Research and Design of Search and Rescue System for Search and Rescue Fleet Based on UWB Technology

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Abstract: With the development of the marine economy, ocean search and rescue has attracted more and more attention and research from all over the world. The major problem of marine search and rescue is that one of the key to ocean search and rescue is the need for high reliability, high coverage and high response speed. According to the characteristics of maritime communication, this paper proposes to use UWB technology to design a search and rescue system, relying on the high reliability of UWB and increasing the high coverage rate of the number of positioning tags, so that the search and rescue efficiency of the whole system can be guaranteed, and at the same time through the distressed personnel. Pre-rescue has improved the probability of rescue of the distressed person and enabled the entire search and rescue operation to be successful. At the same time, the search and rescue system proposed in this paper can improve the coverage of the whole system by improving the small fleet vessel, and its expansion can be guaranteed.

1. Introduction

With the development of China's economy and the strategy of "ocean powers", China began to improve the development capacity of marine resources, protect the marine ecology, develop the marine economy, safeguard the rights and interests of the sea, and build a series of measures to strengthen the country. With the development of China's increasingly frequent marine activities, marine accidents are also increasingly frequent, and various marine accidents and natural disasters have brought great harm to China's marine activities. Although all parts of China have raised their emphasis on marine work and have certain rescue measures in the face of various accidents, for the time being, there is still room for improvement and transformation of these measures. Therefore, based on the "water and air amphibious unmanned search and rescue fleet" and UWB technology, this paper designs a practical search and rescue system on the ocean, which can ensure the efficient and comprehensive marine search and rescue work.

2. Characteristics and current status of maritime communication

2.1 Characteristics of maritime communication

Maritime communications mainly provide communication guarantees for maritime emergencies and natural disasters at sea. Different from the communication security on land, maritime communication security usually needs to face many unfavorable conditions, such as the lack of offshore infrastructure, the harsh environment at sea, and the occurrence of maritime incidents. The emergency window is short and the consequences are serious. Maritime communications should have the following characteristics.

First, maritime communications should be relatively reliable and responsive. For contemporary maritime activities, the scope of its activities is the coverage of communications, and the lack of maritime communication conditions also limits the scope of maritime activities. In the process of search and rescue at sea, the communication conditions often determine the search and rescue plan. Therefore, maritime communication requires high reliability, especially in harsh conditions, and

when maritime communication is used for search and rescue, the rapid response of maritime emergency communication will also provide many conveniences for search and rescue.

Second, maritime communication requires technical means and has a wide coverage. Due to the constraints of the maritime environment, maritime communications are dominated by wireless communications, and the maritime environment and scenarios determine the maritime communications means must be diverse. The occurrence of maritime emergency events may cover all areas of the sea, involving the sky, air, sea, submarine, shore and other environments, which requires communication means to cover many different environments, so that maritime activities such as search and rescue can be carried out normally.

Figure 1. Hull formation and communication drill

2.2 Current status of marine search and rescue

The 21st century is the ocean century. With the continuous growth of marine shipping business at home and abroad, various natural and man-made marine dangerous accidents have gradually occurred, including ships, facilities, collisions at sea, fires, stranding, sinking, including oil. The chemical leaks, or the ship is overturned due to the weather, such as heavy winds and heavy fog. According to the ILO's Fisheries Safety and Health Report, about 100,000 people worldwide have been killed in various shipwrecks, and 80 out of every 100,000 fishermen die each year from various shipwrecks. The importance of marine search and rescue. Water rescue includes maritime water rescue, flood disaster rescue, and other water rescue. The content covers detection, information collection, water emergency rescue command, material supply and rescue programs.

China is a big shipping country. In recent years, China’s investment in maritime search and rescue forces has gradually increased, which has greatly improved the ability of maritime search and rescue. However, on the one hand, there is still a certain gap from developed countries.

First of all, at present, China's professional rescue ships are relatively aging, and the comprehensive sea rescue capability and system are still not perfect. Under the harsh sea conditions of the COSCO Sea, professional rescue vessels have weaker response capabilities to emergencies such as sea fires. Secondly, the quantity and quality of search and rescue equipment at sea in China cannot meet the demand for rapid rescue under the conditions of heavy wind and waves. Therefore, how to improve the search and rescue capability at sea as soon as possible is a problem we need to face.

Under this circumstance, the most commonly used maritime rescue positioning equipment in China includes: First, the radio signal class, the most common one is EPRIB (emergency positioning indicator). The disadvantage of this type of product is that it is bulky and difficult to carry. Generally, this type of equipment is installed on large ships, such as ocean freighters, and is not suitable for individual distressed personnel. The second is the use of smoke signals, flame signals, signal bombs, seawater dyeing, floating lights and so on. The advantage is that it is simple to use and convenient to

carry, and its disadvantages are also obvious. First, it is impossible to actively inform the search and rescue party of its position, and second, its use is greatly affected by external factors, which is not conducive to the rapid and effective execution of search and rescue.

Figure 2. Australian shipwreck search and rescue team

3. UWB technology features

UWB technology is a new type of wireless communication technology. UWB does not use a carrier, but uses a short energy pulse train and spreads the pulse into a range of frequencies by orthogonal frequency division modulation or direct ordering. Based on this, UWB technology has the following characteristics. One is low cost and low power consumption. UWB technology transmits signals by transmitting nanosecond pulses without RF modulation and demodulation. The system structure is easy to digitize, making UWB lower cost. And because of its small transmission power, low power density, its power consumption is often low. Second, multipath resolution and anti-interference ability are strong. The multipath phenomenon means that the signal is refracted by the obstacle, and the reflection is received by the receiver from different paths, so that the signals on the respective paths are received at different times, and the phase superposition finally causes the original signal to be distorted or generated errors, thereby reducing the communication quality. The UWB signal uses a short-wave pulse with a lower duty cycle. The signal power is concentrated in a short range, and the original signal can be separated from the multipath signal by filtering, thereby improving the anti-interference ability and reducing noise interference. Third, the penetration ability is strong and the positioning is more accurate. The UWB signal contains more low-frequency components and has strong penetrating power, and UWB can realize centimeter-level high-precision positioning in complex environments. 3 Search and rescue system design based on UWB technology

4. Search and rescue system design

4.1 The composition of the UWB positioning system

The composition of the UWB positioning system is mainly divided into three parts, a label, a base station, and a user terminal. The main function of the tag is to transmit a UWB signal of a certain frequency to the surrounding base stations, and determine the distance between the tag and each base station within the range covered by the surrounding base stations, thereby determining the location of the tag. The base station is generally placed within a range that needs to be located, and generally requires three or more base stations. After receiving the UWB signal, the UWB signal transceiving module of the base station converts the signal into data and sends it to the microprocessor for data processing, and then transmits the data to the user terminal. The user terminal processes the data sent by the base station and the microprocessor to display the real-time location information of the tag.

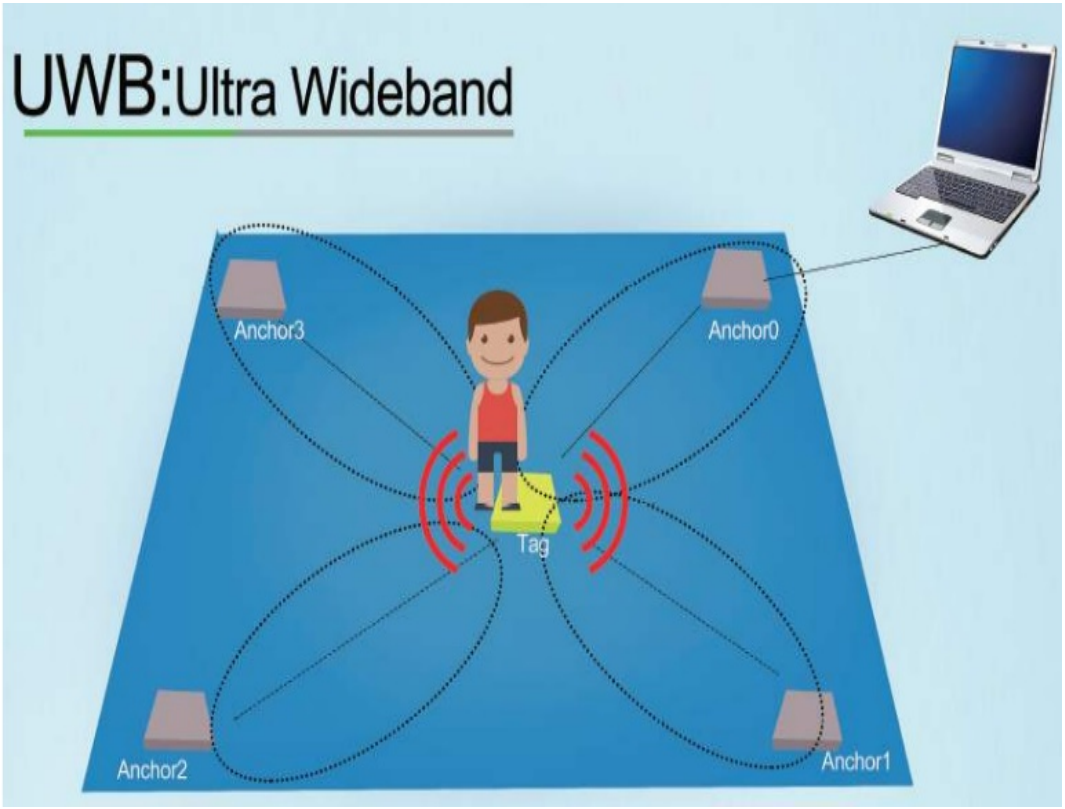

Figure 3. Simple structure of UWB positioning system

4.2 The composition of the UWB positioning system

At present, the commonly used wireless positioning and ranging technologies mainly include: based on the received signal strength (RSSI) method, based on the angle of arrival (AOA) method, based on the signal arrival time method (TOA) and based on the signal arrival time difference (TDOA method). Among them, the TDOA method is currently the most popular method, and the UWB positioning technology is also adopted.

In order to reduce the positioning error caused by the unsynchronized clock between nodes, the relative time is used instead of the absolute time for ranging calculation, which is the basic principle of the TDOA method. The algorithm measures the time difference between the wireless transmission signal from the tag node to each anchor node, so that even if the clocks of the nodes are not synchronized, the result of the positioning ranging is not affected. The positioning process is to first measure the time difference of the radio signal propagation between the positioning tag and the two different positioning base stations by using the wireless transmission signal, thereby obtaining the distance difference between the positioning tag and each group of positioning base stations, and constructing the equations by using the distance difference. Then, the position coordinates of the positioning tag can be obtained by solving the equations by a suitable method.

In three-dimensional space, three coordinates of x, y, and z need to be determined to complete the positioning, so at least three positioning base stations are required for positioning. The equations are as follows:

$$d_{i,12} = \sqrt{(x_1 - x_i)^2 + (y_1 - y_i)^2 + (z_1 - z_i)^2} - \sqrt{(x_2 - x_i)^2 + (y_2 - y_i)^2 + (z_2 - z_i)^2} \quad (1)$$

$$d_{i,23} = \sqrt{(x_2 - x_i)^2 + (y_2 - y_i)^2 + (z_2 - z_i)^2} - \sqrt{(x_3 - x_i)^2 + (y_3 - y_i)^2 + (z_3 - z_i)^2} \quad (2)$$

$$d_{i,31} = \sqrt{(x_3 - x_i)^2 + (y_3 - y_i)^2 + (z_3 - z_i)^2} - \sqrt{(x_1 - x_i)^2 + (y_1 - y_i)^2 + (z_1 - z_i)^2} \quad (3)$$

d_i is the distance difference between the positioning tag and each positioning base station, which can be measured and calculated by UWB technology. The specific coordinates of the positioning tag can be obtained by solving the above three-dimensional one-time equations.

It is worth noting that when the number of positioning base stations is insufficient, three-dimensional positioning cannot be performed, and the number of positioning base stations is larger, and the positioning accuracy is higher.

4.3 Design of Search and Rescue System Based on UWB Positioning Technology

A search and rescue system for the sea area, the most important is two points, one is to quickly and accurately implement search and rescue, to rescue the distress in the most effective time of search and rescue, and the second is to increase the survival of the distress in the first time. The rate is like that the drowning person first throws the lifebuoy and then sends someone to rescue. If the victim can be properly assisted remotely in the sea, it will definitely increase the probability of his final rescue. Therefore, the search and rescue system will design around these two points.

In a search and rescue operation, large-scale search and rescue vessels will release small and medium-sized unmanned vessels with short-term flight functions to quickly reach the area where search and rescue operations are carried out, and the small and medium-sized unmanned vessels will carry simple food. Rescue materials such as drugs, life jackets, etc., and equipped with UWB base station chips and supporting transmission devices. When the small and medium-sized unmanned vessels leave the large search and rescue ship, they will release the sub-small search and rescue fleet. The small search and rescue fleet is equipped with UWB positioning tags, automatic cruise and human body recognition system. The small search and rescue fleet will be automatically in the sea after being released. Inside the carpet search, after a vessel of the small fleet searches for the distressed person, it sends a signal to the nearby small and medium-sized unmanned ship. The nearest unmanned ship will drive to the signal transmission area and send a signal to the large search and rescue ship. Relief supplies are released after reaching the target area.

On the one hand, the system sends a distress signal based on the UWB system, which improves the stability of the system and ensures the smooth communication. On the other hand, when the distress waits for rescue, it provides relief materials for the distressed person and improves the survival rate of the distressed person. At the same time, the system can also improve the specific rescue function in a variety of complex environments by improving the sensors carried on the boat. If the transmission function of the sensor is improved, it still has the proper function of transmitting signals in the polluted sea area.

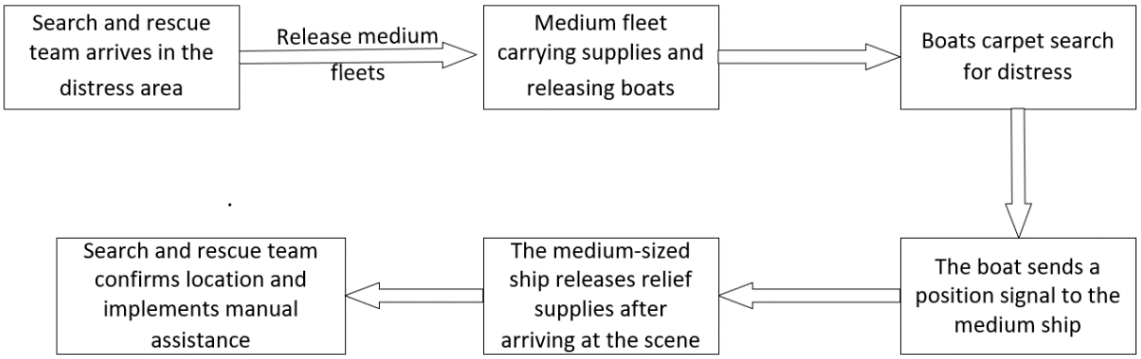

Figure 4. Search system operation flow chart

5. Conclusion

Based on the research on the characteristics of marine communication, the investigation of the status quo of marine search and rescue and the research of UWB positioning module, this paper proposes a search and rescue system based on UWB positioning module. This system has higher stability and higher development than the previous search and rescue mode. Sexual characteristics, and in the implementation of search and rescue, the rescue operation is carried out by providing relief materials to the distressed person to improve the survival rate.

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