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Development of a Life Guard Assist Drone for Search and Rescue

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***Abstract*— Natural disasters and water-related emergencies pose significant challenges for traditional rescue teams, often resulting in delayed response times and increased risk to victims. This project focuses on the development of a Lifeguard Assist Drone for Search and Rescue, designed to assist drowning persons and individuals stranded in hard-to-reach locations during disasters. The drone is equipped with a GPS module, high-resolution camera, and an intelligent navigation system to efficiently locate victims and provide immediate assistance. In water rescue scenarios, the drone can identify drowning individuals, transmit real-time video to rescue teams, and deploy flotation devices to keep victims afloat until further help arrives. In disaster situations such as floods, earthquakes, or landslides, the drone can deliver essential supplies like medicines, food, and first-aid kits to those in need. It can be remotely controlled or operate autonomously based on pre-programmed routes and AI-based victim detection. By integrating advanced communication technologies and real-time monitoring, this drone enhances search and rescue efficiency, reduces response time, and minimizes risks for human rescuers. The project aims to revolutionize disaster response and water safety, making rescue operations faster and more effective.**

I. INTRODUCTION

Search and rescue operations are critical for saving lives in emergencies, particularly in drowning incidents and disaster situations such as floods, earthquakes, and landslides. However, traditional rescue methods often face significant challenges, including delayed response times, difficulty in reaching victims in remote or hazardous locations, and high risks for human rescuers. Lifeguards and emergency teams may struggle to access drowning individuals in rough waters or people trapped in disaster-stricken areas where infrastructure is damaged. Additionally, conventional search methods rely heavily on human intervention, making them slower and less efficient, especially in large-scale emergencies.

To address these limitations, this project presents the Lifeguard Assist Drone for Search and Rescue, an advanced UAV (Unmanned Aerial Vehicle) designed to provide rapid assistance in critical situations. Unlike traditional rescue approaches, this drone is equipped with GPS, a high-resolution camera, and an intelligent payload delivery system to support both water rescues and disaster relief operations. It can quickly locate victims, transmit real-time video feeds to rescue teams, and autonomously or remotely deliver essential supplies such as flotation devices, medical kits, and food. The drone significantly reduces response time by flying over obstacles, reaching areas that are otherwise inaccessible, and ensuring that victims receive immediate aid while minimizing risks to human rescuers. With smart detection capabilities and real-time monitoring, this system enhances the efficiency and safety of search and rescue missions, making it a revolutionary solution for emergency response.

II. LITERATURE REVIEW

The advancement of drone technology has significantly improved search and rescue (SAR) operations, particularly in aquatic and disaster environments. Researchers have explored various aspects of drone-assisted SAR missions, focusing on autonomous detection, navigation in challenging environments, thermal imaging, GPS tracking, and real-time object identification.

Recent studies emphasize the role of autonomous detection and identification systems in SAR drones, enabling them to recognize victims and hazardous conditions more efficiently without human intervention [1]. The integration of thermal imaging technology has further enhanced the ability of drones to detect individuals in water, even in low-light or poor visibility conditions, making them highly effective for nighttime and foggy rescues [2]. However, operating drones in challenging environments such as rough seas, flood zones, and post-earthquake debris fields presents difficulties in maintaining stability and navigation, which has been addressed through improved control algorithms and adaptive flight mechanisms [3].

To overcome instability over water surfaces, researchers have developed flight stabilization techniques, including advanced gyro-stabilization and wind-resistance algorithms, ensuring precise movement and payload delivery during aquatic rescues [4]. Additionally, the use of drones for life-saving equipment delivery has been explored, where UAVs are programmed to

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transport flotation devices, medical supplies, and first-aid kits to victims in distress before human rescuers arrive [5]. This significantly reduces response time and increases survival chances.
Real-time GPS tracking and navigation systems play a crucial role in improving the efficiency of SAR drones, allowing for precise location identification and coordination with ground rescue teams [6]. However, ensuring safety and avoiding collisions in busy aquatic environments require specialized collision avoidance algorithms, which are being integrated into modern drone designs [7]. Research has also explored hybrid drone systems, which combine aerial and underwater capabilities to expand their operational range and effectiveness in complex rescue scenarios [8].
Beyond technological advancements, regulatory challenges also impact the deployment of SAR drones. Compliance with aviation and maritime safety laws is essential to ensure their widespread adoption in emergency response systems [9]. Studies have also emphasized the importance of integrating SAR drones with traditional rescue teams, improving human-drone collaboration for more efficient operations [10]. AI-based real-time object detection and tracking systems have further enhanced the capabilities of drones to identify survivors, obstacles, and critical hazards during missions [11].
Multi-drone systems have been proposed for large-scale rescue missions, where drones operate in coordinated fleets to survey disaster-affected areas more effectively [12]. The use of drones in complex coastal environments has also been studied, focusing on optimizing flight paths and improving communication systems to ensure uninterrupted operation [13]. Energy efficiency is another area of concern, leading to the development of flight optimization algorithms that extend battery life and maximize mission duration [14]. Lastly, advancements in human-drone interaction models have enabled better coordination between SAR teams and drones, improving situational awareness and decision-making in emergency scenarios [15].
Overall, the integration of advanced technologies such as AI-based detection, thermal imaging, GPS tracking, and multi-drone coordination has significantly improved the effectiveness of SAR drones. However, challenges related to regulatory compliance, battery limitations, and extreme environmental conditions still require further research and development to optimize their real-world deployment.

III. PROPOSED MODEL

The Lifeguard Assist Drone for Search and Rescue is designed to provide rapid emergency assistance in aquatic and disaster situations. It integrates GPS tracking, real-time victim detection, and payload delivery systems to improve response time and increase survival chances. The drone is equipped with an APM flight controller, telemetry module, and an ESP camera, ensuring efficient monitoring and communication with rescue teams.

1. System Architecture

The drone is built on a quadcopter or hexacopter platform, ensuring stability and precise movement over water and disaster-prone areas. The APM flight controller provides autonomous navigation, while the GPS module enables real-time location tracking. The ESP camera captures live visuals, helping detect victims and assess surroundings.
The drone uses a telemetry module to transmit flight data and receive commands from a ground control station. A payload delivery system allows it to drop flotation devices, first-aid kits, or essential supplies. Additionally, an obstacle avoidance system ensures safe operation in complex environments.

2. Working Principle

The drone operates in two modes: Aquatic Search and Rescue and Disaster Relief Operations. In aquatic rescue, it autonomously patrols water bodies or responds to distress signals. The ESP camera assists in identifying drowning individuals, and once detected, the drone deploys a flotation device while sending real-time location updates through telemetry.
In disaster scenarios such as floods, earthquakes, or landslides, the drone navigates hard-to-reach areas using GPS and obstacle avoidance. It delivers medical supplies, food, or other necessities while transmitting live video footage to rescue teams, enabling better coordination.

3. Operational Flow

The drone starts by receiving an emergency alert or conducting an autonomous patrol. The ESP camera scans the environment, and once a victim is detected, the GPS system calculates the optimal route.
Upon arrival, the drone either deploys a flotation device or delivers supplies, while continuously transmitting live video and telemetry data to the ground station. Once the task is completed, it either returns to base or continues scanning for additional victims.

4. Advantages of the Proposed Model

The Lifeguard Assist Drone significantly reduces response time, reaching victims faster than traditional rescue methods. It can operate in flooded areas, remote locations, and unstable terrains, making it highly versatile. By minimizing human involvement in dangerous environments, it enhances rescuer safety while improving overall efficiency.
With real-time video monitoring via ESP camera and live telemetry data, rescue teams receive crucial information for better decision-making. The drone’s multi-functional design allows seamless operation in both water rescue and disaster relief, making it a valuable asset in emergency situations

A. Hardware Implementation

The Lifeguard Assist Drone is built with carefully selected hardware components to ensure stability, efficiency, and reliability for search and rescue missions. The primary hardware includes the APM flight controller, GPS module, telemetry system, ESP camera, propulsion system, power system, and payload delivery mechanism.

1. Flight Controller and Navigation

The drone is controlled by an APM flight controller, which provides autonomous flight capabilities, GPS-based navigation, and stability control. The GPS module enables real-time tracking, allowing the drone to reach specific locations accurately. The telemetry module establishes a wireless communication link between the drone and the ground control station, providing live flight data and enabling remote command adjustments.

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2. Vision System: ESP Camera
An ESP camera is mounted on the drone for real-time video streaming. This allows rescue teams to monitor live footage and assess the situation remotely. The camera plays a crucial role in identifying victims and determining the best course of action during emergency missions.
3. Propulsion System
The drone uses 2212 920KV BLDC motors, which offer a balance of thrust and efficiency. These motors are controlled by 30A Electronic Speed Controllers (ESCs), ensuring smooth operation and quick response. The propulsion system is completed with 10-inch propellers, providing the necessary lift for stable flight and maneuverability.
4. Power System
A 3S 11.1V LiPo battery powers the drone, supplying sufficient energy for the motors, flight controller, and electronic components. The battery capacity is selected to ensure optimal flight duration, allowing the drone to cover significant distances before requiring recharging.

5. Emergency Supply Deployment System (E-SDS)
To assist victims in distress, the drone features an Emergency Supply Deployment System (E-SDS) (Fig 2). This system consists of a servo motor-controlled mechanism that can drop flotation devices, emergency medicines, food supplies, and other essential items to those in need.

The servo motor receives a command from the flight controller or the operator, activating the release system to deliver aid accurately and efficiently. This feature enhances the drone's ability to provide immediate relief in critical situations.

6. Structural Design

The drone frame is designed to be lightweight yet durable, using carbon fiber or high-strength plastic to withstand outdoor conditions. The aerodynamic structure ensures stability and endurance, enabling smooth operation even in challenging weather conditions.

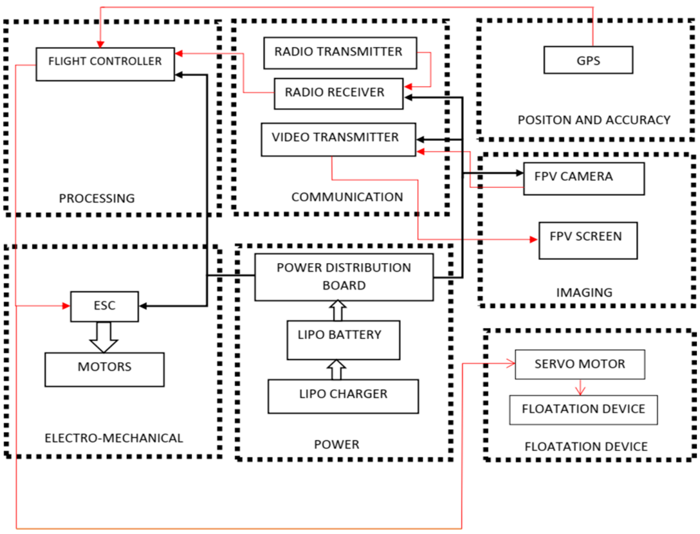

Fig. 1. Block diagram of the Lifeguard assist drone system

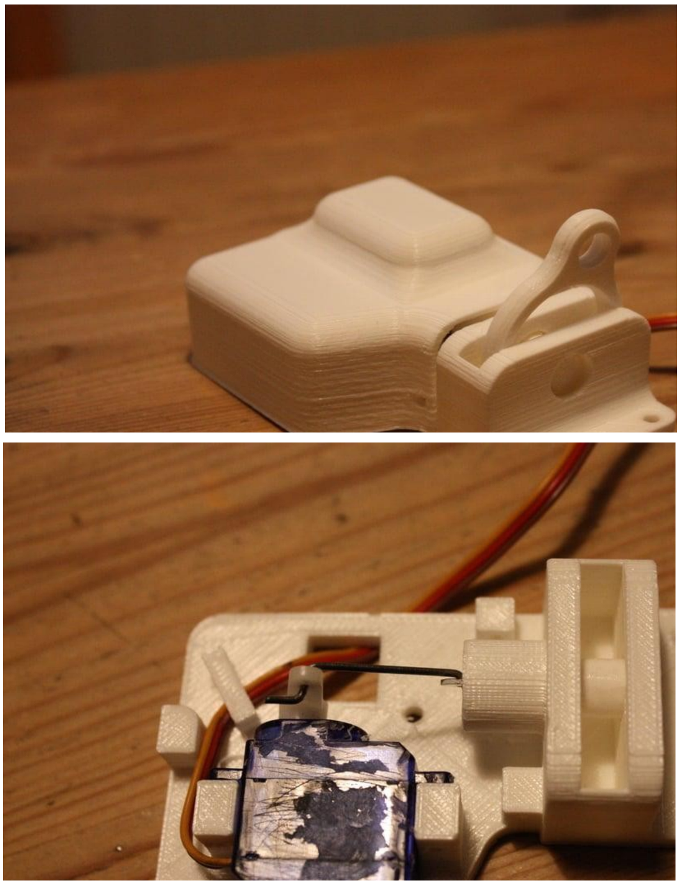

Fig 2. Emergency Supply Deployment System (E-SDS)

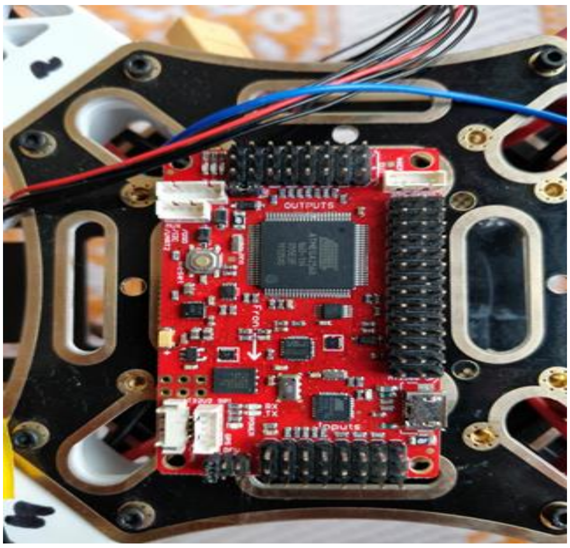

Fig 3. Flight Controlling

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IV RESULTS AND DISCUSSIONS

The Lifeguard Assist Drone was tested under various conditions to evaluate flight stability, GPS accuracy, supply deployment, and real-time imaging. The 2212 920KV BLDC motors, 10-inch propellers, and 30A ESCs ensured stable flight, with the APM flight controller maintaining smooth operation even in moderate wind conditions. However, extending flight time would require a higher-capacity LiPo battery.

The GPS module provided accurate navigation, enabling the drone to reach targets within 1-2 meters. It followed waypoints reliably, making it effective for search and rescue missions, though improved calibration could further enhance precision. The Emergency Supply Deployment System (E-SDS), controlled by a servo motor, successfully dropped flotation devices, medicines, and essential supplies within a 0.5-meter radius, with minor adjustments needed for varying payload weights.

The payload capacity of the Lifeguard Assist Drone is determined by the total thrust generated by its 2212 920KV BLDC motors and the overall weight of the drone. Each motor, when paired with a 10-inch propeller and powered by a 3S (11.1V) LiPo battery, produces approximately 850g of thrust. With four motors, the total thrust generated is around 3400g. To ensure stable flight, the thrust-to-weight ratio should be at least 2:1, meaning the maximum takeoff weight (MTOW) should not exceed 1700g. Given that the drone's frame and electronics weigh approximately 800g, the remaining payload capacity is 900g. However, for better flight efficiency and stability, it is advisable to limit the payload to around 700g.

To increase the payload capacity, we can upgrade to higher-thrust motors, use larger propellers, and switch to a higher voltage battery (such as a 4S LiPo) while ensuring the frame and ESCs support the additional power. Optimizing the weight distribution and material selection for the drone's body can also contribute to improved lift and efficiency.

The ESP camera delivered clear real-time video streaming, with stable transmission up to 500 meters, allowing remote monitoring. However, adding thermal imaging could improve visibility in low-light conditions. The 3S 11.1V LiPo battery provided an average flight time of 15-18 minutes, sufficient for short-range missions but could benefit from a higher-capacity battery or solar-assisted charging.

Fig 3. Complete Lifeguard assist Drone

Fig 3. Complete Lifeguard assist Drone

Overall, the Lifeguard Assist Drone demonstrated strong performance in navigation, imaging, and supply deployment. While effective for emergency response, enhancements like extended flight duration, refined GPS calibration, and thermal imaging could further improve its reliability in critical situations.

V.CONCLUSION

The Lifeguard Assist Drone successfully demonstrated its capability as a search and rescue tool, providing quick response, accurate navigation, and efficient emergency supply deployment. With its stable flight control, real-time imaging, and precise GPS tracking, the drone effectively assists in locating victims and delivering essential supplies in critical situations. The ESP camera and telemetry system ensured seamless remote monitoring, enhancing situational awareness for rescue teams.

While the drone performed well in controlled tests, flight endurance and payload management could be further optimized by integrating a higher-capacity battery and fine-tuning the supply deployment system. Additionally, incorporating thermal imaging could improve performance in low-light and adverse weather conditions. Despite these areas for improvement, the system proves to be a valuable asset for disaster response teams, ensuring faster and more effective rescue operations.

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