Application of UAV Cluster in Sea Rescue

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Abstract

At present, China's sea transportation develops rapidly, the scale is huge, and the rescue work cannot be ignored. Maritime rescue mainly focuses on personnel search and rescue, materials transportation, personnel transportation and other work. Due to the influence of hydrological conditions and wind direction, the scope of search and rescue has been expanded, and the workload of search and rescue has increased. At this stage, due to the characteristics of helicopters and rescue ships, there are certain technical shortcomings. This paper analyzes the basic situation of Marine rescue by analyzing the statistical data of Marine rescue, combined with some cases of Marine rescue operations in the current stage, and explores the idea of UAV cluster playing a role in carrying out Marine rescue tasks from the aspects of application characteristics, technical advantages and cost control.

Keywords

1. INTRODUCTION

With the rapid and efficient development of China's economy, the deepening of the Belt and Road cooperation, the continuous development and improvement of transportation and infrastructure, and the rapid development of maritime transport industry, in 2023, seven ports in China entered the world's top 10 in throughput. Waterway freight volume reached 9.367 billion tons, and the total cargo transported reached 55.7 billion tons, an increase of 8.1 percent over the previous year. The freight transportation turnover was 24,7713 billion tonne-kilometers, up 6.3 percent. Ports handled 17 billion tons of cargo, up 8.2 percent over the previous year, of which 5 billion tons of foreign trade cargo was handled, up 9.5 percent. The port's container throughput was 310.34 million TEUs, up 4.9 percent[1]. In recent years, with the continuous growth of China's foreign trade volume and the continuous development of waterway transport, especially maritime transport, there has been a trend of multiple maritime rescue work, and the situations faced in the rescue process have become more complicated. The former tasks involve many places at home and abroad, and the risks and challenges faced by maritime rescue have further increased in the process of protecting people's lives and property.

2. ANALYSIS OF TRAFFIC ACCIDENTS OF MARITIME TRANSPORT VESSELS

According to the Statistical Bulletin on the Development of the transport industry, there were 103 water traffic accidents (grade accidents) of transport vessels in 2022, down 20.2 percent from the previous year, with 88 people dead and missing, down 42.5 percent, and 33 shipwrecks, down 28.3 percent[2]. Maritime search and rescue centers at all levels organized and coordinated 1,588 search and rescue operations, and successfully searched 969 ships and 9,748 people in distress in China's search and rescue areas of responsibility.

According to the China Maritime Search and Rescue Center, in November 2023, maritime search and rescue centers at all levels organized and coordinated 124 search and rescue operations, and coordinated and dispatched 549 search and rescue vessels and 23 aircraft sorties. A total of 90 ships and 920 people were searched and rescued, 903 of whom were rescued. The success rate was 98.2 percent. From the nature of the distress analysis. There were 34 cases of injury and illness, accounting for 27.4% of the total; 22 cases of ship aircraft damage, accounting for 17.7 percent of the total; 9 cases of ship grounding, accounting for 7.3% of the total; 8 cases of ship collision, accounting for 6.5 percent; And seven cases of ship self-sinking, accounting for 5.6 percent. In December 2023, China's maritime search and rescue centers at all levels organized and coordinated 126 search and rescue operations, sending 1,343 search and rescue ships and 16 aircraft sorties. A total of 97 ships and 1,334 people were searched and rescued, of whom 1,293 were rescued, with a success rate of 96.9 percent. From the nature of the distress analysis. There were 23 cases of injury and illness, accounting for 18.3% of the total; There were 21 accidents of ship aircraft damage, accounting for 16.7% of the total; 11 cases of ship grounding, accounting for 8.7% of the total; 16 cases of ship collision, 12.7 percent; Nine were self-sinking, accounting for 7.1 percent, and seven were fire and explosion, accounting for 5.6 percent.

Marine rescue mainly focused on personnel search and rescue, material and personnel transportation after hazardous chemical leakage, fire, explosion, reef collision, self-sinking and other Marine accidents. People's life safety is the first[3] priority in rescue work, and the fatality rate of people falling into the water is the highest after the occurrence of dangerous accidents. Therefore, Marine search is an important part of Marine rescue. Due to the difficult to predict meteorological and hydrological conditions at sea, it is difficult to accurately judge the point where people fall into the water, resulting in expanded search and rescue scope and increased workload. Even if the probability of survival is not high after a maritime disaster, the search work will continue for a period of time out of humanitarian reasons. Helicopters and rescue ships are the main vehicles of search and rescue at present, which have some inherent shortcomings in use. Helicopters have strong maneuverability and high search efficiency, but rescue helicopters do not have the ability to sail at night. Although rescue ships can meet the search and rescue tasks under bad sea conditions, it is not only difficult to carry out boarding search and rescue or towing operations by forcing close to shipwrecks, which will affect the overall work progress. It is also very easy to produce operational accidents, leading to the occurrence of secondary disasters[4]. The crew can only rely on limited means such as radar and visual search. Rescue ships and search and rescue helicopters carry out personnel search and rescue work for a long time, and fuel consumption is huge. At present, the main professional rescue ships consume about 20 tons of fuel a day. Long-term search and rescue work will also lead to fatigue of rescue workers, and it is difficult to maintain attention and vigilance.

3. THE APPLICATION OF UAV TECHNOLOGY TO MARITIME RESCUE ADVANTAGES

Compared with rescue ships and helicopters, UAV has good mobility performance, better cost control, low take-off and landing environment requirements, accurate line control, more friendly to personnel environment, and more efficient and accurate water target positioning. As a supplement to existing equipment, it can further extend the sensing range and improve the selectivity and adaptation of equipment used in different mission backgrounds. At the same time, with the development of UAV auxiliary equipment[5], positioning technology, target recognition equipment, communication technology and control automation technology, the success rate of UAV search can be further improved. With the development of technology, the expandable functional modules of UAV are also increasing, and the functional modules such as

panoramic camera, infrared sensing and Beidou can further improve the effectiveness of search and the success rate of rescue. The speed performance of small UAVs is closely related to factors such as design, structure, quality and battery. Common small drones have a speed between 20-100km/h, and some high-end models can even reach speeds of more than 200km/h[6]. However, the actual speed performance of small and medium-sized UAVs is affected by many factors, such as wind speed, flight altitude, battery power, load weight and so on. Flight control system technology, automatic return, obstacle avoidance, following, gesture control, etc. With the development of maritime rescue technologies, unmanned ships are expected to be put into use on a large scale, with good maneuverability and flexible steering. They can keep from turning over in strong winds and waves and under rapid steering conditions, and can also be turned back by momentum wheel swing after turning over due to force majeure. The drone and the unmanned ship can communicate through transparent transmission, and the transmission distance can reach up to 500m[7].

Figure 1. Unmanned aerial vehicles seeking assistance at sea

Figure 2. Emergency supplies delivery

Uavs are used in maritime rescue to transport emergency supplies, restore communication support, scout rescue areas, aerial reconnaissance, and assist decision-making. With the help of high-power zoom lens, UAV can overcome geographical and natural environmental restrictions, and with the help of high-altitude perspective of UAV, arrive at key areas to view all-round images of the disaster scene, in-depth annotation, two-dimensional and three-dimensional modeling of key areas, to ensure that the headquarters grasp the scene images and monitor the development of the situation in the first time. In the process of rescue at sea, drones can be used as pioneers in special areas, and some people are equipped with detection and perception tentacles. At present, the maximum load of unmanned aerial vehicles can reach 120 kilograms, and the technology of unmanned aerial vehicles is expected to be realized[8].

Emergency communication support. In maritime rescue, heavy rain and strong winds may interrupt the communication network, and the rescue site cannot transmit information to the outside. The UAV is equipped with the air communication base station system, which can realize the interconnection of images, voice and data, and comprehensively build an integrated emergency communication support system of "air and earth" to provide emergency communication support for the rescue area.

Figure 3. Drone situational awareness

Figure 4. Drone cluster operation

24/7 Coordinated rescue. In maritime rescue, drones are used to carry life-saving equipment or relief materials, and realize accurate delivery of relief materials while sending back images in real time. In night rescue, the UAV equipped with thermal imaging lens and voice module can assume important auxiliary roles such as air voice and lighting, and cooperate with the smooth development of night rescue work.

Drone cluster refers to the collective action mode of using multiple and multiple types of drones to complete tasks together. In maritime rescue, drone clusters can play multiple roles to complete tasks such as surveillance, search and rescue, rescue and support. In search and rescue, multiple UAVs can be used to carry out formation search and rescue according to the accident location area and route division, and quickly and accurately obtain the location and status information of the target. In the rescue process, multiple UAVs can be used to carry rescue materials and rescued personnel in coordination, reducing human and material costs.

In the search and rescue process, the high-horsepower search and rescue ship can not reach the aquaculture area, shallow water, hydrologic complex sea area, can be through the drone cluster, on the one hand as a search and rescue force, to find the rescue target, guide the lifeboat to the target sea area to carry out rescue. Compared with the traditional ship dragnet search

and rescue means, the drone cluster as an extension means, can be more comprehensive coverage of the incident area, and further expand the search and rescue radius, compared with the traditional way, the UAV positioning search and rescue has a wide field of vision, high efficiency, all-weather, high mobility advantages[9].

As a communication relay, the use of video real-time transmission function or shout function, as a sensing end tentacle, real-time mission water situation data to assist mission decision deployment, real-time situation awareness of disaster waters, reduce personnel input, reduce unknown risk of rescue. The UAV is equipped with cameras, head and other equipment for scene investigation, real-time scene picture return, provide information to support auxiliary decision-making, enhance the overall perception and control ability of the event, quickly formulate rescue plans, and strive for favorable opportunities for rescue.

Third, as an important material transport carrier, it provides essential materials for trapped people to ensure the life health and stable signs of rescue workers. The situation at sea is more complicated than on the ground, making it difficult to provide supplies and logistics support, and increasing the survival challenge for people in distress.

They are faced with insufficient supplies and physical discomfort. It can rely on the precision control and material carrying ability of drones to accurately deliver life support materials, and improve the material support ability in areas that cannot be reached by ships. In shallow water areas, breeding areas, poor sea conditions and low-temperature waters, rescue boats cannot arrive in time, and it is particularly important to use drones to provide rescue equipment such as life jackets, life rings and life rafts for people falling into the water in time[10].

4. THE APPLICATION OF DRONE CLUSTER IN SEARCH AND RESCUE

The concept of Cluster first appeared in the field of radio communication, and later it was widely used in the field of computer. Cluster refers to a group composed of a number of independent computers interconnected through high-speed network. As a whole system, they provide users with a group of network resources, and a single computer system in the group is the node of the cluster. Uav cluster uses its own airborne UAV to cooperate to complete the same task through algorithm and communication system. Uav rescue based on the idea of cluster has the following advantages and innovations.

The success rate of maritime search and rescue depends on the delineation of the search and rescue area and the efficiencyof the search and rescue[11]. The discovery target of maritime search and rescue is more complicated than that on the ground, and it is also affected by hydrology and wind direction, so it is difficult to determine the search and rescue area. The key to search and rescue is the accuracy and real-time performance of the target recognition algorithm. In terms of target recognition, due to clustering technology and target path planning, appropriate identification technology and path algorithm are conducive to improving the search efficiency. With the development of artificial intelligence technology today, there are three target recognition methods based on cirrocumulus neural network. Including R-CNN, yolo and SSD series [12].

Table 1. Difference between three recognition models

Methods	Identification Accuracy	Recognition speed	Algorithm
R-CNN	high	Off-slow	Two-stage
YOLO	Low	fast	Phase One
SSD	Medium	Moderate	Phase One

Traditional identification methods are difficult to find Marine targets, but machine learning can meet the needs of ocean big data processing. Deep learning and reinforcement learning are used to achieve rapid retrieval and recognition of targets. Night target identification can be carried out by photoelectric pod cold infrared sensors for target detection[13], and the collected infrared data can be processed by ship-based or shore-based to realize night search and rescue identification and human life condition detection.

Many problems in UAV path planning have been explored and studied, which are mainly divided into two aspects: one is to achieve the maximum search coverage area under the limitation of the hardware conditions of the UAV itself; the other is to search for people in distress under the consideration of wind and wave and ship wake current. There are already a variety of algorithms used to achieve the maximum search coverage area of the UAV[14].

At present, according to the situation, the sea search mainly adopts fan search, extended square search, track line search, parallel line scan search and other methods. Due to the inherent advantages of UAV cluster in seaworthiness, target discovery, function expansion and cost control, the target recognition method and search method are adopted[15].

5. CONCLUSION

At present, UAV cluster as a new technology is being used more and more widely. For maritime rescue, ensuring the life safety of the people is the primary task, and the application of UAV as a new technology is not enough. The application of computer algorithm in the path selection of UAV cluster can improve efficiency and increase the success rate of rescue. With the development of UAV technology and the improvement of its performance, it can be combined with more modules, and is expected to make a breakthrough in manned technology, and further improve its application in sea rescue.

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