IoT Controlled UAV for Forest surveillance

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Abstract. The lifestyle has evolved a lot in the last few years. Technological advancement in the field of embedded systems, computer networks, and the Internet of Things (IoT) has ameliorated our way of living. It has become an essential part of our lives. This paper describes the various aspects of a drone (quadcopter) controlled by the Internet of Things. The flight controller comprises a NodeMCU board and is controlled by an ESP8266 Wi-Fi module setup. Every component has been explained comprehensively. A YOLO and OpenCV based detection system is implemented and a web-database is used to store the data. The main aim is to make the whole process low-cost and multi-purpose with special emphasis in the environment. The drone can be used in rescue operations, environmental monitoring, firefighting operations, surveillance, payload delivery, and more fields.

Keywords: Drones, Forest surveillance, Internet of Things, Embedded Systems, Smart sensors.

1 Introduction

The use of quadcopters is increasing daily due to its wide approach in providing solutions to daily life problems. It is extensively used in various industries and assists in manual work. UAVs can easily fit in various types of terrains and assist in data acquisition. Drones are of various types like Quadcopters, Hexa-copters. Various calibrated sensors and high-definition cameras are mounted on the drone for low-priced image and sensor data acquisition. Thus, using quadcopters can be one of the most prominent ways to conduct forest surveillance [1].

In recent days, technology has completely transformed our lives. New technological advancements like satellite data, machine learning, remote sensing tools have provided good forest surveillance and monitoring opportunities. Many research and academic institutions, service providers, space agencies, and government agencies have been involved in developing unique approaches and techniques that can be used to support forest surveillance.

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Nowadays, drones are used in various sectors due to their low maintenance cost. Since there is an exponential increase in trespassing, animal poaching, illegal cutting down of forest trees, and therefore leading to degradation of forest covers, a combination of drone and forest surveillance modules is a very efficient methodology [2].

This paper explains the features, modelling, and working of a quadcopter-enabled forest monitoring/surveillance system controlled by the Internet of Things principles. The flight controller used here is an IoT module consisting of a NodeMcu board, an ESP8266 module attached to it, and controlled by a web IoT base setup. Each component has been examined and explained constructively in detail. The main aim is to make it cost-effective and multi-purpose with particular emphasis on forest protection. The drone itself can be used in rescue operations, environmental monitoring, firefighting operations, surveillance, payload delivery, and more fields, thus making the system quite efficient and flexible [3].

2 Related Work

Over the past few years, the number, frequency, and severity of wildfires have increased dramatically worldwide, significantly impacting the country's economies, ecosystems and communities. For instance, in 2019, Brazil saw more than 40,000 forest fire outbreaks, with an estimated 906,000 hectares lost to fires that cost around 957 billion to 3.5 trillion US dollars over a period of 30 years. To protect these vast stretches of forest land, early detection and warning along with an immediate response to unknown fire are the only ways to avoid such substantial deprivation of our enriching legacy with nature [4].

The utmost vital goal in fire surveillance is quick and constant detection and localization of the fire. When the location is known, it is much easier to suppress fire in its early stages. Data about the fire's progress is likewise precious for handling it throughout its stages.

Existing wildfire detection and monitoring technologies include satellite imaging, infrared cameras, ground sensors, and remotely piloted vehicles (RPV). However, these systems so far cannot offer a fast and unfailing solution. Various drawbacks of the existing technologies include: - not dependable, particularly under cloudy and foggy weather conditions, comparatively lengthy time delay for satellites to overpass the field, and infeasibility of installing sensors with limited detecting distance ranges. The major drawback in current systems involves aircraft pilots and on-ground personnel, which puts them at risk and requires a high cost to operate [5].

This paper offers a new wildlife detection and surveillance method based on Unmanned Aerial Vehicle aided with the Internet of Things (UAV-IoT) network. The UAVs can offer consistent demands for cellular communication networks and increased data rates. At the same time, the IoT network can connect a massive number of simple-structured, self-powered IoT sensors. This system detects and monitors forest fires through several sensors and sends them to the IoT cloud. Continuous monitoring and uploading values to the cloud can be achieved. The main aim of this research work is to evaluate the reliability of the UAV-IoT networks in detecting wildfires within a limited period [6].

3 Methodology

3.1 Components

1) **BLDC MOTOR-** A brushless direct current motor (BLDC) is without the carbon brushes and copper commutator. BLDC motors have a progressive speed range and better torque to speed ratio. The only wear items in this motor are the bearing which provides long operating life.

2) **PROPELLERS-** It is a device that converts rotary motion into linear thrust. The propellers provide lift for the aircraft by spinning and creating an airflow that provides pressure difference between the bottom and top surfaces of the propeller. Thus, it produces an acceleration of mass of air in one direction, thus providing lift which counteracts the force of gravity

3) **ELECTRONIC SPEED CONTROLLER-** A wired component connects the motors and the battery. It relays a signal to the motors and tells them how fast to spin. Each of the motors could be spinning at different speeds, letting us manoeuvre and change its direction. It is all conducted/controlled by the Electronic Speed Controller, so they are a crucial component of the drone [7].

4) **Node MCU** is an open-source firmware and a development kit that helps prototype an IoT-based product with few Lua script lines. It has ESP-12 based serial Wi-Fi integrated onboard to provide GPIO, PWM, ADC, I2C. Controlling motors and reading sensor data is done by NodeMCU. It also sends PWM signals to control the servo motors. It is also connected to the server by writing relevant authentication code and server hostname in the program [8].

5) **Raspberry Pi 3 Model B-** It is the first of the third-generation Raspberry Pi with built-in Bluetooth 4.1 and Wi-Fi. It has a quad-core 1.2GHz Broadcom (BCM2837 -64bit CPU) with 1 GB RAM. 40-pin extended GPIO,4 USB ports, and the stereo output for audio, which is used with google assistant in our project. Camera Serial Interface (CSI) port is also present for connecting a Raspberry Pi camera [9].

6) **Raspberry Pi camera-** Raspberry Pi camera module of 5MP is used in our project. It is proficient in shooting 1080p videos at 30 frames per second. The resolution and the frame rate can be set according to the internet speed.

7) **Drone Frame-** The main body of a drone usually comes with a cross-style design, with four wings extending out from the central body, i.e., PCB(Printed Circuit Board), which is made up of fiberglass and is strong enough to hold quadcopter weight.

8) **Energy Source-** Lithium polymer batteries, commonly known as LiPo, have a high energy density, high discharge rate, and are lightweight, making them an excellent component for energy providers in drones.

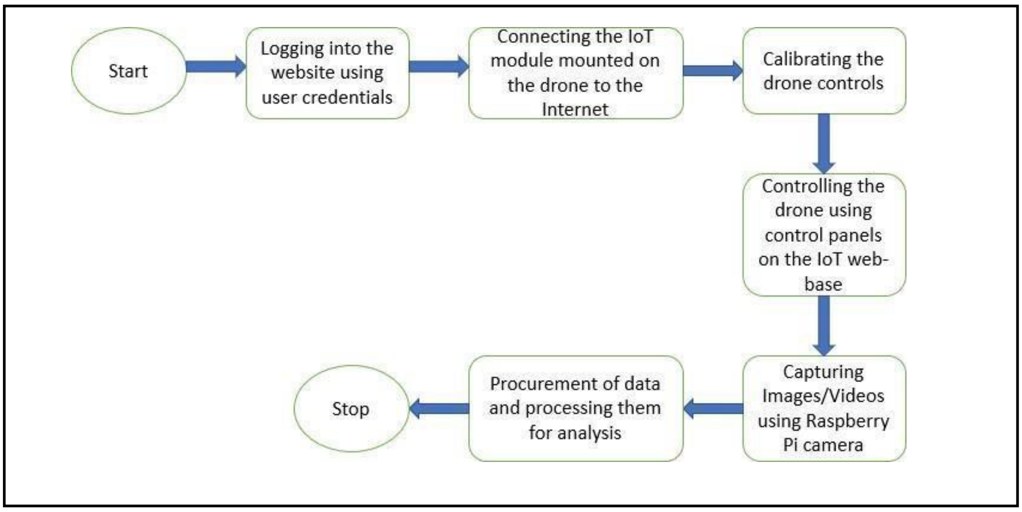

Fig. 1: Drone Control and Image acquisition

Each drone will be mounted with a forest surveillance module. It will Capture surrounding images at various angles with the help of a Raspberry Pi camera which is further connected to the Raspberry Pi 3 Model B board. Then the captured data will be procured at the data processing station for the analysis purpose. The step-by-step procedure (Fig. 2) to function this whole proposed idea:-

1. Surveillance of the forest via a forest surveillance module mounted on a drone. This drone is controlled with the help of the Internet of things environment, which consists of NodeMCU board which has inbuilt ESP8266 Wi-Fi Module, thus connecting the whole system to the Internet and further, the drone is controlled via self-developed IoT website defined controls (Fig. 1).
2. Capturing the surrounding images using a Raspberry pi camera.
3. The drone is controlled to return back to the station with the help of an IoT environment, after doing a surveillance of 500 meters x 500 meters range.
4. Procurement of collected data from the Raspberry Pi camera, storing the image data, and then processing the collected data using the flowchart explained in fig 1.0.
5. The images are combined in the form [F, H, W, D] where F is the number of images/frames captured, H is the height of the image, W is the weight of the image, D is the depth which will be 3 in a case for RGB and 1 for grayscale images.
6. The images are iterated, and pre-processing is done on each image. A pre-trained YOLO model detects the presence of humans in the image. If a human is detected using the model, the YOLO model makes a bounding box that contains the human image and is saved into the database [10].

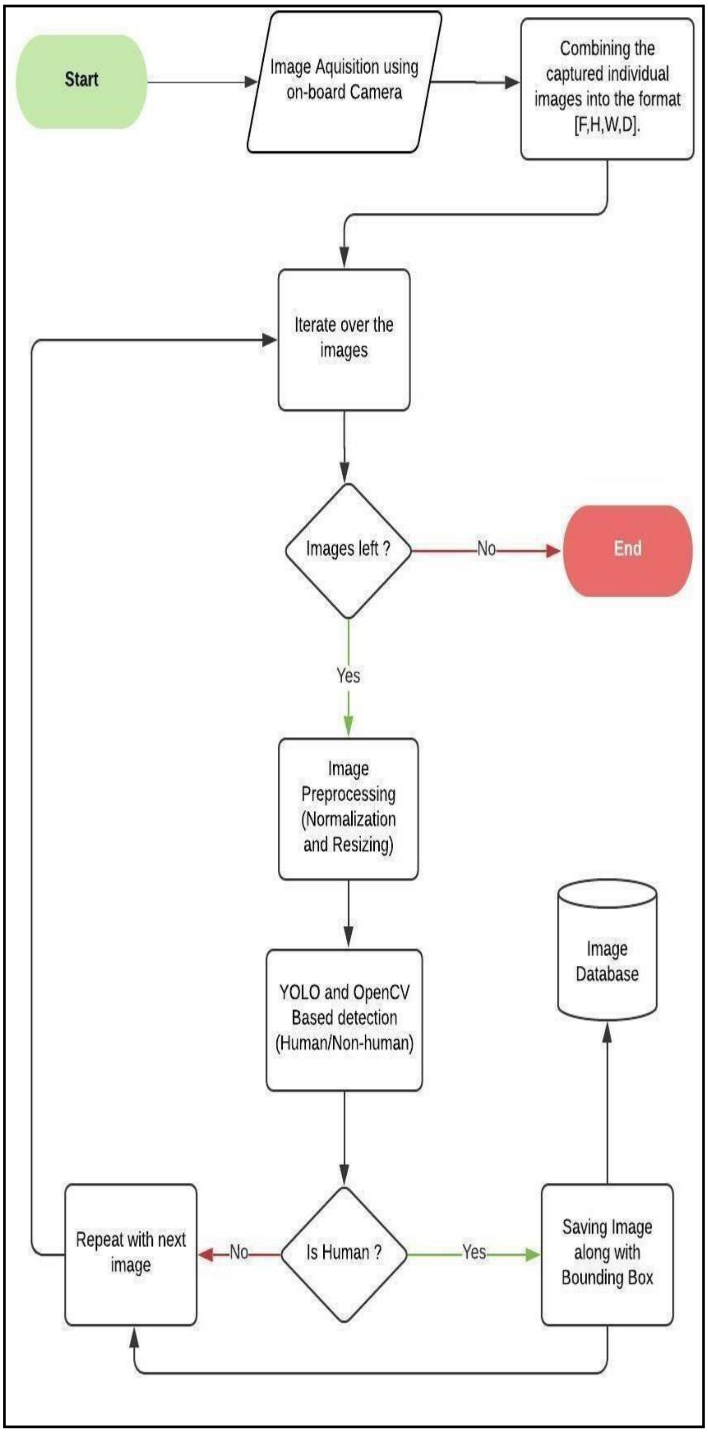

Fig. 2: Image processing Flowchart

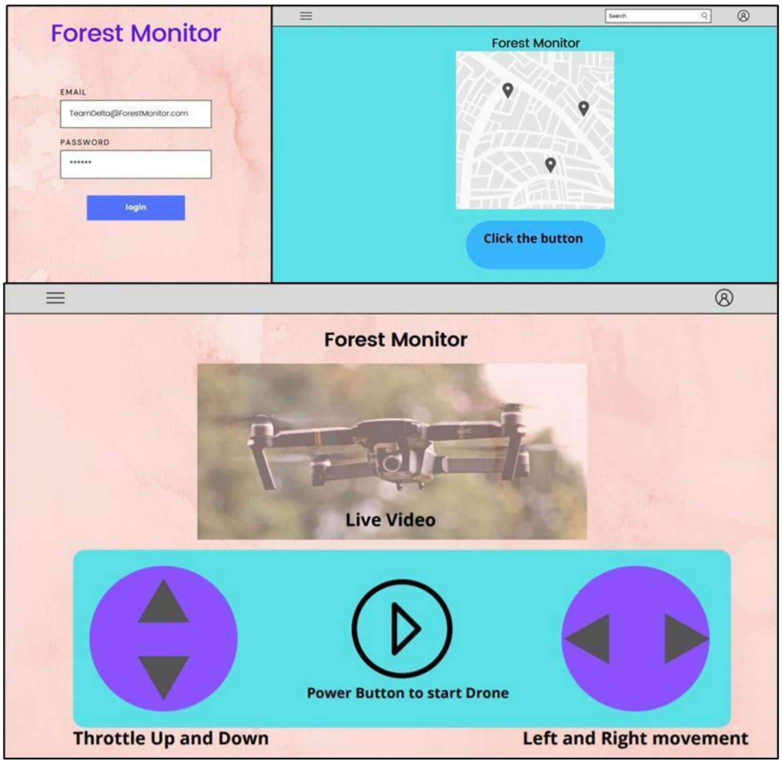

Fig. 3: Website

In the first stage, the user needs to sign up to our website to access the IoT module to control the drone (Fig. 3). We needed this website because we wanted to control the operations of drones precisely and store the data according to user needs. We use several tech-stacks such as HTML, CSS, JavaScript, and My SQL for data collection and website development. Firstly, there will be a signup and verification page on which users have to sign up and verify for the secure operation and usage of drone surveillance. As soon as the user gets logged into our website, now the central stage arrives; the user has to configure the hardware and arm the drone by selecting a specific pin number. As soon as the NodeMCU board gets connected to the Internet with the help of generated unique authentication code, it gets ready to take the flight. With the help of various designed calibrated control panels present on the IoT website window, the user can control the drone. The raspberry pi camera is responsible for capturing images and videos at various angles, which will be further used for analysis [11].

4 Conclusion

We are now already familiar with the fact that rising illegal activities within the forest and deforestation are some significant issues of concern and need to be taken into account. The model proposed in this paper aims at solving these problems by monitoring the forest efficiently. With the help of this model, we will be able to monitor the forest and the activities going on within the forest cover areas, which is the need of the hour. With this, we are not only preventing the damage that could be caused but also protecting the forest's lives [12].

5 Future Scope

Since technology keeps evolving, there's a lot of scope for improvement and development in the coming days. We plan to make our drone more efficient by making it autonomous and giving it the power to analyze the forest covers by itself and warn us only when it's something unusual.

These autonomous UAVs can also be accompanied by other similar drones that aid in firefighting response over a larger affected area. For communication between these drones, we can take the help of ArduPilot, and the sensor data from these devices is collected via the XBee Pro modules through a "cluster network", where we have a single PAN Coordinator which here represents the base station and different drones in a cluster act as Full Function Devices (routers) which further relay information to Reduced Function Devices (sensors, controllers, activators, etc.). For a better data processing and recognition process, we will be adding the Nvidia Jetson nano to our model [13].

This model will work on neural networks which will be trained on the data collected from the forest covers. Also, a swarm of drones would be effective for future monitoring purposes.

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