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Design and Construction of a Vehicle Detection Device Based on Nodemcu Ultrasonic Sensor and Running Text as Information

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Abstract

Driving safety is often compromised by limited visibility, particularly when behind large vehicles or on narrow roads and sharp bends, which can increase the risk of accidents due to inappropriate overtaking decisions. This research designed and built a vehicle detection device based on a NodeMCU ESP8266, an HC-SR04 ultrasonic sensor, and running text as an information medium. It is equipped with a Neo 6M GPS module and Telegram application integration as an IoT feature. The system works by detecting vehicles in front using an ultrasonic sensor. The NodeMCU then processes the data and displays the message "Overtaking is prohibited" or "Please Overtake" on the running text, while also sending the vehicle's location in real time via Telegram. The research used a prototype method with a waterfall model, starting from requirements analysis, design, implementation, and testing. Test results showed that the system is capable of providing clear visual information and accurate location notifications, thus assisting drivers in making safer decisions. However, several limitations were identified, including the ultrasonic sensor's instability in certain weather conditions, the GPS module's time-consuming signal acquisition in closed areas, and the running text's limited character set when configured directly through the program.

Keywords: *NodeMCU_ESP8266, Ultrasonic_Sensor_HC-SR04, IoT, Telegram, Vehicle_Detection.*

1. Introduction

Driving safety is a key aspect that every driver must consider, especially when navigating narrow roads or sharp turns that restrict visibility. In these conditions, drivers often have difficulty determining whether the lane ahead is safe for overtaking. This limited visibility can lead to poor decision-making, such as overtaking at an inappropriate time, which ultimately increases the risk of traffic accidents. A similar situation often occurs when driving behind a large vehicle such as a truck, which blocks the driver's view of the road ahead. Obstacles such as other vehicles, pedestrians, and road obstacles further increase the risk.

The lack of clear and accurate information about traffic conditions ahead is one factor that hinders drivers from making quick and appropriate decisions. This can lead to accidents, especially in situations that require spontaneous reactions. Therefore, a solution is needed that can help drivers obtain a realistic picture of the conditions ahead, thereby improving safety and driving comfort.Based on this phenomenon, the author designed an innovation in the form of an Internet of Things (IoT)-based vehicle detection device utilizing an HC-SR04 ultrasonic sensor mounted on the front of a large vehicle such as a truck. This sensor detects the presence of objects or vehicles in front of the vehicle. The detection results are then sent to the NodeMCU ESP8266 microcontroller for further processing. The detection information is displayed via running text, easily readable by drivers behind the truck. This system displays the message "No Overtaking" if there is an obstacle ahead, and conversely displays the message "Please Overtake" when the lane is clear.

Furthermore, this system is equipped with an additional feature in the form of vehicle location monitoring via the Telegram application. Each time the system is activated, the NodeMCU automatically sends the vehicle's location as a Google Maps link to Telegram. This feature provides added value by making it easier for drivers to determine the vehicle's position and control the system remotely via the "on" or "off" command buttons available in Telegram.This device is expected to improve road safety, especially for drivers who often have difficulty seeing traffic conditions in front of trucks. Furthermore, this device can also reduce the risk of accidents caused by inappropriate overtaking decisions. Based on this thinking, the author designed an innovation titled "Design and Construction of a Vehicle Detection Device Based on NodeMCU, Ultrasonic Sensors, and Running Text as Information."

2. Research Methodology

2.1. Research methodology

This research uses a prototype method to design and build a NodeMCU-based vehicle detection device, ultrasonic sensors, and running text. This method allows for the development of an initial system that can be tested and evaluated so that design flaws can be immediately corrected before final implementation. The research process includes hardware design, microcontroller programming, and system function testing under various conditions to ensure sensor effectiveness and clarity of information on the running text. In addition, this research also uses the Waterfall model as a systematic and structured framework, covering the stages of requirements analysis, design, implementation, testing, and evaluation. The following is an illustration of the Waterfall method.

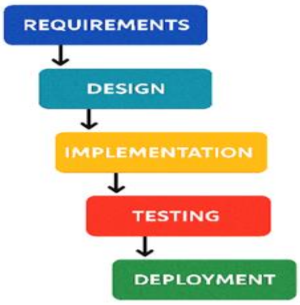

Fig.1: Waterfall Model

2.2. System Requirements Analysis

The system requirements analysis for designing a NodeMCU-based vehicle detection device, ultrasonic sensor, and running text as information includes two main components: hardware and software.

Hardware	Software
NodeMCU ESP8266 / ESP32	Arduino IDE
Ultrasonic Sensor HC-SR04	Telegram
Running Text Module (P10 LED / MAX7219)	Fritzing
Power Supply (5V–12V Adapter / Li-ion Battery)	
Jumper Cables	
Neo 6M GPS Module	
Smartphone	

2.3. Block Diagram System

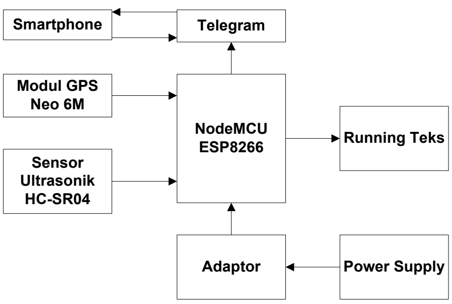

Fig. 2: System Block Diagram

The system block diagram in Figure III.2 shows that this system uses a NodeMCU ESP8266 as the main microcontroller that controls all components. The HC-SR04 ultrasonic sensor serves as an input to detect vehicle presence based on the distance of objects in front of it. When a vehicle is detected within a certain range, the sensor sends data to the NodeMCU for processing. The NodeMCU then processes the data, and when a vehicle is detected, the system sends a notification to the Telegram application via a WiFi connection. In addition to the notification, the detection results are also displayed in a running text as a visual output.

This system is also equipped with a Neo 6M GPS module for location tracking. The NodeMCU sends a vehicle location link via Telegram, allowing users to view the vehicle's position directly via their smartphone. The smartphone is used to receive information from Telegram, both in the form of notifications and to control the system, such as turning devices on or off. For power, the system uses a power supply connected to an adapter. This adapter functions to adjust the voltage to suit the needs of the NodeMCU ESP8266 and the sensors used.

2.4. Overall Tool Set

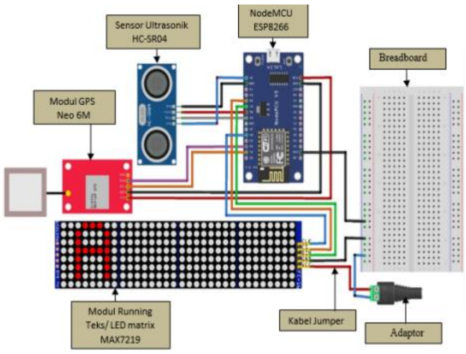

Fig.3: Overall set of Tools

2.5. Circuit Flowchart

The device design begins with the creation of a flowchart to facilitate the planning and development of programs on the microcontroller. The flowchart in this study is designed to provide a clear picture of the system's workflow, thus facilitating understanding of how the device works. In this study, the flowchart includes a control system for the NodeMCU-based vehicle detection device and ultrasonic sensors, as well as running text as information. The flowchart of the device's working system can be seen in Figure III.4 below:

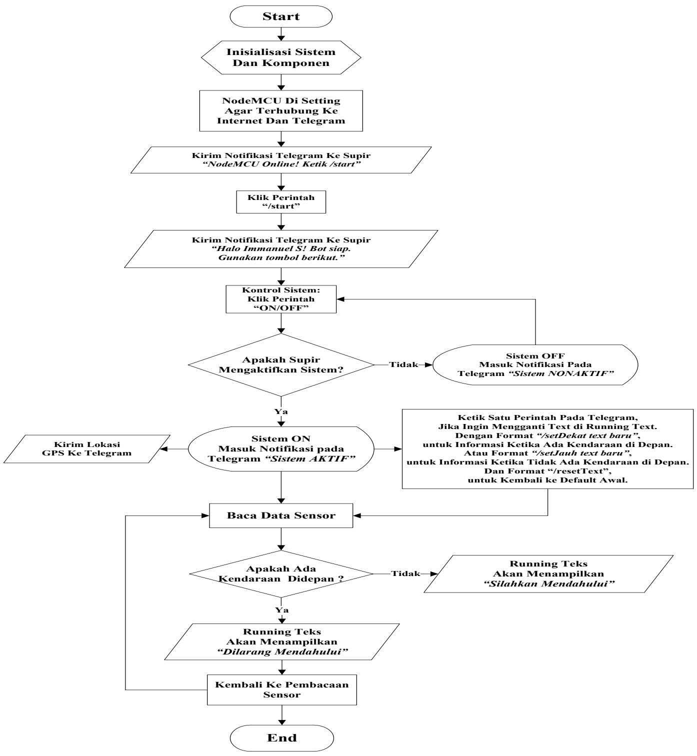

Fig.4: Tool Work Flowchart

3. Results qnd Discussion

3.1. Discussion

This chapter will explain and display the test results of the NodeMCU-based vehicle detection device design, ultrasonic sensors, and running text as information. The test was carried out by designing and programming the device using the Arduino IDE application to manage the functions of the connected electronic components. Through this system, drivers behind large vehicles such as trucks can receive visual information in the form of warnings to overtake or not, as well as receive location information directly through the Telegram application.

3.2. Software Testing

To ensure the proper functioning of the NodeMCU ESP8266 microcontroller circuit used in this vehicle detection system, testing was carried out by programming and inputting data from a computer into the microcontroller through the Arduino IDE application. The

NodeMCU was configured to read the ultrasonic sensor, display information on a MAX7219 LED matrix, send location using a Neo 6M GPS module, and receive commands via Telegram.
The first step in installation was connecting the NodeMCU to the computer using a USB cable. This connection allows the user to program and test the device directly through the Arduino IDE. Software testing was carried out through several key steps, including ensuring the NodeMCU was connected to a WiFi network, verifying that "/on" and "/off" commands from Telegram were received correctly by the system, ensuring that distance data from the ultrasonic sensor could be processed and displayed via the LED matrix, and ensuring that GPS location data could be automatically sent to Telegram. To ensure each software component functioned as intended, testing was conducted in a real-world operational situation.

3.3. Hardware Testing

After the entire "Design and Construction of a NodeMCU-Based Vehicle Detection Device, Ultrasonic Sensor, and Running Text as Information" device was assembled, the next step was to combine all components into a single, integrated system. This integration involved the integration of the NodeMCU ESP8266, the HC-SR04 ultrasonic sensor, the MAX7219 LED Matrix, the Neo 6M GPS module, and the connection to an adapter as the main power source. Each element was installed following the block diagram and circuit schematic created in the previous design phase. This process aimed to ensure that all hardware operated synergistically and according to its intended function. Figure IV.8 below displays the overall assembly of the device circuit, demonstrating how all components are connected to each other within a unified system.

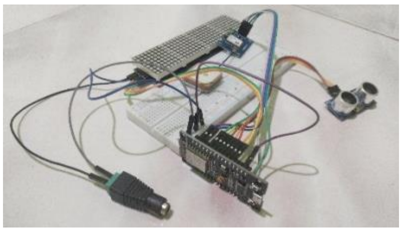

Fig.4: 8 Overall Tool Suite

3.4. Ultrasonic Sensor Test Results and Running Text Display on the LED Matrix

The HC-SR04 ultrasonic sensor detects the presence of vehicles or objects in front of the system. The distance data collected from the sensor is used to determine the message to be displayed on the MAX7219 LED Matrix in running text format. If the distance to the detected object is below the specified limit (for example, 200 cm), the system will display a warning with the text "No Overtaking". Conversely, if no vehicles or objects are detected within this range, the system will display the message "Please Overtake."

Table1: Object Distance Testing on Ultrasonic Sensors

Object	Object Distance from Sensor	Object Test Display	Text on LED Matrix
Toy Car	5 cm		Do Not Overtake
Toy Car	10 cm		Do Not Overtake
Toy Car	30 cm		Do Not Overtake
Toy Car	50 cm		Do Not Overtake
Toy Car	80 cm		Do Not Overtake
Toy Car	110 cm		Do Not Overtake
Object	**Object Distance from Sensor**	**Object Test Display**	**Text on LED Matrix**

Toy Car	140 cm		Do Not Overtake
Toy Car	170 cm		Do Not Overtake
Toy Car	200 cm		Please Overtake
Toy Car	235 cm		Please Overtake

From the test results above, it can be concluded that the HC-SR04 ultrasonic sensor is capable of detecting object distances effectively and responding in real-time on the LED Matrix display. A threshold distance of 200 cm provides fairly accurate and responsive results for both moving and stationary objects. Thus, the system can effectively provide clear visual warnings to drivers behind the vehicle.

3.5. Neo 6M GPS Module Test Results

The Neo 6M GPS module is designed in this system to automatically send the vehicle's location to the Telegram app when the system is activated. The transmitted location data is a Google Maps link, which is useful for tracking the vehicle's position in real time. However, according to test results under various environmental conditions, the GPS signal cannot be reliably acquired. Even though the test was conducted outdoors in clear weather, the GPS module still could not obtain valid coordinates. As a result, the system was unable to send the location link to Telegram as expected.

Table 2 :Neo 6M GPS Module Testing

Test Location	Environmental Condition	GPS Status	Location Link Sent
Indoor	Enclosed	Signal Not Fixed	Not Sent
Under a Roof (Porch)	Cloudy Weather	Signal Not Fixed	Not Sent
Open Area (No Obstacle)	Clear Weather	Signal Not Fixed	Not Sent

From the test results above, it can be concluded that the Neo 6M GPS module in this system is still not functioning optimally. Among the most likely contributing factors are the GPS antenna not being sensitive enough to quickly capture satellite signals and the ongoing interference or signal reflections at the test location.

3.6. Results of System Interaction Testing with the Telegram Bot

To enhance user flexibility and convenience, this system also features a feature for setting alert text via the Telegram bot. Users can not only activate or deactivate the system but also customize the message content displayed on the LED Matrix as needed. Using commands such as /setDekat and /setJauh, users can change the alert text when the detected object is close or far. Additionally, the /resetText command is provided to return the text display to the system's default format. It should be noted that when text is written directly in the program code, the character length is limited to a maximum of 11 characters. However, when text is set via Telegram commands, the character length is more flexible and is not limited to 11 characters. Figure IV.12 below shows the user interaction screen when setting the text directly via Telegram.

Fig.5 : Display of text settings by users via Telegram

Table 3: Telegram Command Testing

Telegram Command / Button	System Response	Status
ON	System activated, starts reading sensor data	Success
OFF	System deactivated, stops reading sensor data	Success
/setDekat	Near-distance text changed to custom text	Success
/setJauh	Far-distance text changed to custom text	Success
/resetText	Text reset to “DO NOT OVERTAKE” & “PLEASE OVERTAKE”	Success

/lokasi	GPS not available, location not sent	Failed

Test results showed that the system received and executed most Telegram commands correctly. The ON/OFF control and LED display text settings worked as expected and responded in real time. However, when the /location command was sent, the system was unable to respond with a location link due to the lack of a stable GPS signal.

4. Conclusion and Suggestions

4.1 Conclusion

Based on the design, implementation, and testing of a prototype vehicle detection device using a NodeMCU, ultrasonic sensors, and an LED Matrix as a data medium, the following conclusions can be drawn:

1. This research successfully designed and built a prototype vehicle detection device using a NodeMCU ESP8266, an HC-SR04 ultrasonic sensor, and a MAX7219 LED Matrix as a running text display. This device can detect the distance of the vehicle ahead and display the message "No Overtaking" or "Please Overtake" in real time according to traffic conditions. The system can also be controlled via the Telegram app to set ON/OFF commands and change the text content, despite the limitations of the LED Matrix with direct input, which can only display a maximum of 11 characters.
2. The implementation of the device demonstrated that the system is capable of providing visual traffic information and vehicle location notifications through integration with the Neo 6M GPS module and the Telegram app. Although GPS testing still encountered difficulties in acquiring a consistent signal, this system has the potential to improve driving safety, especially on narrow roads or bends with limited visibility. Overall, this prototype is worthy of further development for practical application in the field.

4.2 Recommendations

Based on the various limitations identified during the design and prototype testing process, here are some recommendations for future system development:

1. It is recommended to use a GPS module with a high-quality external antenna or one that supports AGPS to accelerate signal acquisition and improve location data stability, especially when testing in open areas.
2. The system could be further improved by incorporating a buzzer or LED indicator for additional feedback, especially when the LED Matrix display is less clear in certain situations, such as during hot days or at night.
3. The placement of the ultrasonic sensor needs to be revised to improve the width and accuracy of the detection coverage. Placing sensors in key locations on the vehicle can improve the system's efficiency in detecting traffic conditions.
4. System trials should be conducted in a variety of real-world situations, such as on winding roads, narrow streets, or in low-light conditions, to understand the system's effectiveness and reliability in the field.
5. For further development, the system can be equipped with camera modules, temperature sensors, or gyroscope sensors to expand functionality and provide more comprehensive safety information to users.

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