AETHERRESQ: AI DRIVEN FIREFIGHTING RESCUE DRONE WITH SMART SURVEILLANCE AND AUTONOMOUS FIRE EXTINGUISHER

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Introduction:

Fire accidents are one of the most critical and life-threatening disasters occurring across industrial zones, residential buildings, forests, and urban infrastructures. These incidents demand immediate attention and rapid response to prevent loss of life and property. However, traditional firefighting approaches rely heavily on human intervention, where firefighters are required to operate in hazardous environments characterized by extreme temperatures, dense smoke, toxic gases, and structural instability. These factors not only increase the risk to human life but also limit the efficiency and effectiveness of rescue operations.

In recent years, advancements in Artificial Intelligence (AI), robotics, and unmanned aerial vehicles (UAVs) have created new opportunities for developing safer and more efficient emergency response systems. UAVs, commonly known as drones, offer the advantage of accessing hard-to-reach areas, providing aerial surveillance, and performing tasks without exposing humans to danger. The integration of intelligent sensing and automation further enhances their capability to respond to dynamic and unpredictable environments.

The proposed project, AetherResQ, aims to address the limitations of conventional firefighting systems by introducing an AI-driven autonomous drone capable of fire detection, human identification, and fire suppression. The system combines smart sensors, real-time data processing, and autonomous navigation to perform firefighting operations efficiently. By reducing human involvement in hazardous situations and improving response time, the project contributes to the development of advanced disaster management solutions. The system is designed to provide real-time situational awareness, enabling faster and more informed decision-making during emergencies.

Figure 1: AtherResQ

Objectives:

1. To design and develop an intelligent firefighting drone system.
2. To detect fire accurately using flame sensors.
3. To identify human presence using PIR sensors.
4. To implement autonomous navigation using Pixhawk flight controller.
5. To integrate an onboard fire extinguishing mechanism.
6. To enable real-time video surveillance and telemetry monitoring.
7. To improve efficiency and speed of emergency response.
8. To reduce risk and exposure to human firefighter.

Methodology:

1. The project AetherResQ system is developed using a combination of hardware components and software integration to achieve autonomous firefighting and rescue operations. The primary control unit of the drone is the Pixhawk flight controller, which ensures stable flight, navigation, and execution of autonomous missions. The drone operates in two modes: autonomous mode and manual mode, providing flexibility in operation.
2. The system utilizes flame sensors to detect fire intensity and location. These sensors continuously monitor the environment and send analog or digital signals to the Arduino microcontroller. In addition, a Passive Infrared (PIR) sensor is used to detect human presence by sensing heat variations and motion in the surroundings. The Arduino processes the sensor data and communicates with the Pixhawk controller using the MAVLink protocol.
3. When the detected fire intensity exceeds a predefined threshold, the system triggers a relay module connected to the onboard fire extinguisher. The extinguisher releases fire-suppressing material through a spray nozzle aimed at the detected fire source. At the same time, a camera module captures live video and transmits it to the Ground Control Station (GCS), allowing operators to monitor the situation in real time.
4. The drone is programmed with GPS-based waypoints for autonomous navigation. It follows a predefined path and can dynamically respond to sensor inputs during flight. The Return-to-Launch (RTL) feature ensures safe landing in case of low battery, signal loss, or mission completion. Telemetry data such as GPS coordinates, altitude, and sensor readings are transmitted continuously to the GCS.
5. The integration of sensor fusion, decision-making algorithms, and autonomous control enables the drone to perform firefighting and rescue tasks effectively. The system is designed to operate efficiently in hazardous environments where human intervention is difficult or unsafe.

Result and Conclusion:

1. The AetherResQ system was successfully designed, developed, and tested in controlled conditions. The Pixhawk flight controller provided stable flight performance and accurate navigation. The drone was able to follow predefined waypoints and maintain balance during operation.
2. The flame sensor demonstrated reliable detection of fire sources, while the PIR sensor effectively identified human presence in the testing environment. The integration of these sensors improved the overall detection capability of the system.

The fire extinguishing mechanism was successfully activated when fire was detected, and it effectively suppressed small-scale fire scenarios.

3. Real-time video streaming and telemetry data transmission enabled continuous monitoring of the environment, providing valuable insights for decision-making. The system significantly reduced the need for human involvement in dangerous situations and improved response efficiency.
4. In conclusion, the project demonstrates the feasibility of using AI-driven autonomous drones for firefighting and rescue operations. The system enhances safety, reduces response time, and provides an effective solution for modern emergency management systems.

Project Outcome & Industry Relevance:

1. The AetherResQ project provides a practical and innovative solution for improving firefighting and rescue operations using advanced technologies. The system can be deployed in industrial plants, residential areas, forests, and disaster-prone regions for early fire detection and response.
2. The project is highly relevant to industries such as firefighting services, disaster management authorities, and smart city infrastructure. It reduces dependency on manual operations and enhances efficiency through automation. The system also contributes to advancements in robotics, UAV technology, and AI-based applications.
3. The implementation of such systems can significantly improve safety standards and reduce damage caused by fire accidents. It also opens opportunities for further research and development in autonomous emergency response systems.

Working Model vs Simulation/Study:

1. The project includes both a working model and simulation study.
2. The working model is developed using a real drone with Pixhawk, GPS, and sensors (flame, gas, PIR).
3. It operates in real-time environment for fire detection and data transmission.
4. Provides practical validation of system performance and reliability.
5. Simulation is carried out using software like Mission Planner.
6. Helps in testing flight control and navigation before real implementation.
7. Reduces risk and improves system accuracy during development.
8. Overall, simulation is used for testing, and the working model is used for real-time execution.

Project Outcomes and Learnings:

1. Gained practical knowledge in UAV system design and implementation
2. Learned integration of sensors such as flame and PIR sensors
3. Hands-on experience with Pixhawk flight controller and telemetry systems
4. Understanding of MAVLink communication protocol
5. Improved skills in embedded systems and real-time processing
6. Enhanced teamwork, project management, and problem-solving abilities

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uture Scope:

Future scope of this project includes:

1. Integration of thermal cameras for better fire detection in low visibility.
2. Use of AI/ML for smart decision-making and fire prediction.
3. Addition of obstacle avoidance systems (LiDAR/ultrasonic sensors).
4. Development of indoor navigation for GPS-denied areas.
5. Implementation of multi-drone coordination for large-scale rescue.
6. Integration with IoT for real-time monitoring and control.
7. Improvement in battery life for longer flight duration.