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An unmanned device designed for drowning rescue

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Abstract

Prevention and rescue work is considered an urgent and crucial job to ensure the safety and life of people. However, this job contains many unpredictable dangers and difficulties that rescuers encounter during the rescue process due to the lack of timely support equipment. Causing a threat to the safety and life of the victim as well as the rescue force. In this paper, we propose to design a drone to assist in rescue and help people in distress get out of drowning more quickly to increase the chance of survival for people in distress by using unmanned aerial vehicles (drones) to carry a self-pumping buoy. When detecting people drowning, the rescuer can control the drone carrying a buoy to automatically pump out the drowning person's position and release the buoy to the person in distress. Experimental results in a controlled environment show the feasibility of the device in service of rescue work. The device has been tested in specific areas such as football fields, lakes, and open spaces as well as areas with obstacles, and achieved the required results.

Keywords: unmanned device; Drone; Drowning rescue; Self-pumping buoy

1. Introduction

According to the World Health Organization (WHO), over the past decade, drowning has claimed the lives of more than 2.5 million people [1]. Drowning is one of the leading causes of death among children aged 5-14 in the world. More than 90% of drowning cases occur in low- and middle-income countries.[2] It is a huge loss for the country, community, and family. In Vietnam, drowning is one of the top 10 causes of death for children aged 5 to 14 years [3]. Facing that fact, many solutions have been proposed such as ways to prevent drowning accidents, but these solutions have not been effective and drowning accidents are still happening. Faced with the situation, training sessions on water rescue work are still carried out regularly, but the above activities are mainly based on people without the effective support of equipment. Being supported leads to many tragic cases occurring, endangering the lives of the victims and the rescuers, causing great loss to the victims' families and society. Nowadays, the development of science and technology allows people to access and research technologies that serve the needs of human life, in which unmanned transport technology is a trend that has high potential and efficiency.

Today, with the need for digital transformation and a more solidified infrastructure, drones are widely applied to more civil fields. People can use drones to do firefighting tasks, track people left on fires in tall buildings, or search and rescue in difficult terrain. Films shot from above with full HD, 2K, or even 4K resolution, this drone is also used for close purposes such as delivery, spraying pesticides, tracking animals wild, media-supported, or simply hovering in the sky in large numbers to create unique artistic shapes [3]. Research related to unmanned aerial vehicles is focused on solving control and balance problems using Microprocessor Units (MPUs) [4]. Studies [5]-[9] focus on the design and calculation of automatic control techniques on

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In this study, we focus on researching and manufacturing drones with the specific goal of serving rescue work. We focus on designing and building drones based on traditional drone equipment, flight methods, and balance methods, but we will design the frame structure of the device to be more suitable for carrying. and release the self-pumping float, and we will design and manufacture the self-pumping buoy to integrate into the device. With the creation of a drone carrying a self-inflating lifebuoy, the device can quickly bring a lifebuoy to the victim, increasing the chances of survival for the person in distress. The self-inflating lifebuoy on the device is designed to be lightweight so that the drone can be easily carried and move faster and more stable. At the same time, it also helps to reduce the cost of equipment, making it easier for more people to access the device.

The main contributions of this paper are:

- Redesigned drone to suit rescue work,
- Design a system to pump and release lifebuoy during flight,
- Change the control method: based on the available controller, design the control mechanism to pump and release the lifebuoy,
- Flight test and simulate the situation to bring the buoy to the simulated position of inflating and releasing the buoy.

2. Material and methods

2.1. Description of the equipment

In this section, details of the device components will be presented. The drone component carrying the self-pumping float will be designed with a frame suitable for the job requirements. The drone's chassis is designed to be compact and lightweight with the goal of simple and effective installation of flight support devices such as motor speed control circuits, flight balance circuits, sensors, and battery sources. drones can move faster and more efficiently. In addition, the materials selected to make the drone frame are lightweight and durable, meeting the needs of a drone frame. This material also offers high efficiency, is easy to process, and has a low cost. With the requirements set, we chose aluminum as the material to make the drone frame with the total weight after completion of the drone is 1.26 kg, the design and details of the drone's chassis are shown in Figure 1.

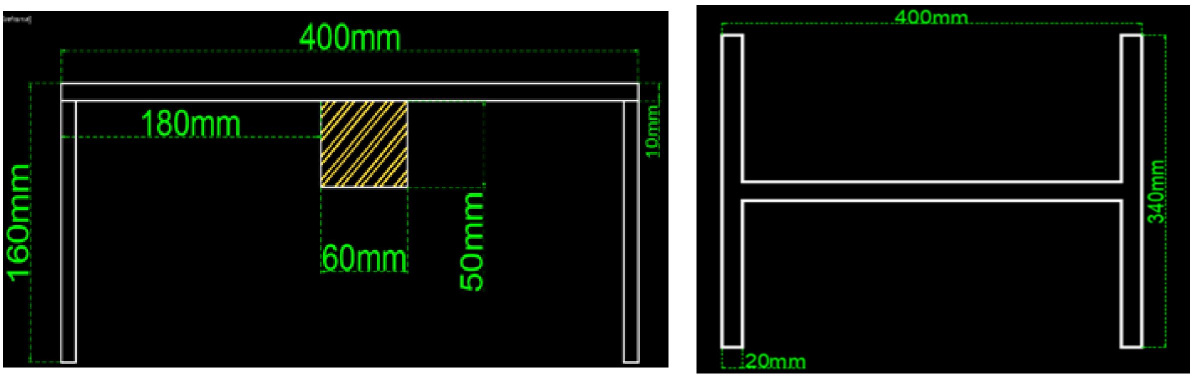

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Figure 1 Drone frame parameter viewed from a) above and b) horizontal

The size of the frame is calculated based on the drone's equipment parameters such as length and width based on the drone's wing length (26cm) in addition to the frame length plus space to install electrical equipment (12cm). The height of the frame is calculated based on the height of the self-pumping buoy (9cm) and adding the distance from the ground in case the drone lands in an uneven position. After designing and calculating the parameters of the frame, we proceed to process and manufacture the frame as the actual image design of the frame is presented as shown in Figure 2.

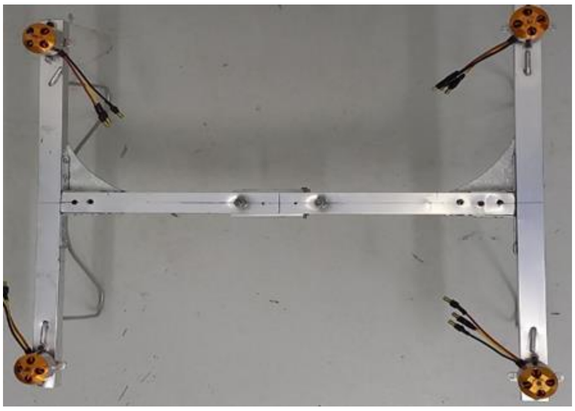

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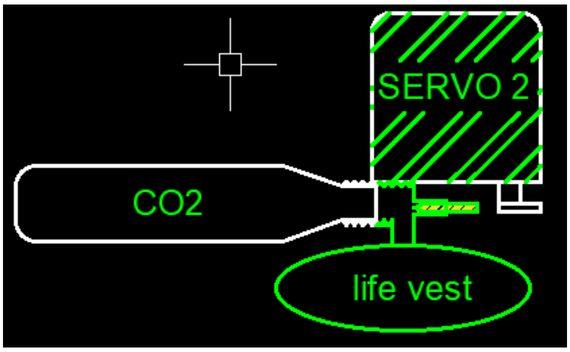
Figure 2 Actual images of the frame and buoy holder viewed from a) above and b) horizontal

2.2. Methodology of design and control buoy pump system

The self-pumping buoy system is one of the two crucial elements of the buoy system. It was a simple yet effectively designed self-inflating float device. The self-pumping buoy has a size of 12cm x 9cm x 7cm, weighs 200g, and the buoy is made up of three main parts: an airbag, a compressed air tank, and a compressed air discharge motor controlled by a microcontroller. The mechanism of operation of the float is quite simple at first, the airbag will have no air and be rolled up to ensure that it does not affect the drone during the move, this is also the main reason for us to design the float. self-pumping. In addition, using a self-inflating float also helps to reduce the cost of making a drone when there is no need to build a drone with too large a size because the device is small and light. The float control mechanism is also designed to be optimal when using devices of the appropriate size, the float is also designed with low energy consumption that does not affect the drone. The float only uses energy when discharging air from the compressed air tank into the airbag. This process only takes place for 5 seconds, before and after the process does not use energy. The actual picture of the float is shown in Figure 3.



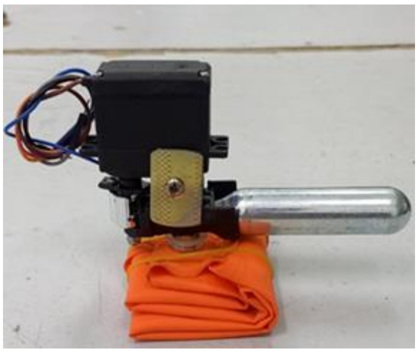


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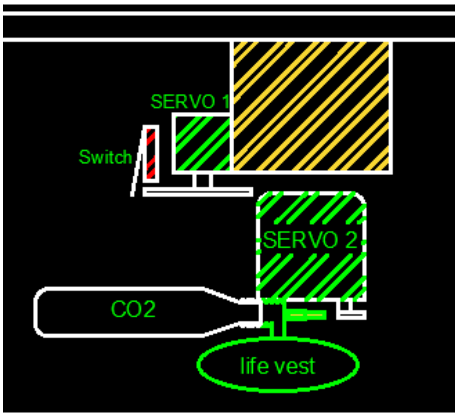
Figure 3 The connection of the components of the float pump system a) diagram; b) real image

In the buoy pump system, there are two main components: the buoy holder and the self-pumping buoy: the buoy holder is made up of a frame containing the float, and a servo motor (servo motor #1) which is controlled by the signal-receiving circuit of the controller. The controller will control the motor to rotate at three different angles corresponding to the three positions of the motor. The buoy holder is also designed with a microcontroller with the task of controlling the servo motor mounted on the self-pumping float; the second component is the self-pumping float, the self-pumping float is composed of a compressed air tank, an air release valve, and a servo motor (servo motor #2). When there is a control signal from the microcontroller, is responsible for discharging compressed air from the compressed air tank through the airbag by opening the air release valve. The design of the float system and the pump system is shown in Figure 4 a). The circuit connection diagram of the automatic pump control system is shown in Figure 4 b).



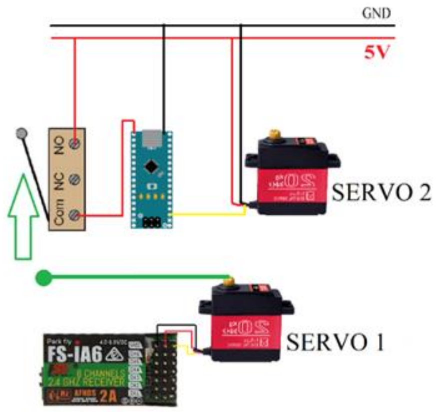


Figure 4 a) The design of the float system and the pump system and b) electronic circuits design

The operation process of the buoy pump system is as follows:

- when servo motor #1 is in the first position, the float is kept on the drone and the pumping process does not take place.
- when servo motor #1 is in the second position, the float is kept on the drone, but currently the normally open contact of the limit switch starts to close to supply power to the microcontroller, Servo motor #2 is active by to the detachable disconnect jack starts to discharge air from the compressed air tank through the airbag (performs the float pumping process).
- when servo motor #1 is in the third position, the buoy will be released to the person in distress (performing the float release process), ending the operation of the float pump system.

To control the drone's flight, we use a common drone controller (shown in Figure 5). In the controller, we use a function channel to perform pump control and float for the device this control channel is connected to a three-contact switch (as shown in Figure 5). When starting the controller, the switch will be in the first position, this is the position to turn off the pump system and release the float. If the switch is pushed to the second position, then the float pump mode will work, after the float is pumped, continue to push the switch to the third position, this is the float release mode, then the float will be dropped into the water.

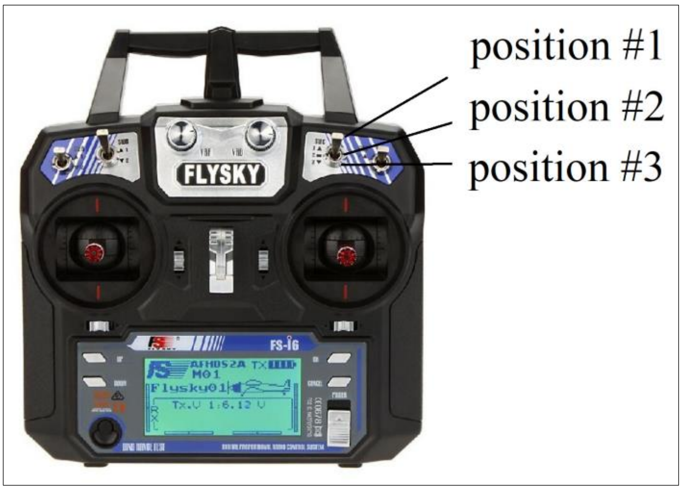


Figure 5 Actual image of the controller used in this study

3. Results and discussions

During the experiment, the components of the device will be tested through several steps. First, the drone will be assembled and then tested, the results show that the drone can fly stably, has good balance, and the ability to receive signals from the controller is good and stable. There is no connection loss. With the light weight of the chassis, the device can fly at high speed and move flexibly according to the wishes of the operator.

The first is tests on self-inflating buoys. Checking that the amount of compressed air in the CO2 tank is sufficient to supply the airbag is performed first. In this test, a 12g CO2 tank is used for testing, the results show that the 12g co2 tank is enough to inflate the air bag. After straining the air bag, we tested the buoyancy of the bag, the results showed that the bag can help a person weighing 70kg float on the water. In addition, the buoyancy's ability to hold compressed air lasts for more than 10 hours. After that, the check of the exhaust engine showed that the engine met the exhaust time when the time to inflate the airbag only took 5 seconds.

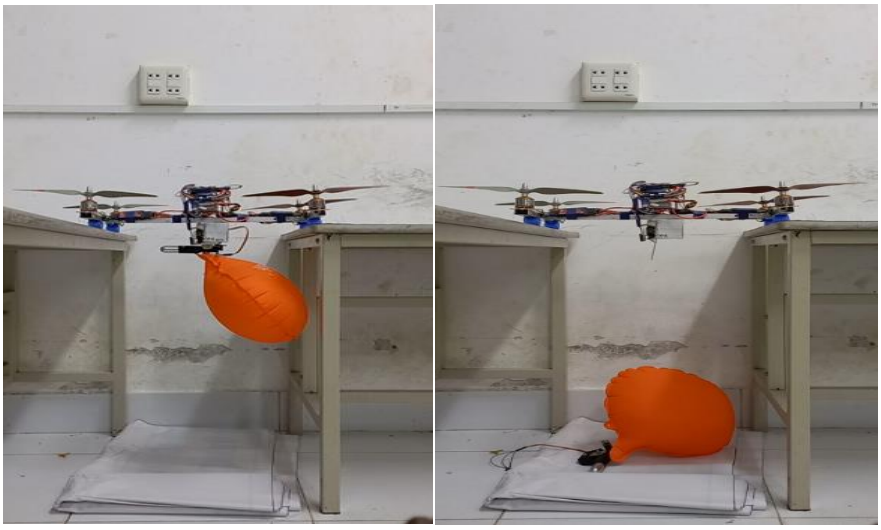


Figure 6 Illustrate the process of self-pumping and releasing the buoy

Table 1 Assessment of the device testing parameters (7-days training rescuer)

Flights	**Flight speed (km/h)**	**Time to identify and hold the position (seconds)**	**Distance to drop buoys off target (cm)**
#1	50	10	60
#2	51	25	55
#3	59	20	58
#4	55	21	60
#5	54	27	50
#6	57	15	55
#7	45	23	58
#8	55	23	65
#9	49	22	68
#10	48	15	63

In this study, we focus on integrating the self-pumping float into the drone to form a complete device. When designing the drone, the flight speed, weight, and carrying capacity are considered. According to the device as well as the way the device is integrated, the flight support modes for the drone such as the ability to keep altitude or position the drone are not prioritized for development in this study. To test the device operation, we have set the criteria for device testing as follows.

- Flight speed: the flight speed of the device is the criterion that determines the time it takes the device to bring the buoy to the person in distress.

- Time to identify and hold the position: as mentioned above, the device is not equipped with many supporting features, determining the location to release the buoy will affect the time the person in distress receives the buoy.
- Distance to drop buoys off target: during operation time, the weather will affect the ability to operate, so when the buoy is released, it will inevitably be affected by the weather and the falling position of the buoy will be skewed.

Experimental results are shown in Table 1 (for operators trained for 1 week) and Table 2 (for operators trained for 1 month). Looking at Table 1, we can see that the flight control results still have a long time to reach the target. Figure 7 shows a comparison between a rescuer with 7-day flight training and a rescuer with 30 days of flight training (the average values). For the case after training for 1 month, the time to reach the target is faster and the deviation is also smaller (38.7cm vs 59.2cm)

Table 2 Assessment of the device testing parameters (30-days training rescuer)

Flights	**Flight speed (km/h)**	**Time to identify and hold the position (seconds)**	**Distance to drop buoys off target (cm)**
#1	60	25	30
#2	58	33	54
#3	59	25	35
#4	55	31	30
#5	60	27	45
#6	57	35	35
#7	60	28	38
#8	60	30	40
#9	58	32	45
#10	59	25	35

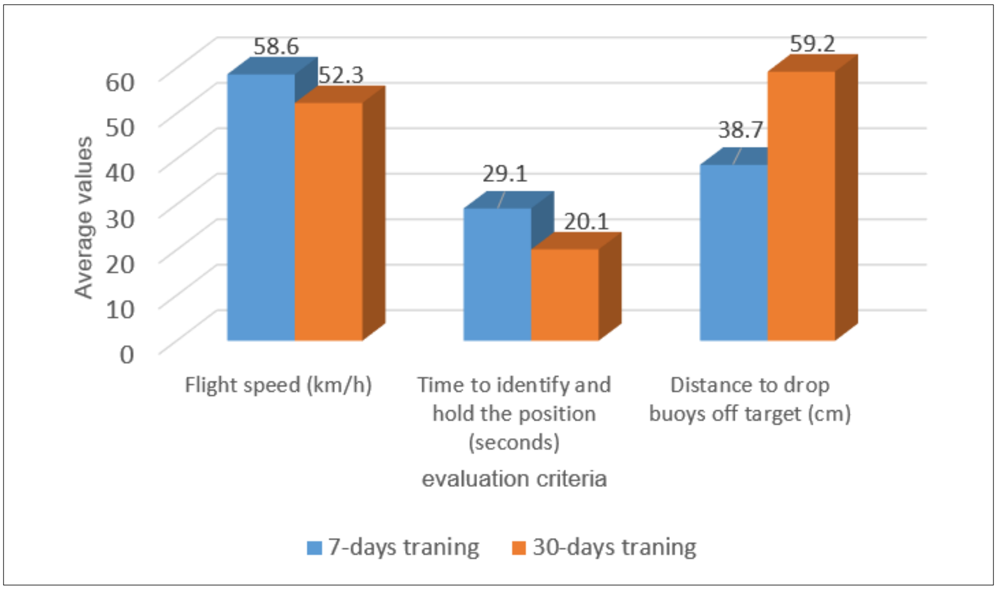


Figure 7 The comparison between 7-days and 30-days training rescuer

We have conducted a test for the drone carrying the float and the test flight, the results show that the drone can fly stably and flexibly when carrying the float and can keep the correct position to release the float stably. When the operator activates the auto-rotation mode of the buoy, the float can float on its own and when the float is released, the float can fall to the desired position of the operator. The results showed that the device was operating according to its design purpose.

However, controlling the device requires the operator to have time to practice with the right equipment to be able to do a good job of control. In addition, the device operator needs to have good reflexes to be able to control the device well and be able to handle unexpected situations that may occur well. The experimental results of the equipment have also shown the feasibility and operational efficiency of the equipment. The design and calculation of the equipment are based on actual needs, so it is definitely feasible. This is also an effective solution to meet the above needs.

4. Conclusion

In this study, a rescue device was designed and manufactured. The device is built based on the equipment, flight method, and balance method of a traditional drone, but we have designed the frame structure of the device to be more suitable for carrying and releasing the self- pumping buoy, Additional, we designed and manufactured self-pumping buoy to integrate into the device. The device has the task of supporting the person performing the rescue work to quickly bring the lifebuoy to the place where someone encounters crutches to increase the chance of survival for the person in distress and at the same time ensure the safety of the rescuer.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to disclosed.

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