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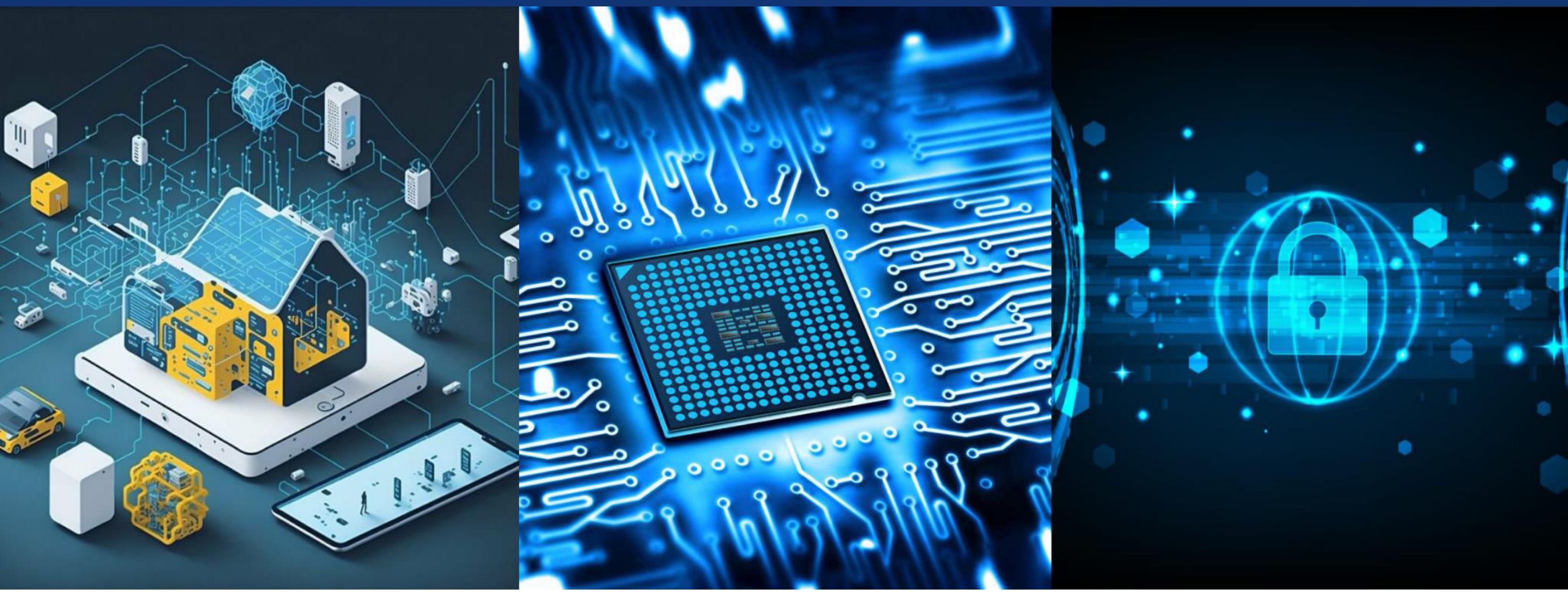

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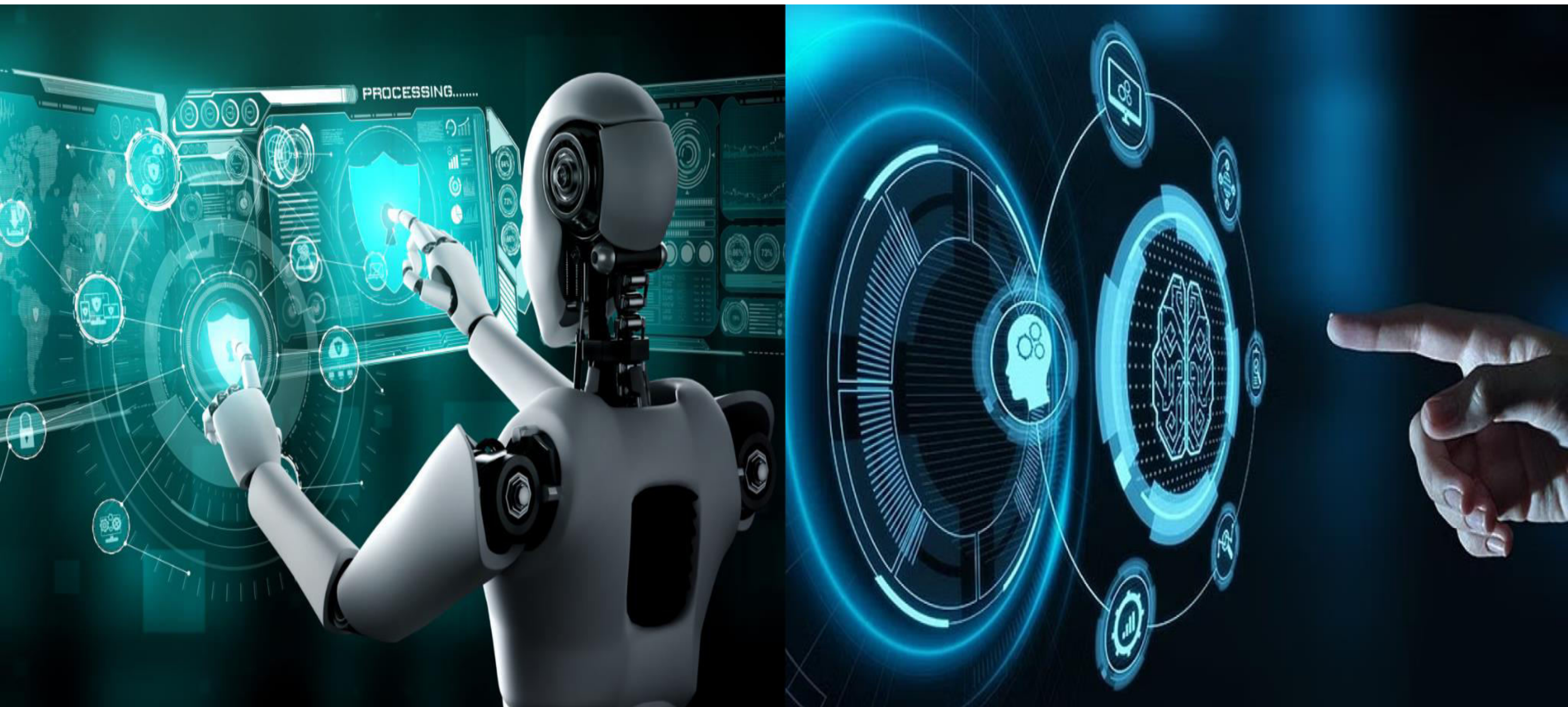

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AI Based Drone Detection System

Avinash O[1], Harsha K R[2], Suraj P[3], Vishwas G [4], Navya shree Y V[5]

UG Students, Department of Electronics and Communication Engineering, PES College of Engineering, Mandya, India[1-4]

Assistant Professor, Department of Electronics and Communication Engineering, PES College of Engineering, Mandya, India[5]

ABSTRACT: The rapid proliferation of drone technology has raised significant security concerns, particularly in no-fly zones where unauthorized drone activities can pose threats to high-value properties, critical infrastructure, and public safety. To address this challenge, this project proposes an AI-based drone detection system leveraging the YOLOv5 (You Only Look Once) model, pre-trained on the COCO dataset with a focus on the airplane class, due to its capability to generalize across various drone types, including quadcopters and RC planes. Implemented in Visual Studio Code, the system processes real-time video feeds or static images to detect drones with high accuracy using computer vision techniques.

KEYWORDS : YOLO V5, GSM module, Battery, Buzzer, Arduino IDE, Microcontroller, bulk converter

I. INTRODUCTION

The increasing accessibility and affordability of drone technology have revolutionized industries such as aerial photography, agriculture, logistics, and surveillance. However, the widespread use of drones also presents significant security risks, particularly in no-fly zones where unauthorized drone operations can threaten public safety, privacy, and critical infrastructure. Incidents involving drones near airports, military installations, and government facilities have highlighted the urgent need for reliable detection and countermeasure systems to prevent potential attacks, espionage, or accidents. Traditional radar-based detection methods often struggle to identify small, low-flying drones, especially in cluttered environments, necessitating the development of more advanced solutions. Artificial Intelligence (AI) and computer vision have emerged as powerful tools for realtime object detection, offering high accuracy and adaptability in identifying drones of various shapes and sizes.This project focuses on designing and implementing an AI-based drone detection system using YOLOv5 (You Only Look Once), a state-of-the-art deep learning model pre-trained on the COCO (Common Objects in Context) dataset. The system is developed in Visual Studio Code, leveraging Python-based frameworks such as PyTorch and OpenCV for real-time image processing. Upon detecting a drone, the system triggers an alert mechanism by sending a signal to a Node MCU microcontroller via a serial communication link. The Node MCU then activates an audible buzzer and sends an SMS alert to a predefined mobile number using a GSM module, ensuring immediate notification for security personnel or relevant authorities.

II. BLOCK DIAGRAM AND METHODOLOGY

2.1 BLOCK DIAGRAM

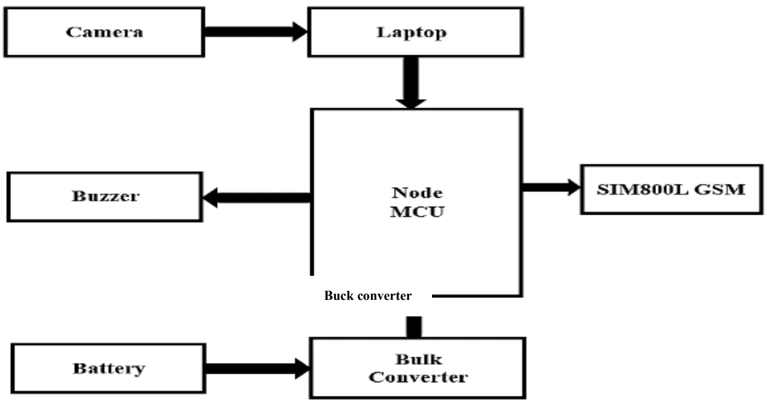

Fig1.Block diagram of AI Based Drone Detection System

2.2 WORKING METHODOLOGY

The methodology for this AI-based drone detection system integrates computer vision, deep learning, and IoT hardware to achieve real-time detection and alert mechanisms, beginning with the selection and optimization of the YOLOv5 (You Only Look Once version 5) model, a state-of-the-art object detection algorithm pre-trained on the COCO (Common Objects in Context) dataset, which includes an "airplane" class that serves as a foundational reference for detecting drone-like structures due to similarities in shape and flight patterns. The trained YOLOv5 model is then deployed in Visual Studio Code using a Python-based environment, leveraging libraries such as PyTorch for deep learning operations and OpenCV for real-time image processing, enabling the system to analyse video feeds from connected cameras (IP cameras, USB cameras,) at high frame rates, with each frame processed through the neural network to identify and localize drones using bounding box predictions and confidence scores. Upon detection, the system triggers an alert protocol by sending a serial command via a UART (Universal Asynchronous Receiver-Transmitter) interface to a Node MCU microcontroller, which acts as the bridge between the software-based detection system and hardware-based alert mechanisms. The Node MCU is programmed using the Arduino IDE to interpret serial commands and activate connected peripherals, including a piezoelectric buzzer for immediate auditory alerts and a SIM800L GSM module to send SMS notifications to predefined phone numbers, ensuring that security personnel or relevant authorities are promptly informed of unauthorized drone activity.

The serial communication between the detection software and Node MCU is established using the pyserial library in Python, with a predefined baud rate (e.g., 9600 bps) to ensure reliable data transmission, while error handling mechanisms (such as checksums and acknowledgment signals) are implemented to prevent communication failures. The GSM module, configured with AT commands, formats and transmits SMS alerts containing detection. To validate the system's performance, extensive testing is conducted in controlled and real-world environments, including open fields, urban settings, and near high-security zones, where the system's detection accuracy, latency, and false-alarm rates are measured against benchmarks. Additionally, the system's scalability is tested by integrating multiple cameras for wider coverage, and its adaptability is verified by retraining the model with new drone variants to ensure long-term relevance. Power consumption and computational efficiency are also analysed, particularly for edge-device deployments where resources may be limited, exploring optimizations like model quantization (reducing precision from FP32 to INT8) and hardware acceleration (using GPUs or TPUs) to enhance performance. The methodology concludes with iterative refinements based on test results, ensuring the system meets operational requirements for accuracy, speed, and robustness, while maintaining a cost-effective and modular design that allows for future upgrades, such as integrating RF signal detection for hybrid verification or deploying autonomous countermeasures (e.g., signal jamming or net-launching drones) in advanced security setups. By combining cutting-edge AI-driven detection with responsive IoT hardware, this methodology provides a comprehensive, real-time solution for drone surveillance in no-fly zones, addressing critical security challenges with a scalable and adaptive framework.

2.2 WORKING FLOWCHART

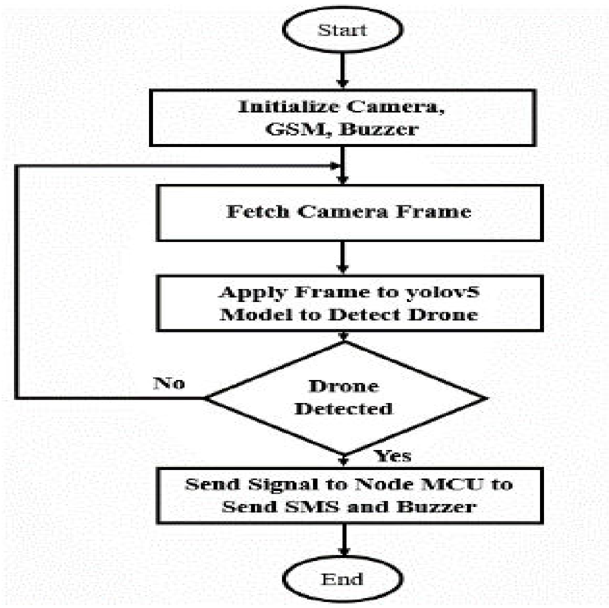

Fig2.Flowchart of the detection system

The above figure2 represent the flow chart of the proposed model i.e., Industrial safety monitoring system using IoT. It explains about the flow of working of the proposed model or the step-by-step representation of the proposed model and its working, this process repeats every 3 minutes once.

III. COMPONENTS REQUIRED

3.1HARDWARE REQUIREMENTS

3.1.1 Buck converter

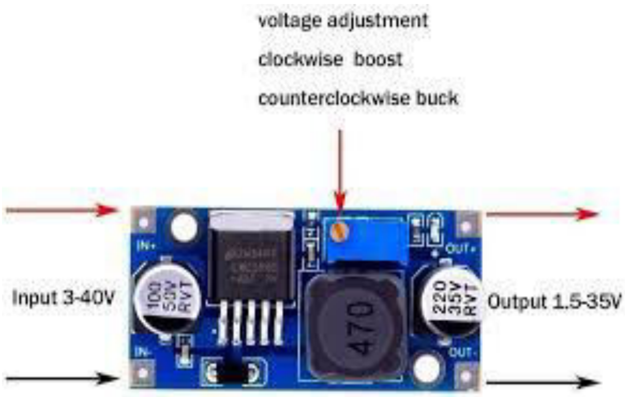

Fig3. lm2596 dc-dc buck converter

The LM2596 is a monolithic integrated circuit that functions as a step-down (buck) switching regulator. This means it efficiently reduces a higher DC input voltage to a lower, regulated DC output voltage. It's a popular choice due to its ease of use and requiring a minimal number of external components.

The LM2596 is a popular and widely used series of monolithic integrated circuits that function as step-down (buck) switching regulators. These converters are designed to efficiently reduce a higher DC input voltage to a lower,

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regulated DC output voltage. They are capable of driving a load of up to 3 Amperes (A) with excellent line and load regulation.

3.1.2 ESP8266 Wi-Fi module

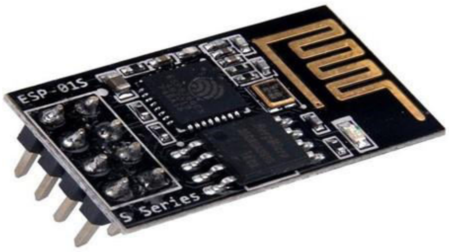

Fig4. ESP8266 Wi-Fi module

The above figure4 shows the ESP2866 Wi-Fi module is an embedded wireless technology thatis web friendly with no use of shields or peripherals. It consists of 8 GPIO pins which can be assigned to various functions such as UART, PWM, and LED light and button programmatically. ESP2866 Wi-Fi SoC is embedded with memory controller, including SRAM and ROM. MCU can visit the memory unit through IBUS and AHB interface. It operates on low voltage that is 3.3 V. ESP8266 delivers highly integrated Wi-Fi SoC solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry. With the complete and self-contained Wi-Fi networking capabilities, ESP8266 can perform either as a standalone application or as the slave to a host MCU. The integrated high speed cache helps to increase the system performanceand optimize the system memory. Also, ESP8266 can be applied to any microcontroller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces.

3.1.3 Buzzer

Fig5. Buzzer

A buzzer is an audio signaling device, commonly used to produce a buzzing or beeping sound. It's used in various applications to alert users, indicate events, or generate simple tones. Buzzers are found in devices like alarms, computers, printers,

3.1.4 GSN Module

Fig6. GSM module

A **GSM module** is a device that allows electronic devices to communicate with each other over the GSM network. GSM is a standard for digital cellular communications, which means that it provides a platform for mobile devices to communicate with each other wirelessly. The GSM module is a specialized device that enables a device to send and receive data over the GSM network.

The GSM network is an essential component of modern communication systems. It is a standard used by mobile devices to communicate with each other wirelessly. The GSM network provides a reliable and secure platform for communication, which makes it a preferred choice for many applications.
A GSM module works by connecting to the GSM network through a SIM card. The SIM card provides the module with a unique identification number, which is used to identify the device on the network. The GSM module then communicates with the network using a set of protocols, which allows it to send and receive data.

3.2 SOFTWARE REQUIREMENTS
3.2.1 ARDUINO IDE
The Arduino IDE provides a user-friendly interface for writing, compiling, and uploading code to Arduino boards. It supports a variety of programming languages, including C and C++, and comes with a range of built-in libraries for different functionalities. The IDE also includes features like syntax highlighting, automatic code indentation, and serial monitoring for debugging. Additionally, it offers extensive documentation and a large community of users who share projects, tutorials, and troubleshooting tips.

3.2.3 Python
Python: A Versatile Programming Language for Modern Applications
Python is a high-level, interpreted programming language developed by Guido van Rossum and first released in 1991. Its simple syntax and readability make it ideal for beginners, while its extensive libraries support professional and academic applications.
Key features include dynamic typing, object-oriented design, and a large standard library. Python supports multiple programming paradigms, including procedural, functional, and object-oriented programming.
It is widely used in web development (Django, Flask), data science (NumPy, Pandas), artificial intelligence (TensorFlow, PyTorch), and automation. Python's flexibility allows integration with other languages like C/C++ for performance optimization.
Jupyter Notebooks enable reproducible research and visualization, making Python a favorite in academia. Its cross-platform nature and open-source community support further drive adoption.
Despite slower execution compared to compiled languages, Python’s productivity benefits outweigh performance concerns in most cases.
Recent versions (e.g., Python 3.12) have improved speed and efficiency, ensuring continued relevance.
Python remains a cornerstone in education, research, and software development.

3.2.4 Open CV
OpenCV (Open Source Computer Vision Library) is an open-source library developed by Intel, released in 2000. It is designed for real-time computer vision and image processing applications. Written in C/C++, with bindings for Python, Java, and others. Supports operations like image filtering, object detection, face recognition, and video analysis. Highly optimized and used in robotics, surveillance, medical imaging, and augmented reality. Includes machine learning algorithms for tasks like pattern recognition and clustering. Works on Windows, Linux, macOS, Android, and iOS platforms. OpenCV is widely used in academia and industry due to its performance and flexibility. Compatible with deep learning frameworks like TensorFlow and PyTorch.It is freely available under the BSD license, encouraging open development and innovation.

3.2.5 YOLO V5
YOLOv5 (You Only Look Once, version 5) is a fast and accurate deep learning model for object detection. It was released by Ultralytics in 2020 and is implemented in **PyTorch**, unlike earlier YOLO versions. YOLOv5 detects multiple objects in images/videos in a single forward pass, ensuring real-time performance. It supports features like transfer learning, multi-scale training, and auto-learning anchors. The model comes in four sizes (s, m, l, x) to balance speed and accuracy for different applications. YOLOv5 can detect objects, draw bounding boxes, and classify them with high precision. It is used in surveillance, robotics, autonomous driving, and industrial automation. Trained models are easy to deploy on edge devices and mobile platforms. It offers integration with tools

like OpenCV, TensorRT, and ONNX for flexible deployment. YOLOv5 is open-source and maintained by an active community on GitHub.

IV. RESULT AND CONCLUSION

4.1. Result

The AI-based drone detection system was successfully developed and tested. The system utilized a trained deep learning model based on Yolov5 to analyze real-time video input and accurately identify the presence of drones. The detection algorithm demonstrated high accuracy in distinguishing drones from other objects such as birds.

Figure 5-drone detected

4.2. Conclusion

As drone technology continues to evolve, so must the methods for detecting and mitigating unauthorized UAV activities. This project presents a practical, AI-driven solution that combines real-time visual detection with IoT-based alert mechanisms, offering a robust defence against drone-related threats. Future enhancements could include multi-camera tracking, drone classification, and automated countermeasures, further strengthening security in sensitive areas.

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