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Smart Light System Designed For Accident Detection Through An Integration Of IOT & Machine Learning Algorithm

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Abstract: These days, road accidents are happening a lot, and it's becoming a big concern everywhere. One of the most important things is how fast we can respond when something goes wrong on the road—it can really help save lives and keep traffic from getting worse. For this project, the idea is to come up with a smart system that can notice when an accident happens, using a mix of IoT devices and machine learning. It's all about making the roads safer with the help of tech. In simple terms, we used streetlight cameras that are connected to the internet to keep an eye on vehicles and record what's happening on the roads. Then, a deep learning model based on YOLO goes through this footage and checks if there's been an accident—while it's still happening. If an accident is spotted, the system doesn't wait. It instantly sends out an alert through email to the traffic control center and turns on nearby alarms. By doing this, help can arrive faster. The goal is not just to detect accidents better, but also to make roads a lot safer for everyone.

Keywords— Accident Detection, NodeMCU, Ultrasonic Sensor, Vibration Sensor, LDR, LED Lighting, Embedded C, IoT, ThingSpeak, Machine Learning, Emergency Alert, Smart Street Light.

I. INTRODUCTION

In recent years, numerous cities have begun employing smart technology to address day-to-day issues, particularly for safety and conserving electricity. One concept in our project is a smart streetlight system that can identify road accidents through IoT and machine learning. Streetlights normally remain lit throughout the night even if there are no cars on the road, consuming lots of power. Additionally, accidents may not be seen in rural or isolated places for quite a long period, thereby taking long before an emergency can be responded to. Our project will offer smart streetlights. These lights can automatically change based on car movement and sense accidents as soon as they happen. For this, we using devices like NodeMCU, ultrasonic sensors, LDRs, and vibration sensors to watch what's going on around the lights. When an Tejaswini B K Student, Dept. of ECE BGS Institute of Technology, Adichunchanagiri University, B G Nagar-571448, Karnataka, India tejaswinibktejaswini@gmail.com Sanjana C K Student, Dept. of ECE BGS Institute of Technology, Adichunchanagiri University, B G Nagar-571448, Karnataka, India sanjanashetty7353@gmail.com Mr. Mohan Kumar K S Assistant Professor, Dept. of ECE , BGS Institute of Technology, Adichunchanagiri University, B G Nagara - 571448, Karnataka, India mohanks.belur@gmail.com accident is detected, the system sends the data to a machine learning model, which understands the situation and immediately sends alerts to emergency services using cloud platforms like ThingSpeak or Blynk. The main goal of this project is to combine IoT devices, cloud communication, and machine learning to improve road safety, give faster response in emergencies, and reduce electricity usage. This will help in building smart and safe cities in the future.

Our key objectives are:

- To design a smart street lighting system that changes brightness depending on car movement and the light around.
- *To detect road accidents in real-time using sensors like vibration and ultrasonic ones.*
- *To add a machine learning model that processes the data from sensors and figures out accident scenarios correctly.*
- *To create an emergency alert system that automatically notifies nearby hospitals or emergency services.*
- *To use IoT platforms such as ThingSpeak or Blynk for real-time monitoring and data visualization..*

Future scopes are:

- Integration with Traffic Management Systems: The smart light system can connect with smart traffic lights and city traffic control centers to help manage congestion and reroute traffic during accidents.
- GPS and Location Tracking: By adding GPS modules, we can quickly locate the accident spot and send it to emergency responders, helping them reach faster.
- Camera-Based Visual Monitoring: Using CCTV or IP cameras can provide live footage of the accident scene, making it easier to make decisions and gather evidence.
- Mobile App Integration: A mobile app can be made for real-time alerts, manual reports, and system monitoring by authorities.
- AI-Based Predictive Analysis: Advanced AI models can help predict accident-prone areas and times, allowing for actions to be taken before accidents happen.

II. LITERATURE SURVEY

This literature review provides a comprehensive overview of AmbuBot- Automated Ambulance Robot for Medical Emergency

a. Smart Street Lighting System based on IoT

This study proposed an automatic street lighting system where the light operates based on the movement of vehicles using IR sensors and NodeMCU. Although it provided energy efficiency, it lacked features like accident detection and the integration of machine learning.IoT Based Accident Detection and Alert System

b. IoT Based Accident Detection and Alert System

This article focused on accident detection using vibration sensors and accelerometers connected to a microcontroller. While it was able to alert emergency services, it was based on predetermined threshold values and didn't implement machine learning for accuracy improvement.Real-Time Accident Detection and Notification using GSM and GPS

c. A Smart City Implementation: Streetlight Monitoring and Control System

The project employed a centralized control system to track streetlight status and power consumption. The solution was expensive and non-scalable because of the absence of real-time automation and flexibility.

d. Real-Time Accident Detection and Notification via GSM and GPS

The system employed GSM/GPS modules to provide notifications upon detection of an accident. The application of ML was not implemented, and the system frequently sent false alarms due to sensor constraints.

III. IMPLEMENTATION

A. Methodology

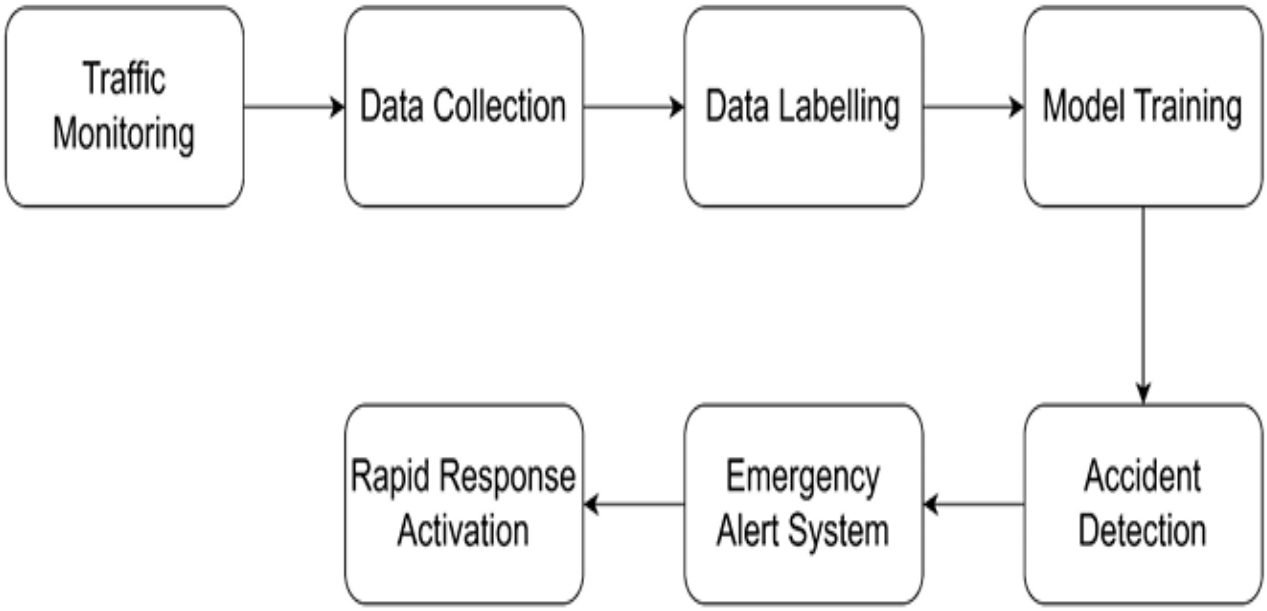

Fig 1: Smart light system designed for accident detection throuhg integration of IOT & ML

• **Monitoring Traffic**: Observing and monitoring traffic patterns, probably via sensors or cameras along the road.
• **Data Gathering**: Gathering information from sources like traffic cameras, sensors, and possibly GPS travel data from vehicles.

• **Data Labeling:** This process is where the gathered data is tagged manually — such as tagging scenes where accidents or abnormal traffic patterns are apparent.

• **Model Training:** The labeled data is then utilized to train a machine learning model so that it can learn to detect accidents or abnormal traffic behavior independently.

• **Accident Detection:** Once the model is trained, it kinda just keeps watching the traffic data all the time and figures out if there's an accident or something weird going on.

• **Emergency Alert System:** If an accident shows up, the system right away shoots out an alert to the emergency folks or whoever's in charge.

• **Quick Response Activation:** The emergency teams get notified super quick and can jump into action—like sending help or redirecting traffic so things don’t get worse.

B. Flow Chart

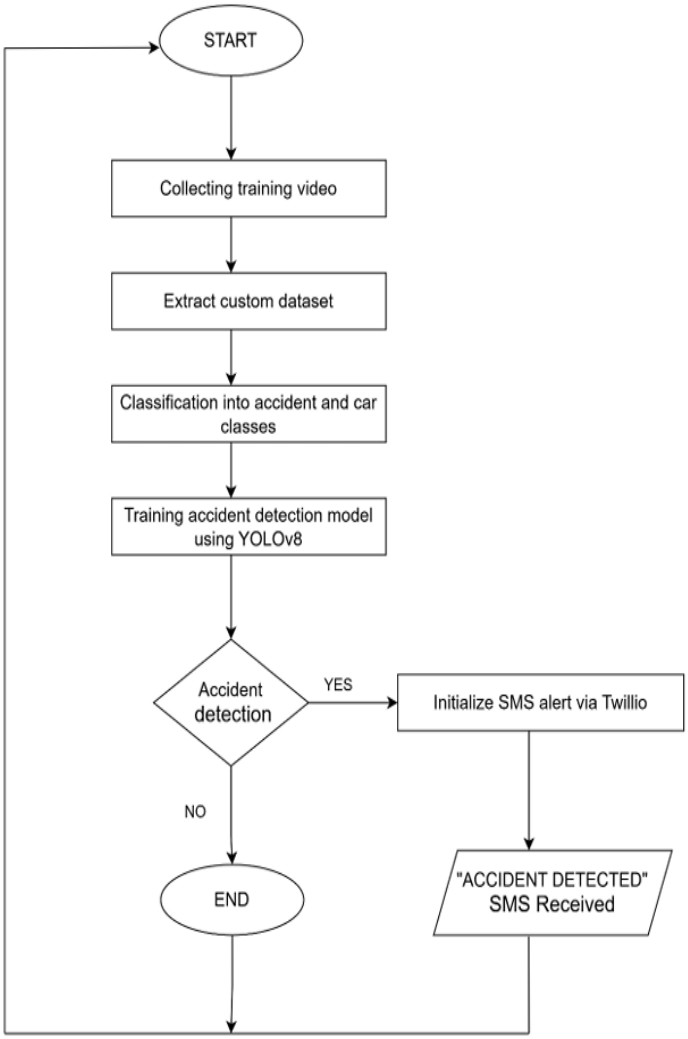

Fig 2 :Flow chart of Accident Detection

• **START:** The process begins.
• **Collecting training video:** Videos of normal driving and accidents are recorded and collected.
• **Extract custom dataset:** Frames related to accidents and cars are cut out from those videos to make a dataset for identifying both.
• **Accident and car class classification:** The data is labeled and seperated into two classes – "accident" and "car".
• **Training YOLOv8 accident detection model:** YOLOv8 model is trained using the dataset so it can learn how to spot cars and detect accidents in the video.
• Accident detection? The trained model checks live or saved video to see if any accident happened.
• **NO:** If no accident is found, then the system stops there.
• **YES:** If it finds an accident, then it moves on to the next step.
• **Initialize SMS alert via Twilio:** An SMS alert gets triggered using Twilio API.
• **"ACCIDENT DETECTED" SMS Received:** A message saying an accident was detected is sent and recieved.
• **END:** The process. ends here, or it can start again to keep checking for accidents

C. Hardware Requirements

Microcontroller ESP-8266
ESP8266 is a low-cost and compact Wi-Fi chip made by Espressif Systems. It's used mostly for giving internet connectivity to small devices, especially in IoT projects. This chip became super popular because of its low power use and powerful features in such a small size. It has a 32-bit Tensilica L106 microcontroller running at 80 MHz (you can even overclock it to 160 MHz). It also has built-in SRAM and supports external flash. The best thing is, it can run its own applications or just handle Wi-Fi work for another processor.

Buzzer
A buzzer, usually a piezo type, is a tiny electronic device that makes sound or alarms. It's simple, cheap, and very light. Even though it's simple, it's reliable too. Buzzers come in different sizes and work at different frequencies to make various kinds of sounds.

Camera
An IoT camera is a smart camera that connects to the internet or network. This lets it talk to other smart devices. With this, you can do things like watch live video from far, get alerts if something happens, and even do some real-time smart analysis.

D. Software Requirements

• **OpenCV (Open Source Computer Vision Library)** is a free and open-source library for computer vision and machine learning. It was made to give a common platform for building vision-based applications and to help increase machine perception in real-world products. Since it's under Apache 2 license, it's also easy for companies to use and change it. OpenCV has more than 2500 algorithms, both traditional and modern ones, used in many computer vision and ML tasks.

• **YOLO** stands for "You Only Look Once", and it is fast and powerful object detection algorithm that came out in 2015. It was created by Joseph Redmon and his team. What makes YOLO different is, it looks at the image only once and guesses where the objects are and what they are, all in one go using a CNN. It's super useful in real-time applications like accident detection or surveillance.

• **Mail – SMTP,** means Simple Mail Transfer Protocol. It is main method used for send emails from one server to another. It does not deal with receiving emails, just sending them out. This is the protocol used when our system needs to send alerts to someone through email.

• **LabelImg** is a free image labeling tool that lets you draw boxes around objects in pictures and give names to them. It's mostly used for training machine learning models like YOLO. It supports many formats like PascalVOC and YOLO and can save labels as XML, TXT, or CSV. It's a must-use tool when preparing custom datasets for object detection tasks.

E. Applications

•**Intelligent Traffic Signal Control –** Alters the timing of traffic lights in real time after it detect the accident so that it can manage traffic more efficiently and direct cars via alternative routes.
• **Smart Street Lighting Systems –** Adapts color or brightness of streetlights if accident occurs in order to provide maximum visibility and safety to the area.
• **Incident Analytics Software –** Aggregates and computes facts about accidents and identifies risky locations to inform urban planning and road safety.
• **Vehicle-to-Infrastructure (V2I) Communication –** Enforces vehicles to speak to smart lights or poles and share data like sudden braking or crashes in real time.

F. Advantages

Real-Time Accident Detection – The system helps to detect accidents at the instant of occurrence using sensors, thus helping assistance reach the location on time.
Automated Emergency Alerts – The instant an accident is detected, it automatically alerts the surrounding hospitals or the police.
Data-Driven Insights – The network employs machine learning to study the data of accidents and forecast what happens, thus planning for secure roads in the future.
Smart Energy-Efficient Lighting – The street lamps vary their lighting based on traffic or sunlight and conserve electricity when not required.
Scalable Infrastructure – Since it's built on IoT, scaling to cover more roads or introducing new features in the future is easy and effective
Enhanced Public Safety – With quicker responses and smarter planning, accidents can be managed better, which could even save lives.
Remote Monitoring & Control – All can be monitored and controlled remotely, eliminating the need for a sizeable on-site crew.
Smart City Integration – The system can be easily integrated into wider smart city strategies, interlinking with traffic management, emergency services, and CCTV networks for efficient functioning.

IV. RESULT

Fig 3 : Trained data

This system is a minimal IoT-based alarm or alert system utilizing the NodeMCU ESP8266 microcontroller and buzzer output. It is primarily utilized in accident detection, intruder alarm, or alarm systems for emergency.

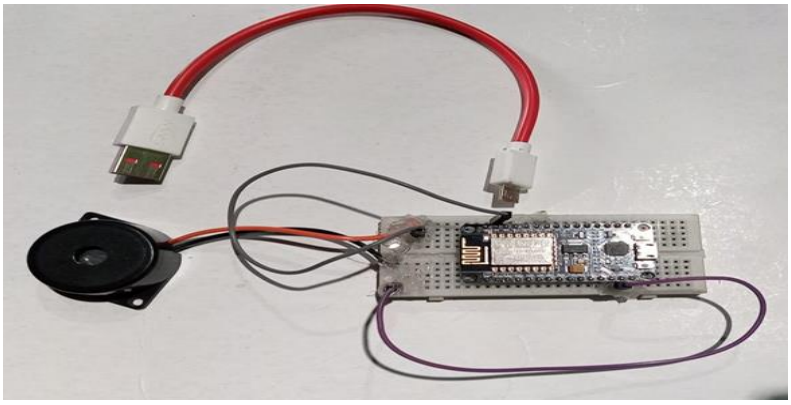

Fig 5: Hardware Components

The NodeMCU, once powered on and set, watches over specific inputs or internal state. When it sees a trigger—such as an accident or a request from a mobile app—it sends a HIGH signal to the GPIO pin connected to the buzzer. This triggers the buzzer, ringing the alarm.

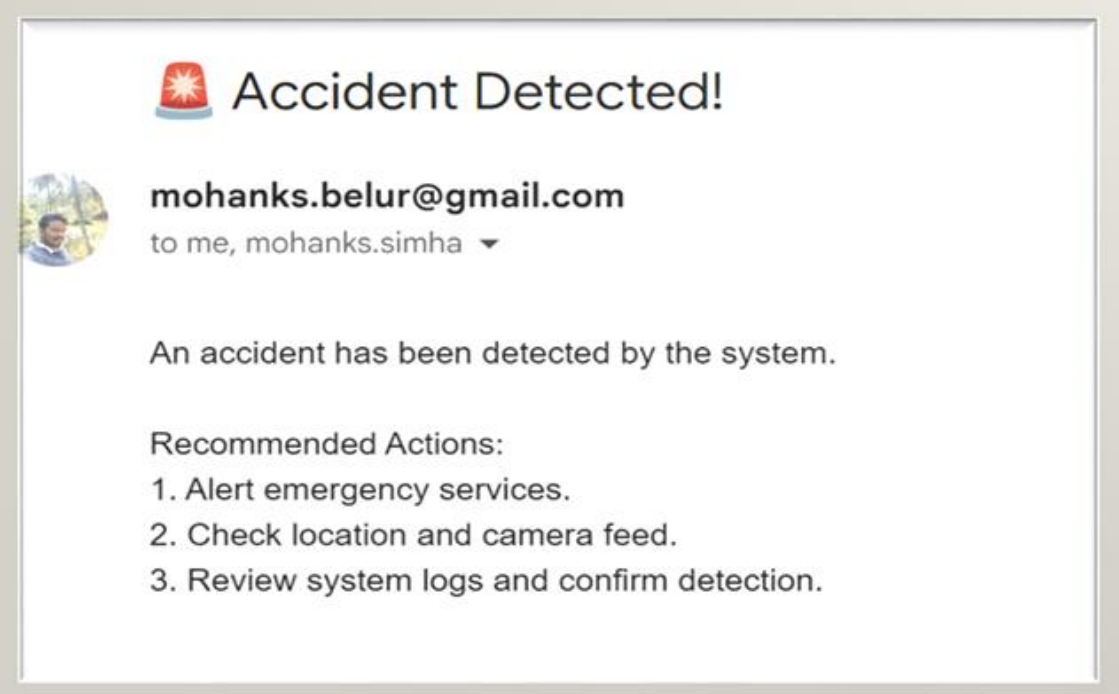

Fig 4: Email Alert System

The figure illustrates an auto-email alert of the IoT-based Accident Detection System. In case of a possible accident, it automatically sends alerts to pre-specified recipients through email, facilitating rapid response and immediate emergency measures.

V. CONCLUTION

Smart Light System for Accident Detection using IoT and machine learning provides a novel solution to improve road safety through real-time monitoring and automated response. The system synergistically integrates the most advanced technologies to address the worldwide trend of traffic accidents and associated deaths. Employing IoT-based streetlight cameras, the system constantly monitors vehicle movement and captures key traffic videos. Utilization of a YOLO-based deep learning model to process such video guarantees quick and accurate accident detection, which translates to huge response time saving.Incorporating automatic sending of alarm and email notification upon accident detection guarantees quick response from control rooms and people nearby, making the system a vital tool for averting additional accidents and deaths.Using a self-collected, tagged dataset to train the model ensures that the system is tailored to the particular road conditions and traffic flows of the deployment site, improving its overall performance and reliability This approach not only helps toward better road safety but also contributes to the trend toward smart cities where IoT technologies play a fundamental part in city operations. The ability of the system to provide real-time automatic surveillance and rapid accident detection holds immense potential for improving traffic control and emergency response times. Additionally, the scalability of the system allows it to be expanded to broader areas, giving a wider safety network to urban regions.

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