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Implementation of Autonomous Drone for Flood Surveillance

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Abstract: Floods are natural disasters that pose significant challenges to both the safety of communities and the effectiveness of response efforts. In recent years, the integration of unmanned aerial vehicles, commonly known as drones, has emerged as a valuable tool in flood surveillance. This paper provides an overview of the multifaceted role of drones in flood-related scenarios, highlighting their capabilities, benefits, and potential challenges. Drones have demonstrated their versatility in flood management by offering several critical functions. Drones enhance the safety of response teams by providing situational awareness without exposing personnel to hazardous conditions. They can be deployed to access remote or inaccessible areas, where human intervention is challenging or dangerous. Drones equipped with thermal imaging cameras also support search and rescue missions, increasing the chances of locating and saving individuals trapped by floodwaters. In addition to assessment and rescue, drones contribute to flood forecasting and early warning systems. By continuously monitoring water levels, weather conditions, and flood dynamics, drones provide essential data for improving flood prediction models. This information helps authorities issue timely warnings, enabling communities to prepare and evacuate when necessary.
Keywords: Unmanned Aerial vehicles, surveillance, hazardous condition, assessment and rescue, and flood dynamics

I. INTRODUCTION

Unmanned aerial vehicles (UAVs), commonly known as drones, represent a significant technological advancement in aviation. These aircraft, devoid of onboard human pilots, are controlled either autonomously by onboard computers or remotely by operators stationed on the ground or in other vehicles. While initially associated primarily with military applications, UAVs have since found diverse roles in civil aviation. Civil applications of UAV technology have proliferated, encompassing tasks such as crop surveillance, aerial cinematography for filmmaking, search and rescue missions, infrastructure inspection, wildlife monitoring, and advertising, among others. Utilizing materials like EPP foam, brushless motors, servos, Electronic Speed Controllers (ESCs), and 2.4 GHz Transmitters and Receivers (Tx/Rx), small-scale UAVs can be designed with relative simplicity. Delta mixing, a technique involving eleven mixing methods, streamlines the hardware requirements and design complexity of UAV models, making them suitable for commercial purposes such as aerial surveillance, remote sensing, and scientific research. The versatility of UAV technology extends across various sectors, serving military and civilian markets alike. With wingspans ranging from 7 inches to 13 feet, UAVs come in diverse physical configurations, including mini-UAVs with wingspans spanning 21 inches to 10 feet. These aircraft adhere to the fundamental principles of thermodynamics and physics, albeit with considerable variation in size and design. unmanned aerial vehicles represent a burgeoning technological frontier with myriad applications spanning military reconnaissance to civilian surveillance and beyond. Their adaptability, driven by advancements in design and technology, continues to expand their role in diverse fields, promising further innovation and development in the future.

II. PROPOSED DRONE SYSTEM

A. Introduction

An autonomous flood monitoring drone refers to an unmanned aerial vehicle (UAV) equipped with sophisticated technology and programmed to perform various tasks related to flood management without constant human intervention. These drones are designed to operate autonomously, carrying out missions for assessing, monitoring, and responding to flood situations, they provide live updates and telemetry on flood conditions, water levels, infrastructure damage, and potential risks, aiding in timely decision-making.

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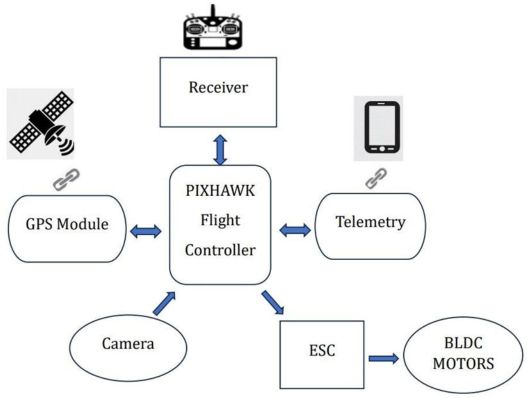

Fig 1: Block diagram of Proposed Drone

This is a block diagram of drone system. It shows different components of the drone and how they are connected. The diagram is made up of different shapes and lines, with labels on each shape to explain what it is. The components of the drone system include a receiver, GPS, Camera, ESC, BLDC motors, Telemetry and Pixhawk flight controller. The receiver is connected to the Pixhawk flight controller, which is connected to the ESC and BLDC motors. The GPS and Camera are also connected to the Pixhawk flight controller.

Fig 1: Aerial view from a drone

The receiver is a device that receives signals from the remote control and sends them to the flight controller. These signals typically include commands for various drone functions, such as throttle, pitch, roll, and yaw. The receiver then relays these commands to the flight controller.

The GPS is used to determine the drone’s location and altitude. It relies on signals from multiple satellites to calculate the drone's position with high accuracy. This information is crucial for features like waypoint navigation, return to home, and geofencing.

Fig 2: GPS module

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The camera is used to capture images and video. Drones can be equipped with various types of cameras, including RGB cameras for photography, and specialized cameras for tasks like thermal imaging or multispectral analysis. The camera's feed is often transmitted to the operator's ground station for real-time monitoring or recording.

Fig 3: Camera

The ESC (Electronic Speed Controller) controls the speed of the motors. An electronic speed controller or ESC is a device installed to a remote-controlled electrical model to vary its motor's speed and direction. It needs to plug into the receiver's throttle control channel.

Fig 4: 30A ESC

The BLDC motors (Brushless DC motors) are used to power the drone and provide lift. They are more efficient and durable compared to brushed motors. BLDC motors are often used in combination with propellers to generate thrust and lift, allowing the drone to move in different directions.

Fig 5: 1000 kV BLDC motor

The telemetry is used to transmit data between the drone and the ground station. It can include information such as battery voltage, GPS coordinates, altitude, and more. Telemetry data is crucial for real-time monitoring, mission planning, and ensuring the drone's safe operation.

Fig 6: Telemetry

The Pixhawk flight controller is the brain of the drone, which processes all the data from the sensors and controls the drone's movement. It processes data from sensors, including GPS, accelerometers, gyroscopes, and barometers. The flight controller uses this data to stabilize the drone, control its movement, and execute flight plans. It also manages communication with other components like ESCs, GPS, and telemetry.

Fig 7: PIXHAWK 4 Flight Controller

B. Implementation

The operational sequence of a drone initiates with the activation of the Pixhawk 1.7 in the transmitter-receiver section. By selecting the Arm option, the Quadcopter becomes operational upon Pixhawk 1.7 activation, whereas opting for Disarm results in the shutdown of the entire circuit. The transmitter-receiver module facilitates manual control of the quadcopter. Subsequently, the GPS system determines the current location of the quadcopter, and the Mission Planner software is utilized to establish a predefined path using waypoints.

The Pixhawk 1.7 module then calculates the difference between the current GPS-derived location and the specified waypoint. Based on this calculation, signals are transmitted to the Electronic Speed Control (ESC) to prompt the quadcopter's movement in the desired direction. The ESC, serving as an interface device, regulates motor speed according to controller inputs. The Pixhawk 1.7 communicates with all four ESCs to ensure the coordinated movement of the quadcopter. Unlike helicopters where a single motor bears the entire weight, each motor in the quadcopter shares 1/4 of the weight, enhancing versatility.

To enhance functionality, a mobile camera is integrated into the quadcopter, allowing ground station control. Brushless motors are chosen for their high torque capabilities. The drone must possess sufficient payload capacity, stabilization, and localization capabilities. Quadcopter movement is dictated by the rotation speed of its four motors. For example, to move forward, the rear motors rotate at a higher RPM than the front motors. The surveillance process employs on-board transmitters and receivers. The ground station, connected wirelessly to the quadcopter, is managed by software commands, enabling autonomous flight.

III. RESULT

The result of an autonomous drone operated by qground control and given waypoints depends on various factors, including the specific mission parameters, drone capabilities, environmental conditions, and the accuracy of the mission planning.

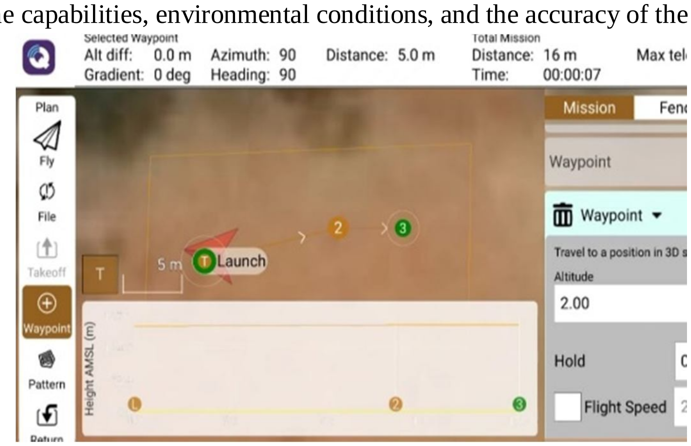

Fig 8: QGROUND Software with waypoints

1) Navigation and Waypoint Following: If the mission planner is designed effectively and the waypoints are accurately set, the drone should navigate through the specified path, following the waypoints in the given order.

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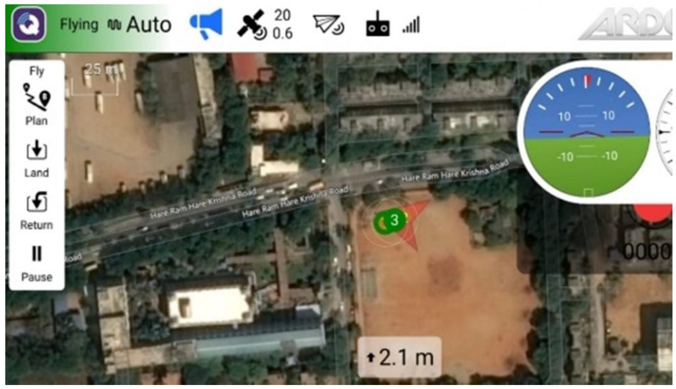

Fig 9: GPS view on QGROUND

2) Autonomous Control: The drone's autonomous control system should handle various aspects such as altitude, speed, and direction based on the mission planner's instructions.
3) Sensor Data and Feedback: The drone may be equipped with sensors like GPS, accelerometers, gyroscopes, and cameras. These sensors provide real-time data to the drone's flight controller, helping it adjust its position and orientation accordingly.
4) Mission Monitoring: QGROUND Control often include monitoring capabilities, allowing operators to track the drone's progress, receive status updates, and intervene if necessary. This could be through telemetry data or a live video feed.
5) Data Collection and Payload Deployment: Depending on the nature of the mission, the drone might be equipped to collect data or deploy payloads at specific waypoints. This could include tasks such as aerial photography, surveying, or delivering goods.

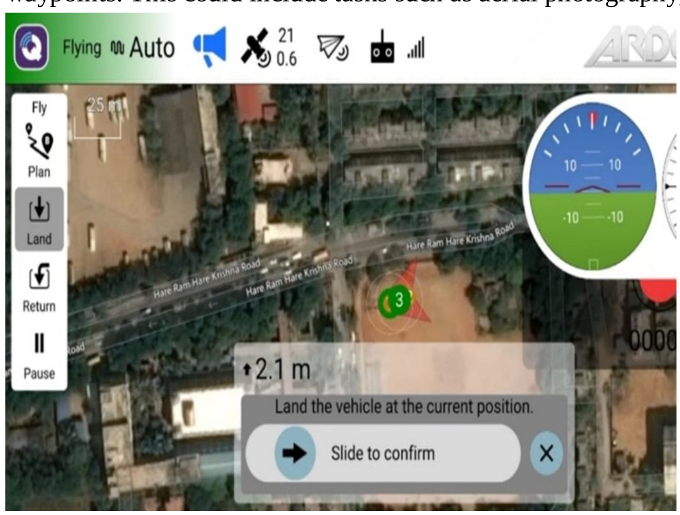

Fig 10: Land the Drone with QGROUND Software

6) Return to Launch (RTL): Many autonomous drones have a "Return to Launch" feature, where the drone automatically returns to its takeoff point if it encounters issues or completes its mission.

It's important to note that the success of an autonomous drone mission heavily relies on proper planning, accurate waypoint setting, reliable hardware, and effective communication between the qground control and the drone. Additionally, compliance with local regulations and airspace rules is crucial for safe and legal drone operations.

Autonomous drones typically operate in various modes to perform specific functions. Here are four common modes:

a) Take off Mode:

Functionality: In this mode, the drone prepares for liftoff and ascends to a predetermined altitude.

Actions: Systems are initialized, motors are powered, and the drone gradually lifts off the ground.

Key Features: Safety checks, such as verifying GPS lock and sensor calibration, are conducted before takeoff.

Fig 11: Takeoff Mode

b) Standby Mode:

Functionality: The drone hovers in a stable position, awaiting further instructions.

Actions: The drone maintains a holding pattern or a stationary hover, conserving energy and staying ready for immediate deployment.

Key Features: Minimal movement and power consumption to extend flight time.

Fig 12: Standby Mode

c) Flight Mode:

Functionality: This is the standard mode for autonomous drone operations during a mission or task.

Actions: The drone follows a predefined flight path, navigates waypoints, and executes mission-specific commands.

Key Features: Utilizes sensors, GPS, and software algorithms for precise navigation. Can include functionalities like obstacle avoidance and adaptive route planning.

Fig 13: Flight Mode

d) Landing Mode:

Functionality: The drone initiates the landing process, descending to the ground or a designated landing platform.

Actions: Motors slow down, and the drone descends smoothly until it reaches the ground.

Key Features: Precision landing and safe shutdown procedures. May include additional safety checks before landing.

Fig 14: Landing Mode

These modes collectively enable autonomous drones to perform a range of tasks efficiently, from takeoff to completing a mission and safely landing. The transition between these modes is often controlled by the drone's autopilot system, which processes input from various sensors and executes pre-programmed instructions.

IV. CONCLUSION

In accordance with the specified design criteria, the surveillance functionality is closely monitored under human supervision, proving advantageous for flood surveillance. Additionally, it can be employed for capturing aerial photographs of flood-affected regions. Its ease of maneuverability offers flexibility in movement, and its adaptability extends to providing night surveillance through infrared cameras. The system has the potential for further enhancement to cater to future needs. The quadcopter is equipped with a GPS data logger that records its current latitude, longitude, and altitude in a comma-separated value file format, facilitating mapping applications. Consequently, the proposed drone serves as a valuable tool for the surveillance and monitoring of diverse locations and terrains. In areas where human intervention involves life-threatening risks and challenging conditions, the deployment of autonomous surveillance drones emerges as a viable solution to mitigate these challenges.

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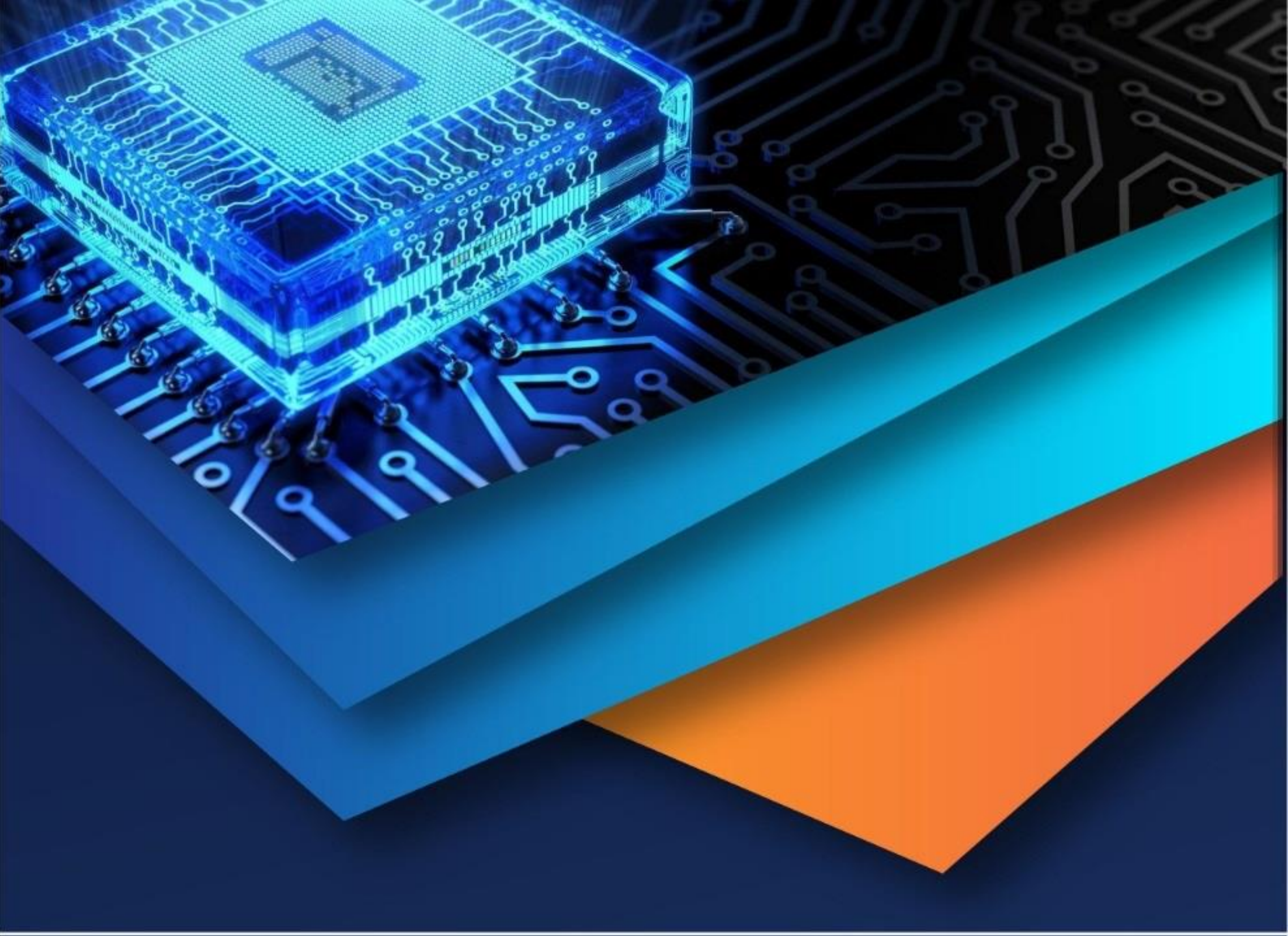

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