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AUTONOMOUS DRONE SURVEILLANCE USING IoT & ML

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Abstract -The field of the Internet of Things (IoT) is growing rapidly and is revolutionizing how we interact with technology. It refers to the interconnectedness of devices, machines, and sensors, enabling them to exchange data and information to perform specific tasks or improve efficiency. In recent years, the integration of IoT with drones has led to the development of drone surveillance, a technology that is being increasingly used in various industries and applications.

Drone surveillance is a kind of aerial surveillance that makes use of drones equipped with high-definition cameras, sensors, and other cutting-edge technologies to monitor and protect various locations and assets. With the help of IoT, drones can now be controlled and operated remotely, making them an excellent option for surveillance in hard-to-reach or dangerous areas. By combining IoT with drone technology, it is now possible to capture real-time data and analyze it to detect any abnormalitiesor potential threats.

The integration of IoT and drone technology has numerous applications, ranging from monitoring traffic and weather patterns to securing critical infrastructure and protecting wildlife. In this context, drone surveillance has developed into a crucial tool for emergency response teams, law enforcement agencies, and other organizations engaged in security and surveillance operations. This technology is expected to play an increasingly significant role in the future, as we continue to explore new ways to leverage IoT and drone technology for more efficient and effective surveillance. A subset of artificial intelligence known as machine learning (ML) focuses on developing models and algorithms that let computers learn and make decisions without explicit programming. It is a powerful tool for analyzing and interpreting large datasets, which is particularly useful in the context of IoT and drone surveillance. By applying ML algorithms to the data collected by drones, it is possible to identify patterns, anomalies, and potential threats more efficiently and accurately. ML can also be used to optimize drone flight paths, improve data collection and analysis, and enhance overall system performance. As IoT and drone technology continue to advance, the integration of ML is expected to play an increasingly important role in enabling more intelligent and efficient surveillance systems.

Keywords - Internet of things (IoT), Autonomous Drone, Drone Surveillance, Machine Learning, OpenCV, YOLOv8.

1. INTRODUCTION

The integration of IoT, drone technology, and machine learning (ML) have created new opportunities for surveillance and security applications. By combining these technologies, it is now possible to create intelligent surveillance systems that can collect, analyze, and interpret vast amounts of data from multiple sources in real-time. This approach is particularly relevant in the context of drone surveillance, where large amounts of data need to be processed and analyzed quickly and accurately.

IoT-based drone surveillance using ML involves equipping drones with various sensors, cameras, and other advanced technologies that enable them to collect and transmit data to a centralized system for analysis. The ML algorithms used in this system are trained to identify patterns and anomalies in the data and alert operators to potential threats or security breaches. The system can also be programmed to optimize drone flight paths, manage data storage and retrieval, and automate certain tasks.

The integration of IoT and ML with drone technology has the potential to transform the way we approach surveillance and security. It allows us to create more intelligent and efficient systems that can adapt to changing conditions and respond quickly to potential threats. This technology is expected to find applications in various sectors, such as law enforcement, critical infrastructure protection, disaster management, and wildlife conservation, among others. As IoT and drone technology continue to evolve, the integration of ML is likely to become an increasingly important aspect of surveillance and security systems.

Our autonomous drone can be used for border security, runway surveillance, private area surveillance, agriculture surveillance, forest and wildlife monitoring and air pollution monitoring.

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2. RELATED WORKS

[1] Surveillance Drone(2020)

Neha karna, Sandhya Yadav, International Research Journal of Innovations in Engineering and Technology(IRJIET) 2020.

This study designs and develops an autonomous unmanned aerial vehicle (UAV) for use in rescue operations Equipped with live streaming capabilities and real-time video output for identifying critical conditions and obstacle detection.

[2] Border Security and Surveillance System UsingIoT

Siham Boukhalfa, International Journal of Information Retrieval Research(2022).

The captured data is processed in real-time using a bio-inspired classification technique called Grouping Cockroaches Classifier (GCC) that detects human gestures to identify intruders.The system distinguishes between soldiers, terrorists, and non-soldier individuals based on their gestures and employs image preprocessing, masking, and an alarm for efficient threat detection.

[3] Design and Development of a Drone for Spraying Pesticides, Fertilizers and Disinfectants Karan Kumar Shaw, Vimal Kumar R, InternationalJournal of Engineering Research & Technology(IJERT) (05, May-2020).

The study develops an efficient solution for carrying up to 3kg of payload using a UAV by designing a lightweight aluminum frame structure and chassis for the drone.To assemble the necessary components and build a stable quad copter with flight control.

[4] Implementation of drone technology for farm monitoring & pesticide spraying

Abdul Hafee, Mohammed Aslam Husain,International Journal of Engineering Research & Technology (IJERT) (25 January 2021).

This study uses drones with sensors and cameras to provide important information like aerial views of harvest, water system, soil variety, pests, and fungal infestations for better crop management.Integration of machine learning algorithms with the drone system for real-time data analysis and prediction of the health condition of crops. Implementation of precision agriculture through the use of drones for low cost and time efficiency.

[5] The use of conservation drones in ecology and wildlife research

Bojana Ivosevic,Youngho Cho, International Journal of Ecology and Environment.

This paper reports on the use of Phantom 2 Vision+ for monitoring areas in two national parks in South Korea. Chiaksan National Park served as the site of the first study area, and Taeanhaean National Park served as the site of the second. This study aims to familiarize scholars and ecologists with conservation drones and to demonstrate how these cutting-edge devices are profoundly advancing the natural sciences.

[6] Formal Modeling of IoT and Drone-BasedForest Fire Detection and Counteraction System Aqsa Tehseen, Nazir Ahmad Zafar, Fatima - Jameel(December 2021).

The detection and suppression of forest fires using drones and the Internet of Things (IoT) are both addressed in this study. The suggested system includes network maintenance. Subnets are deployed as sensors on trees, the ground, and animals to communicate felt data to the control center. Gateway nodes connect every subnet to the control room. In order to save their lives and first safeguard them from fire, alarms are used to warn people and animals.

[7] Autonomous monitoring, analysis, and countering of air pollution using environmental drones

Godall Rohi,O'tega Ejofodomi, Godswill Ofualagba (January 2020).

With this technique, environmental drones (E-drones) are used to automatically check the air quality in a specified area. Every hour, the E-drone ascends to a predetermined height (Altitude), measures the air pollutants there, applies on-board pollution abatement methods to those that are above the advised limit, and then descends to its position on the ground. The ability of this system to assess CO_2, CO, NH_3, SO_2, PM, O_3, and NO_2 air

pollution concentrations, identify when they are too high, and deploy on-board pollution abatement solutions when necessary is its major advantage.

[8] Review on UAVs used for Aerial Surveillance Abayomi O. Agbeyangi,Joseph O. Odiete,Adam B. Olorunlomerue, Journal of Multidisciplinary Engineering Science and Technology (JMEST). Small aircraft that can fly without a human pilot on board are called unmanned aerial vehicles (UAVs), also referred to as drones or remotely piloted vehicles (RPVs). They can transport payloads like cameras, sensors, communication devices, or other items and are either fully or partially autonomous. For aerial surveillance, their applications have been deemed to be the most successful. In this paper, review of thevarious trends in their development and theirapplication in aerial surveillance is given. The results gathered from the review shows that UAVs are very effective for aerial surveillance.The major advantage of UAVs that make them useful for aerial surveillance is that they can move at higher speeds than ground vehicles as they are not restricted to traveling on the road network.

[9] Aerial Surveillance System using UAV
Zainab Zaheer, Atiya Usmani, Ekram Khan, Mohammed. A. Qadee, Thirteenth International Conference on Wireless and Optical CommunicationsNetworks (WOCN).
This paper explains how an unmanned aerial vehicle, or drone, can be used to construct an aerial surveillance system. Outlines the characteristics of an aerial surveillance system before talking about some of the technology that went into its construction. The integration of various technologies into a drone and how they were made to function in harmony to create the desired aerial surveillance system are then discussed. This technology will be a practical and effective replacement for the surveillance methods in use today. It can be used for real-time monitoring of a location at any time of day.

[10] A UAV vision system for airborne surveillance M.Kontitsis, Kmon P.Valavanis, N.Tsoweloudis, IEEE International Conference on Robotics and Automation.
The study introduces an aerial surveillance machine vision system that can read and analyze data from an on-board infrared camera on a UAV. Noise reduction, feature extraction, classification, and decision-making are all part of the system. In terms of a signal from an alarm, decision-making is done. The system has been set up for automatic fire-detection applications, in which the alarm is activated upon the detection of a fire. The method has been tested by producing actual photos in real-time tests.

3. MATERIALS AND METHODS

3.1. Component and Assembly

Drones, also known as unmanned aerial vehicles (UAVs), consist of several components that work together to enable flight and perform various functions.Some of the key components of a drone include:

- **Frame :**

A drone frame refers to the physical structure or chassis of a drone. It is the skeleton on which all the components of the drone are mounted, including the flight controller, motors, propellers, battery, and other electronics. The frame provides structural support and protection to these components, as well as determines the drone's size, weight, and overall design.

Figure 3.1. Frame

- **Controller :**

A flight controller is the central component of a drone that manages and controls its flight. It is responsible for processing data from various sensors, making flight decisions, and sending commands to the motors and other actuators to control the drone's movement.

Figure 3.2. Pixhawk flight controller

- **Motor :**

When it comes to choosing motors for drones, there are several factors to consider, including the size and weight of your drone, desired flight characteristics, power requirements, and payload capacity.

Figure 3.3. Motor

- **ESC :**

ESC stands for Electronic Speed Controller. It is a crucial component in a drone that regulates the speed of the motors. The ESC receives signals from the flight controller and translates them into appropriate power levels to control the rotation speed of the motors.

Figure 3.4. ESC

- **Power Distribution Board and Battery :**

A power distribution board (PDB) is a crucial component in a drone that serves the purpose of distributing power from the drone's battery to various components such as the flight controller, ESCs, cameras, and other onboard electronics. It acts as a central hub for connecting and distributing power.

- **RC (Sender and Receiver) :**

The RC (Radio Control) transmitter and receiver are essential components of a drone's remote control system. They enable the pilot to send control commands to the drone wirelessly, allowing for manual control of the drone's movement and functions.

- **Telemetry** :

Telemetry in a drone refers to theprocess of collecting and transmitting real-time data from the drone's onboard sensors and systems to a ground station or a remote device. It provides valuable information about the drone's flight parameters, status, and performance, allowing the pilot or operator to monitor and analyze the drone's operation in real-time. It is the basic requirement for an Autonomous Drone.

Figure 3.5. Telemetry

- **Camera :**

Camera in the drone is used to capture the feed and transmit to the ground station using the help of a video transmitter and receiver.By using the feed all other processing will be done at ground session.There are several factors to consider, such as image quality, resolution, stabilization, weight, and compatibility with your drone model.

- **Video Transmitter and Receiver :**

When it comes to video transmission for drones, there are several options available. One popular choice is to use analog video transmitters and receivers, commonly known as FPV (First Person View) systems. Another option is to use digital video transmission systems.

Figure 3.6. Video Transmitter and Receiver

- **GPS and Compass:**

By combining GPS and compass functionalities, drones can achieve precise navigation, maintain stability, execute autonomous flight missions, and enhance safety features. These technologies enable a wide range of applications, including aerial photography, videography, surveying, inspections, and more, making drones highly versatile and efficient tools in various industries.

These components work together to enable drones to perform a variety of tasks, ranging from aerial photography and surveying to search and rescue operations, security and surveillance, and even package delivery.

3.2. Data Collection and Detection

In a surveillance drone, the process of pre-processing and object detection involves several steps, which are as follows:

1. Video Capture: The drone's camera captures a video stream of the area under surveillance.

2. Video Stabilization: The video is stabilized to reduce motion blur and camera shake, which can interfere with object detection.

3. Video Compression: The video is compressed to reduce its size and improve transmission speed and storage efficiency.

4. Frame Extraction: The video is split into frames, which are individual images that can be analyzed separately.

5. Object Detection: Each frame is analyzed using object detection algorithms, which use machine learning techniques to identify and classify objects in the scene. The object detection algorithm analyzes the frames and identifies objects of interest such as people,vehicles, or animals.

6. Object Tracking: Once an object of interest is detected, the surveillance drone can use object tracking algorithms to follow the object's movement and recordits path over time.

7. Alert Generation: If the object detection algorithm identifies a potential threat or anomaly, it generates an alert that can be sent to the operator in real-time.

In summary, pre-processing and object detection is a critical process for surveillance drones, which enables them to detect and track objects of interest in real-time. By integrating machine learning algorithms, surveillance drones can identify potential threats or security breaches and provide early warning to operators, allowing them to take appropriate action.

This technology has significant potential to enhance public safety, protect critical infrastructure, and support law enforcement and military operations

3.3. Model

When it comes to training a model, there are several essential components and resources that are typically required to ensure effective and successful training, they are:

- **Python**

Python is one of the most popular programming languages used in machine learning (ML) model training. It offers a wide range of libraries and frameworks that simplify the development and deployment of ML models.

- **OpenCV**

OpenCV (Open Source Computer Vision) is a popular open-source library that provides computer vision and image processing functionalities. It has a wide range of tools and algorithms that can be used for object detection tasks.

Figure 3.7. OpenCV and Python

- **Ultralytics - YOLO v8**

Ultralytics YOLOv8 is a popular open-source deep learning object detection framework developed by Ultralytics. It is an evolution of the YOLO (You Only Look Once) series of object detection algorithms. YOLOv8 builds upon the previous YOLO versions, offering improved accuracy and performance.

Figure 3.8. YOLOv8

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The workflow for drone operations can vary depending on the specific application and mission objectives. However, a typical workflow for a drone operation can be broken down into the following stages:

1. Planning and Mission Design: This stage involves identifying the mission objectives, selecting the appropriate drone platform and sensors, and designing a flight plan. The flight plan includes determining the area to be surveyed or mapped, selecting the optimal altitude and flight path, and defining any waypoints or areas of interest.

2. Pre-Flight Preparation: In this stage, the drone and its components are prepared for flight. This includes charging the battery, calibrating the sensors, checking the camera or other payloads, and performing a pre-flight check to ensure that the drone is functioning correctly.

3. Flight Execution: The drone takes off and follows the pre-defined flight path. During the flight, the drone's sensors and cameras collect data, which is transmitted to the ground control station in real-time. The pilot or onboard computer monitors the flight progress, adjusts the drone's position or altitude as needed, and ensures thesafety of the operation.

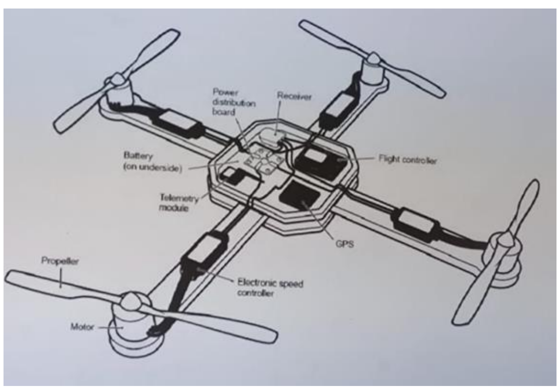

Figure 3.9. Autonomous Drone Architecture

4. Data Acquisition: During the flight, the drone's sensors collect data, such as images, videos, or other sensor data, depending on the application. The data is transmitted to the ground control station and stored for post-flight analysis.

5. Post-Processing: The data collected during the flight is processed to extract useful information. For example, images can be stitched together to create a high-resolution map, or environmental data can be analyzed to identify trends or anomalies.

6. Analysis and Reporting: The processed data is analyzed to derive insights or make decisions. For example, aerial photographs can be used to monitor crop health, or LiDAR data can be used to identify changes in terrain elevation. The analysis results are then reported to the stakeholders, such as clients or decision-makers.

7. Maintenance and Post-Flight Checks: After the flight, the drone is inspected and maintained to ensure that it is ready for the next operation. The data collected during the operation is archived for future reference.

In summary, the workflow for drone operations involves several stages, including mission design, pre-flight preparation, flight execution, data acquisition, post-processing, analysis, and reporting. Each stage is critical for the success of the operation, and careful planning and execution are necessary to achieve the desired outcomes.

4. PROPOSED METHODOLOGY

This project focuses on Autonomous Drone Surveillance using IoT and ML which can be used for Border Security, Wildlife Protection, Perimeter Patrols, Forest Monitoring, Air Pollution Monitoring and also for Agriculture purposes.

The integration of IoT and drone technology has numerous applications, ranging from monitoring traffic and weather patterns to securing critical infrastructure and protecting wildlife.

By applying ML algorithms to the data collected by drones, it is possible to identify patterns, anomalies, and potential threats more efficiently and accurately.

Figure 4.1. Autonomous Drone

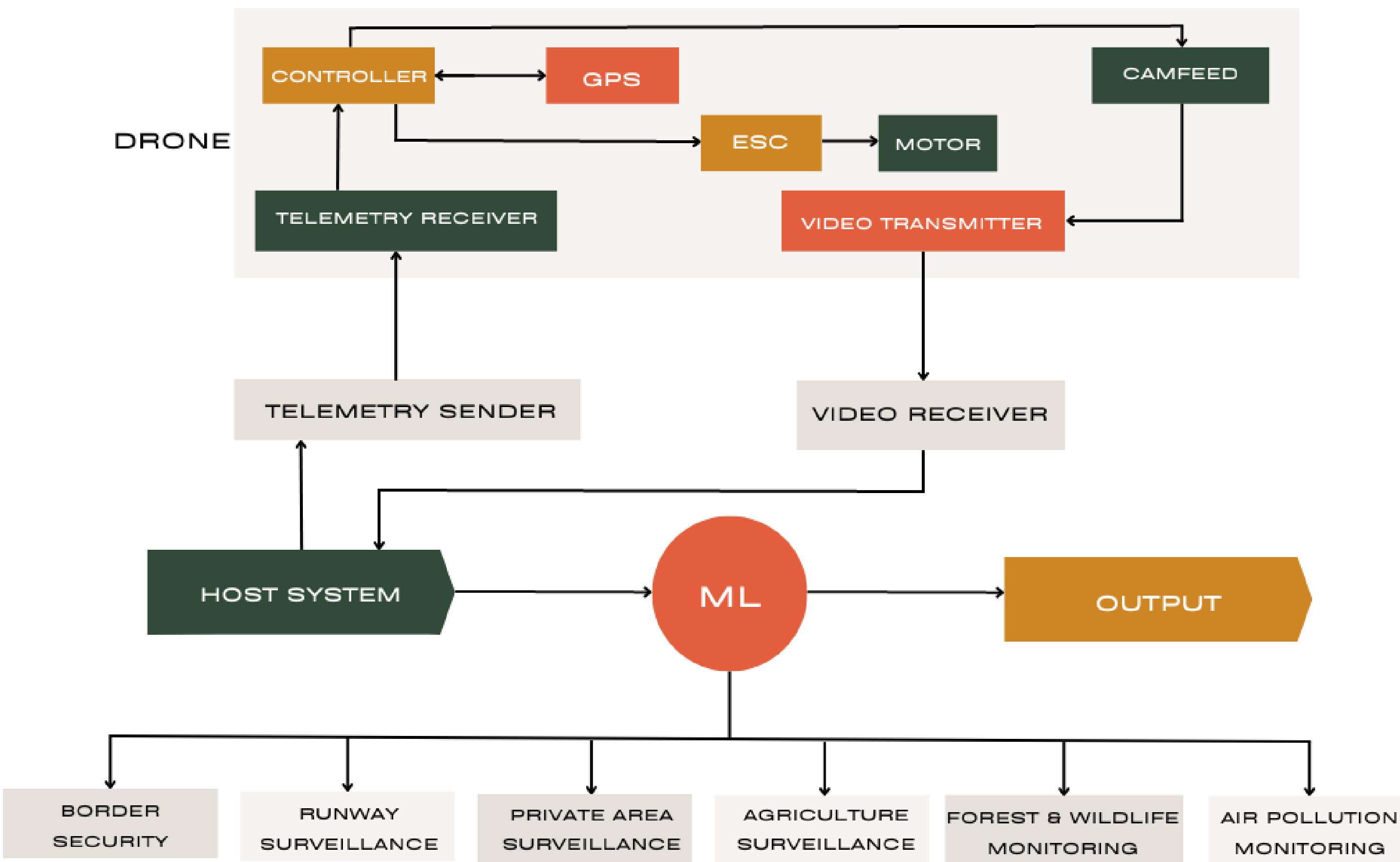

Figure 4.2. Block Diagram

The figure 4.2 describes the entire architecture of the Project , The host system describes the pc or other system of the user. We use Mission planner, a software to plan the autonomous mission and the plan is sent to the drone using a telemetry sender which is connected in the host system.

The telemetry sender will send the plan to the telemetry receiver which is connected with the drone. When the controller (i.e) Pixhawk , it starts the plan to execute with the help of the gps.

The gps sends the data of the current position of the drone, with reference to it the plan will be executed accordingly. The major part is carried out by the gps data the data from it is evaluated by the controller and send the signal to the esc in such a way to execute the plan

The Esc receive signals according to the controlled which evaluated data of the gps according to which the position of the drone is shifted once again the GPS sends the data of the current position and all the process is repeated until the plan is completed.

Simultaneously , the camera sends the feed captured during the plan using the help of a video transmitter which is connected with the drone. The receiver will receive the data which means the video frames are transmitted from the drone and the host system is able to view the feed with the help of the video receiver . The host system is responsible for the camera feed.

At last the major part of the system comes into play (i.e) Machine Learning according to application, users have been selected, the algorithm will be applied and the processed frame will be displayed to the host system.

The annotated frame is used to express the surrounding condition and the environment to the user. By using the annotated frames all the details of the user place will be analyzed easily and quickly.

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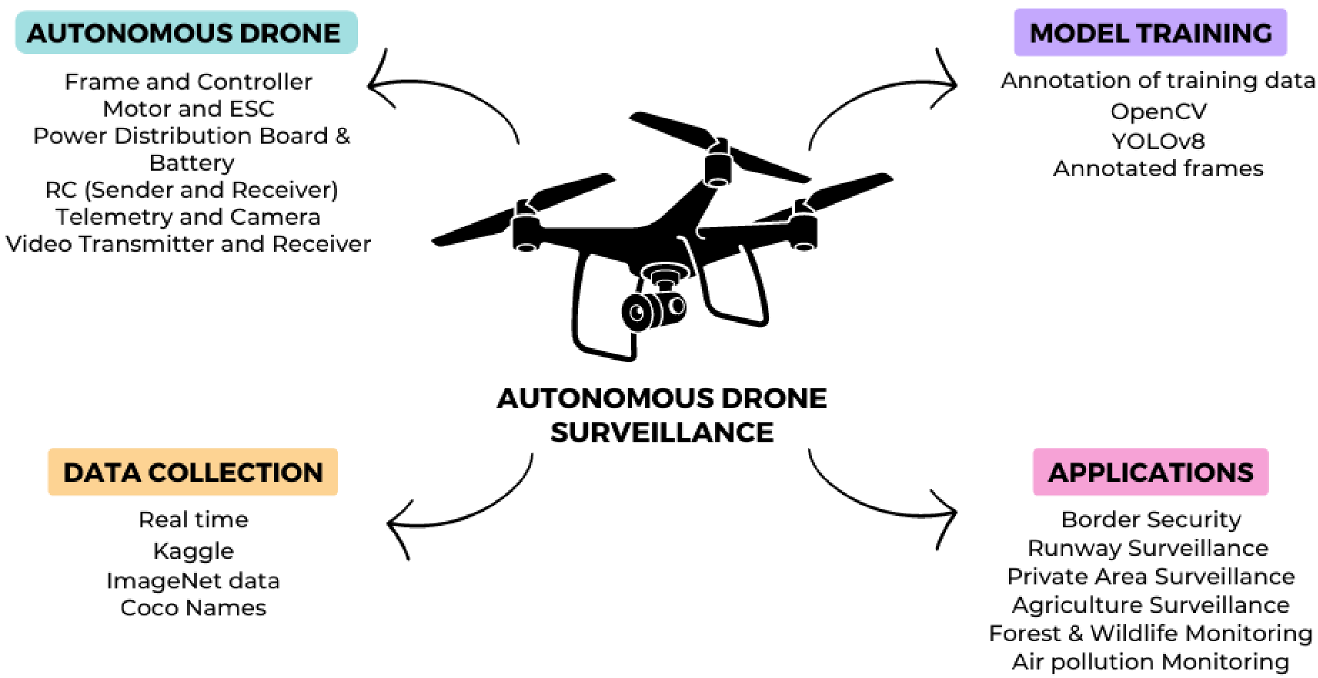

Figure 4.3. Mind Map

The above figure 4.3. describes the mind map of our project. It starts with assembling an autonomous drone with the components such as frame, controller, motor, ESC, power distribution board and battery, RC(sender and receiver), telemetry, camera, video transmitter and receiver. Then comes data collection, real-time data is collected. Data can also be collected from Kaggle, ImageNet and Coco Names. Next the model is trained. In model training, first the training data is annotated, then by using openCV and YOLOv8 the model is trained and the output is in terms of annotated frames. Applications of our autonomous drone are border security, runway surveillance, private area surveillance, agriculture surveillance, forest and wildlife monitoring and air pollution monitoring.

5. RESULTS

5.1. Object Detection Performance

The system's object detection capabilities were evaluated using state-of-the-art ML algorithms, including convolutional neural networks (CNNs) and region-based methods. The evaluation focused on assessing the system's ability to identify various objects of interest in the surveillance videos.

The system demonstrated promising results in accurately detecting objects. However, challenges such as occlusions, scale variations, and complex backgrounds can affect detection accuracy. Further optimization and refinement are required to improve object detection performance in challenging scenarios.

5.2. Tracking Performance

Tracking moving objects is crucial for effective surveillance. The system employed robust tracking algorithms that utilize visual cues and motion estimation techniques to maintain accurate tracks of objects across consecutive frames.

The tracking performance of the system showed positive outcomes. However, challenges such as occlusions and rapid object motion can impact the accuracy of object tracking. Efforts should be made to enhance the system's robustness in handling complex tracking scenarios.

5.3. Anomaly Detection Results

An important aspect of our autonomous drone surveillance system is its ability to detect anomalous events and behaviors. Anomaly detection algorithms based on ML techniques, including unsupervised learning and anomaly scoring methods, were employed for this purpose.

The system demonstrated promising results in identifying anomalous events and behaviors captured in the surveillance videos. However, false positives can still occur, leading to potential false alarms. Further refinement of the anomaly detection algorithms is necessary to minimize false positives and improve the overall system's reliability.

5.4. Real-Time Processing and Efficiency

Efficient real-time data processing and analysis are essential for practical surveillance systems. The system's computational performance, including processing speed and resource utilization, was evaluated to ensure its feasibility in real-world applications.

The system exhibited efficient real-time processing capabilities, with acceptable processing speed and resource utilization. This enables near real-time monitoring and analysis of surveillance data, facilitating timely decision-making and response.

Fig 5.1 Output

6. CONCLUSION AND FUTURE SCOPE

This project focuses on Autonomous Drone Surveillance using IoT and ML which can be used for Border Security, Runway Surveillance, Private Area Surveillance, Wildlife Protection, Perimeter Patrols, Forest Monitoring, Air Pollution Monitoringand also for Agriculture purposes.

Drone surveillance is a type of aerial surveillance that utilizes drones equipped with high-resolution cameras, sensors, and other advanced technologies to monitor and secure different areas and assets. With the help of IoT, drones can now be controlled and operated remotely, making them an excellent option for surveillance in hard-to-reach or dangerous areas. By combining IoT with drone technology, it is now possible to capture real-time data and analyze it to detect any abnormalities or potential threats.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors of this paper.

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