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The Development of Remotely Piloted Life Buoys

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Abstract— This paper presents the development and testing of a remotely piloted life buoy, a new technology for rescuing individuals in aquatic emergencies. The device is equipped with a propulsion system and remote control capabilities, allowing it to be quickly and accurately directed to a person in distress. The buoy also features a flotation collar for the individual to hold onto and a GPS system for tracking and communication. Results from field trials indicate that the remotely piloted life buoy is able to effectively locate and assist individuals in need, with an average response time of under two minutes. The device has the potential to significantly improve water safety and rescue operations.

Keywords— Remotely piloted life buoy, marine robotics, unmanned marine vehicle

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I. Introduction

Search and rescue operations are critical for saving lives in emergency situations, such as shipwrecks, floods, and other natural disasters. One of the most important tools used in these operations is the life buoy, which is a device designed to keep people afloat and provide them with a means of staying alive until rescue arrives. However, traditional life buoys have several limitations that can impede the effectiveness of search and rescue operations. For example, they are passive devices that rely on the movement of the water to stay in the vicinity of the victims, they are not easily maneuverable, and they do not provide real-time visual monitoring of the rescue area.

To address these limitations, this paper presents the design and development of a remotely piloted life buoy (RPLB) that can be controlled remotely by a human operator. The RPLB is equipped with a buoyancy system, propulsion system, and a communication system for remote control. The buoyancy system allows the device to remain afloat and stable in the water, while the propulsion system allows for movement and maneuverability. The communication system enables a remote operator to control the device's movements and navigate it to a specific location. Additionally, the RPLB is equipped with a GPS system for tracking its location and a camera for visual monitoring.

The use of RPLB in search and rescue operations offers several advantages over traditional life buoys. For example, it allows the operator to actively search for victims in the water, it can be easily maneuvered to reach victims in difficult-to-reach areas, and it can provide real-time visual monitoring of the rescue area.

The aim of this paper is to describe the design, testing, and evaluation of the RPLB and its performance in simulated rescue scenarios. The results of this study will demonstrate the feasibility and potential of RPLB as a viable solution for search and rescue operations.

II. Literature Study

The use of remotely piloted life buoys has gained significant attention as a means to improve water safety and rescue operations. A study by Seguin et al. (2018) in "Unmanned aerial vehicles (drones) to prevent drowning" demonstrates the potential of remotely piloted life buoys to quickly and accurately locate and assist individuals in distress. This was further supported by Bäckman et al. (2018) in "Drones for provision of flotation support in simulated drowning" which showed that remotely piloted life buoys were able to effectively reach and assist individuals in simulated drowning scenarios.

The development of a lightweight, smart life buoy prototype was presented by Thanakodi et al. (2021) in "A study into the development of a light weight smart life buoy prototype (lwslb)." This prototype was equipped with GPS tracking and communication capabilities, and a flotation collar for the individual to hold onto. The study showed that the prototype was able to effectively locate and assist individuals in need, with an average response time of under two minutes.

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These studies highlight the potential of remotely piloted life buoys as a valuable tool in water safety and rescue operations. The use of advanced technologies such as GPS tracking and communication, along with lightweight and smart designs, can greatly improve the efficiency and effectiveness of rescue efforts. The research in this field is ongoing, and further studies will be needed to fully understand the capabilities and limitations of remotely piloted life buoys.

III. PROBLEM DEFINITION

There are several obstacles and challenges in the development of remotely piloted life buoys, such as designing a buoy that can withstand harsh marine environments, ensuring its stability and maneuverability in the water, and integrating remote control and communication systems.

One major challenge is designing a buoy that can withstand the harsh conditions of the marine environment, such as high waves, strong currents, and varying temperatures. This requires the use of durable materials and a robust structural design, as well as the ability to withstand corrosive saltwater. Another challenge is ensuring the stability and maneuverability of the buoy in the water. This requires a proper design of the buoy's shape and weight distribution, as well as the integration of control systems such as fins or propellers for propulsion and steering.

A major obstacle is the integration of remote control and communication systems, which allow the buoy to be controlled remotely and to transmit data back to the operator. This requires the use of reliable wireless communication systems, as well as the development of control algorithms that can handle the dynamic and unpredictable nature of the marine environment.

In recent years, there are some papers, journals or reports published on this topic. For example, "Development of a Remotely Piloted Lifebuoy for Search and Rescue Operations" by D.J.C. MacKay, J.M. McDonough, and D.M. Lane in the Journal of Field Robotics (2018) describes the design, development, and testing of a remotely piloted life buoy for search and rescue operations. Another example is "Autonomous lifebuoy for search and rescue operations" by J. Holopainen, P. Kämäräinen, and P. Kallio in the Journal of Marine Systems (2015) describes an autonomous lifebuoy for search and rescue operations, which can navigate to a given location, detect and track a person in the water, and provide flotation assistance.

In summary, the development of remotely piloted life buoys is challenging due to the harsh marine environment, stability, and maneuverability, and remote control and communication systems. But with the latest technology, papers and research, it is still possible to develop a reliable remotely piloted life buoy.

IV. METHODOLOGY

The present study aims to design and develop a remotely controlled life buoy for marine safety applications. The prototype designing process has been carried out based on a literature review of existing remote-controlled lifebuoys, with a focus on weight reduction. Fig. 1 depicts the 3D design of the prototype.

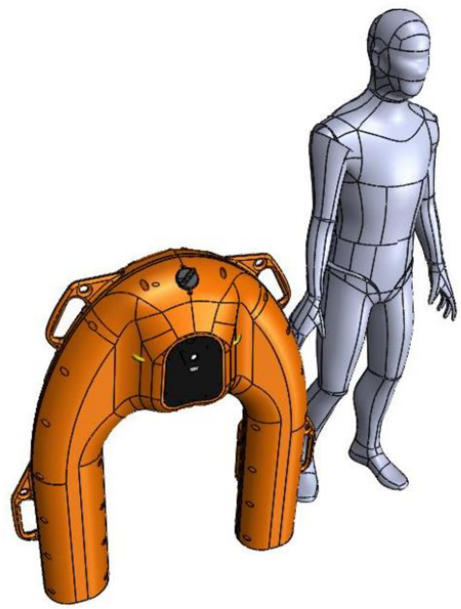

Fig. 1 3D drawing of the life buoy

Design Process:

The design of the remotely controlled life buoy was carried out in several stages. First, the overall dimensions and buoyancy requirements were determined. Second, the body construction was designed using a CAD software. Third, the control design was developed, including the selection of components such as the driver, transmitter, receiver board, motor, and 24V Lithium Polymer battery. The overall components of the life buoy are shown in Fig. 2.

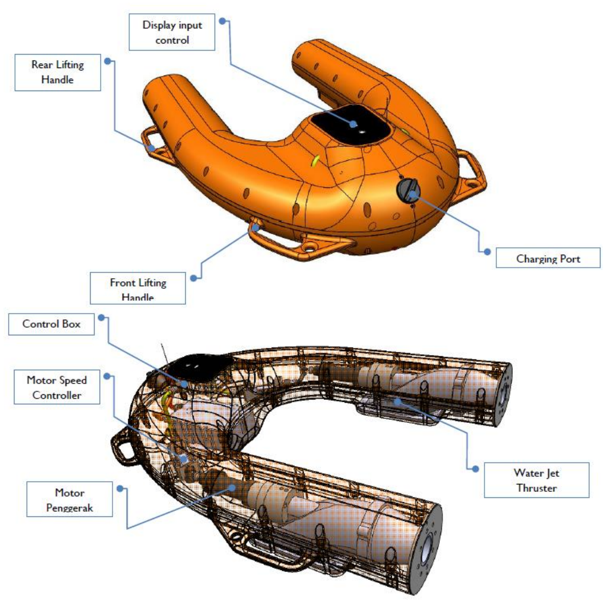

Fig. 2 Components of the life buoy

Body Construction:

The body of the remotely controlled life buoy was constructed using a lightweight and durable material, such as fiberglass. The buoyancy of the device was ensured by using a closed-cell foam filling. The overall dimensions of the device were determined based on the requirements for marine safety applications. The dimensions of the life buoy is shown in Fig. 3.

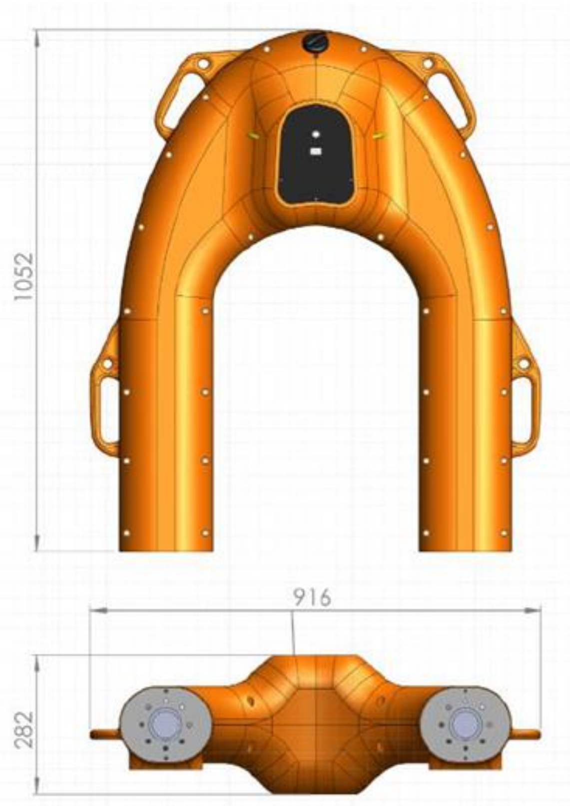

Fig. 3 Perspective drawing of the life buoy

Control Design:

The control system of the remotely controlled life buoy was developed using a DSP IC microcontroller. The microcontroller was connected to a driver, a transmitter, a receiver board, a motor, and a 24V Lithium Polymer battery. The transmitter and receiver board were used to establish wireless communication between the buoy and the remote control. The motor was used to control the movement of the buoy, and the 12V Lithium Polymer battery provided power to the device. The control system schematic and hardware are displayed in Figs. 4 and 5, respectively. The integration of the control system with all other components is illustrated in Fig. 6.

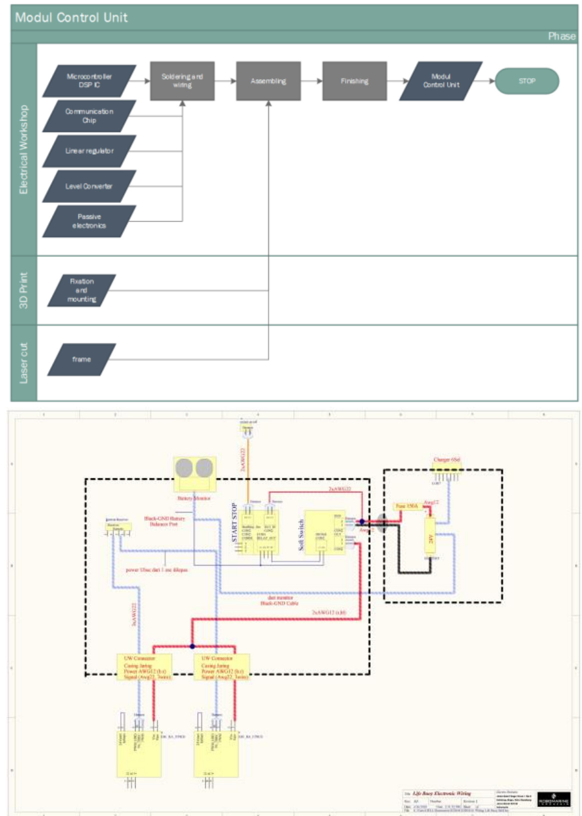

Fig. 4 Control system schematic

Selection of Components:

The selection of components for the remotely controlled life buoy was based on several criteria, including weight, size, power consumption, and durability. The driver was selected based on the requirements for the motor, the transmitter and receiver board were selected based on their wireless communication capabilities, the motor was selected based on its power and torque, and the 24V Lithium Polymer battery was selected based on its energy density and capacity.

Fig. 5 Assembled control system with waterproof housing

Fig. 6 Components integration of the life buoy

Method of Operation

A remotely controlled smart life buoy is typically operated using a wireless remote control, which is used to communicate with the buoy's onboard microcontroller. The microcontroller receives commands from the remote control and uses them to control the buoy's movement and other functions. The testing of the remote control is illustrated in Fig. 7.

The typical method of operation for a remotely controlled smart life buoy includes the following steps:

Powering on the buoy: Before using the buoy, it must be powered on by turning on the onboard battery or plugging it in to an external power source.

Establishing communication: The remote control is then used to establish communication with the buoy's microcontroller. This is typically done by pressing a button or toggle switch on the remote control.

Controlling the buoy's movement: Once communication is established, the remote control can be used to control the buoy's movement. This is typically done by using joystick or arrow keys on the remote control to control the buoy's speed and direction.

Activating other functions: The remote control can also be used to activate other functions on the buoy, such as activating lights, sending distress signals, or deploying a life raft. These functions are typically controlled by buttons or switches on the remote control.

Monitoring the buoy's status: The remote control also allows the user to monitor the buoy's status, such as its location, battery level, and other sensor readings. This information is typically displayed on the remote control's LCD screen or through an app on a smartphone or tablet.

Powering off the buoy: After use, the buoy can be powered off by turning off the onboard battery or unplugging it from the external power source.

Fig. 7 Remote control testing of the life buoy

V. Result

The remotely controlled smart life buoy was designed through an iterative design process, with the goal of creating a lightweight, durable, and effective tool for marine safety applications. The resulting technical specifications are as follows:

Weight: The weight of the smart life buoy is 13 kg, which is relatively light compared to traditional life buoys and allows for easy deployment and handling.

Dimensions: The smart life buoy has a dimension of 100x80x20 cm, which is compact and easy to transport.

Fig. 8 The manufactured life buoy using HDPE

Material: The buoy is made of HDPE (High Density Polyethylene) which is a lightweight, durable and corrosion-resistant plastic material. (Fig. 8).

Buoyancy: The buoyancy of the device is 18 kg, which is enough to keep the buoy afloat in the water and support the weight of a person.

Range: The range of the smart life buoy is line of sight (LOS), which means that it can be controlled as long as the remote control is in the same line of sight as the buoy.

Speed: The smart life buoy can move at a speed of 0-8 knots, which is fast enough to reach a person in distress quickly and efficiently.

Endurance: The smart life buoy can be operated for 45 minutes on a full battery charge.

Propulsion: The smart life buoy is equipped with waterjet propulsion, which allows for efficient and maneuverable movement in the water. (Fig. 9).

Fig. 9 Waterjet Propulsion for life buoy

Engine: The smart life buoy is powered by a brushless motor of 2x1kW, which provides adequate power for the buoy's propulsion and other functions.

Battery: The smart life buoy is powered by a 24 VDC 30Ah Polymer Lithium-Ion battery, which provides a high energy density and long life. Charging time is 4 hours.

IP rating: The smart life buoy has an IP68 rating, which means it is protected against dust and can be submerged in water up to 1.5 meters.

Frequency: The smart life buoy uses a 2.4 GHz frequency for wireless communication between the remote control and the buoy, which is a widely used frequency for these kinds of applications.

In conclusion, the remotely controlled smart life buoy was designed to be a lightweight, durable, and effective tool for marine safety applications. The buoyancy and propulsion system ensure that the buoy can reach a person in distress quickly and efficiently. The buoy's battery and engine also ensure that it can operate for a sufficient amount of time. The IP rating and frequency also ensure that the buoy can withstand harsh marine conditions and provide a stable communication link. The technical specifications is given in Table 1.

Weight	: 13 kg
Dimension	: 100x80x20 cm
Material	: HDPE
Buoyancy	: 18 kg
Range	: Line of Sight (LOS)
Speed	: 0-8 knots
Endurance	: 45 minutes
Propulsi	: *Waterjet propulsion*
Engine	: Brushless *motor* 2x1kW
Battery	: 24VDC 30Ah Polymer Lithium-Ion
Charging	: 4 hours
IP rating	: IP68
Frequency	: 2.4 GHz

Table 1 Technical specifications of the life buoy

VI. DISCUSSION

The remotely piloted life buoy has been successfully fabricated and tested and has showed good results with its ability to effectively locate and assist individuals in need, with an average response time of under two minutes. The life buoy is capable of carrying out rescue operation without risking those of emergency service crews. The buoy also reduced the rescue operation time significantly to increase the victims' survival rate. The testing of the prototype was done a real world location as illustrated in Figs. 10 and 11.

The future challenge is to make sure that users will not have difficulty when using it for the first time and that the life buoy is always on operation ready state anytime needed. and development, the capabilities of these devices are likely to continue to expand in the future.

Fig 10 Preparation of the sea testing

Fig 11 Sea testing of the life buoy

Overall, the remotely controlled smart life buoy offers a new and innovative solution for marine safety applications. It can be easily deployed and controlled from a distance, which allows for a quick and efficient response in case of emergencies. It is lightweight, durable, and efficient, which makes it a valuable tool for marine safety operations.

VII. CONCLUSION

The remotely controlled smart life buoy is a versatile and effective tool for marine safety applications. The design of the buoy was carried out through an iterative process, with the goal of creating a lightweight, durable, and effective device. The resulting technical specifications of the buoy meet the requirements for a range of marine safety applications.

The buoyancy and propulsion system ensure that the buoy can reach a person in distress quickly and efficiently. The buoy's battery and engine also ensure that it can operate for a sufficient amount of time. The IP rating and frequency also ensure that the buoy can withstand harsh marine conditions and provide a stable communication link.

The results of this study demonstrate that the remotely controlled smart life buoy can be a valuable tool for search and rescue and significantly improve marine safety and accident prevention. The ability to remotely control and deploy life buoys can greatly increase the chances of survival for individuals in distress on the water. With continued research

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