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Design And Implementation Of Search And Rescue Drones

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Abstract- In disaster-stricken areas, the ability to rapidly locate survivors and deliver essential aid can significantly influence survival rates and recovery efforts. However, traditional search and rescue (SAR) operations are often hindered by inaccessible terrain, hazardous conditions, and the time-sensitive nature of emergency response. To address these challenges, this paper presents the design and development of an autonomous drone system tailored for SAR missions. The proposed drone integrates a Pixhawk 6C flight controller, GPS navigation module, high-definition Wi-Fi camera, and Mission Planner software to enable autonomous flight, real-time aerial surveillance, and precise payload delivery. The system is capable of executing missions with minimal human intervention while providing live telemetry and video feedback to ground teams. Field tests conducted in controlled environments demonstrate the drone's reliability, accuracy, and endurance under simulated disaster conditions. This research highlights the potential of UAV technology to enhance emergency response efficiency, reduce operational risks, and deliver critical supplies swiftly in regions where traditional methods fall short.

Index Terms- Autonomous Navigation, Disaster Management, Pixhawk 6C, Search and Rescue Drones, UAVs.

1. INTRODUCTION

Natural and man-made disasters often lead to widespread devastation, displacing populations and destroying infrastructure. Earthquakes, floods, cyclones, and industrial accidents frequently result in isolated regions where immediate assistance is critical. Traditional search and rescue (SAR) efforts, relying on ground teams or helicopters, face challenges such as blocked roads, hazardous terrain, and adverse weather, causing delays that can cost lives.

Manned aerial operations, while effective, are expensive, weather-dependent, and require skilled personnel. Ground vehicles often struggle with debris or collapsed structures, making timely response difficult. In contrast, Unmanned Aerial Vehicles (UAVs), or drones, offer a promising solution. They can access difficult terrains, provide real-time aerial data, and minimize risks to human rescuers.

Modern drones equipped with GPS, obstacle avoidance, and live video streaming have become vital tools for emergency response. Beyond surveillance, drones can deliver essential supplies such as food, medicine, and communication devices to survivors, bridging the critical time gap until ground assistance arrives.

This paper presents the design and implementation of an autonomous Search and Rescue Drone built with a Pixhawk 6C controller, GPS navigation, Wi-Fi camera, and Mission Planner software. Capable of autonomous flight, real-time monitoring, and payload delivery, the drone enhances SAR operations by providing rapid, flexible, and reliable support in disaster scenarios.

2. DRONE OR UAV

Unmanned Aerial Vehicles (UAVs), also known as Unmanned Aircraft Systems (UAS), are commonly referred to as drones (Kumar and Sharma, 2020). The term "Drone" is derived from Dynamic Remotely Operated Navigation Equipment (Patel et al., 2019). A UAV is an aircraft that can operate without an onboard pilot, guided either remotely or autonomously using pre-programmed flight paths and GPS navigation (Singh et al., 2019). In broader terms, UAV refers to the entire system, including the aerial platform, ground control station, and communication link (Verma and Roy, 2020). Small to medium UAVs can be remotely piloted via telemetry or can execute missions autonomously based on software-controlled flight operations.

3.TYPES OF SEARCH AND RESCUE DRONES

Search and Rescue (SAR) drones are designed to support emergency operations. Based on their structure and flight capabilities, they are classified into multi-rotor, fixed-wing, and hybrid drones.

Multi-Rotor Drones

Multi-rotor drones, like quadcopters and hexacopters, offer high maneuverability and vertical takeoff and landing (VTOL) capabilities. They are ideal for localized searches and precision supply drops, especially in urban disaster areas. However, they have shorter range and flight time due to higher energy consumption.

Fixed-Wing Drones

Fixed-wing drones provide longer flight endurance and can cover large areas quickly, making them suitable for wide-area mapping and surveillance. They require more space for takeoff and landing and are best for rural or open regions.

Hybrid Drones

Hybrid drones combine VTOL capabilities with efficient forward flight, balancing hover and long-range performance. They are effective in complex terrains like forests and mountainous regions.

Payload Capacity and Range

- **Lightweight Drones:** Carry up to 2–5 kg, suitable for basic supplies.
- **Medium-Lift Drones:** Carry 10–20 kg, used for heavier rescue equipment.
- **Heavy-Lift Drones:** Under development for loads above 20 kg.

Flight performance:

- **Multi-Rotor Drones:** 3–10 km range, 20–30 minutes flight time.
- **Fixed-Wing Drones:** 50–200 km range, 2–3 hours flight time.
- **Hybrid Drones:** 30–100 km range, combining flexibility and endurance.

4. METHODOLOGY

The Search and Rescue Drone system was designed through a structured approach involving hardware selection, integration, software configuration, and field testing.

Initially, key components were selected, including a Pixhawk 6C flight controller for autonomous flight management, a GPS module for real-time positioning, brushless motors with ESCs for propulsion, and a Wi-Fi camera for live surveillance. The frame was assembled to securely mount all components while maintaining optimal weight distribution.

Mission Planner software was utilized to configure the flight controller, set autonomous waypoints, and calibrate sensors. Power connections were organized using a Power Distribution Board, and electronic speed controllers were connected to motors for synchronized control.

The system was tested under controlled conditions to validate flight stability, GPS accuracy, video transmission quality, and payload deployment capability. Modifications were made based on initial trial results to enhance system reliability and performance during actual search and rescue operations.

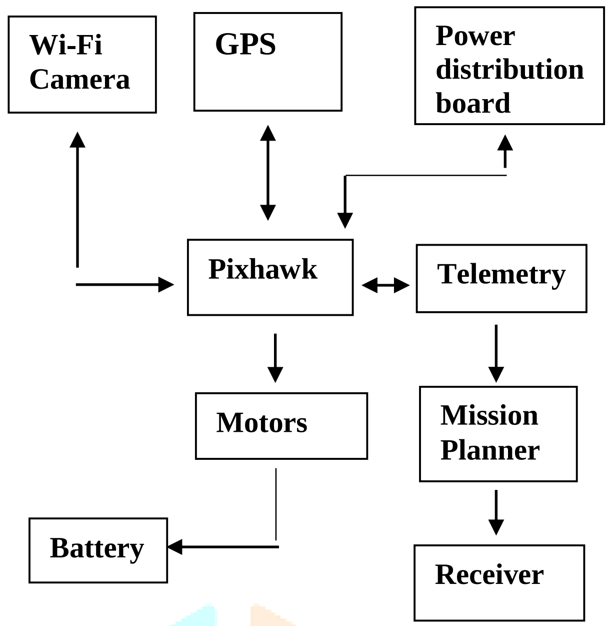

Fig: Block diagram of Search and rescue Drones

The above Figure shows the block diagram of the Search and Rescue Drone system. The Pixhawk 6C flight controller acts as the central processing unit, interfacing with the GPS module, ESCs, motors, Wi-Fi camera, and payload mechanism. Power from the battery is distributed through the Power Distribution Board to all major components. Remote control signals and live video transmission are managed through the ground control station, enabling autonomous and manual operations.

5. COMPONENTS OF DRONE

Frame/Chassis

The frame serves as the skeleton of the drone where all modules such as motors, battery, and sensors are mounted. For SAR drones, lightweight and impact-resistant frames made of carbon fiber or reinforced plastics are used to survive harsh conditions and rough landings.

Motors

Brushless motors are employed to spin the propellers with high efficiency. In SAR drones, more powerful motors provide better thrust for carrying rescue payloads. Motor speed (kV rating) affects the lift and speed capabilities essential for quick search operations.

Propellers

Propellers generate lift by rotating rapidly. In SAR drones, carbon fiber propellers are preferred for durability and performance. Longer blades offer greater lift at lower RPMs, while shorter blades enable faster maneuvering—important during rapid search missions.

Electronic Speed Controller (ESC)

ESCs manage the power delivered to each motor, ensuring accurate speed control and rotational direction during flight. Reliable ESCs are critical for maintaining stability during complex search patterns and sudden maneuvers.

Flight Controller

The flight controller acts as the brain of the SAR drone, interpreting sensor inputs (GPS, IMU, receiver) and adjusting motor outputs accordingly. It handles critical functions such as autopilot, waypoint navigation, and failsafe return-to-home operations.

Radio Transmitter and Receiver

This system enables manual control of the drone by the operator. A minimum of 6 channels is preferred for SAR drones, allowing additional control for camera gimbals, payload drop mechanisms, and flight mode switching.

Battery
High-capacity Lithium Polymer (LiPo) batteries are used to provide sufficient energy for extended missions. Proper battery selection balances weight and flight duration, crucial for maximizing search time without compromising drone agility.

Camera
The SAR drone is equipped with an HD or thermal imaging camera. Cameras mounted on gimbals offer stabilized video feeds, enabling real-time assessment of disaster zones, locating survivors, and identifying critical areas for rescue intervention.

Sensors
SAR drones utilize a variety of sensors, including thermal sensors for heat detection, optical sensors for visual imaging, LiDAR sensors for terrain mapping, and obstacle avoidance sensors to navigate complex environments safely.

GPS Module

GPS provides real-time positioning data necessary for autonomous navigation, waypoint tracking, return-to-home functions, and geo-fencing during search and rescue missions.

Accelerometers
Accelerometers measure linear acceleration and help maintain flight stability during rapid changes in direction or altitude.

Gyroscopes
Gyroscopes detect angular motion, allowing the flight controller to adjust roll, pitch, and yaw—ensuring smooth and balanced flight during rescue operations.

Other Components

Additional systems such as payload scanners, two-way communication radios, rescue supply dropping mechanisms, and remote control stations enhance the drone's mission versatility in search and rescue scenarios.

6. APPLICATIONS

Disaster Area Surveillance:

SAR drones are deployed immediately after natural disasters such as earthquakes, floods, and landslides to survey affected areas. They provide aerial images and real-time video, allowing emergency teams to assess damage, locate survivors, and prioritize rescue efforts without putting human lives at risk.

Victim Detection and Localization

Equipped with cameras and thermal imaging sensors, SAR drones help locate trapped or injured individuals in inaccessible locations. By scanning large areas quickly, they significantly reduce the time required to find survivors, even in dense forests, collapsed buildings, or flooded zones.

Emergency Supply Delivery

Search and Rescue drones can carry critical supplies such as medical kits, food, water, and communication devices to isolated or stranded individuals. Payload mechanisms allow drones to precisely drop life-saving materials at designated GPS coordinates, ensuring fast relief to those in need.

Real-Time Communication Relay

In disaster zones where communication infrastructure is damaged, drones can act as mobile communication nodes. By hovering over affected areas, they help establish temporary wireless networks, enabling communication between rescue teams and victims.

Mapping and 3D Reconstruction

Drones equipped with advanced cameras and sensors can create detailed maps and 3D models of disaster sites. This information assists rescue coordinators in planning safe routes for ground teams and identifying unstable or dangerous structures.

Search Operations in Remote and Hazardous Areas

SAR drones are particularly useful in remote regions such as mountainous terrains, dense forests, deserts, or offshore locations where traditional vehicles or teams face accessibility challenges. They extend the reach of rescue operations to locations that would otherwise be impossible or too dangerous to access.

Support for Military and Border Patrol Operations

Beyond civilian disaster scenarios, SAR drones are also utilized in military rescue missions and border surveillance operations, where rapid identification and extraction of personnel in hostile environments are critical.

7. RESULTS

Fig1: Drone captured during stable hover in flight test phase.

The drone during takeoff at the beginning of its flight. This phase tested the drone's ability to remain stable in the air and begin real-time monitoring from above, proving its usefulness for search and rescue tasks.

Fig2: Image captured by the drone's onboard camera during flight testing.

During testing, the drone's onboard Wi-Fi camera successfully transmitted real-time footage to the ground station. The above Figure shows an example of a captured frame, demonstrating the drone's stable altitude and clear visual output, which is crucial for search operations in real-world scenarios.

Fig3: Drone performing a payload drop during flight testing.

The above figure shows the drone performing a payload drop during testing. This demonstrates its ability to deliver essential supplies accurately from the air, a key feature for search and rescue operations in inaccessible or disaster-affected areas.

8.CONCLUSION

The development of the Search and Rescue Drone outlined in this project demonstrates a practical solution for enhancing emergency response in disaster-affected regions. By combining a Pixhawk 6C flight controller, GPS navigation, and a high-definition Wi-Fi camera, the system effectively supports autonomous flight, aerial monitoring, and targeted payload delivery. Field evaluations confirmed the drone's stability, accuracy in navigation, and capability to transmit real-time visuals while executing supply drop missions. These results highlight the potential of UAV-based systems to significantly reduce response time and improve operational safety in critical situations. The modular design allows for future integration of advanced features, making the drone a scalable platform for a wide range of search and rescue applications.

9.FUTURE SCOPE

Future enhancements to the Search and Rescue Drone can significantly expand its operational capabilities. Incorporating thermal imaging and infrared sensors would allow detection of survivors in low-visibility and night-time conditions. Integrating AI-based victim detection algorithms can automate search patterns and improve efficiency. Swarm drone technology could be developed to allow multiple UAVs to collaboratively search large areas in a coordinated manner. Further advancements in battery technology and lightweight materials can increase flight endurance, while 5G-enabled communication modules can provide faster real-time data transmission over longer distances. Expanding payload capacity and autonomous decision-making capabilities will make SAR drones even more reliable assets in critical missions.

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