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Automatic Sensory Fire Fighting Drone

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ABSTRACT: To accomplish this objective, the project designed and implemented a novel automatic sensory fire-fighting drone with a flight controller from Arduino UNO. The drone is integrated with a gripper module designed to hold and drop a fire extinguisher ball effectively at the fire source. Moreover, it has an ESP32 cam module, which serves surveillance and as a fire detector with much better sensory abilities. Thus, the drone with this module detects the fire in real-time as well as the zone, thereby enabling an immediate accurate response to the fire-break incident. By integrating Arduino UNO and ESP32 cam to the drone into the wild, the drone can maneuver autonomously to the fire source, perform the surveillance, and finally act as a firefighter efficiently. This capability potentially will redefine the emergency response process in fire management.

KEY WORDS: Arduino UNO, ESP32 cam, accurate response.

I. INTRODUCTION

In addressing the urgent demand for new approaches to fire management, this project presents an automatic sensory fire-fighting drone that was developed with an Arduino UNO as the central flight controller. A singular drone equipped with a distinctive manipulator module was created to be able to carry and release the fire extinguisher ball to the middle of a fire . A net connection to the camera was also established via the ESP32 module to supplement surveillance activity and acquire sophisticated fire detection data that constructed the drone able to identify an area and react to fire quickly.

1.1. PROBLEM STATEMENT

Design and develop an automated fire fighting drone that can detect fires using ESP32 cameras, navigate to the fire location, and extinguish the fire using a fire extinguisher ball. The drone should be controlled remotely using a transmitter and equipped with sensors to detect and track the fire. The system should be able to operate in various environments and ensure the safety of firefighters and bystanders.

1.2. OBJECTIVE

- **Fire Detection:** Use ESP32 cam to detect fires and track their spread.
- **Navigation:** Use the transmitter to control the drone and navigate it to the fire location.
- **Fire Extinguishment:** Use a fire extinguisher ball to extinguish the fire.
- **Safety:** Ensure the safety of firefighters and bystanders by operating the drone in a controlled and monitored manner.

II. COMPONENTS

2.1 COMPONENTS AND SPECIFICATIONS

- Atmega 328P
- Frame
- Electronic Speed Controller (ESC)
- Motor
- Propeller
- Landing Gear
- Lipo Battery
- Transmitter and Receiver
- Gripper Module
- ESP32-Cam

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2.1.1 ATMEGA 328P

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

2.1.2 FRAME

A drone frame refers to the basic structural component of an unmanned aerial vehicle (UAV) or drone, typically constructed from lightweight materials such as carbon fiber, aluminum alloy, or composite materials. The frame provides the foundation upon which other components, such as motors, propellers, flight controller, and battery, are mounted and secured. It is designed to withstand the stresses and forces experienced during flight maneuvers while maintaining stability and rigidity to support the overall structure of the drone. Drone frames come in various shapes and sizes, ranging from quadcopters and hexacopters to octocopters, each tailored to specific applications and flight requirements. The design of the frame influences factors such as aerodynamics, weight distribution, and payload capacity, thus impacting the drone's performance, maneuverability, and endurance.

- Model: S500.
- Frame Weight: 405gm
- Wheelbase: 500 mm
- Moter Mounting Hole Dia.: 3 mm
- Landing Gear Material: ABS
- Arm Size: 220 x 40 mm.
- Landing Gear Length: 200mm

2.1.3 ELECTRONIC SPEED CONTROLLER (ESC)

ESC stands for Electronic Speed Controller, an essential component in a drone's propulsion system. It regulates the speed of the motors by controlling the amount of power delivered to them from the drone's battery. ESCs receive commands from the flight controller, which interprets user input or autopilot commands, and adjusts the motor speeds accordingly to achieve desired flight maneuvers such as acceleration, deceleration, and changes in direction. ESCs convert direct current (DC) power from the battery into alternating current (AC) to drive brushless motors, which are commonly used in drones for their efficiency and reliability. ESCs come in various configurations and specifications depending on factors such as motor type, voltage, current rating, and the number of motors in the drone's propulsion system. They play a crucial role in ensuring smooth and stable flight performance by precisely controlling motor speeds and maintaining balance and stability during flight.

- Model: SIMONK 30A.
- Constant Current: 30A (Max 40A < 10 sec).
- BEC: 5V 2A.
- Suitable Batteries: 2-3S LiPo.

2.1.4MOTOR

The RS2205 2300KV BLDC Motor has been designed and built specifically for FPV Racing. These series are great affordable motors for the beginner who wants to get in the air and learn all of the basics of flying FPV! This is medium-priced high-quality Brushless DC Motors for Drone or Quadcopters. Here is RS2205 2300KV Brushless DC Motor for QAV250 QAV300 Racing Drone. This Brushless motor for Drone is featuring a self-cooling technique that can reduce the temperature of the motor up to 30% which in turn increases the service life of this BLDC Motor.

The cooling fins and high-grade N52 Neodymium Magnets make them unique over other Drone DC Motors. Also, the genuine Japanese NMB Bearings and enhanced Anti Off U Ring bring more quality to the working of this motor.

- Motor KV: 2300 RPM/V
- Li-PO Batteries: 3-4S
- Shaft Diameter: 5 mm
- Propellers: 5″
- Thrust: 1024 gm

2.1.5 PROPELLER

The Orange HD Propellers 5045(5X4.5) Carbon Nylon Props are the high-quality propellers specially designed for multi-copters.

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These Orange Propellers are light in weight and high strength propeller has a 15° angle design at the end of the propeller to avoid whirlpool while the multi-copter is flying. They are useful in drones as well as in multi-copters.
The Orange Carbon Fiber Props is of high endurance and flexibility for great impact. Orange propellers help to improve the air-powered efficiency and aerofoil stability.

- Length: 5″.
- Pitch: 4.5″.
- Weight: 17 gm.
- Shaft Diameter: 5mm.
- Total length: 5 inch / 125 mm.
- Material: Carbon Nylon.

2.1.6 LANDING GEAR

The landing gear has a ground clearance of 200mm and allows the mounting of the camera and other accessories at the bottom of the mainframe. The landing gear has plenty of height making it suitable for gimbals. The Plastic Landing Gear can withstand sudden crashes during the flying of FPV Quadcopters.
The added lift capacity makes this frame ideal for carrying larger payloads such as camera systems and other electronic components.
Landing Gear Length: 200mm

2.1.7 LIPO BATTERY

Orange 3S 30C/60C Lithium polymer 2200mah battery Pack (LiPo) is known for performance, reliability, and price. So it's no surprise to us that Orange lipo battery is useful in drones or any other multirotor systems; likewise, health & fitness devices. The 2200mAh battery Pack (LiPo) delivers full capacity at a price everyone can afford; likewise, we assure a quality product and the best customer support.
The Orange 3S 30C/60C 2200mAh battery Pack (LiPo) is available with heavy-duty discharge leads; above all to minimize resistance and sustain high current loads. Orange batteries stand up to the punishing extremes of aerobatic flight and RC vehicles. Each pack is available with plating of gold on connectors and JST-XH style balance connectors. The assembling of all Orange Lithium Polymer battery packs is done using IR match cells, in addition, to providing high reliability.

- Model No: ORANGE 2200/3S-30C
- Weight: 175.0g
- Voltage: 11.1V
- Dimensions : 23x34x106(mm)
- Max Continuous Discharge: 30C(66.0A)

2.1.8 TRANSMITTER AND RECEIVER

Using a drone is easy but controlling a drone is a tough job that's why a transmitter is needed. You can't fly a multirotor without it because it uses radio signals to send commands wirelessly to a Radio Receiver. And Flysky is one of the popular brands that only manufactures a Diverse Range of high-quality Transmitters and Receivers at an affordable price. Flysky CT6B 2.4 GHz 6CH transmitter is an entry-level 2.4 GHz radio system offering the reliability of 2.4 GHz signal technology and a receiver .it is ideal for quadcopters and multirotor that require the 6ch operation. FlySky Transmitter and Receiver is gaining so much popularity due to its originality and compatibility in high-end drone projects and Industrial people are interested in this type of Transmitter.

- Model Type: Digital Radio Transceiver.
- Sensitivity: 1024.
- Bandwidth: 500 kHz.
- Default Operating Mode: Mode 2 (Left-Hand Throttle).
- No. of Channels: 6.
- Operating Voltage: 12V DC (1.5AA x 8 Battery).

2.1.9 GRIPPER MODULE

A gripper is a device which enables the holding of an object to be manipulated. The easier way to describe a gripper is to think of the human hand. Just like a hand, a gripper enables holding, tightening, handling and releasing of an object. A gripper is just one component of an automated system.

- Material - aluminum alloy
- Maximum opening - 55mm

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- Overall length - 108mm
- Package includes - 1 x parallel jaw robotic aluminium gripper
- Package doesnt include the servo motor-mg995.

2.1.10 SERVO MOTOR

MG995 servo is a powerful servo motor that is capable of spinning and controlling things that a small hobby servo motor could never accomplish doing. It comes with a bunch of accessories so you could connect it easily with the outer world, and it's being controlled like every other servo motor, via PWM.

- Model: MG995
- Weight: 55 gm
- Operating voltage: 4.8V~ 7.2V
- Servo Plug: JR
- Stall torque @4.8V : 9.4kg-cm
- Stall torque @6.6V : 11kg-cm

2.1.11 ESP32-CAM

The ESP32-CAM-MB is a versatile development board that combines the power of the ESP32 microcontroller with built-in WiFi and Bluetooth capabilities and an integrated OV2640 camera module. This board is designed for various applications, including IoT projects, robotics, surveillance systems, and more, where wireless communication and image capture are essential. Below is a description of the key features and components of the ESP32-CAM-MB development board.

III. DESIGN OF A FIRE FIGHTING DRONE

3.1 QUADRACOPTER CONFIGURATION

A quadcopter, also known as a quadrotor, is a type of unmanned aerial vehicle (UAV) characterized by its configuration of four horizontally oriented rotors, each mounted at the end of a separate arm. These rotors generate lift and control the vehicle's motion through differential thrust, allowing for vertical takeoff and landing, as well as agile maneuverability in various directions. Typically, quadcopters feature two pairs of rotors spinning in opposite directions to counteract torque and maintain stability. They are widely used in applications such as aerial photography, surveillance, agriculture, and recreational flying due to their simplicity, versatility, and relatively easy control compared to other multirotor configurations.

3.2 THRUST AND MOTOR

The Thrust RS2205 2300KV motor is a popular choice for drone enthusiasts and professionals alike due to its exceptional performance and reliability. With its high RPM (revolutions per minute) capability and efficient design, this motor generates considerable thrust, making it well-suited for various drone applications, including racing and freestyle flying. Its 2300KV rating signifies that it spins at 2300 revolutions per minute per volt when no load is applied, offering a balance between power and efficiency. The motor's robust construction and precise engineering ensure smooth operation and longevity, contributing to stable flight characteristics and responsive control. Whether powering racing drones or aerial photography platforms, the Thrust RS2205 2300KV motor is valued for its performance, durability, and versatility in the drone community.

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3.3 BLOCK DIAGRAM

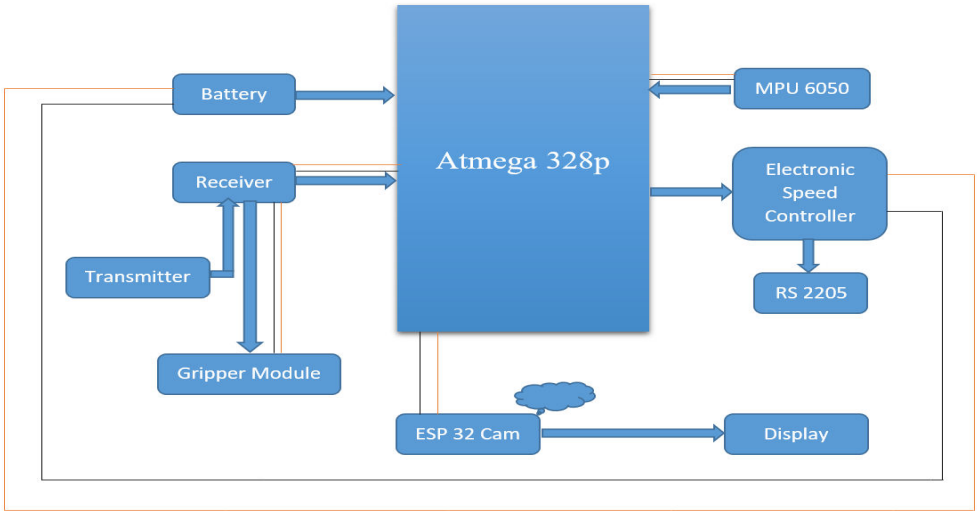

Fig 3.3 – BLOCK DIAGRAM

3.4 WORKING

The AUTOMATIC SENSORY FIRE FIGHTING DRONE project utilizes Arduino Uno as the flight controller, ESP32 Cam for surveillance and fire detection, and a transmitter for control. The system detects fires using thermal imaging and cameras on the ESP32 Cam, which sends the data to the Arduino Uno. The Arduino Uno then navigates the drone to the fire location using the transmitter, ensuring precise control. Once at the fire location, the Arduino Uno controls the servo motor to drop the fire extinguisher ball, effectively extinguishing the fire. This autonomous system enhances fire detection and extinguishment capabilities, reducing the risk of injury to firefighters and improving overall fire safety.

3.5 FIRE EXTINGUISHER BALL

A fire extinguisher ball is an innovative and compact firefighting device designed to extinguish small fires rapidly. Typically, it is spherical in shape and contains dry chemical powder or other extinguishing agents inside. When exposed to flames, the ball activates automatically, bursting open and releasing the extinguishing agent to smother the fire. This mechanism makes it ideal for use in various environments, including homes, offices, vehicles, and industrial settings. Fire extinguisher balls are known for their simplicity and effectiveness in suppressing fires quickly, potentially preventing them from spreading and causing significant damage or injury.

IV. RESULT AND DISCUSSIONS

The AUTOMATIC SENSORY FIRE FIGHTING DRONE project uses Arduino Uno as the flight controller and ESP32 Cam for surveillance and fire detection. The drone is controlled using a transmitter to navigate to the fire location. The ESP32 Cam captures thermal images and detects fire hotspots, which are then transmitted to the Arduino Uno for navigation. Once at the fire location, the Arduino Uno controls the servo motor to drop the fire extinguisher ball. The drone's performance was evaluated through various metrics, including flight stability, sensor accuracy, firefighting efficiency, and autonomous operation. The results demonstrate significant advancements in firefighting capabilities, showcasing the drone's ability to navigate complex environments, detect fire hotspots accurately, and suppress fires rapidly and effectively. The drone's autonomous operation capabilities also highlight its capacity to navigate autonomously, identify fire threats, and make informed decisions without human intervention. Overall, the project demonstrates a significant leap forward in modern emergency response capabilities, combining cutting-edge technologies to transform firefighting strategies worldwide

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V. CONCLUSION

In conclusion, the AUTOMATIC SENSORY FIRE FIGHTING DRONE project successfully integrates Arduino Uno as the flight controller, ESP32 Cam for surveillance and fire detection, and a transmitter for control. The drone's autonomous capabilities enable it to detect fires using thermal imaging and cameras, navigate to the fire location, and extinguish the fire using a fire extinguisher ball. The project's results demonstrate significant advancements in firefighting capabilities, showcasing the drone's ability to navigate complex environments, detect fire hotspots accurately, and suppress fires rapidly and effectively. The drone's autonomous operation capabilities also highlight its capacity to navigate autonomously, identify fire threats, and make informed decisions without human intervention. Overall, the project's innovative integration of technologies has the potential to revolutionize firefighting strategies worldwide, enhancing fire safety and reducing the risk of injury to firefighters.

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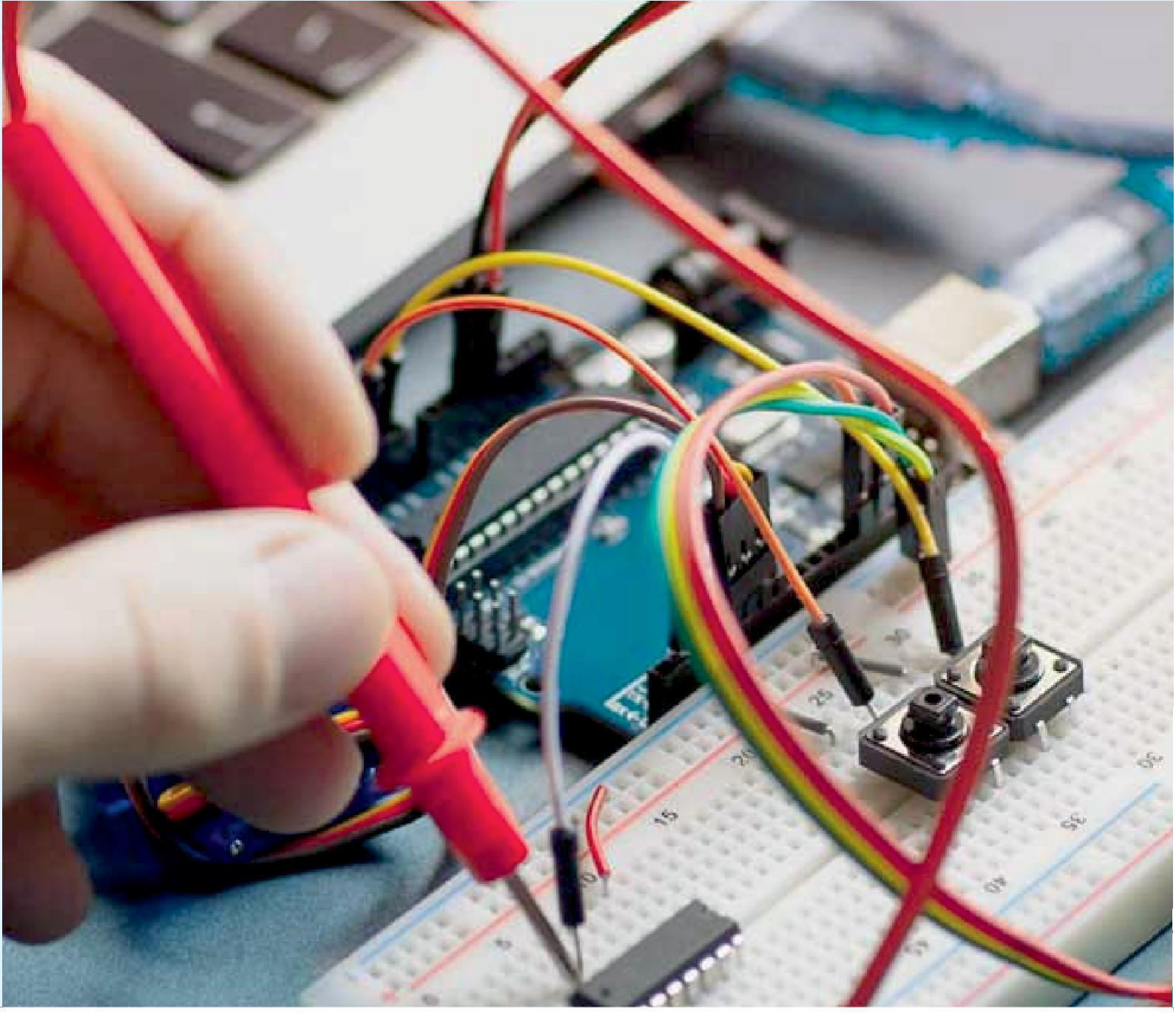

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