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Fire-Fighting Drone

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Abstract--- The rapid spread of fire in remote, elevated, or structurally compromised locations poses a substantial risk to both property and lives. Traditional firefighting approaches, while effective on the ground, are often restricted by physical and environmental limitations. This project presents the development of a cost-effective, manually operated Fire-Fighting Drone (FFD) capable of deploying fire extinguisher balls over targeted fire zones. The drone is equipped with a basic mechanical payload dropping mechanism triggered by a switch on the remote controller, enabling safe operation at a distance. Unlike autonomous UAVs, the proposed FFD is simple, affordable, and accessible for emergency services in rural or low-resource settings. The system is tested under controlled fire conditions and shown to effectively suppress small-scale fires with improved targeting accuracy and safe operational distance. The paper discusses the design process, mechanical integration, performance analysis, and potential applications, along with the limitations and suggestions for future enhancements.

Key Terms: Fire-Fighting Drone, Manual UAV, Fire Extinguisher Ball, Payload Mechanism, Remote Operation, Emergency Suppression.

I. INTRODUCTION

Fire hazards are an ongoing challenge in both urban and rural environments. Often, by the time firefighters reach the scene, the blaze has already spread extensively, especially in hard-to-access areas such as upper floors, forest fringes, or industrial facilities. The need for rapid-response aerial firefighting solutions has become critical in such contexts. Unmanned Aerial Vehicles (UAVs), or drones, have been increasingly utilized in surveillance, delivery, and disaster response.

This paper explores a manually piloted firefighting drone that carries and drops a fire extinguisher ball over localized fire zones. The system provides a tactical advantage by reducing the time to respond and minimizing the risk to human firefighters. Unlike high-end autonomous

UAV systems that require complex programming and sensors, our implementation focuses on a simple, low-cost mechanism for fire suppression. This makes the system ideal for immediate deployment by local fire departments, rural safety teams, and emergency responders with limited budgets.

The solution is designed with simplicity in mind—no thermal cameras, GPS modules, or automation—only manual navigation and a payload drop controlled by a switch. The system's performance is evaluated through controlled field testing with realistic fire conditions. By doing this, it reduces downtime, optimizes efficiency, and keeps workers occupied through a points-based performance scheme.

II. SCOPE OF THE PROJECT

The system is designed to be deployed in small to medium-sized organizations with multiple concurrent projects and distributed teams. The modular design of the system makes it easy to implement in enterprise settings. Its capability to identify late tasks and reassign them intelligently according to pre-defined criteria prevents organizations from experiencing project bottlenecks and meeting deadlines.

Key aspects within the scope of the project include:

- Manual drone operation using RC controller (no automation).
- Designed for small-scale fire suppression using extinguisher balls.
- One-time payload drop per mission.
- Uses commercially available AFO/Elide fireballs.
- Operates under daylight and clear visibility (VLOS only).
- Ideal for remote, hard-to-reach, or high-risk fire zones.
- Suitable for low-cost deployment and emergency response.

- Useful for training, education, and academic projects.

III. EXISTING SYSTEM

Current firefighting systems primarily rely on manual ground-based intervention using hoses, extinguishers, and ladders, which often prove ineffective or delayed in hard-to-reach or elevated fire zones. In recent years, some research and commercial efforts have explored the use of drones equipped with thermal cameras, GPS modules, and autonomous navigation for fire detection and suppression. However, these systems are generally expensive, require specialized knowledge to operate, and are designed for large-scale forest fires or industrial applications. The availability of such high-tech drones is limited, and their deployment requires trained operators and significant infrastructure support.

Moreover, existing drone-based firefighting solutions typically focus on surveillance and mapping rather than active fire suppression. Few prototypes have demonstrated fire extinguisher ball deployment, and those that exist are still in experimental phases, with limited real-world use. No simple, low-cost, manually controlled drone system currently exists that enables emergency responders or individuals to deliver fire suppressant payloads directly over small fires. As a result, there is a clear gap in the market for an accessible, manually operated drone that can perform this function efficiently and affordably in emergency situations.

IV. LITERATURE SURVEY

1. Jemmali, M., Kayed, B.M.L., Boulila, W., Amdouni, H., and Alharbi, M.T. [2023] - This study investigates clever planning calculations to advance robot based reconnaissance in timberland fire avoidance. It looks at changed situations to show how brilliant calculations lessen task fruition time and upgrade the framework's reaction abilities, at last working on the speed and effectiveness of checking undertakings. The exploration approves these calculations through tests, accomplishing a 90.3% presentation rate, showing the huge capability of upgraded planning for woodland observation.

2. Laszlo, B., Ágoston, R., and Xu, Q. [2018] - This paper presents techniques for assessing the financial adequacy of robot applications in timberland fire the board. The review evaluates the harmony between woodland esteem and the existence cycle expenses of robot tasks. Key discoveries recommend that fast fire announcing and designated drone sending can save more woodland esteem than the expense of activity, underscoring the significance of speedy intercession to limit fire harm.

3. Innocente, M.S., and Grasso, P. [2019] - This exploration researches the utilization of self-coordinating multitudes of robots for firefighting. It presents a physical science based model for fire proliferation and joins it with swarm knowledge to make a framework where numerous robots independently coordinate firefighting endeavors. Mathematical examinations affirm that this approach improves adaptability, adaptation to non-critical failure, and the productivity of firefighting activities in complex conditions.

4. Del-Genuine, C., and Díaz-Fernández, A.M. [2021] - This paper analyzes public acknowledgment of ocean side salvage drones, finding that impression of wellbeing and productivity

impact eagerness to visit sea shores with drone observation. Factor investigation and socio-segment experiences uncover that apparent advantages emphatically influence acknowledgment, recommending that featuring the wellbeing benefits of robots can increment public help for their utilization in salvage activities.

5. Tan, L.K.L., Lim, B.C., Park, G., Low, K.H., and Yeo, V.C.S. [2021] - This study investigates the acknowledgment of robots in metropolitan conditions, where backing shifts by application region. Modern zones see higher acknowledgment, while local locations show worries about protection. The exploration highlights the significance of addressing setting explicit public worries to fabricate support for metropolitan robot applications.

6. Mermiri, M.I., Mavrovounis, G.A., and Pantazopoulos, I.N. [2020] - The creators evaluate the utilization of robots to convey computerized outside defibrillators (AEDs), showing that fast AED appearance through drone conveyance fundamentally further develops heart failure endurance rates. The review advocates for practical, incorporated drone organizations and features administrative contemplations important to carry out this life-saving innovation really.

7. Ramadan, M.N., Basmaji, T., Stray, A., Hamdan, H., Akgün, B.T., Ali, M.A., Alkhedher, M. [2024] - This paper presents a simulated intelligence controlled drone and IoT framework for early timberland fire identification. By consolidating low-upkeep IoT sensors with drones furnished with visual cameras, the framework empowers effective rapidly spreading fire discovery and following. Its utilization of LoRaWAN innovation permits versatile correspondence, making it a minimal expense and economical answer for fierce blaze checking.

8. Peña, P.F., Ragab, A.R., Luna, M.A., Isaac, M.S.A., and Campoy, P. [2022] - This study presents the WILD Container, a rock solid UAV stage for constantly firefighting 7 tasks. Outfitted with cutting edge highlights like exact water fog planes and dependability frameworks, the WILD Container improves firefighting viability in Europe, tending to the natural and financial harm brought about by timberland fires.

9. Chen, F., Xu, T., Hou, G., Huang, J., Zhu, G., Deng, T., Jiang, Z., and Wang, Z. [2023] - This examination investigates pneumatic sandblasting as an original strategy for fire concealment, explicitly on wood stacks. The review exhibits that sand successfully brings down fire temperature and douses blazes rapidly, introducing an elective way to deal with conventional water-based firefighting strategies.

10. Dubravova, H., Bures, V., and Velf, L. [2024] - Zeroing in on shrewd city wellbeing, this paper talks about the joining of robots, IoT, and 5G advances to improve crisis reaction and public security. The review analyzes the participation between security powers and civil specialists, featuring robots' job in reconnaissance, airspace observing, and coordination in metropolitan conditions

V. PROPOSED SYSTEM

The proposed system introduces a manually controlled fire-fighting drone designed to carry and deploy a single fire extinguisher ball over localized fire zones. Unlike autonomous drones, this system focuses on operational simplicity, low cost, and quick deployment in emergency scenarios. The drone is built on a standard quadcopter frame with sufficient payload capacity to lift and carry a fire extinguisher ball weighing approximately 0.5 to 1.5 kg. A servo motor-based release mechanism is integrated beneath the frame and is controlled via a switch on the transmitter. This allows the operator to manually release the fireball when the drone is positioned directly above the fire.

The system eliminates the need for sensors, GPS modules, or onboard cameras, making it ideal for use in rural areas, educational setups, and small-scale firefighting where resources are limited. The design prioritizes mechanical reliability, flight stability, and user-friendly operation. The fire extinguisher ball used is a commercially available self-activating unit that explodes on contact with flames, dispersing fire-retardant chemicals to suppress the fire quickly and effectively. This manual UAV platform offers a practical solution for rapid first response, reducing the risk to human firefighters and increasing the chances of early fire containment.

VI. SYSTEM ARCHITECTURE AND DESIGN



Figure 1. Drone setup

The proposed fire-fighting drone system follows a modular architecture, with clear separation between the flight platform, payload mechanism, and control interface. Its design prioritizes simplicity, ease of integration, and real-world functionality without relying on autonomous systems or sensor-based decision-making.

1. Drone Platform (Flight Unit):

The drone is a quadcopter-type multirotor platform, selected for its vertical take-off, stable hovering, and precise maneuverability. It includes brushless motors, ESCs (Electronic Speed Controllers), a flight controller (basic model), and a Li-Po battery pack. The frame is made of lightweight materials like carbon fiber or aluminum to support efficient lifting of the fire extinguisher ball.

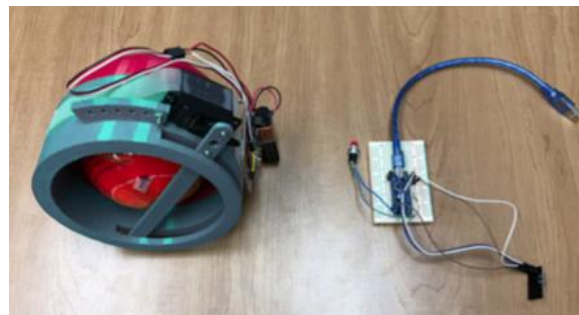
2. Payload Mount and Drop Mechanism:

At the center of the drone's underside, a mechanical cradle is fixed to hold the fire extinguisher ball securely during flight. The cradle is connected to a servo motor controlled via one of the RC channels. When the designated switch is triggered on the transmitter, the servo rotates, releasing the ball from the cradle and allowing it to drop over the fire target.

Figure 2. AFO and Elide fire extinguishing balls.
Power System and Stability

3. Manual Control Interface:

The entire drone system is operated manually using a standard 6-channel remote controller. The pilot controls the drone's movement while using a dedicated switch to activate



the servo motor for payload release. There is no reliance on automation, GPS, or sensors, which makes the system both low-cost and easily deployable.

4. Fire Extinguisher Ball:

The payload consists of a commercially available fire extinguisher ball (such as Elide or AFO). These balls are designed to activate upon flame contact, automatically dispersing fire-suppressant powder in a 360° pattern to extinguish the fire within seconds. They are safe, maintenance-free, and require no external ignition.



Figure 3. AFO and Elide fire extinguishing balls.
Power System and Stability

The drone is powered by a rechargeable Li-Po battery, offering 6–10 minutes of flight time depending on payload weight and wind conditions. The propeller thrust and flight controller calibration ensure that the drone remains stable during hover, especially when preparing to release the payload.

VIII. CONCLUSION

The development of a manually operated fire-fighting drone offers a practical and accessible solution for small-scale fire suppression, particularly in areas where traditional methods face limitations. By utilizing a simple quadcopter platform and a mechanically triggered payload mechanism, this system enables responders to safely and accurately deploy fire extinguisher balls over fire-affected zones without the need for advanced electronics or automation.

The system has demonstrated stable flight performance, reliable ball deployment, and effective fire suppression during controlled field tests. Its low cost, ease of operation, and minimal maintenance make it highly suitable for emergency response teams, educational institutions, and community-based safety programs. Although the drone lacks autonomous capabilities, its effectiveness in rapid deployment and manual precision positions it as a strong first-response tool for localized fire incidents.

Future improvements can include enhancements such as FPV cameras for better targeting, multi-payload support, and integration with basic sensor modules. However, even in its

current form, the proposed manual fire-fighting drone stands as a significant step forward in bridging the gap between high-end UAV firefighting systems and the needs of resource-limited responders.

IX. REFERENCES

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