

AI & IOT – Driven Smart Streetlight With Crime Detection and Accident Monitoring

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Abstract—

The proposed IoT-Driven Smart Streetlight with Crime Detection system is intended to enhance public safety and minimize energy consumption in urban and rural settings. The system incorporates an LDR sensor to control streetlights automatically according to ambient light conditions, thus optimizing power consumption. IR sensors are utilized to detect pedestrian and vehicle movement, thereby facilitating smart lighting control during night time. To improve safety, vibration and sound sensors are incorporated to detect unusual or suspicious events like physical assault, accidents, and vandalism. Once such events are detected, a GSM module immediately triggers warning messages to the concerned authorities or control rooms. An ESP32-CAM module is utilized to offer live video streaming of the crime site, thus facilitating real-time monitoring and prompt crime response. The proposed system presents a cost-effective, efficient, and scalable solution for smart city applications by integrating smart street lighting with automated crime detection and warning systems.

Index Terms-- Artificial Intelligence

(AI), Internet of Things (IoT), Smart Streetlight System, Crime Detection, Accident Monitoring, Energy Efficiency, ESP32-CAM, GSM Module, Smart Cities.

1. Introduction: Road accidents are a leading cause of death globally, and two-wheeler riders are most susceptible to life-threatening

injuries. Drunk driving and the lack of immediate medical attention after an accident are major contributors to fatalities. The lack of automatic accident detection and emergency

communication services makes the situation even worse.

Recent advances in Internet of Things (IoT) technology have made it possible to create intelligent safety solutions for the transportation sector. Smart helmets with sensor and wireless communication technology capabilities can automatically monitor the rider's status in real time and react accordingly to dangerous situations. This minimizes the need for human intervention and optimizes emergency response efficiency.

This paper proposes a Smart Helmet for Alcohol Detection, Accident Detection, and Notification by IoT for improving rider safety. The proposed system prevents drunk driving by disabling car ignition if alcohol levels exceed a certain limit. The system also detects accidents using vibration sensors and immediately transmits the rider's location to emergency contacts and medical services via GPS and GSM modules. The proposed system is expected to minimize fatalities due to accidents and promote safe transportation through IoT-based smart helmet technology.

2. Related Works:

1. Shivam More (2023) proposed an IoT-based public safety monitoring system using sensor networks for the detection of abnormal activities and real-time alert generation. Although the system enhanced emergency response, it didn't incorporate adaptive street lighting control and real-time video-based monitoring.

2. C. V. Suresh Babu (2023) proposed a smart lighting control system that was enhanced with environmental sensing and automation for energy efficiency; however, the system didn't incorporate security monitoring and intelligent event detection.

3. The Jaipur Smart City Project Team (2022) introduced an IoT-based smart lighting system to optimize energy consumption and minimize operational expenses; but the system did not integrate real-time crime detection and automatic emergency alerting.

4. Chua Tze Yong (2023) analysed an IoT-based urban monitoring system that used sensor fusion and cloud computing to improve situational awareness; but the study did not integrate adaptive street lighting or real-time video alerting.

3. The Proposed Construction:

The proposed system offers an AI and IoT-based smart streetlight system that encompasses adaptive lighting control, crime detection, and accident monitoring for improving public safety and minimizing energy consumption.

The proposed system is designed as a distributed system in which each streetlight acts as an intelligent node that supports sensing, processing, and communication.

3.1 Intelligent Lighting Control

The system uses a Light Dependent Resistor (LDR) to detect the intensity of light. During the day, the streetlight will be OFF, and in low light conditions, it will turn ON automatically. Moreover, Infrared (IR) sensors are used to detect the movement of pedestrians and vehicles, allowing the brightness to be adjusted dynamically.

3.2. Crime and Accident Detection Mechanism

In order to provide safety to the public, the system uses sound and vibration sensors to detect any irregular activity like accidents, vandalism, or physical disturbance. When the sensor values go beyond the threshold values,

the microcontroller identifies the situation as a possible emergency.

3.3. Communication and Alert System

When a suspicious event or accident is detected, the system triggers a GSM communication module to send immediate alert notifications to the concerned authorities or control rooms in the surrounding area. The alert notification contains information about the event and the location, thus enabling a quick response to the emergency situation even in regions where internet connectivity is not available.

3.4. Real-Time Video Monitoring

The ESP32-CAM module is incorporated into the system to enable live video streaming of the location of the incident.



Figure 3.4.1 ESP32 Microcontroller.

3.5. System Integration and Scalability

Each module is also interconnected in a microcontroller-based architecture, which enables all the units of sensing, processing, and communication to work in synchronization.

The proposed system is low-cost, scalable, and can be easily implemented in both urban and rural areas, thus supporting smart city applications by integrating intelligent lighting with automated security surveillance.

4. System Model:

The proposed AI & IoT Driven Smart Streetlight System is designed as a distributed edge-based system that combines intelligent sensing, edge processing, and emergency communication support. The system consists of self-contained nodes that are capable of real-time monitoring and decision-making.

4.1. Architectural Framework

The system is developed based on a four-layer hierarchical architecture that includes:

- 1.Sensing Layer
- 2.Edge Processing Layer
- 3.Communication Layer
- 4.Application Layer

4.2. Sensing Model

Let the system input vector at time t be represented as:

$$X(t) = \{L(t), M(t), S(t), V(t)\}$$

Where:

- $L(t)$ → Ambient light intensity (LDR)
- $M(t)$ → Motion detection (IR sensor)
- $S(t)$ → Sound intensity
- $V(t)$ → Vibration magnitude

Each sensor continuously transmits real-time data to the processing unit.

4.3. Lighting Control Model

Streetlight state $SL(t)$ is defined as:

$$SL(t) = \begin{cases} 1, & \text{if } L(t) < L_{th} \\ 0, & \text{otherwise} \end{cases}$$

Where:

- L_{th} is the predefined light threshold.
- $SL(t) = 1$ indicates ON state.
- $SL(t) = 0$ indicates OFF state.

Brightness adjustment is defined as:

$$B(t) = \begin{cases} B_{max}, & \text{if } M(t) = 1 \\ B_{min}, & \text{if } M(t) = 0 \end{cases}$$

4.4. Accident and Crime Detection Model

An emergency event $E(t)$ is triggered when:

$$E(t) = \begin{cases} 1, & \text{if } S(t) > S_{th} \wedge V(t) > V_{th} \\ 0, & \text{otherwise} \end{cases}$$

Where:

- S_{th} → Sound threshold
- V_{th} → Vibration threshold
- Logical AND operation reduces false positives.

4.5. Communication Model

If $E(t) = 1$, the system performs:

1. GSM-based alert transmission
2. Activation of camera module
3. Incident logging

Communication latency T_c is minimized through edge processing without cloud dependency.

4.6. System Assumptions

- Sensors operate within calibrated threshold ranges.

- GSM network availability is assumed.
- Environmental noise variations remain within tolerable limits.

4.7. Model Characteristics

- Low computational complexity
- Real-time processing capability
- Energy-efficient operation
- Scalable for smart city deployment.

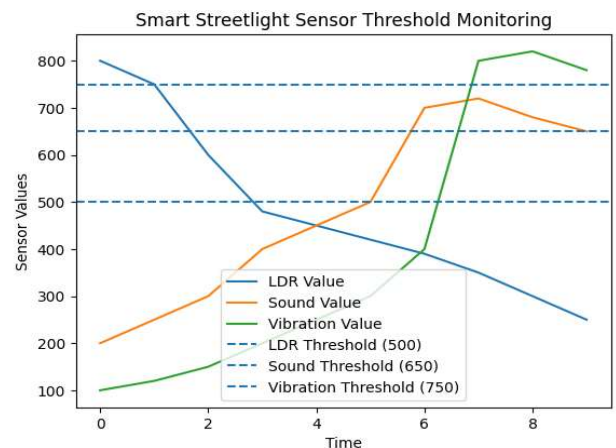


Figure 4.1.1 Sensor Threshold Monitoring.

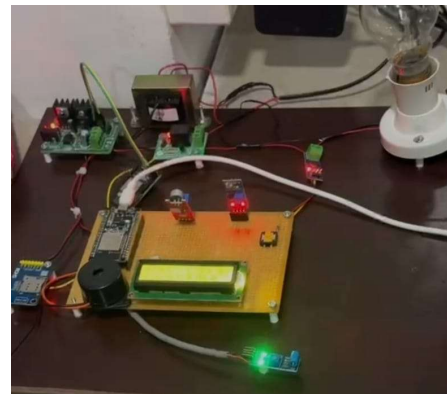


Figure 4.1.2 Working Model.

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development of this project. The authors would also like to thank the researchers and developers who have contributed to the development of Internet of Things (IoT), embedded systems, and smart streetlight systems that have given valuable insights and knowledge to this study.

6.Future scope:

The proposed smart street lighting system can be further improved by implementing advanced artificial intelligence methods for more precise identification of accidents and suspicious events. Future enhancements may include cloud-based monitoring for large-scale smart city implementation and real-time data analysis. Moreover, the combination of computer vision, solar-based modules, and GPS-enabled emergency response systems can greatly enhance the efficiency, scalability, and reliability of the system.

7.Conclusion:

This work proposed an AI and IoT driven smart streetlight system that combines intelligent lighting control with crime detection and accident monitoring to address the limitations of conventional street lighting infrastructure. By utilizing environmental and motion sensors, the system dynamically controls streetlight operation, significantly reducing unnecessary energy consumption. The integration of sound and vibration sensors enables the detection of abnormal events such as accidents and suspicious activities, improving public safety.

The GSM communication system used for the transmission of instant alerts and the ESP32-CAM module used for real-time video surveillance ensures a quick response and effective situational awareness. The proposed system is cost-effective, scalable, and reliable,

making it ideal for use in both urban and rural settings. In general, the system makes a significant contribution to energy efficiency, security, and the implementation of smart city projects.

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