AUTOMATIC VEHICLE DETECTION SYSTEM BASED ON NODEMCU AND ULTRASONIC SENSOR WITH INTERACTIVE RUNNING TEXT OUTPUT

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ABSTRACT

This study aims to design and implement a vehicle detection system prototype based on NodeMCU ESP8266, HC SR04 ultrasonic sensor, MAX7219 LED matrix, Neo 6M GPS module, and Telegram. The system is designed to detect objects in front of the vehicle and display real time visual information in the form of the messages "No Overtaking" and "Safe to Overtake." The research applied a prototype approach consisting of requirements analysis, design, implementation, testing, and evaluation. The test results showed that the HC SR04 sensor was able to detect objects within a range of 5 to 235 cm with a decision threshold of 200 cm. At distances of 5, 10, 30, 50, 80, 110, 140, and 170 cm, the system displayed the message "No Overtaking," while at distances of 200 cm and 235 cm, the system displayed the message "Safe to Overtake." These results indicate that 8 out of 10 test points were classified as unsafe conditions and 2 out of 10 test points as safe conditions. The LED matrix successfully displayed 2 main status messages clearly and responsively. Telegram integration also worked properly through 5 control functions, namely ON, OFF, setDekat, setJauh, and resetText. However, the Neo 6M GPS module has not performed optimally because, in 3 location conditions, namely indoors, under a roof, and in an open area, it was unable to obtain a stable fix status. Overall, the system is considered feasible as an initial prototype of an Internet of Things based driving safety system.

Keywords: Internet Of Things, Nodemcu Esp8266, Telegram, Ultrasonic Sensor, Vehicle Detection

1. INTRODUCTION

Traffic safety is an always relevant issue, especially on roads with limited visibility. Drivers who are behind large vehicles, such as trucks or busses, often have difficulty seeing the traffic conditions ahead. This visual obstruction can lead to overtaking decisions being made without adequate information, thereby increasing the risk of collisions with oncoming vehicles or other objects in the lane ahead [1],[2],[3].

The problem becomes more serious when vehicles pass thru narrow roads, sharp turns, or two-way lanes with limited maneuvering space. In such situations, drivers need an indicator that can provide simple yet quick information about the presence or absence of objects in front of large vehicles. Visual information that appears directly on the back of the vehicle can help other drivers make safer and more measured decisions [4], [5].

The development of microcontrollers and Internet of Things (IoT) technology opens up opportunities to build a vehicle detection system that is inexpensive, simple, and easy to implement [6],[7],[8]. NodeMCU ESP8266 has the advantage of data processing capability along with WiFi connectivity, making it suitable for use as a system control center. The HC-SR04 ultrasonic sensor can be used to measure the distance of objects in front of the vehicle, while the LED matrix can be used as a medium for running text that displays visual warnings in real-time [9]. The integration of Telegram and GPS modules also expands the system's functionality, as it allows devices to be controlled remotely and supports the transmission of vehicle location information.

Based on these conditions, this research focuses on the design and development of a vehicle detection tool based on NodeMCU, ultrasonic sensors, and running text as information. This system is designed to detect the presence of objects in front of the vehicle, process distance data, and then display the message "No Overtaking" when the distance is considered unsafe and "Please Overtake" when the lane is deemed safe. This research also integrates an ON/OFF control feature, text settings via Telegram, and location tracking using the Neo 6M GPS module [10].

This research has two main objectives. First, design and build a vehicle detection prototype based on NodeMCU, ultrasonic sensors, and running text. Second, implement the system and test its functionality to determine the feasibility of the tool in providing driving safety information. With this system in place, it is hoped that drivers can receive clear, simple, and easy-to-understand visual warnings, thereby minimizing the risk of accidents due to improper overtaking maneuvers.

2. METHODOLOGY

This research uses the prototype method, which is a system development approach that emphasizes the creation of an initial model, testing, evaluation, and iterative refinement until a system that meets the needs is obtained. Although prototype-oriented, the research work stages are still structured following the waterfall flow to ensure the development process is systematic, starting from needs analysis, system design, implementation, testing, to evaluation and maintenance. Below is the block diagram of the vehicle detection tool circuit [11], [12].

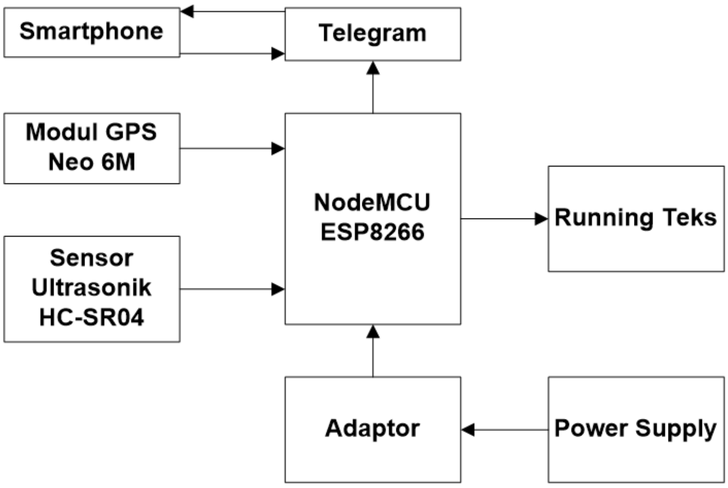

Figure 1. Block Diagram of Vehicle Detection Device

At the needs analysis stage, the researchers identified the required hardware and software components. The hardware used consists of the NodeMCU ESP8266 as the main controller, the HC-SR04 ultrasonic sensor as the distance detection input, the MAX7219 LED matrix as the medium for displaying running text, the Neo 6M GPS module as the location determiner, an adapter and power supply as the power source, jumper wires, a breadboard, and a smartphone as the user interaction medium [12], [13].

The software used includes Arduino IDE for programming, Telegram as the IoT communication interface, and Fritzing to assist in circuit design. Below is the proposed circuit in the development of the vehicle detection tool.

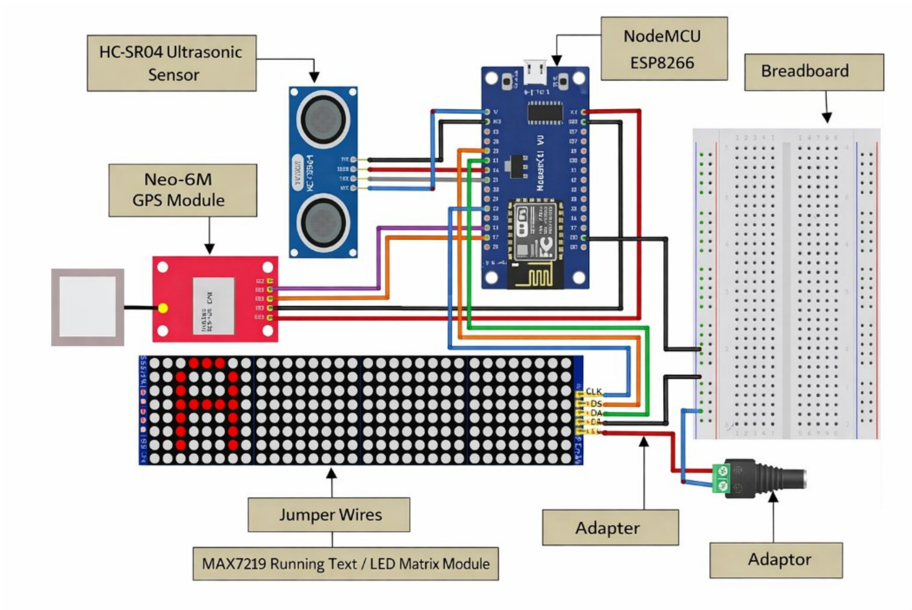

Figure 2. Vehicle Detection Device Circuit

The design phase is carried out by creating a system block diagram, an overall device circuit, and a work flowchart. In this design, the ultrasonic sensor is positioned at the front of the vehicle to detect the presence of objects in the front path. Data from the sensor is sent to the NodeMCU to be processed based on a certain threshold. If an object is detected at a distance of less than 200 cm, the NodeMCU sends a command to the LED matrix to display the warning "No Overtaking." Conversely, if no object is detected or the distance is equal to or greater than 200 cm, the LED matrix displays "Please Overtake."

IoT integration is carried out by connecting NodeMCU to the WiFi network and the Telegram bot. Thru Telegram, users can send commands /start, ON, OFF, /setNear, /setFar, and or /resetText. The system is also designed to read coordinate data from the GPS Neo 6M, and then send location links in the form of Google Maps to Telegram periodically when the system is active. Thus, in addition to functioning as a visual warning tool, the system also serves as a medium for remote monitoring and control [14], [15].

The system implementation is carried out by writing a program in C/C++ on the Arduino IDE. The program includes WiFi connection configuration, LED matrix initialization, ultrasonic sensor distance reading, GPS data reading, and Telegram bot message processing. In the program, sensor readings are performed periodically, and the detection results are translated into text messages displayed as scrolling text on the LED matrix. At the same time, the system checks for message updates from Telegram to process user commands [16], [17].

Testing is conducted in several stages. First, software testing to ensure the compile and upload process to the NodeMCU is successful without errors. Second, hardware testing to ensure all components are connected and functioning as intended. Third, functional system testing, including ultrasonic sensor distance reading tests, running text display tests, Telegram command tests, and GPS location reading and sending tests. The results of each test are recorded and analyzed to determine the system's strengths, limitations, and success rate [18].

3. RESULTS AND DISCUSSION

The system implementation shows that the NodeMCU ESP8266 is capable of functioning as a control center that coordinates all components.

3.1 RESULTS

After the program is successfully uploaded via Arduino IDE, the device can connect to the WiFi network and start communicating with the Telegram bot. The LED matrix can also display scrolling text according to the conditions read by the ultrasonic sensor, thus successfully performing its main function as a visual information provider to the driver behind the vehicle. Below is the display of the NoteMCU instruction coding.

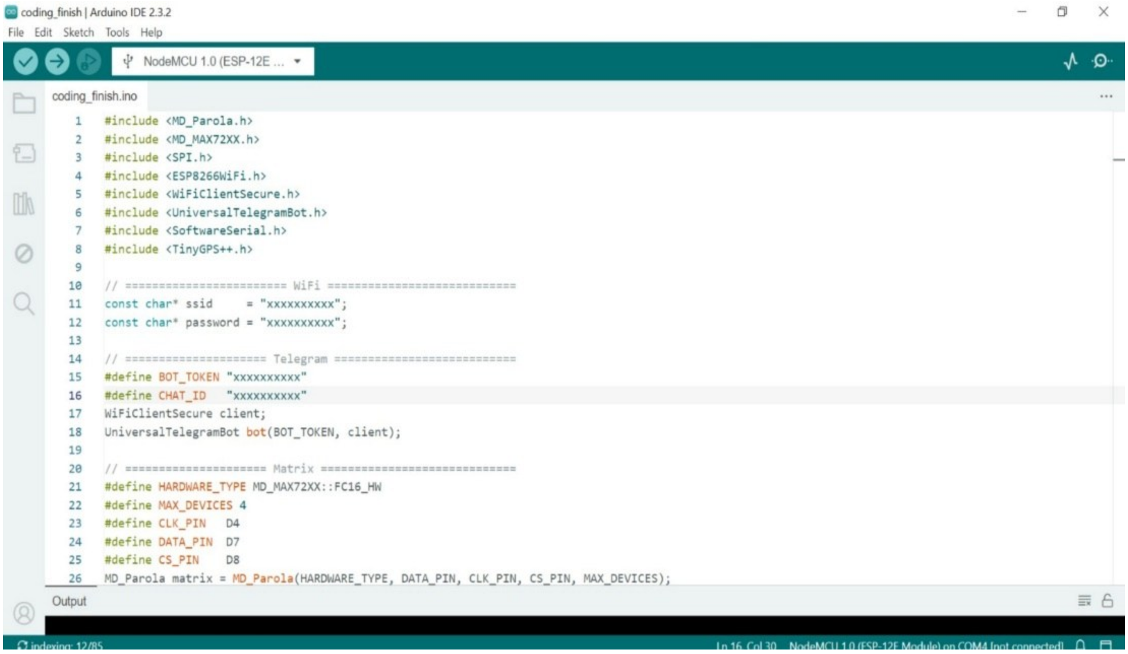

Figure 3. NoteMCU Instruction Command.

In the testing of the HC-SR04 ultrasonic sensor, several objects were placed at varying distances from the sensor, ranging from 5 cm to 235 cm. The test results showed that the system displayed the message "No Overtaking" when the objects were at distances of 5 cm, 10 cm, 30 cm, 50 cm, 80 cm, 110 cm, 140 cm, and 170 cm. When the objects were at distances of 200 cm and 235 cm, the system displayed "Please Overtake." These findings indicate that the 200 cm threshold set in the system can be effectively and consistently used to distinguish between safe and unsafe conditions.

From the responsiveness side, the ultrasonic sensor is capable of reading objects in real-time, and the NodeMCU can immediately update the display on the LED matrix. This is important because the functionality of the tool highly depends on the speed of information change. This test shows that the combination of HC-SR04 and NodeMCU is quite effective for a simple warning system prototype. However, the ultrasonic sensor has characteristics that are sensitive to the surface conditions of the object, the angle of reflection, and the surrounding environment. Therefore, in real-world implementation on the highway, more extensive testing is required to ensure the stability of readings under various weather conditions and vehicle speeds. Below are the instructions to compile the program to detect and fix errors so that the vehicle detection system functions as designed.

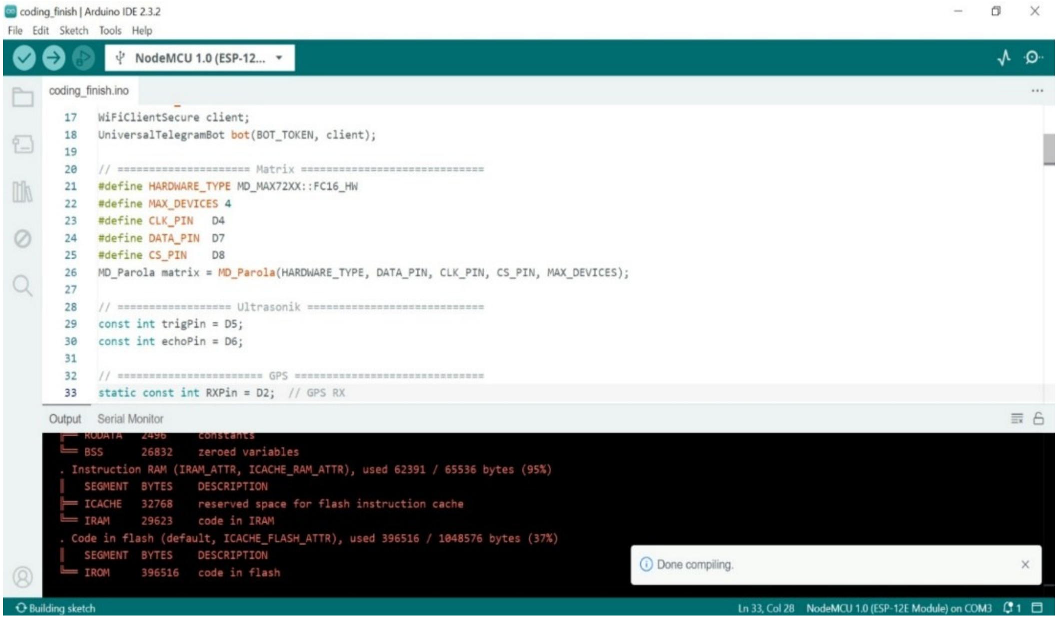

Figure 4. The Instruction Compile Process on Arduino

3.2 DISCUSSION

Testing the MAX7219 LED matrix shows that running text media is effective as a means of delivering visual information. The displayed message can be read quite clearly and moves dynamically, thus attracting the attention of the driver behind. Another advantage of this system is the flexibility of the message content. When the text is written directly in the program, the character length is relatively limited, but when set thru Telegram, the message content can be adjusted more flexibly. This adds practical value to the tool because users can change the message without needing to modify the program code or re-upload it. Below is the hardware circuit of the vehicle detection tool based on the NodeMCU ultrasonic sensor in displaying information.

Figure 5. Vehicle detection device circuit in displaying information

The Telegram integration works well with almost all control functions. Based on the testing, the ON command successfully activated the system, starting the sensor reading, while the OFF command successfully deactivated the sensor reading and cleared the display. The /setDekat and /setJauh commands also successfully changed the message content for near and far object conditions, while or resetText could restore the message content to its initial settings. The success of this integration proves that using Telegram as an IoT interface is very helpful in increasing the operational flexibility of the system.

Nevertheless, the testing of the Neo 6M GPS module showed suboptimal results. The testing was conducted in three locations: indoors, under a roof, and in an open area. In all three conditions, the GPS module has not achieved a stable fix status, preventing the system from sending location links to Telegram. This condition indicates that the main issue of the research does not lie in the program logic, but rather in the GPS device's ability to consistently acquire satellite signals. The possible causes include low antenna sensitivity, environmental interference, and a relatively long signal acquisition time. Below are the test results with the controlling application on the vehicle device in detecting road obstacles to generate information.

Figure 6. Text settings on the vehicle detection device

Overall, the research results show that the vehicle detection prototype has been able to perform its core function well, namely detecting objects in front and displaying visual messages based on the detected conditions. From a safety perspective, this system has the potential to help drivers make better decisions when overtaking large vehicles. However, this tool still has limitations, especially because it only uses one type of distance sensor and relies on GPS stability for the tracking feature. Therefore, further development is needed so that the tool can be implemented more reliably in actual field conditions.

Table 1. Relationship Between Components, Functions, and Implementation Outcomes of the System

Component/Feature	**Test Result**	**Notes**
HC-SR04 Sensor	Able to detect objects from 5–235 cm	Response matches the 200 cm threshold
LED Matrix	Displays two main statuses	Text is clear and responsive
Telegram Bot	ON/OFF and text change functions worked successfully	Remote control works well
Neo-6M GPS	Has not been able to send location data stably yet	Constrained by signal acquisition

Table 1 explains that the test results in the table can be concluded that most of the system components have been functioning well according to their purpose. The HC-SR04 sensor is capable of detecting objects within a range of 5 to 235 cm, with a response still appropriate at the threshold of 200 cm, while the LED matrix chan display two main statuses with clear and responsive text. Additionally, the Telegram bot also shows good performance as it successfully executes the ON/OFF function and text changes for remote control. However, the Neo 6M GPS module is still not functioning optimally because it cannot send location data stably due to issues in the signal acquisition process.

4. CONCLUSION

Based on the results of the design, implementation, and testing, it can be concluded that this research:

1. This research successfully designed and built a vehicle detection prototype based on NodeMCU ESP8266, HC-SR04 ultrasonic sensor, and MAX7219 LED matrix as a visual information medium. The system is capable of detecting the distance of objects in front of the vehicle and displaying the message "No Overtaking" when the distance is less than 200 cm, and "Please Overtake" when the conditions are deemed safe.
2. The test results show that the system can operate in real-time and is quite effective as an initial prototype. The ultrasonic sensor is capable of accurately reading distance changes, the LED matrix can convey information clearly, and the Telegram integration successfully allows for the activation, deactivation, and modification of the running text message from a distance.
3. However, the system still has limitations, particularly with the GPS Neo 6M module, which has not been able to obtain a stable satellite signal during testing. Therefore, this device is deemed suitable as an initial prototype, but it still requires further development to be optimally applied in real operational conditions.

5. SUGGESTIONS

The recommendations for this research include:

1. Future research is advised to use a more sensitive GPS module or equip it with an external antenna to ensure that the tracking and location transmission processes are more accurate and stable.
2. The system should be developed by adding sensors or other supporting devices, such as cameras, buzzers, or additional sensors, to increase detection accuracy and diversify the types of warnings provided.
3. Further testing is needed under more varied road conditions, such as sharp turns, narrow roads, and real traffic situations, as well as optimizing the mechanical design and sensor placement to ensure more consistent distance readings in different environmental conditions.

REFERENCES

[1] I. Surbakti, A. Fauzi, and M. Khadapi, "Design and Construction of a Vehicle Detection Device Based on Nodemcu Ultrasonic Sensor and Running Text as Information," vol. 5, no. 1, 2025.

[2] M. A. Sahraei and S. R. M. Al Mamari, "A Review of Internet of Things Approaches for Vehicle Accident Detection and Emergency Notification," *Sustain. 2025, Vol. 17, Page 6510*, vol. 17, no. 14, p. 6510, Jul. 2025, doi: 10.3390/su17146510.

[3] E. N. Budisusila, M. Khosyi'In, S. A. D. Prasetyowati, B. Y. Suprapto, and Z. Nawawi, "Ultrasonic Multi-Sensor Detection Patterns on Autonomous Vehicles Using Data Stream Method," *Int. Conf. Electr. Eng. Comput. Sci. Informatics*, vol. 2021-October, pp. 144–150, 2021, doi: 10.23919/EECSI53397.2021.9624313.

[4] S. Singh, A. Suri, V. Patel, U. Shukla, and H. Sisodia, "Interfacing of GPS and GSM with the Help of NodeMCU for Vehicle Monitoring and Tracking," *Sustain. Mobil. Policies, Challenges Adv.*, pp. 159–172, Jan. 2024, doi: 10.1002/9781394166831.ch9.

[5] K. Dutt, A. Misra, R. G. Tiwari, R. Singh, M. Mishra, and A. Kaur, “Automatic Controlled Robotic Car Based on Node MCU for Real-Time Obstacle and Explosive Detection,” *Proc. - 4th Int. Conf. Technol. Adv. Comput. Sci. ICTACS 2024*, pp. 1001–1005, 2024, doi: 10.1109/ICTACS62700.2024.10840726.
[6] M. Alfanny, A. Fauzi, and H. Sembiring, “Design and Build a System for Turning on an IoT-Based Motorcycle Starter Using Voice,” *J. Artif. Intell. Eng. Appl.*, vol. 3, no. 1, pp. 357–362, Oct. 2023, doi: 10.59934/jaiea.v3i1.328.
[7] A. Patwari, “NodeMCU and IoT-based Safety and Security Ecosystem for Heavy Vehicles,” *Int. J. Emerg. Trends Eng. Res.*, vol. 8, no. 5, pp. 1482–1490, 2020, doi: 10.30534/ijeter/2020/02852020.
[8] M. A. Sahraei, S. Ramadhan, and M. Al Mamari, “A Review of Internet of Things Approaches for Vehicle Accident Detection and Emergency Notification,” 2008, doi: 10.3390/su17146510.
[9] P. S. V. R. Kiran and V. Pavan, “Implementing an Arduino-Based System to Prevent Collisions and Detect Cracks on Rail Tracks,” pp. 1140–1151, May 2025, doi: 10.2991/978-94-6463-718-2_95.
[10] P. Gupta, P. Tripathi, P. Tyagi, and S. K. Singh, “IoT-Based Automatic Vehicle Tracking and Accident Alert System,” *Sustain. Mobil. Policies, Challenges Adv.*, pp. 149–158, Jan. 2024, doi: 10.1002/9781394166831.ch8.
[11] R. Suganya, R. Nethra, K. P. Guganya, and B. Nila, “Iot-Based Fleet Tracking with Engine Control for Automobiles,” *Lect. Notes Networks Syst.*, vol. 317, pp. 287–297, 2022, doi: 10.1007/978-981-16-5640-8_23.
[12] H. Zulfiqar, H. M. Ul Haque, F. Tariq, and R. M. Khan, “A survey on smart parking systems in urban cities,” *Concurr. Comput. Pract. Exp.*, vol. 35, no. 15, p. e6511, Jul. 2023, doi: 10.1002/cpe.6511.
[13] A. Srinagesh, C. H. Aparna, M. V. P. Chandra, and S. Rao, “A GPS- enabled Fuel Sensor based Vehicle Tracking System for Fleet Management using the Internet of Things,” *Scalable Comput. Pract. Exp.*, vol. 26, no. 1, pp. 34–47, Jan. 2025, doi: 10.12694/scpe.v26i1.3479.
[14] N. Venu, “IOT Surveillance Robot Using ESP-32 Wi-Fi CAM & Arduino,” *Ijfans Int. J. Food Nutr. Sci.*, vol. 11, no. 5, pp. 198–205, 2022, [Online]. Available: https://www.researchgate.net/publication/367380053
[15] H. Tabassum, S. Sahana, S. Hunagund, S. S. Santolli, S. A. Rehman, and H. Najmusher, “Integrated Railway Infrastructure Optimization and Control System: Leveraging IoT for Advanced Railway Management and Monitoring,” *1st Int. Conf. Electron. Comput. Commun. Control Technol. ICECCC 2024*, 2024, doi: 10.1109/ICECCC61767.2024.10593837.
[16] H. Tabassum, J. Jenita, S. Hunagund, S. Sahana, S. S. Santolli, and S. Abdul Rehman, “IoT-enabled Asset Monitoring and Optimization Railway System,” *2024 IEEE 3rd World Conf. Appl. Intell. Comput. AIC 2024*, pp. 1242–1248, 2024, doi: 10.1109/AIC61668.2024.10730953.
[17] V. Dange, P. Shinde, N. Shinde, P. Shelke, A. Shirsath, and S. Bahulekar, “Battery-Powered and Sensors based Smart Luggage Vehicle with Real Time Surveillance System using GPS, GSM and ESP32 Camera Modules,” *3rd Int. Conf. Innov. Mech. Ind. Appl. ICIMIA 2023 - Proc.*, pp. 1412–1420, 2023, doi: 10.1109/ICIMIA60377.2023.10425863.
[18] R. G. Sangeetha *et al.*, “Density Based Real-time Smart Traffic Management System along with Emergency Vehicle Detection for Smart Cities,” *Int. J. Intell. Transp. Syst. Res. 2024 222*, vol. 22, no. 2, pp. 328–338, May 2024, doi: 10.1007/s13177-024-00400-9.