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Smart Lifebuoy Based on Unmanned Boat Technology That Can Be Used for Unmanned Rescue in Rivers and Lakes

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Abstract

This paper introduces an intelligent lifebuoy based on unmanned boat technology, which aims to improve the efficiency and reduce the cost of rescue in small waters. The paper first summarizes the development status of unmanned boat technology at home and abroad, emphasizes the technological progress in environmental perception, path planning, obstacle avoidance, and points out the progress in the research and development of unmanned lifeboats in China. In particular, the importance of using unmanned boat technology for rescue in small waters such as inland rivers and lakes is proposed, and the research and development background of the intelligent lifebuoy is introduced, including the drowning problem faced by China and the social demand for such technology. In summary, the intelligent lifebuoy based on unmanned boat technology represents an important innovation in the field of small water rescue. It not only improves the efficiency and safety of rescue, but also reduces the operating costs, providing effective technical support for future emergency rescue.

Keywords

Unmanned ship technology; Intelligent lifebuoy; Innovation.

1. Background

(1)The domestic and foreign research status of unmanned water lifeboats shows significant development trends and application prospects. In recent years, research in this field has mainly focused on the applications of unmanned vessels (USVs) and unmanned aerial vehicles (UAVs), including environmental perception, trajectory planning, obstacle avoidance technology, and homogeneous/heterogeneous autonomous agent formation coordination.

Internationally, the development of unmanned lifeboat technology has received widespread attention, especially in developed countries such as the United States, Britain, and Norway. These countries have made significant progress in unmanned lifeboat technology and formed a relatively complete industrial chain and business model. Domestically, although it started late, with the support of national policies, state-owned and private enterprises have joined the field of unmanned lifeboat research and development and have made significant progress. Unmanned lifeboat technology is developing towards higher precision and intelligence, and communication technology, energy management and endurance technology are also constantly improving. Overall, the research and application of unmanned lifeboats on water are in a stage of rapid development, showing broad prospects both at the technical level and in application fields. With the continuous advancement of technology and the expansion of application fields, unmanned water lifeboats will play an important role in future emergency rescue, marine resource exploration, maritime transportation and other fields. The above research mainly focuses on the sea. However, in inland lakes, there is still very little research on the application of unmanned ships for rescue and other related aspects. Moreover, the operation cost of unmanned ships in small waters is high and complicated. Therefore, this team plans to create a system based on Smart lifebuoy with unmanned ship technology.

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In recent years, the drowning problem in China has attracted widespread attention. As the summer vacation approaches and the weather gets hotter, swimming in the river or the sea has become a choice for many people to cool down. However, they do not know that danger is approaching quietly under this behavior. According to incomplete statistics from the National Health Commission and the Ministry of Public Security, about 59,000 people die from drowning in my country every year, of which minors account for more than 95%. The proportion of deaths among young people due to drowning is also increasing year by year. The whole society has a common responsibility to prevent drowning incidents. This includes raising public awareness of the dangers of drowning, strengthening education on swimming and water safety, and improving supervision and facilities for water activities.

Therefore, the smart life buoy was born. The smart life buoy can save people autonomously without the need for staff operation. It can detect the drowning person and send out information reminders in a short time after falling into the water, which greatly increases the chance of rescue of the drowning person and can better prevent the loss of the best rescue time due to time shortage. At the same time, it can also reduce labor costs, be faster and more efficient, especially in large lakes like West Lake. The emergence of smart life buoys is of great significance to the safety of drowning people. Therefore, our team plans to make a smart life buoy based on unmanned boat technology.

(2)This paper uses STM32F4xx series microcontrollers, DSP control systems, various specifications of motors and steering gears, various specifications of LCD display screens and other related professional technologies. In addition, the team members and instructors have a certain application foundation in unmanned ship related technologies, the application of GPS positioning systems and inertial navigation systems, the application of wireless communication technology, complete photovoltaic energy storage technology, unmanned driving technology, and the fusion of different sensors.

2. Research objectives and main contents

2.1. Research objectives

This paper studies a smart lifebuoy that can autonomously rescue people in a small area of water and can stay outdoors for a long time.

The machine can perform tasks at any time, including collecting on-site information such as wind speed, flow rate, temperature, etc., automatically searching for drowning people for rescue and transmitting the drowning address back.

2.2. Main content

2.2.1. Solar power generation and energy management system

Based on the structure of unmanned lifeboats on the market, we divide the energy endurance system of the smart lifebuoy made by our team into two major systems: energy collection system and energy management system. Energy collection system: In order to help the country's dual carbon goals and carry out efficient management, the team will use more environmentally friendly and highefficiency monocrystalline silicon (C-SI) solar panels. The solar panels use double-sided PERC (full-screen back passivation technology) and can provide higher power generation in actual applications. On this basis, the maximum power point tracking (MPPT) technology will also be used to improve the energy collection efficiency of solar panels. The incremental derivative method (INC) is used to calculate the incremental derivative of current or voltage to determine the gain direction, so that the solar panels can work at the maximum power point regardless of whether they are in open waters with strong light or in the closed area of indoor swimming pools with weak light. The light receiving area of

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solar panels can also be increased by introducing technologies such as intelligent solar sensor arrays and using concave mirrors to track the sun.

Energy management system: The battery is the energy core of the smart lifebuoy. In order to improve the space utilization of the smart lifebuoy, a lithiumion battery with a smaller size and higher storage capacity will be selected. Lithium-ion batteries can solve the intermittent and unstable power generation problems of solar panels. By storing excess power and releasing it when water rescue is needed, the overall efficiency and power supply stability of the photovoltaic power generation system can be improved. In terms of battery safety, a battery management system (BMS) based on domestic chips ESP32-C3 and LS76920 is designed to realize multi-mode and multi-state data acquisition and control of power batteries, so as to constantly detect the internal parameters of lithium-ion batteries: temperature, power, gas concentration, etc.

2.2.2. Information acquisition and data transmission system

This paper intends to design an information acquisition module based on the stm32 module information acquisition method. It is mainly divided into three parts.Self-independent parts: communication module, acquisition module, and power supply module.

Communication module: There are many ways to complete communication tasks. For the purpose of this study, communication can be used at a long distance: such as park pools, lakes in scenic areas, etc. This project plans to use SIM800C (GPRS) module. GPRS has better coverage, and its transmission speed of 85.6kbps can fully meet the data transmission. It can also be used with mobile phone cards. Using public communication is faster and faster for rescue missions. At the same time, it can be connected to an external real-time clock in the outside world.

(RTC) module controls SIM800C to achieve accuracy and real-time performance. Data acquisition module: converts external information into digital signals or analog signals through some sensors (temperature, flow rate and other sensors), such as temperature, water flow rate, relative position of the boat, etc., and finally transmits them to the controller to complete autonomous control of the hull. It can also be transmitted back to the ground through the communication module to realize real-time monitoring of the boat.

Power supply module: used to control the function and endurance of the system. The built-in lithium battery can achieve a long endurance. At the same time, the photovoltaic charging technology of the boat's overall energy endurance system can make solar charging more environmentally friendly and further extend the module's endurance.

2.2.3. Intelligent lifebuoy control system

To achieve the normal operation, steering and acceleration of the motor in the water, this paper intends to use the PC104 main control board to realize the control of the dual propeller thruster.

PC104: PC104 in embedded control system best meets the requirements of our intelligent lifebuoy. Its size can reduce the space of intelligent lifebuoy. The stack bus mode is also very reliable and can work reliably in complex water environment. Moreover, the adoption of this standard can meet the subsequent additional serial communication port (CAN\RS-232\RS-485) to add digital I/O control and other requirements. Speed control module: In order to have sufficient power, this project plans to use two MMTDC12DP50BL speed control modules. Its speed ratio is 1:80, which can start at low speed with large torque, ensure sufficient power and realize remote start and stop. This speed control module can isolate the control and power supply to avoid interference of low voltage and high current on the control system.

Propeller: In order to improve the maneuverability, speed and steering efficiency of the smart life buoy, This project installs a reversible propeller thruster on each side of the tail of the intelligent lifebuoy, symmetrically. The direction of the smart life buoy is controlled by adjusting the rotation direction and speed of the propellers of the two propellers.

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2.2.4. Hull design

The main body of the intelligent lifebuoy is a semi-enclosed structure, including the lifebuoy main body, power supply, propeller, remote control, wireless receiver, controller and counterweight. The main body of the intelligent lifebuoy includes a first side body and a second side body. The propeller is respectively arranged at the tail end of the first side body and the second side body. The counterweight is respectively arranged at the tail end of the first side body and the second side body. The counterweight is arranged in such a position that the main body of the intelligent lifebuoy automatically adjusts back to the right position when the main body of the lifebuoy is reversely placed in the water. The main body of the intelligent lifebuoy has a pointed U-shaped structure. The cross-sectional area of the first side body and the second side body decreases as the distance to the tail end decreases. The lower surface of the first side body and the second side body has a pointed protrusion. Propellers are used for propulsion. The central axis of the propeller is lower than the middle line of the main body of the intelligent lifebuoy. The central axis of the propeller forms an angle with the middle line of the main body of the intelligent lifebuoy, and the angle is 5 to 22 degrees. The power supply is placed on the first side body and the second side body. The main body of the intelligent lifebuoy is provided with a plurality of handles.

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References

[1] Yang Geng. Application of electrical automation technology in solar power generation [J]. Communications World, 2024, 31 (04): 58-60.

[2] Xu Xiang, Li Jian. Nanjing inland waterway information collection technology based on "unmanned ship + multi-beam" [J]. Water Safety, 2024, (04): 16-18.

[3] Chen Xuekun, Hu Hongjie. Design and implementation of turntable signal processor based on PC104+[J]. Automation and Instrumentation, 2019, 34 (09): 75-78.

[4] Tao Yihan, Du Jialu. Intelligent Collision Avoidance Decision Making and Trajectory Tracking Control for Unmanned Surface Vehicles in Congested Waters[J]. Control and Decision, 1-9.

[5] Chen Shan, Wu Lisha, Zhang Kai, Cheng Yihong, Cheng Yaping, Feng Chi. Design of Large-Scale Electricity Information Collection and Transmission System Based on LoRa Communication[J]. Automation Technology and Applications, 2024, 43 (10): 153-157.