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IoT-Based Pedestrian Zone Safety System

R. Monica Lakshmi[1], Gangineni Poojitha[2], Manju R[3], Nandhitha S[4]

Assistant Professor, Department of Computer Science and Business Systems, R.M.D. Engineering College, RSM Nagar, Kavaraipettai, Chennai-601206[1]

Student, Department of Computer Science and Business Systems, R.M.D. Engineering College, RSM Nagar, Kavaraipettai, Chennai-601206[2-4]

Abstract: Unauthorized two-wheeler access through pedestrian pathways at significant safety and regulatory concerns, leading to traffic violations and pedestrian inconvenience. Traditional systems rely on manual monitoring or basic sensors, which are inefficient and prone to errors. To address this issue, our project implements an AI-powered automated gate control system using ESP8266 as the main controller. An camera captures real-time video and pass on it to a server hosting a YOLOv8-based AI model, which accurately differentiates between motorcycles and humans. If a pedestrian is detected, the gate remains open, ensuring smooth passage, whereas if a motorcycle is identified, the wifi-contoller triggers the gate to close, preventing motorcycle access. In this system an ultrasonic sensor is used to measure the distance between the detected entity and the gate. This automated approach put an end to the need for manual monitoring, ensuring a safe, efficient, and intelligent pathways system that enhances pedestrian safety and enforces traffic rules. By merging AI-driven image processing with IoT-based hardware control, this system effectively prevents motorcycle entry while allowing pedestrian movement, thereby improving overall pathways management and security.

Keywords: Pedestrian Safety, Urban Environments, IoT-Based System, Ultrasonic Sensors, Infrared Sensors, Real-Time Alerts, Sustainable Ecosystem.

I. INTRODUCTION

This project focuses on developing an AI-powered automated gate control system to prevent two-wheeler access through pedestrian pathways, while ensuring free movement for pedestrians. The system integrates an microcontroller, an ESP32-CAM for real-time video capture, and a YOLOv8-based AI model for object detection.

The camera streams live video to a server where the AI model processes the footage to classify whether the detected entity is a motorcycle or a pedestrian. If a pedestrian is identified, the gate remains open, allowing smooth passage, whereas if a motorcycle is detected, the ESP8266 activates the gate mechanism to block entry.

Additionally, an ultrasonic sensor measures the distance of the detected entity from the gate, ensuring precise and real-time operation. Traditional methods relying on manual monitoring or basic sensors are inefficient and prone to human errors, whereas this AI-based approach enhances security, improves traffic regulation, and reduces the need for human intervention.

By combining IoT-based hardware with AI-driven object detection, this system ensures efficient pathways management, enhances pedestrian safety, and prevents unauthorized vehicle access, making it a smart and reliable solution for modern traffic control.

II. MECHANICAL DESIGN

The mechanical design of the IoT-Based Pedestrian Zone Safety System focuses on integrating the physical components required for the functionality of system. It includes strategically placed sensors on pedestrian paths and compact actuators on vehicles, particularly two-wheelers. The sensors detect vehicle movement and relay data to the system in real time. Sensors with a micro servo motor is designed to automatically stop vehicles before they enter the pedestrian zone. The entire system is built to be durable, weather-resistant, and compact to ensure operation in busy urban environments.

III. CIRCUIT DESIGN

Circuit design mainly consists of two parts:

1. Sensors
2. Power Supply

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1. sensors

A. IR Infrared Sensor

An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode,The resistances and these output voltages, change in proportion to the magnitude of the IR light received.

B. ESP-32 camera

The IoT-based pedestrian zone safety system using the ESP32 camera helps improve safety by detecting pedestrians in restricted zones and alerting authorities in real-time. The camera captures live footage and, with the help of IoT technology, sends alerts if unauthorized vehicles or individuals enter the area.this system can be integrated with smart traffic management to reduce accidents by providing real-time updates to drivers and pedestrians. The automated monitoring ensures better enforcement of pedestrian path way zones, enhancing overall safety in busy urban areas..

C. Ultrasonic Sensor

Ultrasonic detection is most commonly used in industrial applications to detect hidden tracks, discontinuities in metals, composites, plastics, ceramics, and for water level detection. For this purpose the laws of physics which are indicating the propagation of sound waves through solid materials have been used since ultrasonic sensors using sound instead of light for detection. An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.

D. Servomotor

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller..

E. OLED

An IoT-based pedestrian zone safety system uses sensors and smart technology to improve pedestrian safety. It can detect people crossing the road and alert drivers using signals or lights, reducing accidents. Additionally, it can monitor traffic conditions and adjust warnings accordingly, ensuring a safer and more efficient pedestrian environment

2. Power Supply

The battery is a critical part in the supply of an IoT-based system, providing for constant operation of the microcontroller, sensors, and other hardware. It gives a portable and constant source of power, and thus the system becomes operational even in locations not connected to the electrical grid directly. Such batteries are commonly rechargeable lithium batteries, as they have high energy density, with long life. To maintain voltage levels as uniform as possible to sensitive devices, the output from the battery is usually controlled with voltage regulators (e.g., LM7805 or LM1117 for 5V or 3.3V). Within a pedestrian zone safety system, the battery provides power for the microcontroller and sensors to monitor continuously and engage actuators or indicators where necessary at all times, even during outages, with effective safety action.

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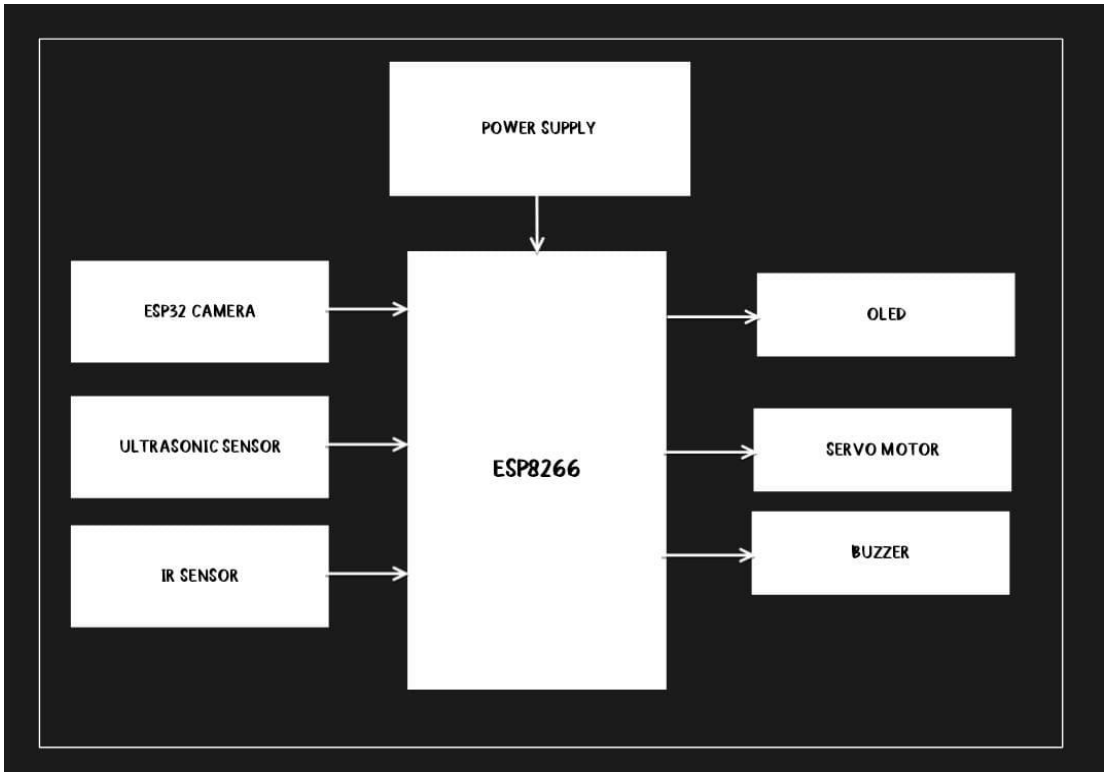

Fig.1.Block Diagram

IV. ALGORITHM

Step 1: Start.
Step 2: Power supply is provided to the system components (microcontroller, sensors, indicators, communication modules).
Step 3: Initialize all sensors and modules:

- PIR sensor for pedestrian detection.
- Ultrasonic or proximity sensor for vehicle detection. □ Indicators and communication modules.

Step 4: Monitor the pedestrian zone for activity:

- Check if pedestrians are present in the zone using the PIR sensor.

Step 4.1: If **pedestrians are detected**, activate visual and auditory alerts (e.g., LEDs, buzzer).
Step 4.2: If **no pedestrians are detected**, continue monitoring without activating alerts.
Step 5: Check for vehicles approaching the pedestrian zone using the ultrasonic sensor.
Step 5.1: If a vehicle is detected:

- Check if pedestrians are present in the zone.
- If **pedestrians are present**, send alerts to the driver and pedestrians.
- Trigger the vehicle's braking system to stop it before entering the pedestrian path.

Step 5.2: If no vehicle is detected, or no pedestrians are present, allow the vehicle to proceed.
Step 6: Monitor and send real-time alerts to authorities using IoT communication (e.g., Wi-Fi/GSM) if a safety breach is detected.
Step 7: Repeat the monitoring process in a loop for real-time operation.

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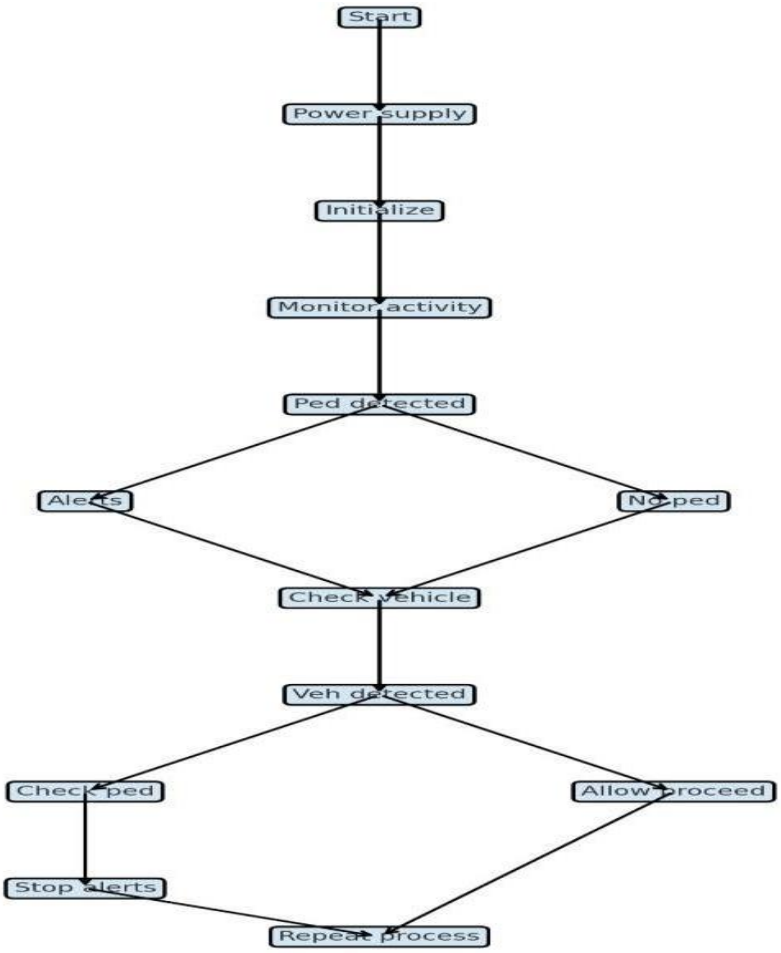

Fig.2.Flow chart of the system

V. PROTOTYPE SETUP

To develop a **prototype setup** for the IoT-Based Pedestrian Zone Safety System, several key components and steps are required to simulate its real-world functionality. The setup begins with a **microcontroller** (such as Arduino) to act as the central processing unit. **IR sensors** are positioned to detect pedestrian movement within the designated zone, while **ultrasonic or proximity sensors** are installed to monitor approaching vehicles. A **power supply**, such as a rechargeable battery, ensures the system operates reliably. For real-time alerts, the system integrates **LED indicators**, **buzzers**, and an **LCD screen** to notify pedestrians and drivers. Additionally, an **IoT module** (such as ESP8266 or GSM) enables real-time data transmission to authorities or cloud dashboards.

The prototype involves arranging these components on a scaled-down model of a pedestrian zone, with a motorized two wheeler representing the vehicle. The system is programmed in such a way that if a vehicle approaches,the system activate alerts and sends a command to an **electronic braking system** to stop the vehicle before it enters the zone. The prototype This setup effectively demonstrates the system's ability to enhance pedestrian safety and create organized, pedestrian-friendly urban spaces.

VI. COMPONENTS

1. IoT-Enabled Sensors-
   IR Sensors – To detect the Human Movement.
2. Motion sensors
3. Processing Unit-(Arduino)
4. Alert Systems Buzzer or Speakers LED Displays
5. Notifications Power Supply

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1. **PIR Sensors:**
Detect human movement to monitor pedestrian activity.
2. **Motion Sensors:**
Monitor the motion of vehicles and pedestrians in the area.
3. **Processing Unit (Arduino):**
Processes sensor data and controls system responses.
4. **Alert Systems (Buzzer or Speakers):**
Provide audible warnings to alert pedestrians and authorities of potential danger.
The buzzer system will be placed at the entry and key points within the pedestrian zone to ensure effective alerts. When a vehicle enters the restricted area, the system will activate a loud buzzer and flashing LED lights to immediately warn pedestrians and authorities of potential danger. The buzzer used will be a high-decibel alarm, ensuring that the alert is noticeable even in noisy environments. This real-time warning system helps prevent accidents by ensuring pedestrians are aware of unauthorized vehicle entry.
5. **Power Supply:**
Powers all the IoT components, ensuring the system runs continuously.
6. **LED Display:**
The LED display will show real-time warnings and alerts to inform pedestrians about unauthorized vehicle entry.

VII. APPLICATION

Automated Pedestrian path Management: Ensures seamless pedestrian movement by preventing motorcycle entry. Reduces manual monitoring and enhances security at pedestrian path. Improves traffic regulation with real-time AI-based gate control. **Smart Access Control for Restricted Zones**: Prevents unauthorized vehicle access in pedestrian-only pathways. Enhances security in metro stations, parks, and restricted areas. Provides efficient and automated access control using AI and IoT.

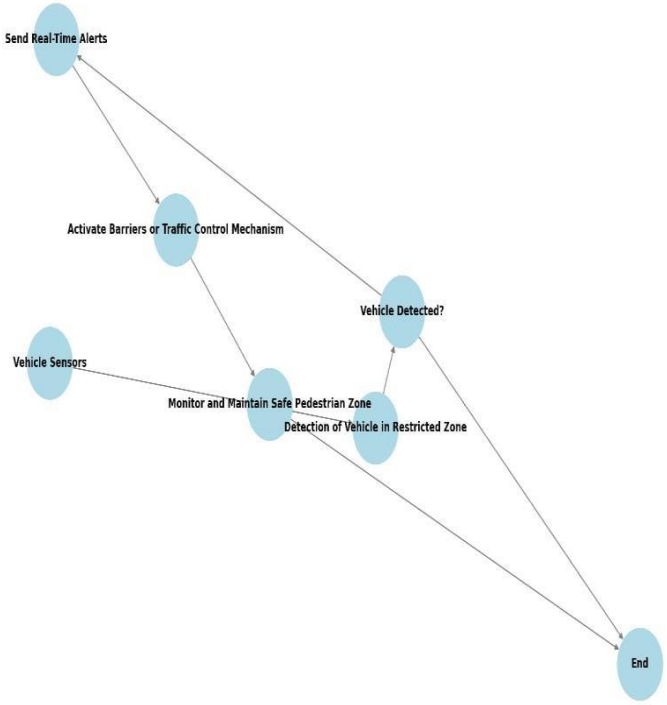

Fig.3.Flow chart for proposed solution

VIII. CONCLUSION

This project introduces an intelligent, autonomous pedestrian path management system that utilizes AI-driven object detection and IoT integration to improve security and traffic control. Through the use of an ESP32-CAM for real-time video capture and a YOLOv8 model for precise object classification, the system is able to differentiate between pedestrians and unauthorized motorcycles. The ESP8266 serves as the master controller, which receives classification

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outputs from the server and controls the gate mechanism accordingly. An ultrasonic sensor also increases reliability by determining the distance between objects detected and the gate, allowing for accurate operation. When a pedestrian is detected, the gate stays open for smooth passage, while the detection of a motorcycle triggers automatic gate closure to avoid unauthorized entry. This method does away with manual supervision, lowering operational costs and enhancing efficiency in tollgate management. the system can be used in several restricted areas, e.g., metro stations and parks, to effectively manage pedestrian pathways. The AI and IoT combination guarantees real-time decision-making, giving a scalable and dynamic solution for urban infrastructure in today's modern age. Overall, this project is enhancing security, averting unauthorized entry, and automating pedestrian traffic management, and it provides an economical and intelligent solution to existing tollgate monitoring systems

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