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IntelliCross: Smart Pedestrian Crossing and Traffic Management System

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ABSTRACT-- In urban areas, road networks are constantly challenged with the task of balancing pedestrian safety with efficient traffic flow. The struggle to find this balance often results in congestion and accidents at crossings. Traditional traffic signal systems operate on fixed timers, which fail to adapt to real-time pedestrian movement and vehicle density, causing unnecessary delays or unsafe crossings [1].

IntelliCross is a smart traffic management and pedestrian crossing system that leverages GSM-based communication to dynamically control traffic signals, ensuring optimized pedestrian and vehicle coordination. The system integrates infrared (IR) sensors to detect pedestrian presence and GSM-triggered signal changes to adjust traffic lights accordingly. RGB LED-embedded pathways enhance pedestrian visibility, especially during low-light conditions, improving overall safety [6].

IntelliCross leverages the power of GSM technology to provide seamless remote traffic signal adjustments. This innovative solution eliminates the need for manual intervention, allowing for efficient real-time pedestrian crossings and adaptive traffic control. This approach minimizes traffic congestion, improves pedestrian safety, and enhances road efficiency, making it a scalable and cost-effective solution for urban infrastructure [4].

KEYWORDS: GSM-Based Traffic Control, Adaptive Traffic Signals, RGB LED, Pathways, Pedestrian Detection System, Vehicle and Pedestrian Coordination, Infrared (IR) Sensors.
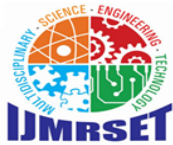
I. INTRODUCTION

In rapidly urbanizing cities, pedestrian safety and efficient traffic management remain critical challenges. Traditional fixed-time traffic signal systems often fail to accommodate real-time pedestrian movement and vehicle density, leading to unnecessary delays, congestion, and an increased risk of accidents. Pedestrians frequently struggle with unpredictable signal changes, while vehicles face unnecessary stoppages, reducing overall traffic efficiency[7].

To address these challenges, IntelliCross introduces a smart traffic management and pedestrian crossing system that utilizes GSM-based communication and infrared (IR) sensors for dynamic traffic signal control. Unlike conventional systems, IntelliCross automatically detects pedestrian presence and triggers GSM-based alerts to modify traffic signals accordingly, ensuring a safe and seamless crossing experience. The integration of RGB LED-embedded pathways further enhances pedestrian visibility, especially in low-light conditions, reducing the likelihood of accidents[2].

The key advantage of IntelliCross is its real-time adaptability. By eliminating fixed-timer-based traffic signals and replacing them with a sensor-triggered system, it optimizes pedestrian crossings and vehicle movement simultaneously. Additionally, the GSM-based signal control mechanism allows for remote traffic light modifications, reducing the need for manual intervention while ensuring efficient traffic flow[11].

II. OVERVIEW

The IntelliCross: Smart Traffic Management and Pedestrian Crossing System is designed to enhance pedestrian safety and traffic efficiency by replacing traditional fixed-time traffic signals with an automated, real-time adaptive system. Using infrared (IR) sensors, the system detects pedestrian presence at crossings and triggers GSM-based signal control

to modify traffic lights accordingly. This ensures that vehicles stop only when pedestrians are present, reducing unnecessary delays and optimizing traffic flow. Additionally, RGB LED-embedded pathways enhance pedestrian visibility, particularly in low-light conditions, further improving road safety[3].

The system operates with minimal manual intervention, making it a scalable and cost-effective solution for urban road management. By dynamically adjusting signal timings based on real-time pedestrian and vehicle activity, IntelliCross prevents congestion and reduces the risk of accidents. The integration of GSM communication allows remote traffic light adjustments, ensuring seamless coordination between pedestrian movement and vehicle flow. As cities continue to face challenges with increasing traffic density, IntelliCross presents an innovative approach to improving road infrastructure, reducing pedestrian accidents, and enhancing smart urban mobility[13].
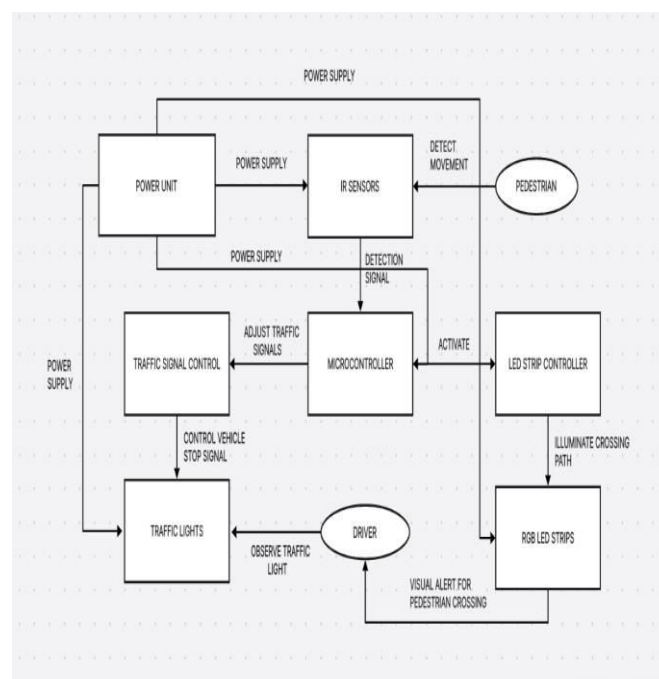

Fig.1. Architecture diagram for proposed system

III. COMPONENTS

1. Infrared (IR) Sensors
Function: Detects pedestrian presence at the crossing.

2. GSM Module (SIM800L/SIM900A)
Function: Sends a GSM-triggered signal to change traffic lights remotely.

3. Traffic Signal LEDs (Red, Yellow, Green)
Function: Displays the appropriate signal to vehicles and pedestrians.

4. RGB LED-Embedded Pathways
Function: Illuminates pedestrian crossing paths for better visibility.

5. Microcontroller (Arduino/ESP8266)
Function: Processes sensor inputs and triggers GSM-based commands for traffic signal control.

6. Power Supply Unit (Battery/Solar Panel)
Function: Provides power to the sensors, microcontroller, and GSM module.

IV. EXISTING SYSTEMS

Current pedestrian crossing and traffic management systems primarily rely on fixed-time traffic signals or manual intervention, which often fail to adapt to real-time pedestrian and vehicle movement. These conventional systems present several limitations, including inefficient traffic flow, increased congestion and compromised pedestrian safety[5].

In many urban areas, pedestrian crossings operate on pre-set timers, causing unnecessary stoppages for vehicles even when no pedestrians are present. In some cases, pedestrians are forced to wait for long signal cycles, leading to jaywalking and unsafe crossings. Additionally, manual push-button crossings require pedestrian input, which can be unreliable, especially in high-traffic zones. Lack of adaptive control mechanisms and poor visibility in low-light conditions further contribute to accidents and traffic inefficiencies. These challenges highlight the need for a smarter, automated, and real-time traffic management solution, such as IntelliCross, to ensure safe and efficient pedestrian crossings[8].
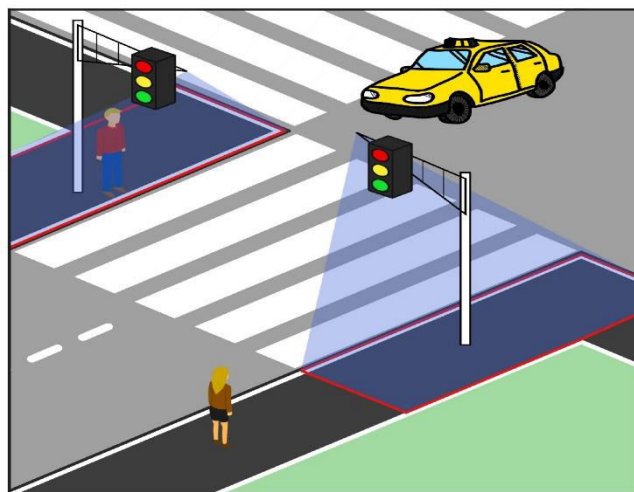

Fig.2. Traditional Timed Waiting System

V. PROPOSED SYSTEM

A. Objective

Automating traffic signal adjustments based on real-time pedestrian detection using IR sensors. Utilizing GSM communication to trigger traffic light changes remotely, eliminating manual interventions. Enhancing pedestrian visibility with RGB LED-embedded pathways, especially in low-light conditions. Reducing congestion by dynamically managing signal durations, ensuring smooth vehicle movement. Creating an energy-efficient solution by integrating solar-powered components where applicable[7].

B. Methodology

The IntelliCross: Smart Traffic Management and Pedestrian Crossing System is designed to provide real-time pedestrian detection and adaptive traffic signal control using GSM-based automation. The system follows a structured methodology that integrates infrared (IR) sensors, microcontrollers, GSM modules, and LED indicators to ensure efficient and safe pedestrian crossings. The following steps outline the working mechanism of IntelliCross[9]:

1. Pedestrian Detection Using Infrared (IR) Sensors

The system starts by detecting pedestrians approaching the crossing. Infrared (IR) sensors are placed near the pedestrian crossing zone to monitor movement. When a pedestrian is detected. The IR sensor sends a signal to the microcontroller (e.g., Arduino). The system confirms the pedestrian's presence and triggers further processes. This automated pedestrian detection eliminates the need for manual push buttons, making crossings more efficient and accessible, especially for elderly individuals and visually impaired pedestrians[14].

2. Microcontroller Processing and GSM-Based Traffic Signal Control
Once the pedestrian is detected, the microcontroller (Arduino/ESP8266) processes the sensor data and activates the GSM module to communicate with the traffic light controller. The GSM module (SIM800L/SIM900A) sends a signal to change the traffic light from green to red for vehicles. This ensures that vehicles stop only when a pedestrian is present, reducing unnecessary traffic delays. The system then activates the pedestrian crossing signal (green light for pedestrians). This approach ensures real-time adaptive control of traffic signals, preventing fixed-time signal inefficiencies while enhancing pedestrian safety[10].

3. RGB LED-Embedded Pathway Illumination for Enhanced Visibility
Once the pedestrian signal is activated, the RGB LED-embedded pathway lights up to provide visual guidance to pedestrians and alert drivers of an active crossing. The LED strips illuminate the pedestrian path, ensuring high visibility, especially in low-light conditions or high-traffic zones. This prevents pedestrian accidents due to poor visibility at night or during adverse weather conditions. By integrating RGB LEDs with sensor-based activation, IntelliCross improves pedestrian awareness and reduces roadside accidents caused by low visibility[5].

4. Traffic Flow Optimization Through Dynamic Signal Timing
To prevent congestion and ensure efficient traffic movement, IntelliCross dynamically adjusts traffic signal durations based on: Real-time pedestrian demand (number of pedestrians waiting to cross). Minimum wait times for vehicles to reduce unnecessary stop pages[12].

VI. IMPLEMENTATION OF PROJECT

The IntelliCross system is implemented through a structured process involving hardware setup, software development, system integration, and real-world deployment to enable automated pedestrian detection and GSM-based traffic signal control. The system begins with the installation of infrared (IR) sensors at pedestrian crossings to detect movement. These sensors send signals to a microcontroller (Arduino/ESP8266), which processes the input and activates a GSM module (SIM800L/SIM900A) to communicate with the traffic light controller[15].

Fig.3. Implementation of smart pedestrian system

The traffic signals then dynamically change to allow pedestrians to cross safely, ensuring real-time coordination between pedestrians and vehicles. Additionally, RGB LED-embedded pathways illuminate when a pedestrian is detected, enhancing visibility, especially in low-light or high-traffic conditions. The system is powered by a battery backup or solar panel, ensuring continuous operation even in areas with unstable electricity supply[3].

The software for IntelliCross is programmed using Arduino IDE to control pedestrian detection, GSM communication, and traffic light automation. The system undergoes rigorous testing and calibration to ensure accurate pedestrian

detection, reliable GSM-triggered signal switching, and smooth LED activation. Once validated, the system is deployed in real-world conditions, where it dynamically adjusts traffic signals based on pedestrian demand and traffic flow[14].
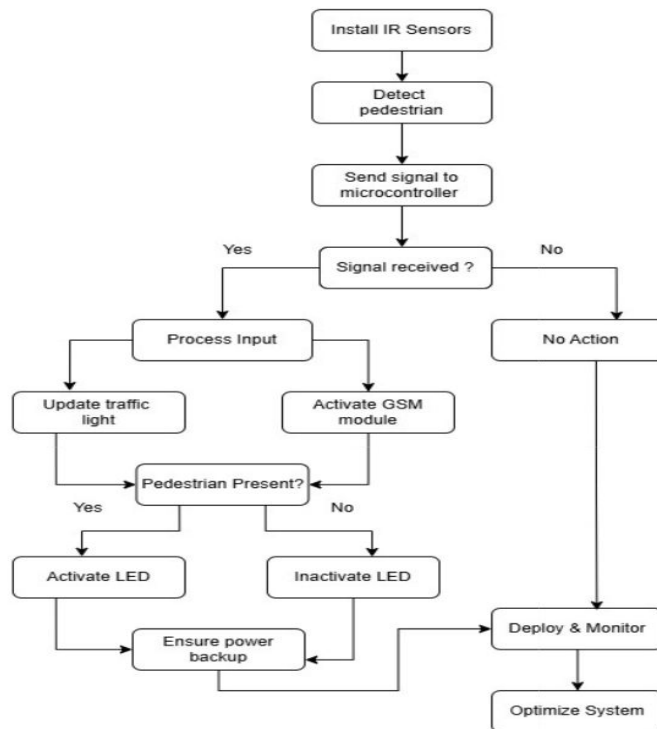

Fig.4. Working flow of smart pedestrian system

VII. ADVANTAGES

1. Real-time pedestrian detection improves safety by ensuring timely traffic signal changes and preventing accidents.
2. RGB LED pathways enhance visibility, especially at night or in adverse weather conditions, making pedestrians more noticeable to drivers.
3. Dynamic signal timing reduces unnecessary vehicle stoppages, optimizing traffic flow and minimizing congestion.
4. GSM-based traffic control allows automatic and remote signal adjustments, eliminating the need for manual intervention.

VIII. FUTURE ENHANCEMENTS

1. Integration of AI-based pedestrian detection using cameras for improved accuracy in identifying pedestrian movement and intent.
2. Implementation of vehicle detection sensors to optimize traffic signal timing based on both pedestrian and vehicle density.
3. Addition of voice assistance at crossings to aid visually impaired pedestrians with real-time audio alerts

VIII. CONCLUSION

The IntelliCross system improves pedestrian safety and traffic efficiency by using GSM-based signal control and real-time pedestrian detection. It dynamically adjusts traffic signals, reduces congestion, and enhances visibility with RGB LED pathways. With its cost-effective, scalable, and energy-efficient design, IntelliCross seamlessly integrates into existing traffic systems.

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