings

Han Liangliang of Harbin Engineering University is aiming at the possible rotation and scaling jitter in the process of obtaining the target image, and extracting and matching the SIFT feature points in the scale space, and further screening by using the Rasanc algorithm to obtain the affine

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transformation model of the interframe motion[11]. Image compensation based on bilinear interpolation algorithm. The experimental results show that the proposed algorithm achieves better image stabilization for the obtained maritime target video.

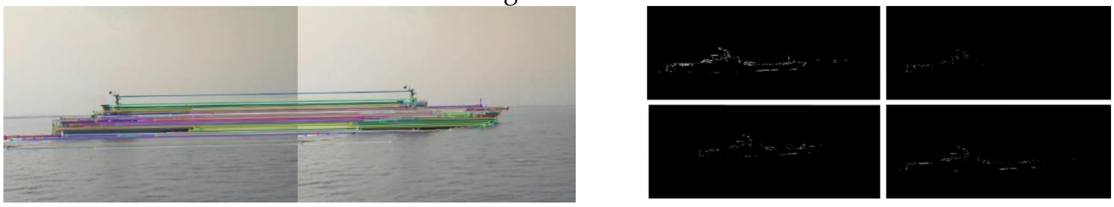

Figure 3. Eliminate SIFT feature point pairs obtained by pairing after mismatch

The University of Maryland has focused on military image stabilization technology and has successfully developed a variety of image stabilization algorithms that have been successfully applied to weapons and equipment. The University of Maryland has developed a digital image stabilization system that can process image sequences with large deformations. The system has been implemented in parallel processing image processing hardware (Datacube Max Video 200) connected to SPARCstation 20/61 [12]. The processing algorithm tracks a set of image sequences based on multi-resolution motion estimation of the two-dimensional features, which in turn estimates the motion form and pose of the camera. Stabilization is achieved by using a combined estimate of the reference frames to correct the current frame. The experimental conditions of the algorithm are similar to those of the unmanned surface vehicles shaking on the water surface, and can be used as a reference for the image stabilization of the unmanned light vision system. Using a video sequence of an unmanned camera-mounted camera running on a rugged road, the algorithm has a processing capacity of 15 frames/s and can process successive frames of up to 21 pixels between frames. However, sometimes the sequence acquired under shaking conditions cannot be processed stably, and the robustness of the whole system needs to be improved.

In summary, the image stabilization methods applied on unmanned surface vehicles mainly include: interframe compensation method, image feature based method, image block based method, etc. [16]. The interframe compensation method can only be used for static background and the camera is fixed, but the image stabilization effect is excellent; the image stabilization based image feature can calculate the stable features of the target such as contour, color, corner and texture, etc. The accuracy of the method does not ensure the real-time processing; the image block-based image stabilization method reduces the computation time in real-time image stabilization, and has good robustness, but is susceptible to external interference, and the accuracy needs to be improved. When using a single electronic image stabilization algorithm to process images, the expected effect can not be achieved. It is also worthwhile to study with two different image stabilization methods. It is also worth considering the motion parameters obtained by the motion filtering process. With the continuous improvement of the stability of the camera system by the environment-aware technology, the application of electronic image stabilization technology on unmanned surface vehicles will become more and more extensive. At present, the basic algorithm of electronic image stabilization has been perfected, and it can be quickly and accurately stabilized for image sequences with translational motion, simple rotational motion, and moving objects with small targets on image [17].

2.2 Study on Defogging and Enhancement of Water Surface Image

Clear scene information is one of the powerful guarantees for the function of the unmanned visual system. 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. 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 [18] recovery methods based on physical models, establishing image degradation models, using existing knowledge to recover scenes;

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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[19].

Another method of defogging is a sea fog dehazing method based on the physical model of atmospheric scattering. Harbin Engineering University uses the atmosphere [20] to solve the problem of video image quality degradation caused by the scattering of atmospheric particles under sea fog conditions. Aiming at the obvious characteristics of sea image boundary line and large sky area, the image is segmented, the sky area feature is analyzed to obtain 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. The defogging rate of the image. Compared with several existing terrestrial dehazing methods, the structural similarity (SSIM) of the processed image and the original fog image is smaller than that of Retinex and He, and the image is defogged. better result. 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 [21]. 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.

Figure 4. Method based on guided filtering sea fog removal

Figure 5..Improved Retinex algorithm, He algorithm and comparison of the a atmosphere algorithm

At the same time, the Naval Academy also combined the atmospheric scattering physical model to propose a defogging method based on the depth of field of a single video image [22]. The basic characteristics of foggy video images are analyzed from the aspects of contrast attenuation, color histogram and frequency distribution, as the basis for adjusting the parameters in the atmospheric model, and modifying and optimizing the model. The dark primary color value of each pixel is corrected by the similarity of the color between the pixels in the neighborhood of the image, and the transmittance of the traditional dark primary method is improved by estimating the sky brightness interval in the dark primary histogram and selecting a reasonable atmospheric light value. The problem of blockiness breaks through the limitations of the classical gas scattering model on depth of field. The results of processing the foggy and degraded images of multiple scenes show that the

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method approximates or exceeds the interactive method and He method in terms of average gradient, edge intensity, information entropy and histogram correlation coefficient. The average gradient is about 50% higher, which verifies the effectiveness and high accuracy of the algorithm.

The PLA University of Science and Technology has developed a method of applying wavelet transform to dehaze water surface images [23]. The main method is to use wavelet transform to suppress low-frequency information, and appropriately enhance the scene information in the defogging image; then, based on the SSR color constant algorithm, apply a series of processing such as stretching and color reduction to improve the image brightness. Experiments show that the algorithm has a good visual effect. Fig. 6 is a diagram showing the effect of the picture in the presence of the sea fog taken.

Figure 6. Wavelet transform + SSR defogging

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 [24,25]. 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 Sea-sky line detection

Whether for target detection of monocular vision or for target ranging of binocular vision, sea antennas or coastlines are a very meaningful piece of information. When the unmanned surface vehicles sail, most of the images appear in the image are sea antennas, and when the carrier returns, most of the images appear in the image. We refer to the water antenna and the water shore line as the sea-sky line[2]. High-precision detection of water boundaries is critical for unmanned surface vehicles applications. For example, a water antenna can be used to solve stereo camera calibration problems; water boundary detection is sometimes a critical step in surface target detection, which can narrow the search space.

College of Electrical Engineering Naval University of Engineering proposes a new method which is based on histogram analysis and linear fitting is proposed[26]. It can obtain the information of pixels near the Sea-sky-line through an analysis of the histogram, and calculating the rough area to get rid of irrelevant pixels in order to extract the sea-sky-line through the method of linear fitting.

The experimental results show that this method has many advantages such as strong robustness, speedy calculation and high practical value. Southwest Institute of Technical Physics presents a texture model by analyzing the texture distributing feature at ocean line area of classical sea-sky images. The textural image is got by using gradient operators. Then the positions of likely sea-sky-line can be obtained by clustering the peak value of gradient[27]. The correct sea-sky-line was detected by comparing the textural parameters of all those positions. The method does not need to perform preprocessing such as line detection and image segmentation, has good adaptability to different scenes through simple gradient calculation and analysis, and can better resist large-area cloud group interference, water surface bright band, strong Interference such as clutter. Nanjing University of Science and Technology detect the sea-sky horizon by examining the approximate image of a Haar wavelet decomposition of the original image. And the equation of the sea-sky horizon is set up, no matter whether the sea-sky horizon is horizontal or not. Since the sea-sky horizon is located, not only the potential area but also the strip direction of noise is got. And it works well when sea-sky horizon line is oblique or in heavy noise[28]. National Defense University proposes a novel method，basedon phase grouping and gray statistics was presented[29].

Wang Bo of Harbin Engineering University proposed a sea-antenna detection method based on gradient saliency[30]. The calculation of gradient saliency effectively enhances the linear characteristics of the sea horizon and suppresses various interference factors. The regional growth method is used to detect and identify the sea antenna. Finally, the optical image acquired by the unmanned surface vehicles in the actual sea environment is used. verification. The image sequence detection results in various weathers show that compared with Hough transform, Radon transform, RANSAC straight line fitting and shear wave transform, the accuracy of the proposed method is as high as 95%, which is higher than the above four methods. 11%~27%, Figure 8 shows the sea-antenna detection based on gradient significance. At the same time, the time taken for water antenna detection in each frame is about 50% less than the fastest of the four types of Hough, which proves that the accuracy and real-time of the method used are excellent.

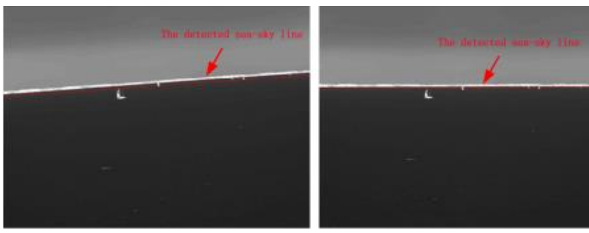

Figure 7. Sea-sky detection based on haar wavelet decomposition

Figure 8. Sea-sky line detection based on gradient significance

Finding the region of interest is the current mainstream method for water boundary detection, with the aid of the region of interest to determine the position of the sea antenna. Xiao Zhengmo of Nanyang Technological University selects the region of interest by conversion and cropping, and further processes the region of interest to obtain the position of the water antenna. The sea-sky line detection algorithm was tested by using the image image global sparsity and Hough variation, and the sea antenna detection algorithm was tested using the acquired four image sequence data [31]. By selecting the detected maximum horizontal distance of the horizontal line spectrum to the ground truth value is less than 10 pixels, the average horizontal accuracy is 93.0%. The original image has

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high sampling accuracy and fast calculation speed, as shown in Fig 9. However, the real-time effect of this method is inferior to the traditional method, and the actual application effect on the project is not good.

Ran Gladstone, Israel's Signal and Image Processing Laboratory, estimates the distance between the target and the camera by detecting the water antenna and using its distance as a reference [32]. The method estimates the point of contact between the target and the sea surface by finding the region of maximum stability. Then, the geometry of the earth and the optical properties of the camera are used to calculate the distance. Figure 10 shows the effect of the water antenna detected. The method was tested on several videotapes of sea exercises with an average error of 7.1%.

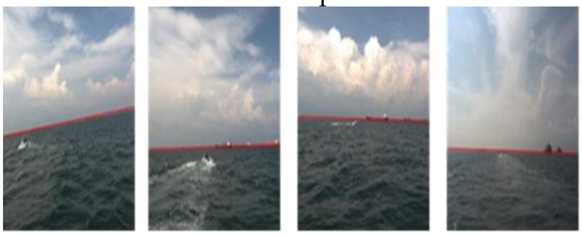

Figure 9. Sea-sky line detection based on global sparsity

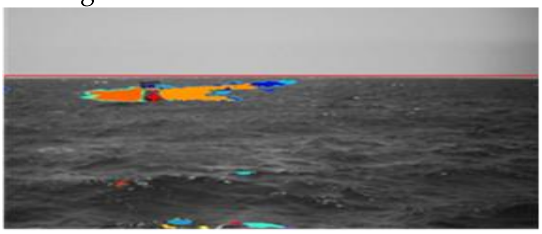

Figure 10. The detected line is marked as red

National University of Defense Technology Hao Guo applies the Kalman filter to water antenna detection [33], estimates the approximate parameters of the camera pose based on the prediction, and obtains candidate image pixels in a small region of interest around the predicted horizontal position. Then, within the candidate image pixels, the candidate line segments are determined, and the final horizontal line is selected according to the geometric characteristics of the candidate line segments, and FIG.11 is the actual detection result. Bok-Suk Shin et al. proposed a hierarchical random sampling consistency algorithm to detect water antennas [34]. First, the RANSAC is used to estimate the water antenna position in the reduced gradient image, and the neighborhood defining the estimated water antenna is defined as the region of interest, and after detecting the water antenna in the small-sized image, the water antenna is re-projected to the original image. An appropriate amount of image blocks are then sampled in the edge detection image of the region of interest of the original image, and a straight line fit is performed using RANSAC in the image block. Finally, RANSAC is used to aggregate candidate image blocks with smaller variance to calculate the final water antenna. This method solves the difficulties caused by the reflection of sunlight, occlusion, poor light, and staggering in the boundary area. Experiments were carried out in different scenarios of the data set, and the standard Hough transform (HT), least squares (LSO) and standard random sampling consistency algorithms showed that the proposed method HR is more accurate than other traditional methods. Figure 12 compares the accuracy of water antenna detection using different methods. The limitation of the proposed method is that it does not work well for scenes with large noise.

In summary, the detection of unmanned water boundaries has a relatively mature method, but they all have their own limitations, mainly the problem of real-time and accuracy have a lot of room for improvement. At present, there are many literatures on the extraction of sea-sky lines, mainly based on the principles of row mapping histogram, gradient transformation, wavelet transform, Radon transform, maximum inter-class variance method, texture feature and Hough transform. And although many research methods have been proposed, most of the methods have not been verified on unmanned surface vehicles, and the practicality remains to be verified. Researchers still need to study in depth to adapt to their characteristics, and to balance real-time and accuracy. Due to the

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rapid development of artificial intelligence, the detection of sea-sky lines based on deep learning will become a new research direction in this field, and more excellent methods are expected.

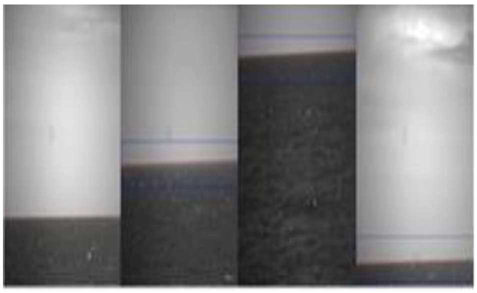

Figure 11. Region of Interest and sea-sky line detection results

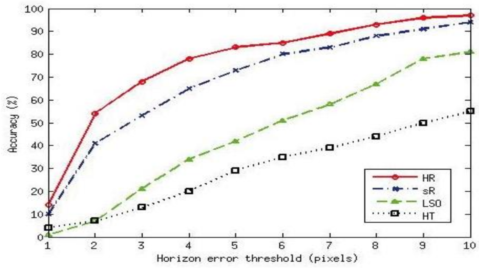

Figure 12. Comparison of sea-sky line detection accuracy using different methods

4 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. With the development of related technologies, the surface motion detection technology based on information fusion has become more mature. According to the characteristics of unmanned surface vehicles, it can be equipped with various sensing devices such as cameras, laser radars, infrared sensors, and millimeter wave radars. Different sensors can extract different features for the same target, exert their respective advantages, and integrate detection information to improve the detection effect of moving targets. Therefore, target detection based on multi-sensor information fusion is a development trend.

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 [35]. 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 [36]. The Mean-shift segmentation algorithm is used to filter the clustering first. The following figure is the segmentation result. Figure 13 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.

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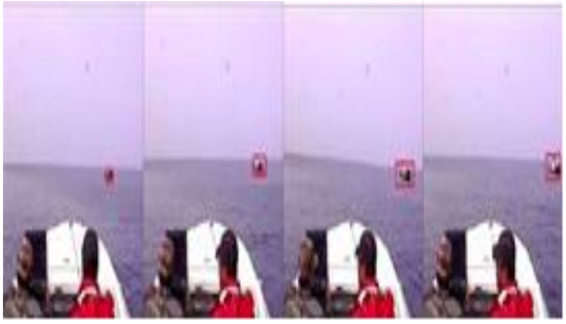

Figure 13. Automatic detection results of offshore targets based on coastline information

Because the surface motion target is significantly different from the information contained in the surrounding environment, some research scholars propose detection ideas based on the difference between the water surface target and the surrounding environment. Chang Li, a national processing laboratory for multispectral information processing, proposes the use of the notion of salientity to obtain salient features, namely the use of target-proposed rapid target detection methods [37]. Although there are many environmental noises, the obstacles around the unmanned surface vehicles are very unique, blending objects and significant results, calculating the significant density of each object proposal and eliminating false alarms. The algorithm was tested with several challenging data sets collected in the marine environment. The average accuracy was 82%, and the time per frame was 0.268s. The results show that the algorithm has higher accuracy and lower false positive rate. Li Chang of the same laboratory and Cao Zhiguo of Huazhong University of Science and Technology for the rapid detection of surface moving targets, object uncertainty and perspective illumination changes, proposed a rapid surface motion target detection method based on target surface features [38]. The algorithm is tested on several data sets collected in the actual marine environment. Figure 14 below shows the effect of partial video frame detection. The results show that the algorithm has the advantage of higher precision. Compare accuracy with the DPM algorithm to measure accuracy and time. In the later period, Li Chang combined the target characteristics and significance on the basis of the two, and eliminated the false targets to get the exact position of the target. The algorithm has better adaptability, and it has a great improvement in both the detection effect of the target and the speed compared with other existing target detection algorithms [39]. According to the data sets collected, the verification accuracy is above 80%.

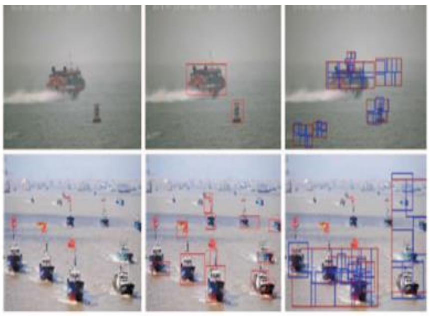

Figure 14. shows the detection effect of partial video frames

序号	序列名称	准确率（%）	平均时间（ms）
1	M1_2015_27	92.5%	177
2	M2_2015_26	88.4%	185
3	M3_2015_26	80.7%	193
4	M4_2015_26	92.3%	196

Figure 15. Improved algorithm target detection and recognition result statistics

Image sparsity is an important feature of images. Sparse indicates that some large values of coefficients concentrate most of the image. In images that contain surface targets (obstacle), these targets may have a large coefficient, including most of the energy and information of the image, and

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contribute to the detection of the target based on sparsity. Xiao Zhengmo of Nanyang Technological University proposed an obstacle detection algorithm based on unmanned surface vehicles by exploring the global sparsity of image blocks [40]. It shows higher accuracy than traditional methods and advanced saliency detection methods. In this method, the sampled image blocks of the sea surface are considered to be the main cluster, and the outliers are regarded as obstacles. The clustering process is based on the global sparsity of each image block, which is sparse in the whole image, but has similar texture information to the sea surface, which is significantly different from the sea surface obstacle. Figure 16 is re-aggregation with features (green) and significant Compared with the method of sex detection (blue), it can be seen that the proposed algorithm (red) is superior. Although the algorithm shows good performance, only grayscale images and texture features are used, and the characteristics of color information of ocean images are not studied. In addition, test data in more complex cases should be collected to study the robustness of the algorithm. On the basis of this, Wang Hao of Nanyang Technological University developed a real-time obstacle detection system. The system is capable of detecting and locating multiple obstacles in the range of 30 to 300 meters [41]. In different situations, it is sufficient to detect multiple obstacles and estimate the obstacle position. The detected position is compared with the GPS position recorded on the target ship. Field tests have proven that the system's performance and reliability are excellent. In the later process, a real-time visual remote object detection and tracking algorithm is proposed. Using high-definition images (2736*2192), the object distance is estimated to reach higher precision.

Yan Xiao zheng of Nanyang Technological University proposed a real-time vision-based long-distance target detection and tracking algorithm for unmanned surface vehicles. High-resolution images (2736 × 2192) were used in the study to obtain a high-precision target distance[42]. In order to ensure the real-time performance of this high-resolution image, a coarse-to-fine method is proposed. Firstly, the position of the sea-antenna and the target is roughly estimated on the lower-resolution image corresponding to the HD image, and then the target sense is detected. Area of interest. The region of interest is projected onto the original high-definition image, and finally the extracted regions of interest on the high-definition image are stereo-matched in the original image to present more accurate 3D information. In the tracking task, the target tracking based on the 2D image is combined with constraint template matching to calculate depth.

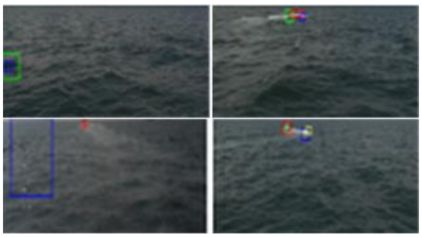

Figure 16. proposed algorithm (red) compared with the classic method

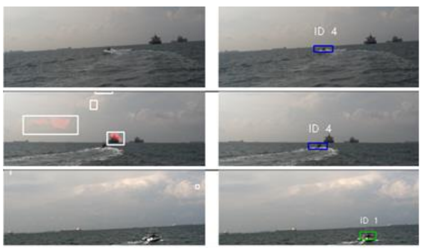

Figure 17. Vision-based unmanned surface vehicles target tracking test renderings

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

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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. [43]. 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 [44]. Figure 18 is a test display diagram of obstacle detection and positioning. 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 [45]. 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 19 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 18. experimental results

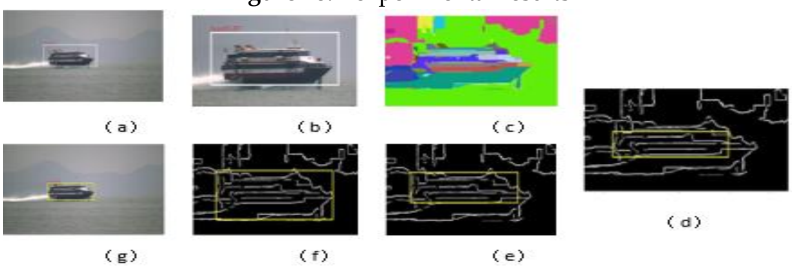

Figure 19. (a) initial detection frame (b) area image (c) segmentation image (d-f) process of superpixel combination in the initial detection frame (g) precise detection frame

It is also possible to detect the objects contained in the image by scene understanding and semantic analysis of the water surface image. Matej Kristan of the University of Ljubljana, Slovenia, proposed a new graphical model for the detection of moving targets by unmanned surface vehicles against surface targets through unsupervised segmentation [46]. The model interprets the semantic structure of the marine environment by applying weak structural constraints. Using the Markov random field framework, an efficient algorithm is derived for simultaneously optimizing model parameters and segmentation mask estimation. The specific principle is shown in Fig. 20. Experiments have shown that the proposed model is superior to the related method and exhibits excellent performance in terms of segmentation accuracy and speed. The limitation is that the algorithm can only get the best results in the YCrCb and Lab color spaces.

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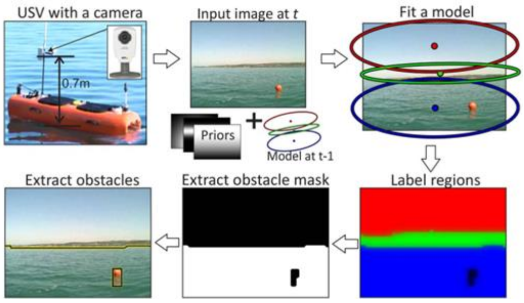

Figure 20 . Target detection flow chart

An important use of unmanned surface vehicles for target detection is to plan paths for unmanned surface vehicles and provide accurate environmental information to avoid obstacles. This is a research institute that involves more complex projects and is currently working together to integrate the entire process. Not a lot. South Korea's Jonghong Park uses unmanned surface vehicles equipped with monocular cameras for precise positioning of water targets and self-collision avoidance [47]. In order to estimate the range and orientation of each target relative to the unmanned surface vehicles, the Extended White Motion (CWNA) model of the Continuous White Noise Acceleration (CWNA) model is used to accurately locate the obstacle. Then the obstacle avoidance strategy was proposed according to COLREGS and verified by the water surface test. When the estimated distance between the target and the own ship is less than the predetermined safe distance, the ship changes its heading angle to avoid an emergency collision. The feasibility and effectiveness of the scheme were proved by field experiments. Fig 21 is the result of the detection area and the center point of the DBSCAN, and FIG. 22 is the result of the field experiment based on the visual collision. Terry Huntsberg of the National Jet Propulsion National Laboratory also conducted obstacle avoidance tests based on obstacle information. He proposed a stereo vision system for autonomous navigation of unmanned surface vehicles in a marine environment. The built Hammerhead visual obstacle detection system can generate grid-based hazard maps, and the R4SA control system uses these inputs for sensor-based navigation, including static obstacle avoidance and dynamic target tracking [48]. The team integrated these systems on a number of unmanned surface vehicles and provided experimental results for a vision-based integrated navigation system. In 2009, the Trident's unmanned surface vehicle was tested in the James River Basin.

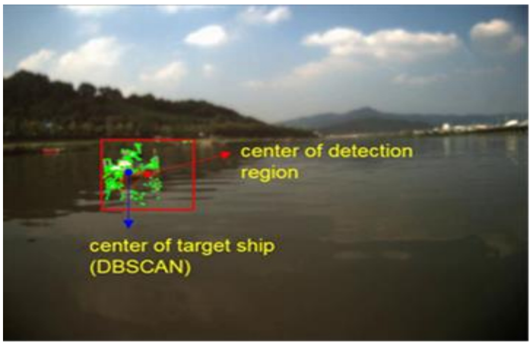

Figure 21. shows the detection result of the detection area and the center point of the DBSCAN.

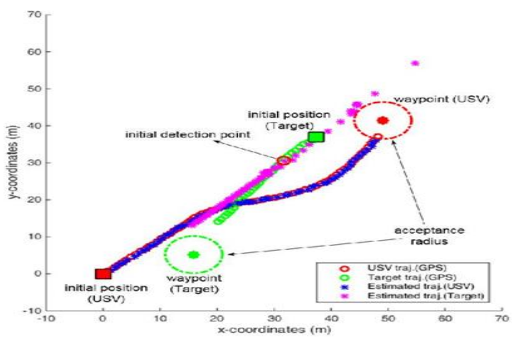

Figure 22. Field experiment results based on visual collisions

The use of visual information to detect inbound vessels at port terminals is also conducive to the development of unmanned surface vehicles sensing systems. Domenico Bloisi of the Department of Computer and Systems Science at the University of Rome presented an autonomous maritime surveillance system [49]. Vessels are inspected by the Haar classifier to obtain different sizes of

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moving targets on the surface of the water, as well as to park stationary vessels near the coast. The unmanned surface vehicles test proves that the method can achieve target detection under different lighting conditions and different positions of the camera. The system is able to provide users with AIS data and add a global view of the visual dimensions. Figure 23 shows the orientation information of the unmanned surface vehicles and the target in the experiment. Tests have shown that the detection method can maintain a speed of 10 fps. The future work is to complete the evaluation of the entire system and add IR data to the data fusion solution to further improve the performance of the system.

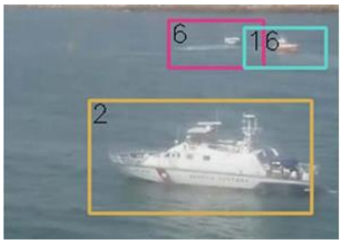
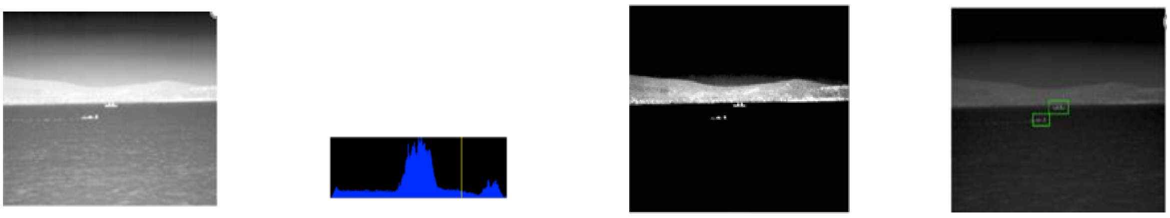


Figure 23. detects the surface vessel

Figure 24. Geographic projection and VTS track. The camera (+) is located in the center of the port

Andrea Sorbara of the Institute of Intelligent Automation Systems of Italy proposed a sensor design for obstacle detection in the marine environment of unmanned surface vehicles. The sensor combines passive and active optics, and Based on the new concept of optoelectronic systems [50], it is designed to be easily installed on small and medium-sized USVs. Its innovation lies in the integration of different sensors, and through the detection steps of Figure 25, demonstrates the ability to detect and identify outstandingly. It has been proved by experiments that the scheme can ensure the navigation accuracy of the unmanned surface of the water surface and the effectiveness of collision avoidance. The unmanned surface vehicle successfully escaped the obstacles detected by the collision avoidance system.



(a) (b) (c) (d)

Figure 25. Test System Flow. (a) original image; (b) Histogram obtained with dynamic threshold; System Analysis Results; (d) System Analysis Results

The use of optical vision to obtain the target position and motion information of the unmanned surface vehicles is a necessary condition for the unmanned surface vehicles to autonomously navigate and safely avoid obstacles, which is beneficial to the intelligentization of the unmanned surface vehicles. At present, the main methods are frame difference method, optical flow field method and background subtraction, and improvements in these three methods. The main problems are the target feature robustness and computational complexity. The robustness of target detection is mainly affected by apparent differences within classes and apparent differences between classes. Large intra-class apparent differences and small differences between classes usually lead to reduced robustness of target detection methods [51,52]. The difficulty is that the target can appear anywhere in the image, the target has a variety of sizes and the target can have a variety of different shapes. The

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computational complexity of target detection mainly depends on the number of target categories to be detected, the dimensions of the category's apparent descriptors, and the acquisition of a large number of tagged data. Due to the rise of deep learning, the trend of target detection is to adopt the method of deep learning. This method relies on the accumulation of a large amount of training data in the early stage, and the lack of real data for the actual offshore scene of the unmanned surface vehicles, resulting in a model with insufficient training data can not achieve the performance of high-precision detection.

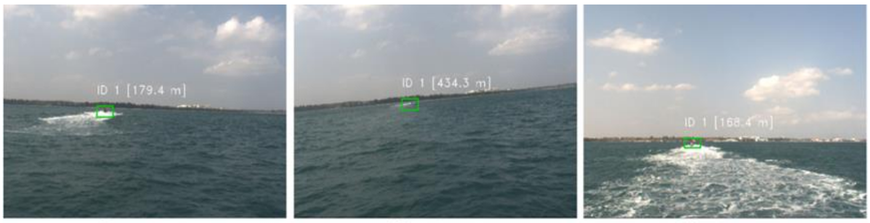
5 surface motion target tracking

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 [53]. 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. The following are some of the main challenges in surface tracking: (1) occlusion is one of the most common challenges in surface tracking, and occlusion is divided into partial occlusion and full occlusion. There are usually two ways to solve partial occlusion: use the detection mechanism to determine whether the target is occluded; divide the target into multiple blocks, and use the block that is not occluded for effective tracking. (2) Deformation is also a major problem in the tracking of surface targets. The shape of the surface moving target is constantly changing, which usually causes the tracking to drift. A common way to solve drift problems is to update the apparent model of the target. (3) Multi-target interference refers to the fact that there are very similar targets around the surface target to be tracked that cause interference to the tracking. Commonly used to solve such problems is the data trajectory, the general trajectory of the prediction motion or the use of a large number of sample frames around the target to update the classifier. (4) Scale change is a phenomenon in which the scale of the water surface is changed from far and near or from near to far. The size of the target frame is also a challenge in target tracking. Of course, in addition to the above common challenges, there are other challenging factors: lighting, low resolution, motion blur, fast motion, beyond view, rotation, and so on. All of these challenge factors together determine that surface tracking is an extremely complex task.

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 [54]. 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 FIG. 26. The Korea Marine Robotics and Intelligent Mechanical

Engineering Laboratory Eternal Hall uses a monocular camera mounted on an unmanned surface vehicle to perform accurate measurement and autonomous tracking of surface ship distances [55]. Automatic extraction of target features and tracking filtering algorithms for visual detection and real-time tracking. This information is transmitted to the target tracking system by computer vision to obtain the position and range information of the target relative to the ship. The distance between the obtained camera and the target is used to further calculate the exact distance between the two, and the detection servo program is designed to improve the observability of the target tracking filter. The feasibility and performance of the scheme were verified by two offshore unmanned surface vehicles.

Ran Gladstone et al. [56] 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 28 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.



(a) Video #1 (b) Video #1 (c) Video #2

Figure 27. shows the results of testing and tracking challenging frames

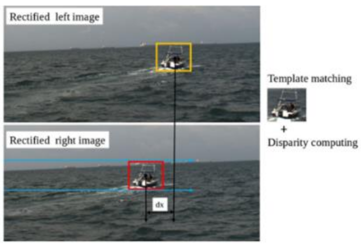


Figure 26. Template matching for target distance estimation

Figure 28. Water Antenna and Target Detection

Serdar Cakır and others at the University of Adollo used a feature selection and evaluation mechanism to achieve accurate tracking of surface targets. The performance of the feature set is compared using a support vector machine, and those feature sets that yield the highest detection performance are used in the covariance-based tracker [57]. It is observed that the proposed tracking scheme is capable of tracking sea surface targets with reasonable accuracy, and the results show that the gradient-based features are along with various position and intensity values. The performance of the proposed tracking strategy is also compared with some well-known trackers, including correlation Kanade-Lucas-Tomasi features and trackers based on scale-invariant feature transforms.

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Experimental results and observations show that the proposed target tracking scheme is superior to other trackers in maritime surveillance scenarios.

There are also research institutes that apply new information fusion methods to surface target detection and tracking tasks, mainly based on fusion of vision and lidar or integration of vision and GPS. Nanyang Technological University Xiao Zhengmo et al. [58] proposed a method based on stereo vision for static obstacles in unmanned surface vehicles. In this system, the monocular camera is integrated with GPS and compass information. The proposed method avoids the complicated calibration work and huge equipment layout problems in the previous binocular stereo perception system, and can obtain more through the USV movement. The baseline is thus increased by 500 to 1000 meters, as shown by the straight line in Figure 29. The actual position of the detected static obstacle is reconstructed while the USV is traveling, and then the obstacle map model is constructed, and the final reconstruction result is synthesized by multi-frame weighting. Tests were performed on the test data set. Figure 31 is a flow chart of the obstacles in the test. The results demonstrate the practicability of the system. D. Hermann ∗ R of the Technical University of Denmark directly combines radar and visual information to develop a target tracking system for high-speed unmanned surface vehicles that can be used for unmanned surface vehicles operating at 30 m/s [59]. Since the detection distance of the laser radar is closer than that of the monocular camera, the detection distance of this method is closer than that of Xiao Zhengmo's method, and the obstacle can only be detected in real time within the range of 175 meters. The obstacle detection process is shown in Figure 30. The attitude-based statistical measurement helps to further reduce clutter, and the computer vision level detector can achieve highly accurate attitude estimation. The position and attitude estimation based on Kalman filter is designed and implemented, and the sea wave interference can be minimized to accurately track the moving target trajectory.

Figure 29. ORB feature detection, tracking and matching

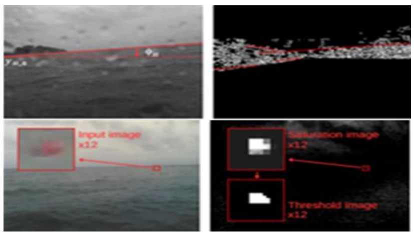

Figure 30. Obstacle detection steps

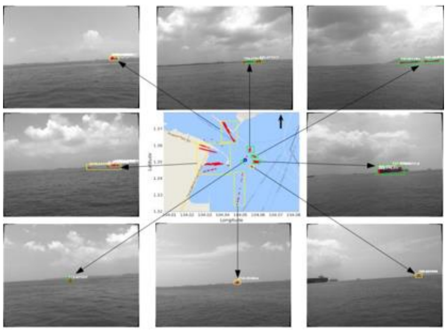

Figure 31. The straight line in the image is connected to the obstacle map (middle) produced by the USV (Seq-3)

Zhang Xiangli of Shanghai Jiaotong University proposed a new radar clustering method for the tracking of unmanned surface vehicles on surface ships. In the process of integrating the data from cameras and radars to identify and track vessels in lakes [60], namely in Figure 32 The spatial angle

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based clustering method is shown. After the target verification, the Kalman filter is used for target tracking in Lidar. Experimental results from the test data set extracted from the real outdoor lake view show that the fusion method has a higher true positive rate in ship detection and classification. And the false positive rate is lower, and the fusion result is more reliable than the result provided by a single sensor. The unmanned surface vehicles test results show that the accuracy of fusion radar and vision is 95.68%, and the false positive rate is 2.25%.

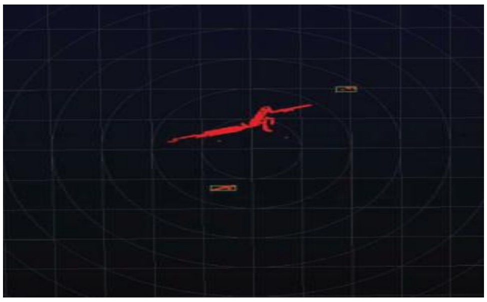

Figure 32. Ship detection results based on spatial angle clustering method

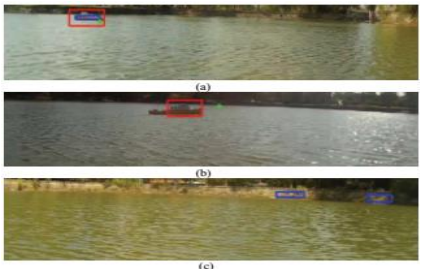

Figure 33. Target detection results after information fusion

Tracking the target of interest by the s unmanned surface vehicles is an important task that the unmanned surface vehicles need to perform, but the target tracking is required to perform surface image preprocessing and target detection and identification. The former removes the interference information and maximizes the retention of useful details; the latter is to detect the target of interest and to track the selected target for the target. Unmanned surface vehicles can carry a variety of sensors, the mainstream is the camera and laser radar, and now the methods are based on visual target tracking, target tracking based on visual information and lidar information fusion or target tracking based on different kinds of sensor information[61-66]. Therefore, multi-sensor information fusion is a trend to detect and track water surface targets, and is an important solution to improve tracking performance under all weather. However, how to achieve true information fusion and ensure long-term accurate detection and tracking of the target is a difficult problem. In addition, the sensing device that the unmanned surface vehicles can carry also has infrared, sound detection, etc. How to further integrate multiple types of sensors for target tracking is also faced the problem.

6 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:

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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. The method used by the system must be robust to disturbances such as scene understanding errors, motion-induced image noise, and video detector offsets.

2. The working mode of unmanned and unmanned vehicles is similar, but 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. Based on the data processing and behavior prediction after inputting information by the sensor (camera or radar), the information is classified and classified according to the characteristics of the object ,and the motion trajectory of the moving object is predicted and fed back to the sensing system for correction. And predictions are issues that need to be addressed.

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). The unmanned vehicle is equipped with digital maps and digital sensors to help the unmanned vehicle to identify the specific location and surrounding environment. The sensor will sort the surrounding object information and classify it. The processing software will perform the object according to the size, shape and motion track of the object. Identification ;subsequently, the processing software predicts the trajectory of the moving object; the processing software selects a safe driving speed and driving route for the driverless car. Unmanned and unmanned vehicles work in a similar pattern, but the working environment is more complicated, and the stability requirements of their own systems are higher than those of unmanned vehicles.

The future development of this field should be based on the solution of the above problems. The main development trends are:

1. Multi-professional cross-integration. In fact, unmanned surface vehicles are similar to sensory systems, brain systems, and decision systems. They are a multidisciplinary, multi-disciplinary system. With the maturity of high-tech such as computer, automatic control, information processing, communication and network, power and energy, and new materials, unmanned surface vehicles are showing a comprehensive development trend. Information and judgment in the field of environmental perception can be used as a basis for control and planning, which in turn can assist and correct environmental perception results. Even the source of environmentally aware information is no longer limited to single-direction input. The combination of vision and other sensor information such as radar, underwater acoustics and infrared also opens up new avenues for unmanned surface vehicles environment-aware technology, although there are many studies. The gap, including overcoming the shortcomings of each sensor, provides real-time, accurate and non-redundant context-aware information ,etc., but there is no doubt that the cross-fusion of multi-domain information is a process of information refinement and complementarity, and is informative and The process of verification. In the future, the unmanned surface vehicles system will gradually become an integral part of the system. Its technical system is bound to be the unification of optical vision and other sensing technologies, and it is the cross-integration of environmental perception and control and planning.

2. Further development of modularization, standardization and generalization. The purpose of research and development of unmanned surface vehicles is to replace humans in carrying out various complex and dangerous tasks. Its versatility and high standards determine that unmanned surface vehicles need to work on the diversity and accuracy of functions. This is especially true in the field of environmental perception. The unmanned surface vehicles can intelligently select the appropriate method for normal perceptual detection, and standardization and generalization make the sensing system suitable for various models and tasks.

Modular design enhances the diversity of unmanned surface vehicles sensing functions and allows for different combinations of functions depending on the task. Modularity allows unmanned surface vehicles to assemble a variety of "plug and play" task modules in an hour, enhancing the diversity of functions while speeding up the development process and effectively reducing R&D costs. Such design development features will be in the future. It will also continue to grow. Standardization is used to calibrate the components used in each series of models, and on the basis of meeting the requirements, the product has high precision, stable performance, simple structure, and the connection between modules is as simple as possible. After standardization and modularization, the coordination between the overall and sub-system development units is simplified. The sub-system development unit does not have to wait for the overall space to be reserved and coordinate, and can directly install the structure according to the standard to achieve generalization.

3. Will be highly intelligent. The highly intelligent unmanned surface vehicles will have the following characteristics: First, it has the ability of memory and thinking, that is, it can store the perceived external information and the knowledge generated by thinking, and can use the existing knowledge to analyze the perceived information. Computation, comparison, judgment, association, decision-making; second, learning ability and self-adaptive ability, that is, by perceiving the external environment information, by continuously learning and accumulating knowledge, so that they can adapt to environmental changes; third, they have behavioral decision-making ability, that is, External stimuli respond to form decisions and convey appropriate messages.

Artificial intelligence has relatively mature technology in the field of unmanned surface vehicles control and planning. Israel's "silver marlin" is equipped with "autonomous helmsman system", which is an advanced decision with advanced decision-making ability and adaptive ability. An expert system that automatically adjusts controls for changes in the environment and tasks. In the autonomous maritime navigation system, the United States combines three-dimensional digital imaging, artificial intelligence, and sensor fusion technology to improve the autonomy of unmanned surface crafts when working alone or in collaboration with other platforms. How to introduce artificial intelligence into the unmanned light vision system reasonably, on the basis of ensuring accuracy and stability, improve the understanding of the unmanned surface vehicles on the environment, the ability to identify and track the target, and make the unmanned surface vehicles highly intelligent. It is one of the problems that need to be solved urgently. With the further development of artificial intelligence and the urgent need for the intelligentization of unmanned surface vehicles, this will certainly become a reality.

4. Enhanced restoration studies of water surface images. The working environment and tasks of unmanned surface vehicles require unmanned surface vehicles to work frequently in rain, fog and

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snow. These working environments make the water surface image unclear, the image quality deteriorates, and some key information is lost and damaged. 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. Moreover, to meet the real-time requirements of surface image information acquisition, the image restoration system must meet the requirements of real-time and accuracy.

5. Research on algorithm fusion of traditional perceptual algorithm and deep learning perceptual algorithm. The traditional perceptual algorithm has the characteristics of strong theory, wide application range and high reliability. The perceptual algorithm of deep learning has strong robustness and high accuracy. The traditional algorithm and the deep learning algorithm can be integrated, which can avoid the disadvantages of low robustness, low accuracy and deep learning algorithms requiring a large amount of data and manual labeling, and obtain a sensing framework with the advantages of both algorithms to improve the surface of the water. The ability of the unmanned surface vehicles to sense the environment.

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References

1. Liao Y L , Zhang M J , Wan L , et al. Trajectory tracking control for underactuated unmanned surface vehicles with dynamic uncertainties[J]. Journal of Central South University, 2016, 23(2):370-378.
2. Zeng Wenjing, Wan Lei, Zhang Tiedong, et al. Fast Detection of Sea Line Based on the Visible Characteristics of Marine Images[J]. Acta Optica Sinica, 2012, 32(1):0111001.
3. Campbell S，Naeem W，Irwin G W. A review on improving the autonomy of unmanned surface vehicles through intelligent collision avoidance manoeuvres[J]. Annual Reviews in Control，2012，36(2):267-283.
4. Zheng L， Beetz M， Gedikli S. Visual tracking system for water surface moving targets[C]// International Symposium on Multispectral Image Processing and Pattern Recognition. International Society for Optics and Photonics，2007.
5. Yun G L. Video stabilization based on human visual system[J]. Journal of Electronic Imaging，2014，23(5):053009.
6. Uomori, Kenya, Morimura, Atsushi, Ishii, Hirofumi. Electronic Image Stabilization System for Video Cameras and VCRs[J]. Smpte Journal, 101(2):66-75.
7. Fan Zhang, Xiao-tong Wang, Xiao-gang Xu, & Chang-qing Yang. . Electronic image stabilization algorithm based on fixed-lag smooth filtering. Optoelectronics Letters(04), 74-77.
8. Tian S, Peng Z, Wang N, et al. Aims at moving objects' improvement based on gray projection of algorithm of the electronic image stabilization[C]// 2010.
9. Yantai X , Tao W . A New Horizon Electronic Image Stabilization Algorithm Based on SVM[C]// International Conference on Optoelectronics & Image Processing. IEEE, 2011.
10. Zhong-Li M A , Hui-Feng L I , Jie W , et al. Electronic image stabilization algorithm for high speed surface vehicle vision system[J]. Application Research of Computers, 2014.
11. Dai L , Liu X , Zhao Y , et al. An improved algorithm applied to electronic image stabilization based on SIFT[J]. Proceedings of SPIE - The International Society for Optical Engineering, 2012.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 November 2019

12. Morimoto，C.，and R. Chellappa. "Fast electronic digital image tabilization." International Conference on Pattern Recognition IEEE，2002:284.
13. Censi A， Fusiello A， Roberto V. Image Stabilization by Features Tracking[C]// Image Analysis and Processing，1999. Proceedings. International Conference on. IEEE，1999:665-667.
14. Zhong P. Research on methods of motion estimation and compensation in electronic image stabilization technique[J]. Proceedings of SPIE - The International Society for Optical Engineering， 2005.
15. Erturk S， Dennis T J. Image sequence stabilisation based on DFT filtering[J]. IEE Proceedings - Vision Image and Signal Processing，2000，147(2):95-102.
16. Ma Z , Wen J , Hao L , et al. Multi-targets recognition for surface moving platform vision system based on combined features[C]// 2014 IEEE International Conference on Mechatronics and Automation (ICMA). IEEE, 2014.
17. Hong-Ying Z , Hong J , Jing-Wu X . Overview of the electronic image stabilization technology[J]. Optics and Precision Engineering, 2001, 8(3):149-160.
18. WU Di, ZHU Qing-Song. The Latest Research Progress of Image Dehazing[J]. Acta Automatica Sinica, 2015.
19. LEI Qin, SHI Chaojian, CHEN Tingting. Single Sea Image Haze Removal Method Based on Segmentation of Sky Area[J]. Computer Engineering, 2015.
20. Ma Zhongli, Wen Jie, Harbin Engineering University. Single-scale Retinex Sea Fog Removal Algorithm Fused the Edge Information[J]. Journal of Computer-Aided Design & Computer Graphics, 2015, 27(2):217-225.
21. Wen Jie. Research on video image enhancement technology of unmanned boat vision system under sea fog [D]. Harbin Engineering University, 2015.
22. WANG Xiaotonga, GUO Jiaa, JIN Xina,. Maritime Video Image Defogging Method Based on Assisted Signal Empirical Mode Decomposition[J]. Opto-Electronic Engineering, 2013.
23. Wang M，Zhou S. The study of color image defogging based on wavelet transform and single scale retinex[C]// International Symposium on Photoelectronic Detection and Imaging. 2011：81940F.
24. Fattal R. Single image dehazing[C]// ACM，2008：1-9.
25. Shi J. Enhancement MSRCR algorithm of color fog image based on the adaptive scale[C]// Society of Photo-Optical Instrumentation Engineers. Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series，2014：91591B.
26. Jiang C , Jiang H , Zhang C , et al. A New Method of Sea-Sky-Line Detection[C]// Third International Symposium on Intelligent Information Technology & Security Informatics. IEEE, 2010.
27. Bing-Xue W , Yang Y , Yi-Hua H , et al. Sea-sky-line Detection Algorithm Based on Texture Analysis[J]. Infrared Technology, 2013.
28. Kong X , Liu L , Qian Y , et al. Automatic detection of sea-sky horizon line and small targets in maritime infrared imagery[J]. Infrared Physics & Technology, 2016, 76:185-199.
29. Gui Y , Yang X , Zhu X W , et al. Sea-sky-line detection based on phase grouping and gray statistics[J]. Guofang Keji Daxue Xuebao/Journal of National University of Defense Technology, 2011, 33(6):111-115.
30. Bo W , Yu min S , Lei W . A Sea-Sky Line Detection Method for Unmanned Surface Vehicles Based on Gradient Saliency[J]. Sensors, 2016, 16(4):543-.
31. Mou X，Wang H. Global sparsity potentials for obstacle detection from Unmanned Surface Vehicles[C]// International Conference on Image and Vision Computing New Zealand. IEEE，2016：1-6.
32. Ran G，Moshe Y，Barel A，et al. Distance estimation for marine vehicles using a monocular video camera[C]// Signal Processing Conference. IEEE，2016：2405-2409.
33. Guo H，Zhang Y M，Zhou J，et al. A fast and robust vision-based horizon tracking method[C]// International Computer Conference on Wavelet Active Media Technology and Information Processing. IEEE，2016：71-74.
34. Mou X，Shin B S，Wang H. Hierarchical RANSAC for accurate horizon detection[C]// Control and Automation. IEEE，2016：1158-1163.
35. Zeng W J , Wan L , Zhang T D , et al. Fast detection of weak targets in complex sea-sky background[J]. Guangxue Jingmi Gongcheng/Optics and Precision Engineering, 2012, 20(2):403-412.
36. Zeng Wenjing, Wan Lei, Zhang Tiedong, et al. Fast Detection of Sea Line Based on the Visible Characteristics of Marine Images[J]. Acta Optica Sinica, 2012, 32(1):0111001.
37. Li C，Cao Z，Xiao Y，et al. Fast object detection from unmanned surface vehicles via objectness and saliency[C]// Chinese Automation Congress. IEEE，2016：500-505.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 November 2019

38. Li C，Cao Z，Xiao Y，et al. Fast object detection from unmanned surface vehicles via objectness and saliency[C]// Chinese Automation Congress. IEEE，2016：500-505.
39. Li C, Cao Z, Xiao Y, et al. Fast Object Detection from Unmanned Surface Vehicles via Objectness and Saliency[C]. In Chinese Automation Congress (CAC), 2015 (pp. 500-505). IEEE.
40. Mou X，Wang H. Image-Based Maritime Obstacle Detection Using Global Sparsity Potentials[J]. Journal of Information & Communication Convergence Engineering，2016，14(2)：129-135.
41. Wang H，Wei Z，Ow C S，et al. Improvement in real-time obstacle detection system for USV[C]// International Conference on Control Automation Robotics & Vision. IEEE，2012：1317-1322.
42. Shin B S，Mou X，Mou W，et al. Vision-based navigation of an unmanned surface vehicle with object detection and tracking abilities[J]. Machine Vision and Applications， 2017.
43. Wang G , Xie S , Xiumin C , et al. Image Recognition Method of Ships in front of Unmanned Surface Vessel Based on Deep Learning[J]. Ship Engineering, 2018.
44. J Han，J Kim，NS Son，et al. Persistent automatic tracking of multiple surface vessels by fusing radar and lidar. Oceans，2017：1-5.
45. Jian Yanga，Yang Xiaoa，Zhiwen Fangb，Naiwen Zhanga，Li Wangc，Tao Lic. An object detection and tracking system for unmanned surface vehicles [C]. Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series，2017：10-31.
46. Kristan M，Sulic K V，Kovacic S，et al. Fast Image-Based Obstacle Detection From Unmanned Surface Vehicles.[J]. IEEE Trans Cybern，2015，46(3)：641-654.
47. Park J，Cho Y，Yoo B，et al. Autonomous collision avoidance for unmanned surface ships using onboard monocular vision[C]// Oceans. IEEE，2016.
48. Huntsberger T，Aghazarian H，Howard A，et al. Stereo vision–based navigation for autonomous surface vessels[J]. Journal of Field Robotics，2011，28(1)：3-18.
49. Bloisi D Iocchi L， Fiorini M，et al. AUTOMATIC MARITIME SURVEILLANCE WITH VISUAL TARGET DETECTION[C]// International Defense and Homeland Security Simulation Workshop (DHSS)，2011.
50. Sorbara A，Odetti A，Bibuli M，et al. Design of an obstacle detection system for marine autonomous vehicles[C]// Oceans. IEEE，2015.
51. Xuecheng An, Wei Hong, Hua Xia. Research on binocular vision absolute localization method for indoor robots based on natural landmarks[C]// 2015 Chinese Automation Congress (CAC). IEEE, 2015.
52. Kolev D G, Markarian G, Kangin D. Data fusion for unsupervised video object detection, tracking and geo-positioning[C]// 2015.
53. K. Rasool Reddy, K. Hari Priya, N. Neelima. Object Detection and Tracking -- A Survey[C]// 2015 International Conference on Computational Intelligence and Communication Networks (CICN). IEEE, 2015.
54. Sinisterra A J，Dhanak M R，Ellenrieder K V. Stereovision-based target tracking system for USV operations[J]. Ocean Engineering，2017，133：197-214.
55. Cho Y， Park J， Kang M， et al. Autonomous detection and tracking of a surface ship using onboard monocular vision[C]//International Conference on Ubiquitous Robots and Ambient Intelligence. IEEE，2015：26-31.
56. G Ran，Y Moshe，A Barel，E Shenhav. Distance Estimation for Marine Vehicles Using a Monocular Video Camera[C]//gnal ProcessingConference，2016：2405-2409.
57. Cakir S，Aytac T，Yildirim A，et al. Classifier-based offline feature selection and evaluation for visual tracking of sea-surface and aerial targets[J]. Optical Engineering, 2011, 50(10): 107205.
58. X Mou，H Wang，et al.Wide-Baseline Stereo-Based Obstacle Mapping for Unmanned Surface Vehicles[J]. Sensors，2018，18 (4).
59. Hermann D， Galeazzi R， Andersen J C， et al. Smart Sensor Based Obstacle Detection for High-Speed Unmanned Surface Vehicle[C]// Ifac Conference on Manoeuvring and Control of Marine Craft，2015.
60. Zhang X，Wang H，Cheng W. Vessel detection and classification fusing radar and vision data[C]// Seventh International Conference on Information Science and Technology. IEEE， 2017：474-479.
61. J Han，J Kim，NS Son，et al. Persistent automatic tracking of multiple surface vessels by fusing radar and lidar[J]//IEEE Oceans，2017：1-5.
62. Soltan R A， Ashrafiuon H， Muske K R. ODE-based obstacle avoidance and trajectory planning for unmanned surface vessels[J]. Robotica， 2011， 29(5):691-703.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 November 2019

63. Ru-jian Yan, Shuo Pang, Han-bing Sun,. Development and Missions of Unmanned Surface Vehicle[J]. Journal of Marine Science & Application, 9(4):451-457.
64. Chen Y, Chen X, Zhu J, et al. Development of an Autonomous Unmanned Surface Vehicle with Object Detection Using Deep Learning[C]//IECON 2018-44th Annual Conference of the IEEE Industrial Electronics Society. IEEE, 2018: 5636-5641.
65. Shin Kamada, Takumi Ichimura. An Object Detection by using Adaptive Structural Learning of Deep Belief Network[C]// 2019 International Joint Conference on Neural Networks (IJCNN). 2019.
66. Nilsson N J. Principle of artificial intelligence[J]. Intelligent Systems IEEE， 1982， 29(2):2 - 4.