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Design and Implementation of Fire Extinguisher Drone for Disaster Management

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Abstract: The Fire Extinguisher Drone is designed to provide a fast and safe solution for firefighting, especially in areas that are dangerous or difficult for humans to reach. The system uses a drone fitted with a fire-extinguishing mechanism that can spray water or fire-suppressant materials once a fire is detected. The main objective of this project is to reduce the risk to human life, increase the speed of emergency response, and improve the effectiveness of fire control operations. This drone can be used in residential buildings, forest regions, and industrial zones to detect and suppress fires at an early stage. The project demonstrates the practical application of engineering and technology in developing safer and more efficient emergency response systems

Keywords: Fire Extinguisher Drone, Firefighting, Safety System, Disaster Management

I. INTRODUCTION

Fire accidents are unpredictable events that can result in serious loss of human life, property, and environmental damage. Traditional firefighting techniques usually require firefighters to operate directly in hazardous conditions, which puts their lives at risk and limits effective action in difficult locations such as high-rise buildings, industrial areas, and forest zones. Recent developments in unmanned aerial vehicle (UAV) technology have led to the use of drones in firefighting applications. Drone-based systems offer faster response, better access to critical areas, and improved safety by reducing direct human exposure to danger [1], [2].

This project focuses on the design and development of a Fire Extinguisher Drone capable of controlling fires using an onboard fire-extinguishing unit. Previous studies have shown that drones can be effectively used for fire detection and suppression, helping to reduce response time and minimize risks to human like [3]-[5]. By allowing wireless control and aerial access to dangerous areas, the proposed system improves the efficiency of firefighting operations and provides a base for future advancement in autonomous emergency and disaster management systems.

II. METHODOLOGY

The Fire Extinguisher Drone was developed using a well-planned and step-by-step approach that involved system design, hardware assembly, software setup, and practical testing. Each phase was carried out carefully to achieve reliable fire detection, effective fire suppression, and reduced human involvement. The development process followed methods commonly used in recent research on drone-based firefighting systems [6], [11].

A. System Design

The proposed system uses a quadcopter structure controlled by a flight controller to maintain stable, balanced, and smooth movement during flight. A lightweight water tank along with a pump mechanism is fixed to the drone frame to spray water or fire-suppressant liquid directly onto the fire location. This design follows the concepts used in sensor-based UAV firefighting systems reported in earlier studies [13], [14].

B. Working Principle

The drone works on a real-time fire detection method. When a flame is sensed from a fire source, a signal is sent to the onboard controller. Based on this signal, the controller turns on the pump to spray the extinguishing agent onto the

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affected area while the drone maintains a stable position in the air. The system allows both manual and semi-automatic control through a wireless remote, following operating methods similar to those reported in earlier studies [6], [12].

C. Hardware Components

The main hardware components used in the system used:

- **Cross Flight Controller** – Maintains flight stability and controls motor speed
- **Water Pump or Container**– Delivers water or fire-extinguishing agents
- **ESCs and Brushless Motors** – Provide thrust and directional control
- **Li-Po Battery** – Supplies power to all electronic modules

These components were chosen for their reliability and suitability for UAV-based firefighting applications [7], [8].

D. Software Implementation

The Cross flight controller was set up and calibrated through its interface to achieve smooth and stable flight operation. The onboard microcontroller continuously processes sensor data and activates the pump automatically when fire is detected. In addition, a wireless remote-control system is provided to allow manual control and override during emergency conditions, similar to approaches used in UAV-based emergency response systems [9], [10].

E. Testing and Performance Evaluation

The prototype was tested in a controlled environment to assess its performance and reliability. During the tests, the drone was able to detect and extinguish small fires within a short time. The experimental results showed stable flight operation, accurate fire detection, and quick response, which confirms the effectiveness of the proposed system. These results are in agreement with observations reported in similar firefighting drone research works [6], [11].

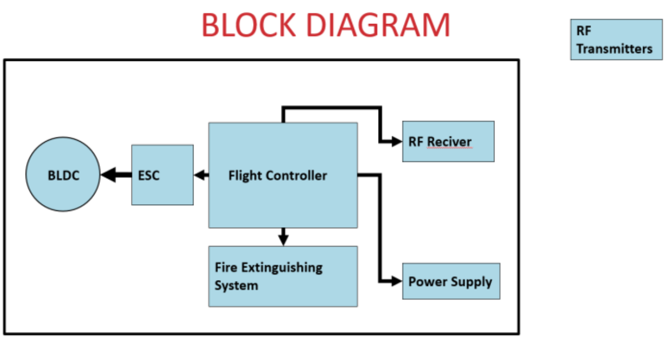

Figure 1: Block diagram

II. IMPLEMENTATION

The implementation of the Fire Extinguisher Drone was completed in several stages, beginning with hardware assembly and followed by software integration and system testing. Each stage was carried out carefully to achieve reliable fire detection, stable flight control, and efficient fire suppression. The overall approach follows concepts used in IoT-based UAV firefighting systems and stability design practices discussed in earlier studies [15], [20].

A. Hardware Implementation

The hardware implementation started with assembling the quadcopter frame and mounting the brushless DC motors, propellers, and electronic speed controllers (ESCs). A Cross flight controller was employed to maintain balance, orientation, and stable flight, even while carrying the additional payload. This design follows stability analysis methods and thermal monitoring considerations discussed in earlier studies [20], [18].

A lightweight water tank or fire-extinguishing agent, such as CO_2, was securely mounted on the underside of the drone to release the extinguishing material directly onto the fire source. All hardware components were powered by a high-capacity Li-Po battery, providing sufficient power for both flight and fire suppression operations. The complete hardware arrangement is illustrated in **Figure 2.**

Figure 2: Implementation

B. Circuit Diagram

All system components were connected using jumper wires as per the circuit diagram shown in Figure 3. When fire conditions were detected, the controller automatically activated the servo motor to release water or fire-extinguishing liquid. At the same time, the ESCs received PWM signals from the Cross flight controller to control motor speed and maintain stable hovering during the extinguishing process. This integrated control method follows coordination and control strategies discussed in earlier studies [16].

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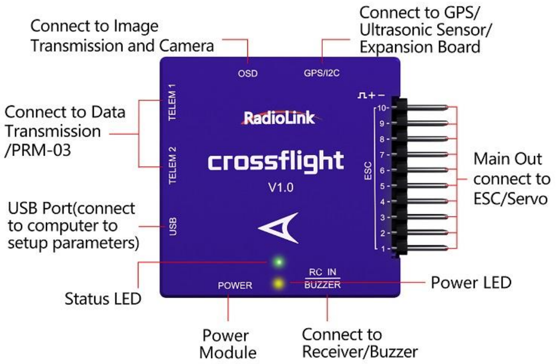

Figure 3: Circuit diagram

C. Software Configuration

The software setup was aimed at ensuring steady flight control, dependable fire detection, and quick activation of the extinguishing system. The Cross flight controller was calibrated through its interface to achieve stable and responsive flight. The transmitter and receiver were paired to enable manual control during operation, using control methods commonly used in drone-based disaster management systems [21].

The onboard microcontroller was programmed to constantly monitor user inputs. When it detects a fire, the servo motor releases the extinguishing agent automatically, without needing human intervention. This automated response matches aerial fire suppression methods described in [22], providing faster reaction times and better safety during operation.

Figure 4: Software Specification

D. Testing and Validation

After completing system integration, the Fire Extinguisher Drone was tested in a controlled environment using small and safe fire sources. In these tests, the drone was able to detect flames and activate the water spray with very little delay, showing good coordination between the sensor and the actuator. Multiple flight trials also proved that the drone maintained stable lift and controlled maneuverability, even while carrying the extra weight of the water tank and pump. These outcomes are consistent with the fire suppression performance described in [22] and the safety-focused UAV monitoring improvements discussed in [23].

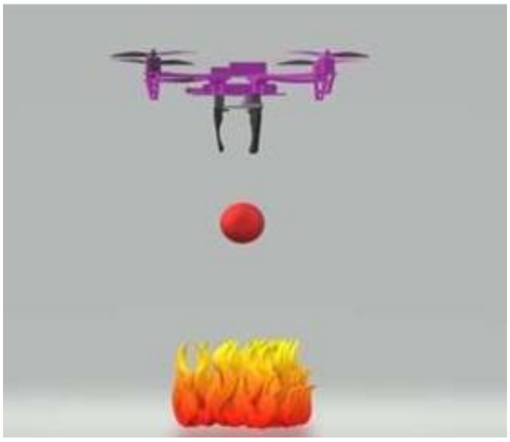

Figure 5: Working of the Proposed System

III. RESULTS AND DISCUSSION

The Fire Extinguisher Drone was successfully designed, built, and tested for fire detection and suppression. During several experiments, the system showed stable flight, quick response, and dependable performance in controlled conditions. These results support the use of UAV-based systems to improve safety and efficiency in firefighting, as noted in recent studies on UAV fire monitoring [23].

A. Experimental Results

The drone was tested in a controlled environment using small and safe fire samples. Once a fire was detected, the microcontroller activated the servo motor, which dropped water or a CO_2 ball directly onto the flame. The fire was extinguished within a few seconds, showing the fast response and efficiency of the proposed system.

B. Performance Analysis

The system's performance was evaluated based on flight stability, sensing accuracy, extinguishing capability, and power efficiency:

- The **Cross flight controller** kept the drone stable and balanced during the tests.
- The **sensor unit** detected flames quickly and accurately, with minimal delay.
- The **spraying/dropping mechanism** successfully targeted and suppressed small fires.
- The **battery capacity and motor** thrust were enough to support short emergency firefighting operations.

Overall, the results show that the proposed Fire Extinguisher Drone is a reliable and effective solution for small-scale fire suppression and provides a solid basis for future improvements in autonomous firefighting systems.

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C. Discussion

The experimental results show that drone-based firefighting systems can greatly reduce human risk and improve emergency response time. The quadcopter maintained stable performance, supported by efficient brushless motor operation as evaluated in [25], which allowed reliable maneuvering even while extinguishing fires. Although the current prototype is designed for small-scale fire suppression, it successfully proves the feasibility of using UAVs in firefighting applications.

The results suggest several possible improvements, such as increasing payload capacity for larger extinguishing agents, adding thermal imaging cameras for better fire detection, and using GPS-based autonomous navigation for more accurate and automated operation. With these upgrades, the proposed system could become a stronger and smarter solution for real-world disaster management.

D. Visual Results

The figures below show the different stages of project implementation and testing:

V.CONCLUSION

The Fire Extinguisher Drone project presents a new and effective method for improving fire safety and emergency response. By combining flame and temperature sensors, a Cross flight controller, and a dropping mechanism, the system can suppress fires efficiently. Testing showed strong stability, quick response, and accurate control, making the drone suitable for handling small fires both indoors and outdoors [26], [27].

One major advantage of this system is its ability to work in dangerous areas where it is unsafe or difficult for humans to go. This reduces the risk to firefighters and improves the speed and accuracy of fire suppression [28], [29]. The use of automation, aerial mobility, and real-time sensing highlights the strong potential of drones in emergency response and public safety [30].

This project also sets the stage for future improvements, such as GPS-based autonomous navigation, thermal imaging for better fire detection, and increased payload capacity for larger or multiple extinguishing agents. With continued research and technological progress, UAV-based firefighting systems could become reliable and scalable solutions for smart cities, disaster management, and emergency services [26]–[30].

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