International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2643-9026
Vol. 10 Issue 5 May - 2026, Pages: 20-28

Design And Implementation Of An Intelligent Vehicle Over-Speed Detector And Report System In A Semi-Urban Area Using Esp8266 Mcu And Gsm- A Case Study Of Amassoma

Gabriel Ebiowei Moses, Agidi Daniel, Sopreye Egberipou

gabrielebiowei@ndu.edu.ng
Department of Electrical and Electronics Engineering, Niger Delta University, Bayelsa, Nigeria

ABSTRACT*: The continuous rise in road accidents due to over-speeding has become a critical issue, especially in semi-urban areas where monitoring infrastructure is minimal and or absent. This research presents the design and construction of an intelligent vehicle over-speed detector and report system using the ESP8266 microcontroller and GSM technology. The system uses infrared (IR) sensors to measure the time interval between two fixed points. Once the speed exceeds a predefined threshold, the ESP8266 triggers the GSM module to send an SMS alert containing the speed violation details and location. The system is designed to be compact, cost-effective, and suitable for integration into various types of vehicles. The proposed design ensures real-time detection, immediate reporting, and can be deployed in areas lacking internet connectivity. This work demonstrates a practical application of embedded systems in road safety and can be extended with features such as cloud integration, speed logging, and automated penalties.*

KEYWORDS: Road safety, ESP8266 Microcontroller, GSM Module (SIM800L), Infrared (IR) Sensors, Vehicle Over-speed Detection, Intelligent Transportation System (ITS), Real-time Reporting, Road Safety, SMS Alert System, Semi-urban Areas, Embedded Systems

INTRODUCTION

BACKGROUND OF THE STUDIES

Road accidents resulting from over-speeding continue to pose a serious threat to public safety, especially in developing and semi-urban communities where traffic control systems are inadequate. As vehicular traffic increases, the absence of effective, real-time speed monitoring mechanisms contributes to rising accident rates and property damage. Traditional speed enforcement methods such as speed bumps or manual patrols are often inefficient and manpower-intensive. Hence, there is a growing need for automated systems that can detect over-speeding vehicles and promptly report violations for action.

This research presents the design and construction of an Intelligent Vehicle Over-Speed Detector and Reporting System using the ESP8266 microcontroller, infrared (IR) sensors, and a GSM module (SIM800L). The system detects the speed of a moving vehicle prototype, compares it with a preset threshold, and triggers both a buzzer and SMS alert if the speed limit is exceeded. The design is compact, energy-efficient, and adaptable for real-time speed monitoring in semi-urban areas.

PROBLEM STATEMENT

Over-speeding remains one of the major causes of road accidents in Nigeria and other developing countries, particularly in semi-urban areas where road safety enforcement is weak. Manual methods of speed detection are time-consuming and prone to human error. There is, therefore, a need for an automated, portable, and affordable system that can:

- Accurately detect vehicle speed in real time,
- Automatically compare it against a preset speed limit, and
- Instantly report violations through GSM communication.

Without such a system, road authorities face delayed responses, poor enforcement, and increased accident risks.

OBJECTIVES OF THE RESEARCH

The primary objective of this research is to design and construct an intelligent vehicle over-speed detection and reporting system using an ESP8266 microcontroller and GSM module.

1. Measure the time it takes a vehicle (or object) to travel between two fixed IR sensor points and use this time to calculate its speed.

2. Compare the calculated speed with a predefined speed limit stored in the microcontroller.
3. Trigger a buzzer alarm to immediately alert when an over-speeding vehicle is detected.
4. Send an automatic SMS alert via the GSM module to a designated phone number, reporting the over-speeding event.
5. Display the vehicle speed and system status in real time on the LCD screen.
6. Develop a compact, low-cost, and low-power prototype suitable for semi-urban road monitoring and demonstration purposes.

SIGNIFICANCE OF THE STUDIES

This research provides a practical, low-cost solution to enhance road safety by automating the detection and reporting of vehicle over-speeding incidents without internet or GPS dependence.
By combining IR sensors, an ESP8266 microcontroller, and GSM communication, the system demonstrates how embedded electronics can support road safety management in resource-limited settings.
The key significance of the research includes:

1. Automation of speed monitoring: Reduces the need for manual patrols or handheld speed guns.
2. Low-cost and energy-efficient design: Uses affordable and readily available components.
3. Real-time feedback: Provides both on-site (buzzer) and remote (SMS) alerts for quick response.
4. Safety awareness: Encourages drivers to adhere to speed limits, reducing accident rates.
5. Educational and research value: Serves as a practical demonstration of sensor-based embedded system design.
6. Scalability: Can be upgraded to include GPS tracking, solar power, or cloud-based data logging.

SCOPE OF THE STUDIES

This research covers the design, construction, and testing of a prototype system that detects and reports over-speeding using infrared sensors and GSM communication. The system is implemented with an ESP8266 microcontroller, two IR sensor pairs, a SIM800L GSM module, an LCD display, and a buzzer. The prototype performs the following core functions:

1. Speed detection: Determines the time taken for an object to pass between two IR sensors separated by a fixed distance, and computes speed using the distance–time relationship.
2. Speed evaluation: Compares the computed speed against a predefined speed limit stored in the ESP8266 program.
3. Alert and reporting: Triggers a buzzer alarm and sends an SMS message through the GSM module when an over-speeding event is detected.
4. Information display: Shows real-time speed and system status messages on the LCD.
5. Autonomous operation: Operates without internet connectivity, relying solely on GSM for communication.

Exclusions:

- The prototype does not interface directly with a vehicle's engine control unit (ECU) or brake system.
- The system is not GPS-based and does not provide vehicle location tracking.
- It is designed primarily for demonstration and educational purposes, though it can be scaled for real roadside deployment with further enhancements.

LIMITATIONS OF THE STUDIES

The system has the following constraints:

1. Environmental lighting and sensor alignment may affect the accuracy of the infrared detection beams.
2. GSM functionality depends on network coverage, which may be unreliable in remote areas.
3. No direct penalty enforcement, only reporting capability.
4. Limited to land vehicles (not applicable for aerial or marine use).

APPLICATIONS OF THE STUDIES

The system can be deployed in various scenarios, including:

1. Traffic law enforcement: Automated speed monitoring on highways.
2. Fleet management: Tracking commercial vehicles (e.g., buses, trucks).
3. Private vehicles: Self-monitoring for safety and insurance purposes.
4. Community roads: Enhancing safety in semi-urban/rural zones with poor surveillance.

LITERATURE REVIEW

OVERVIEW

This section presents a comprehensive review of the existing literature and studies relevant to the development of an intelligent over-speed detection and reporting system. It covers the concept of reckless driving, effects of speeding, the rationale behind speed limits, historical development of traffic regulation, and the current state of road safety measures. The aim is to highlight the research gaps and justify the need for intelligent, automated solutions in vehicle speed monitoring (Jayanthi Rao, 2023).

OVERVIEW OF RECKLESS DRIVING

Reckless driving is defined as the operation of a motor vehicle in a manner that demonstrates a willful or wanton disregard for traffic laws and the safety of others (FindLaw, n.d.). It includes behaviors such as over-speeding, erratic lane changes, tailgating, and ignoring traffic signals. Reckless driving is often associated with road rage, impaired judgment, or lack of driver education. Among these, over-speeding is the most common and dangerous form, particularly in semi-urban and rural areas where road monitoring infrastructure is often insufficient. Studies have shown that human behavior is a dominant factor in road accidents, contributing to more than 70% of such incidents, with risky behaviors like speeding being a significant contributor (Al-Hajri et al., 2024).

THE EFFECTS OF RECKLESS DRIVING

The consequences of reckless driving are far-reaching, affecting not just the driver but also passengers, pedestrians, and society at large. Common effects include:

1. High fatality rates: Over-speeding increases the risk and severity of collisions, as modest increases in speed cause large increases in crash energy (IIHS, n.d.; International Transport Forum [ITF], n.d.).
2. Property damage: Accidents often result in damage to vehicles, road infrastructure, and nearby properties.
3. Medical costs: Victims of road crashes require urgent and often long-term medical treatment.
4. Economic loss: Productive time is lost, vehicles are written off, and repairs become expensive.
5. Psychological trauma: Survivors may suffer long-term psychological distress.

According to the World Health Organization (WHO), in 2021, around 1.2 million people world-wide died in road accidents, with speeding being one of the key risk factors addressed in global road safety measures (Development Aid, n.d.).

OVERVIEW OF SPEED LIMIT

Speed limits are legal restrictions placed on the maximum speed at which vehicles may travel on specific roads. These limits are designed to improve safety by reducing the chances of collisions and ensuring that vehicles can stop safely within the visible road ahead (Arizona Department of Transportation, n.d.). Speed limits vary based on road type, vehicle category, and environmental conditions.

In Nigeria, for example, according to the Nigeria Highway Code, typical speed limits are:

1. Urban/Built-up roads: 50 km/h (for private cars, taxis, buses, motorcycles)
2. Rural highways: 80 km/h (private cars, taxis, buses); 50 km/h (tankers & trailers)
3. Expressways: 100 km/h (private cars); 90 km/h (taxis & buses); 60 km/h (tankers & trailers) (Nigeria Highway Code, n.d.).

Despite their importance, speed limits are often ignored due to lack of enforcement or ineffective detection systems — making intelligent monitoring systems a necessity.

HISTORICAL BACKGROUND OF SPEED LIMIT

The concept of speed regulation dates back to the 19th century. One of the earliest recorded speed limits was introduced in the United Kingdom in 1861 under the "Locomotive Act," which set limits of 10 mph on open roads and 5 mph in inhabited areas for powered locomotives (Wikipedia, n.d.). Over time, as vehicle technology and road infrastructure evolved, speed limits became more formalized and enforced. In Nigeria, speed regulation became prominent with the creation of the Federal Road Safety Commission (now Corps) through Decree No. 45 of 1988 in February 1988 (Federal Road Safety Corps [FRSC], n.d.). The agency was tasked with setting speed limits, enforcing compliance, and conducting public awareness campaigns. Despite efforts, enforcement remains a challenge due to limited manpower, equipment, and presence in semi-urban and rural areas.

ROAD TRAFFIC SAFETY

Road traffic safety refers to methods and measures for reducing the risk of road crashes and injuries. It encompasses:

1. Legislative controls (e.g., driver licensing criteria, vehicle registration, speed limits, drink-driving laws, seatbelt laws) (gTKP, n.d.).
2. Engineering controls (e.g., road signs, speed bumps, smart traffic lights).
3. Behavioral approaches (e.g., driver education, awareness campaigns).
4. Technological interventions (e.g., intelligent transport systems, vehicle monitoring tools).

Recent advancements in embedded systems and communication technologies have led to the development of Intelligent Transportation Systems (ITS). These systems often include components like sensors (inductive loop, radar, LiDAR, video cameras, environmental sensors), control systems (traffic signal control, ramp metering), and communication networks (DSRC, 5G, fiber optics) (RGBSI, n.d.). These innovations play a significant role in modernizing road safety, especially in areas where manual enforcement is difficult.

International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2643-9026
Vol. 10 Issue 5 May - 2026, Pages: 20-28

METHODOLOGY

SYSTEM CONCEPT

The system consists of two major detection points simulated by two IR sensor pairs; each placed at a fixed distance apart. When a vehicle passes through the first sensor pair, a timer starts, and when it passes the second pair, the timer stops. The time taken to travel the known distance is used to calculate the vehicle's speed. If the calculated speed exceeds a pre-set limit (e.g., 60 km/h), the system automatically sends an alert message using the GSM module (SIM800L) to a designated phone number representing the checkpoint control unit.

PROTOTYPE DESIGN DESCRIPTION

Unlike physical roadside installation, the system is implemented as a table-top prototype. The IR sensors, ESP8266, GSM module, LCD display, and power supply are mounted on a breadboard or PCB board for demonstration purposes. The prototype simulates vehicle passage using an object (such as a card or toy car) that interrupts the IR beams, allowing testing and verification of the system logic.

FUNCTIONAL BLOCK DIAGRAM

The block diagram of the system is shown below:

- IR Sensor Pair A: Detects the first passage of the vehicle and triggers the timer start signal.
- IR Sensor Pair B: Detects the second passage and triggers the timer stop signal.
- ESP8266 Microcontroller: Processes the input from both sensors, calculates the vehicle speed, and controls communication with the GSM module and LCD.
- LCD Display: Displays the vehicle speed and alert messages.
- GSM Module (SIM800L): Sends SMS alerts to the monitoring unit when overspeed is detected.
- Power Supply: Provides the necessary DC voltage (typically 5V) for all components.

This modular design allows individual components to be tested and replaced without affecting the entire system.

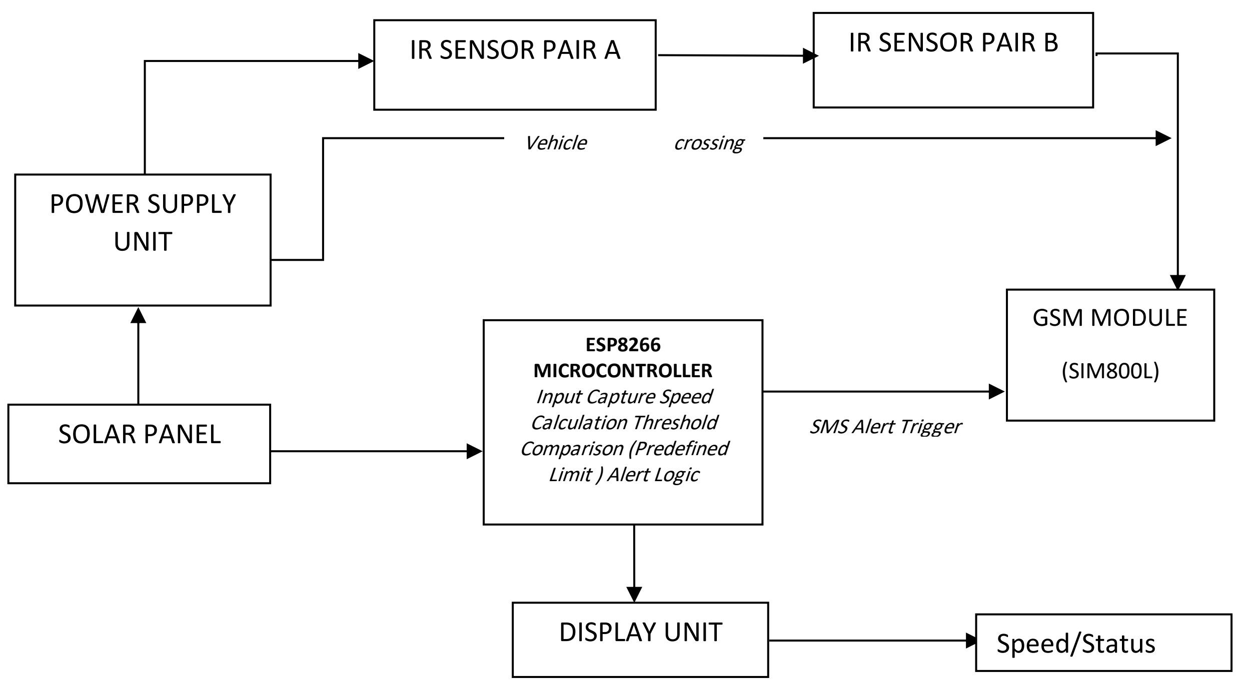

Figure 1: Functional Block Diagram of the System

FLOWCHART OF SYSTEM OPERATION

The flowchart illustrates the logical sequence of operations from sensor detection to alert transmission. It represents how the ESP8266 executes program logic to measure, evaluate, and report over-speeding activities (Mazidi, Naimi, & Naimi, 2018). The flowchart describes the step-by-step operation of the system:

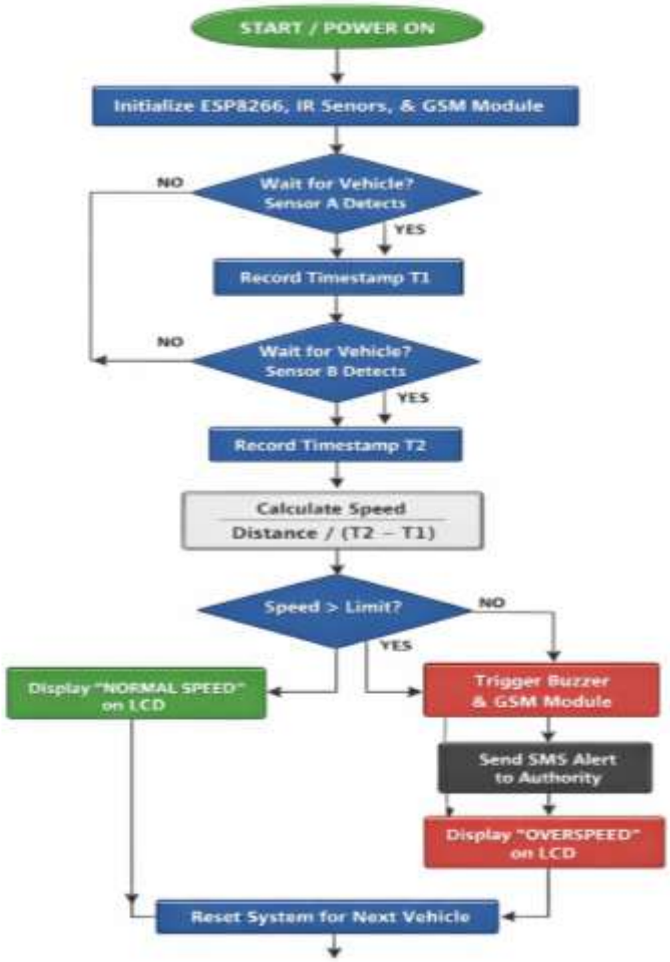

Figure 2: Flowchart of System Operation

START: System initializes and connects to the GSM network.
INITIALIZE SENSORS: ESP8266 sets IR Sensor 1 and IR Sensor 2 as inputs.
AIT FOR VEHICLE: System monitors Sensor 1.
SENSOR 1 ACTIVATED:
No: Loop back to Step 3.
Yes: Record Start Time (T1) using millis().
WAIT FOR SENSOR 2: System monitors Sensor 2.
SENSOR 2 ACTIVATED:
No: Wait (with a timeout to reset if the car stops).
Yes: Record End Time (T2).
CALCULATE TIME: Time Difference (dt) = T2 - T1.
CALCULATE SPEED: Speed = $\frac{Distance\ (0.15)}{dt}$
THRESHOLD CHECK (e.g., > 60km/h?):
No (Normal): Display speed on LCD and return to Step 3.
Yes (Over-speed): Proceed to Alert.

1. SEND ALERT:
   - Trigger Buzzer/LED.
   - Display "Over-speed" on LCD.
   - ESP8266 sends SMS command to GSM Module (SIM800L).
2. SMS SENT: Notification delivered to authorities/database.
3. RESET: System returns to Step 3 for the next vehicle.

HARDWARE IMPLEMENTATION

All components are connected according to the designed circuit diagram:

- The IR sensors are connected to the digital input pins of the ESP8266.
- The GSM module is interfaced using UART communication (TX and RX pins).
- The LCD display (16x2) is connected via I2C for easy wiring and power efficiency.
- A regulated 5V DC adapter or USB power source is used to power the circuit.

Since this is a prototype, the sensors are placed a few centimeters apart (not 5 meters as in a real setup). The equivalent distance (e.g., 5 meters) is set in the code, and the calculated speed is scaled accordingly to simulate real-life conditions.

SOFTWARE DESIGN

The system software was developed using Arduino IDE. The ESP8266 code was written in **C/C++**, incorporating the following key modules:

- IR Sensor Input Module: Detects beam interruptions.
- Timing and Speed Calculation Module: Computes speed using distance/time.
- GSM Communication Module: Sends SMS alerts using AT commands.
- LCD Display Module: Displays system status and measured speed.

The program flow ensures that sensor readings are debounced to prevent false triggers, and that SMS alerts are sent only once per event.

ADVANTAGES OF THE PROTOTYPE DESIGN

1. Low-Cost Development: The system can be built with easily available electronic components.
2. Safety During Testing: The prototype allows testing without actual vehicle traffic.
3. Scalability: The design logic can easily be adapted for full roadside implementation.
4. Energy Efficiency: IR sensors consume very low power, making the system ideal for battery-powered operation.
5. High Accuracy: IR sensors provide precise detection timing for speed measurement

RESULTS AND DISCUSSION

TESTING OBJECTIVES

The main objectives of testing were to:

1. Verify that the IR sensors detect vehicle motion accurately.
2. Validate the speed calculation logic based on the measured time difference.
3. Confirm that the GSM module sends accurate alert messages when a speed violation occurs.
4. Evaluate the stability of the system under continuous operation.
5. Ensure that the prototype's performance aligns with real-world checkpoint expectations on a smaller scale.

TESTING EQUIPMENT AND SETUP

The prototype was assembled on a breadboard using:

- ESP8266 microcontroller (NodeMCU- ESP8266 Dev. Board)
- Two IR sensors (break-beam type) placed 15 cm apart to simulate a real-world distance of 5 m through calibration
- GSM module (SIM800L) connected via UART interface
- 5 V DC regulated power supply
- Laptop (Arduino IDE) for programming and serial monitoring

A test track was simulated by moving an opaque object (representing a vehicle) across the sensor beams at different speeds. Each crossing was logged on the serial monitor for verification.

TESTING PROCEDURES

MODULE TESTING

1. IR Sensor Testing
   Each sensor was tested individually by interrupting its beam with an object. The ESP8266 registered digital HIGH and LOW states accordingly. The results confirmed proper detection without false triggering under stable lighting conditions.
2. GSM Module Testing
   The GSM module was configured using AT commands. Test SMS messages were sent to a registered phone number to verify connectivity and delivery reliability.

3. ESP8266 Processing Test
   The ESP8266 internal timer was used to record timestamps when Sensor A and Sensor B were triggered. The time difference was then used to compute speed using the equation:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

The result may be displayed via the serial monitor and optionally on an OLED display.

INTEGRATED SYSTEM TEST

Once the individual components were verified, the system was integrated. The test sequence was as follows:

1. Power up the system.
2. Initialize ESP8266, IR sensors, and GSM module.
3. Allow the simulated "vehicle" to pass Sensor A and Sensor B sequentially.
4. Record timestamps T_1 and T_2.
5. Calculate the speed.
6. Compare it with the preset threshold (e.g., 60 km/h).
7. If speed > limit → Send SMS alert to designated number.
8. If speed ≤ limit → Display "Normal Speed" message only.

The system successfully performed these steps consistently.

RESULTS AND OBSERVATIONS

Table 1: Summary results of repeated tests

Trial	Time Difference (ms)	Calculated Speed (km/h)	Result
1	180	50.0	Normal
2	130	69.2	Overspeed
3	170	52.9	Normal
4	120	75.0	Overspeed
5	200	45.0	Normal

Observations:

1. The IR sensors showed consistent detection accuracy within ±5%.
2. The GSM module delivered messages within 4–6 seconds of detection.
3. Environmental light had minimal impact when sensors were properly aligned.
4. Power stability was crucial; GSM module current peaks required good regulation.

PERFORMANCE EVALUATION

Table 2: Table of key parameters used for system's performance evaluation

Parameter	Measured Performance	Remark
Sensor Accuracy	≈ 95%	Reliable within short range
Speed Calculation Error	± 5 %	Acceptable for prototype scale
GSM Alert Reliability	100 % within network coverage	Reliable
Power Stability	Stable at 5 V/3.3 V	Adequate
Response Time	< 6 seconds total	Suitable for real-time operation

These results demonstrate that the prototype effectively meets the functional objectives of real-time detection, decision-making, and remote reporting. According to Pressman (2019), effective system evaluation depends on both functional correctness and performance reliability**,** both of which were achieved by this design.

CHALLENGES ENCOUNTERED

1. GSM Network Fluctuation: Occasional SMS delays were observed due to weak network signal.
2. Power Supply Issues: Voltage drops during GSM transmission required adding electrolytic capacitors for stabilization.
3. Sensor Misalignment: Improper alignment caused false readings, corrected through precise beam positioning.
4. Scaling Challenge: Converting real checkpoint distances into scaled prototype distances requires careful calibration in software.

SUMMARY

This testing methodology, observed results and performance evaluation of the Intelligent Vehicle Over-Speed Detector and Report System prototype is presented. The results confirmed that the ESP8266, IR sensors, and GSM module work together to detect, compute, and report over-speeding events effectively. The system met its design objectives and demonstrated the feasibility of a low-cost, real-time checkpoint monitoring system. This research focused on the design and construction of an intelligent vehicle over-speed detector and reporting system suitable for semi-urban areas. The system integrates an ESP8266 microcontroller, two IR sensors, a SIM800L GSM module, an I2C LCD, and a buzzer. The operation of the system is based on the time-of-flight principle, where two infrared (IR) sensors are positioned a known distance apart along the road. When a moving vehicle passes the first and second sensors consecutively, the time interval between these two interruptions is recorded by the ESP8266. Using this time difference and the known distance between the sensors, the vehicle's speed is computed.

If the calculated speed exceeds a preset limit (for example, 60 km/h), the microcontroller triggers a buzzer alarm and sends an SMS notification via the SIM800L GSM module to a predefined mobile number, alerting authorities or the road safety unit of an over-speeding incident. The measured speed and system status are displayed in real time on the LCD screen. The system was designed, coded, and tested successfully. During testing, it accurately measured vehicle speed and effectively triggered alerts when the threshold was exceeded. The results confirmed the system's potential to serve as a low-cost, reliable, and efficient speed monitoring and reporting solution for semi-urban roads where traditional traffic monitoring infrastructure is limited.

CONCLUSION

The intelligent vehicle over-speed detector and reporting system developed in this research provides a practical and automated approach to addressing road safety issues caused by speeding. It combines IoT technology, GSM communication, and embedded systems design to detect and report over-speeding in real time. This system's use of an ESP8266 microcontroller ensures network compatibility and remote communication capability, while the SIM800L GSM module extends its application to areas without Wi-Fi coverage. The system proved to be cost-effective, energy-efficient, and easy to maintain.

In conclusion, the research achieved its objectives by:

1. Successfully detecting vehicle speed using IR sensors.
2. Comparing the measured speed with a set limit to identify over speeding.
3. Sending automatic SMS alerts to relevant authorities.
4. Displaying real-time data on an LCD for on-site monitoring.

Hence, the system can significantly assist in reducing road accidents and improving enforcement of traffic regulations, especially in areas where advanced monitoring systems are unavailable.

RECOMMENDATIONS

Based on the success of this research, the following recommendations are made for future improvements and wider deployment:

1. Integration with GPS: Future versions of the system can include a GPS module to capture the exact location of over speeding vehicles for better reporting accuracy.
2. Solar Power Integration: To ensure continuous operation in remote areas, the system can be powered by solar panels with battery backup.
3. Data Logging and Cloud Storage: Adding a memory card or cloud database can allow long-term storage and analysis of traffic data, helping authorities make informed decisions.
4. Use of Radar or Ultrasonic Sensors: For higher accuracy and operation under varying weather conditions, radar-based sensors can replace IR sensors.
5. Multiple Lane Support: The system can be expanded to monitor multiple lanes simultaneously, improving its coverage and reliability in busy semi-urban roads.
6. Integration with Road Safety Networks: Linking the system with local road safety or police monitoring centers can enable real-time coordination and faster response to over speeding incidents.

CONTRIBUTION TO KNOWLEDGE

This research contributes to the growing body of research in embedded IoT-based traffic monitoring systems. It demonstrates how low-cost microcontrollers and GSM communication can be combined to develop an efficient system for vehicle speed monitoring and reporting. This work provides a foundation for more advanced intelligent transportation systems adaptable to developing regions.

IMAGE OF THE BUILT SYSTEM

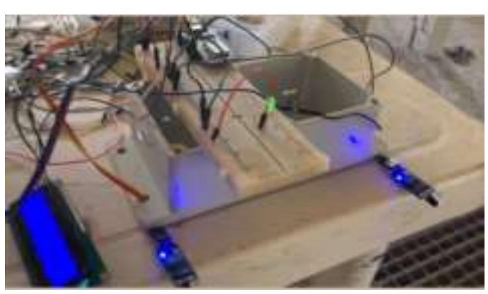

Figure 3: Complete prototype of the Intelligent Vehicle Over-Speed Detector and Reporting System.

REFERENCES

Al-Hajri, S. A., Al-Shukaili, A. M., & Al-Hinai, S. (2024, January). Risky behaviors and road safety: An exploration of age and gender influences on road accident rates. *PubMed Central*, *10*(1), 10802962. https://pmc.ncbi.nlm.nih.gov/articles/PMC10802962/

Arizona Department of Transportation. (n.d.). *How do traffic engineers determine speed limits?* Retrieved July 25, 2025, from https://azdot.gov/faq/how-do-traffic-engineers-determine-speed-limits

Banzi, M., & Shiloh, M. (2014). *Getting Started with Arduino* (3rd ed.). Maker Media.

Bee Maps. (n.d.). *What Are the Limitations of GPS Technology?* Retrieved July 25, 2025, from https://beemaps.com/blog/limitations-of-gps/

Boylestad, R. L., & Nashelsky, L. (2020). *Electronic Devices and Circuit Theory* (12th ed.). Pearson Education.

Development Aid. (n.d.). *Road safety and traffic accidents: Global statistics*. Retrieved July 25, 2025, from https://www.developmentaid.org/news-stream/post/198146/road-safety-and-traffic-accidents-global-statistics

Espressif Systems. (2022). *ESP8266-WROOM-32 Technical Reference Manual*. Retrieved from https://www.espressif.com/en/support/documents/technical-documents

Federal Road Safety Corps (FRSC). (n.d.). *About Us*. Retrieved July 25, 2025, from https://frsc.gov.ng/about-us/

FindLaw. (n.d.). *Reckless Driving Laws by State*. Retrieved July 25, 2025, from https://www.findlaw.com/traffic/traffic-tickets/reckless-driving.html

GSM Association. (2022). GSM Technology Overview. https://www.gsma.com/mobilefordevelopment/resources/gsm-technology-overview/

gTKP. (n.d.). *TRAFFIC LEGISLATION*. Retrieved July 25, 2025, from https://www.gtkp.com/document/4-10-traffic-legislation/

Hambley, A. R. (2020). *Electrical Engineering: Principles and Applications* (7th ed.). Pearson.

Horowitz, P., & Hill, W. (2015). *The Art of Electronics* (3rd ed.). Cambridge University Press.

IEEE. (2021). *IEEE Standard for System Design Methodologies*. IEEE Press.

Insurance Institute for Highway Safety (IIHS). (n.d.). *Speed*. Retrieved July 25, 2025, from https://www.iihs.org/research-areas/speed

International Transport Forum (ITF). (n.d.). *Speed and Crash Risk*. Retrieved July 25, 2025, from https://www.itf-oecd.org/sites/default/files/docs/speed-crash-risk.pdf

Jayanthi Rao, E. al. (2023). Intelligent Traffic Monitoring System Using Vehicular Ad Hoc Network. *International Journal on Recent and Innovation Trends in Computing and Communication*, *11*(10). https://doi.org/10.17762/ijritcc.v11i10.8557

Mazidi, M. A., Naimi, S., & Naimi, S. (2018). *The AVR Microcontroller and Embedded Systems Using Assembly and C*. Pearson.

Nigeria Highway Code. (n.d.). *IX. SPEED LIMITS ON DIFFERENT ROADS AND FOR DIFFERENT VEHICLES*. Retrieved July 25, 2025, from https://www.highwaycode.com.ng/ix-speed-limits-on-different-roads-and-for-different-vehicles.html

Pressman, R. S., & Maxim, B. R. (2019). Software Engineering: A Practitioner's Approach (9th ed.). McGraw-Hill Education.

Pressman, R. S., & Maxim, B. R. (2020). *Software Engineering: A Practitioner's Approach* (9th ed.). McGraw-Hill Education.

RGBSI. (n.d.). *Key Components of Intelligent Transportation Systems (ITS)*. Retrieved July 25, 2025, from https://blog.rgbsi.com/components-of-intelligent-transportation-systems-its

Serway, R. A., & Jewett, J. W. (2018). *Physics for Scientists and Engineers* (10th ed.). Cengage Learning.

Sharma, R. K. (2021). "Design and Testing of IR Sensor-Based Speed Measurement Systems." International Journal of Emerging Trends in Engineering Research, 9(4), 1125–1130. https://doi.org/10.30534/ijeter/2021/09942021

SIMCom Wireless Solutions. (2021). *SIM800L GSM/GPRS Module Hardware Design*. Retrieved from https://www.simcom.com/product/SIM800L.html

Sommerville, I. (2016). Software Engineering (10th ed.). Pearson Education.

Wikipedia. (n.d.). *Locomotive Acts*. Retrieved July 25, 2025, from https://en.wikipedia.org/wiki/Locomotive_Acts