JTEC
Journal of Telecommunication, Electronic and Computer Engineering
ISSN: 2180 – 1843 e-ISSN: 2289-8131 Vol. 15 No. 4
jtec.utem.edu.my

Enhancing Road Safety: A Speed Detection System Using IoT Technology

F. A. Azidin, Muhamad Sofian Ahmad Zamri, and Zulkarnain Zainudin
Fakulti Teknologi dan Kejuruteraan Elektronik dan Komputer (FTKEK),
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya,
76100 Durian Tunggal, Melaka, Malaysia
faridarafat@utem.edu.my

Article Info
Article history:
Received Sep 21st, 2023
Revised Dec 13th, 2023
Accepted Dec 28th, 2023

Index Terms:
Speed Detection
Infra-red Sensor
Blynk Application
Internet of Things

Abstract
The Malaysian Police Force requires technological advancement to keep up with the highway thugs and illegal racers. The primary objective of this project is to deter unethical activities on the road. Thus, a simple speed sensor detection utilizing an Infra-red (IR) sensor is designed. The project leverages a NodeMCU ESP8266 microcontroller, an IR sensor detector, and Blynk application platform for controlling and monitoring using smart phone. The system operates when a vehicle or object passes the IR sensor. After detection, both Liquid Crystal Display (LCD) display and Blynk application will show the vehicle's speed. If the vehicle exceeds the speed limit, NodeMCU will notify the user's device, alerting them to the speeding vehicle. This innovative system offers several advantages to authorities compared to traditional methods of addressing road rage incidents. It enables prompt action and resolution of cases, ultimately contributing to safer road conditions and improved law enforcement capabilities.

I. INTRODUCTION

Numerous researchers have proposed various techniques for measuring and detecting speed using the concept of speed detection. This project encompasses both hardware components, equipment or devices and computer software.

The expansion of the population has led to significant technological advancements. The annual increase in the number of cars on the road has contributed to a rising number of daily incidents. Among these incidents, road accidents stand out as the most prevalent and consequently, the leading cause of injuries. High-speed driving is a primary contributor to highway collisions. Consequently, it is imperative for vehicles to maintain a constant speed within the established speed limits in specific areas.

In the present era, the incorporation of the latest technology is essential in various sectors, including the Police Force within national law enforcement agencies under the Malaysian civil service sector. The continued use of outdated technology has contributed to a surge in road accidents. According to a study by Sarani and Voon in 2016 [1], the number of accidents has been steadily increasing year after year. Data available up to 2020, as reported by the Ministry Transport of Malaysia 2020, indicates an average 3700 total recorded fatalities in Malaysia due to these accidents.

According to research conducted by Karmakar in 2021[2], there has been a significant surge in public interest in wearable sensors in recent years. These devices have become more affordable, rendering them accessible to a wider audience. Researchers are increasingly utilizing these gadgets to capture and manage data, as well as to continuously monitor patient health. The IoT has the potential to ensure that low-cost, reliable, and high-quality devices are available to everyone.

Furthermore, NodeMCU can be seamlessly integrated with the Blynk application to design IoT-based applications for monitoring purposes, enhancing user responsiveness to take appropriate actions.

Building upon the findings of Sharma and Parveen Kantha [3] in 2020, they developed a NodeMCU-based Internet of Things system. This system enables real-time monitoring of data outputs from various sensors and empowers users to make informed decisions regarding the control of associated electrical loads. This wireless multiple sensor network operates within a Wi-Fi (wireless networking technology) local hotspot network, utilizing the “SSID" (service set identifier) and password credentials provided by the user in the firmware. The system includes meticulously designed hardware and real-time monitoring of sensor outputs, relay on/off status through the Blynk Application, and real-time relay control, all of which validated the system's effectiveness.

The project introduced by Jing et al. [4] in 2013 presents a Speeding Detection System (SDS) built upon Radio-Frequency Identification (RFID) technology, specifically, RFID Systems on Roads (RSR). This system comprises both an RFID reader and RFID tags, strategically positioned at different locations but integrated into a unified system.

In this setup, RFID readers are installed within vehicles, while RFID tags are affixed to the road surface. The primary objective of the SDS is to analyze and identify instances of speeding on the road. The speeding detection process occurs concurrently with the RFID tag interaction, with both parameters being integral to the proposed SDS's functionality for detecting speeding violations [5].

It is worth noting that the current coverage of speed radar systems is limited, and the associated costs for a comprehensive road deployment are prohibitively high. As an alternative, systems relying on speeding warnings based on GPS (Global Positioning System) and speedometers have been explored [6]. However, these alternatives still encounter challenges despite their potential to enhance driving safety. Several issues arise when issuing speeding tickets through this system, which are the inconsistent availability of GPS signals. In certain areas, such as tunnels, dense urban environments, or remote locations, GPS signals may be weak or completely unavailable. This can hinder the accurate tracking of vehicle speeds and the issuance of speeding tickets based on GPS data. The next problem encountered is some drivers may attempt to evade detection by disabling tracking systems in their vehicles. This can be achieved by simply cutting off the power supply to the tracking device or using signal jammers. When these systems are disabled, it becomes difficult to monitor and enforce speeding violations effectively.

These issues highlight the need for robust and reliable technological solutions to address the challenges associated with issuing speeding tickets. Furthermore, it might be essential to implement legal and regulatory actions to discourage drivers from trying to avoid such systems and to guarantee impartial enforcement of speeding laws.".

The primary objective of the next research described by Malik et al. [7] in 2014 is the development of an automatic speed limit detection system capable of identifying instances of vehicle over speeding using monitoring technology. When a driver exceeds the speed limit, a camera is activated to record the vehicle's license plate where a Canon DSLR camera is employed for this purpose. The captured image undergoes processing using Digital Image Processing (DIP) techniques, which are facilitated by MATLAB. DIP techniques are utilized to extract the license number from the image, and the results indicate a high level of accuracy. Figure 1 shows image of over speeding vehicle 's plate.

Figure 1. Captured images and license plate region extracted

The next process involves Automatic Number Plate Recognition (ANPR) algorithms, which play a crucial role in extracting and classifying the license plate numbers. MATLAB was chosen due to its versatility in handling various image processing techniques. The license plate region is defined and extracted as an initial step. Common license plate features are utilized for this purpose. Subsequently, the characters on the license plate are segmented and distinguished from one another. Optical Character Recognition (OCR) techniques are employed to compare the segmented characters with templates of stored characters in the system, ultimately classifying them. Figure 2 presents a sample of the processed image after OCR.

RIA 33626

Figure 2. Sample of OCR results

Once the license number is successfully extracted, it is transmitted via email to the toll plaza authorities, who subsequently bill the driver for the fine incurred due to over speeding.

Jeng, Chieng, and Lu [8] in 2014 publication, introduced a side-looking single-beam microwave vehicle detection (VD) device designed to predict the speed of individual vehicles as they pass by a roadside camera in figure 3. This device utilizes Frequency-Modulated Continuous-Wave Radar (FMCW Radar) data to extract both the range and speed of each vehicle, achieved through the application of an inverse synthetic aperture radar (ISAR) algorithm. The results and simulations presented in the paper demonstrate the accuracy of the estimated vehicle data, including vehicle length and speed. This suggests that the VD device is effective in providing precise measurements. Vehicle detectors play a crucial role in intelligent transportation systems (ITS) by collecting traffic data, such as speed estimation and vehicle length, as vehicles cross a specific lane. VDs employ various sensor technologies to fulfil their functions.

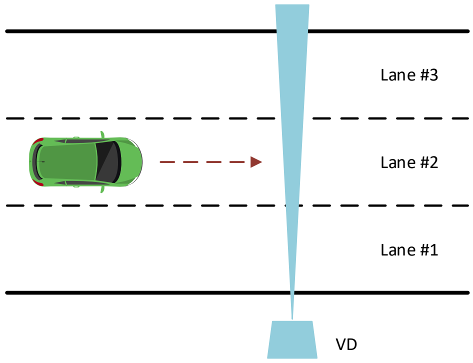

Figure 3.Side-looking vehicle detection systems.

Radar-based detectors are highlighted in the paper as a mature technology with a history of military applications. These detectors offer the advantage of continuous operation and can function effectively in various conditions. The FMCW Radar is commonly used for traffic data collection [9]. It transmits a signal and calculates range and speed by comparing frequency differences between transmitted and reflected signals. Unlike forward-looking detectors that are parallel to the direction of the traffic lane, the side-looking radar detector is positioned to illuminate the traffic in a vertical direction. When correctly positioned and coupled with signal processing techniques, a single radar detector can cover multiple lanes, making it a versatile option for traffic data collection.

II. METHODOLOGY

In this section, the detailed design and development of a straightforward speed sensor detection system using an IR Sensor is discussed.

A. Hardware Architecture

The system architecture serves as a conceptual framework that encapsulates the system's attributes, enabling readers to grasp its functionality. This device is designed to calculate the speed of a moving vehicle by measuring the time it takes to traverse a fixed distance between two sensors, thereby detecting instances of over speeding. The system architecture is shown in figure 4.

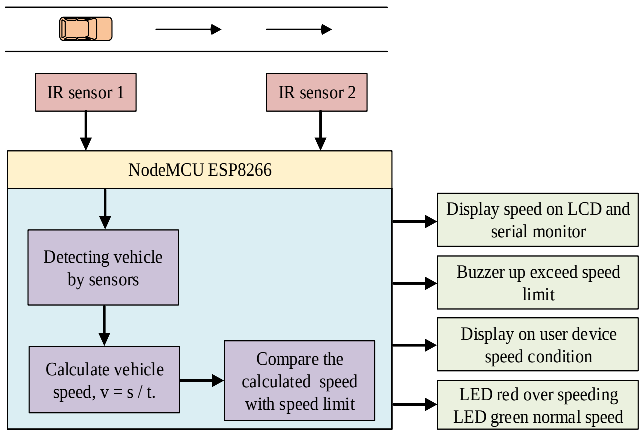

Figure 4. Design architecture

The crucial component in this circuit design is the employment of IR Sensors. The device records the time elapsed as the vehicle crosses the first IR sensor (FC 51 infrared sensor), initiating a timer to track this duration until the vehicle reaches the second IR Sensor [10] and [11]. A microcontroller processes this time data, calculating the vehicle's speed in kilometers per hour, which is then displayed on a 16X2 LCD Module [12]. In cases where the vehicle exceeds the speed limit, both a buzzer and an LED indicator are activated. Additionally, an "Over Speed Detected!!" message is displayed on the LCD, and a corresponding alert message is sent to a user device, accompanied by the illumination of a red LED on the interface. The circuit schematic diagram is presented in figure 5.

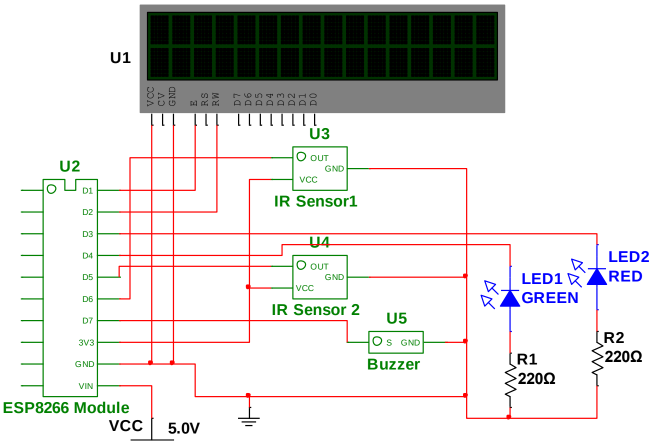

Figure 5. Speed sensor detection schematic circuit

B. *Software Description Arduino IDE*

The abbreviation for Arduino IDE stands for Arduino Integrated Development Environment, and it is software used for writing code in programming languages such as C and C++ [13]. Arduino IDE is widely employed in the field of electrical and electronic innovation, and it offers a user-friendly interface that is particularly accessible to novice programmers. The typical workflow involves using Arduino IDE to develop code in C language, followed by compiling and uploading it to an Arduino-compatible board via a cable connection. The code or sketch created within the IDE is translated into a Hex file before being transferred to the microcontroller IC or the Arduino-compatible board. Additionally, Arduino IDE offers a range of standard input and output functions to facilitate program development for programmers [14]. Sample of the source code in Arduino IDE shows in figure 6.

```
void setup() {
  digitalWrite(buzzer, HIGH);
  //digitalWrite(ledgreen, HIGH);
  //digitalWrite(ledred, HIGH);
  pinMode(ir_s1, INPUT);
  pinMode(ir_s2, INPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(ledgreen1, OUTPUT);
  pinMode(ledred1, OUTPUT);
  lcd.init();
//initialize the LCD
```

Figure 6. Source code in Arduino IDE

This source code program adheres to the process flowchart described in figure 7. In summary, the program begins by declaring and defining variables [15]. It then initiates timers and gathers vehicle speed data from sensors as input variables. Using this input data, the program calculates the vehicle's speed. Next, it compares this speed to the predefined normal speed. The result of this comparison is used to update output variables that are connected to various components, including an LCD display, LED indicators, a buzzer, and the Blynk platform.

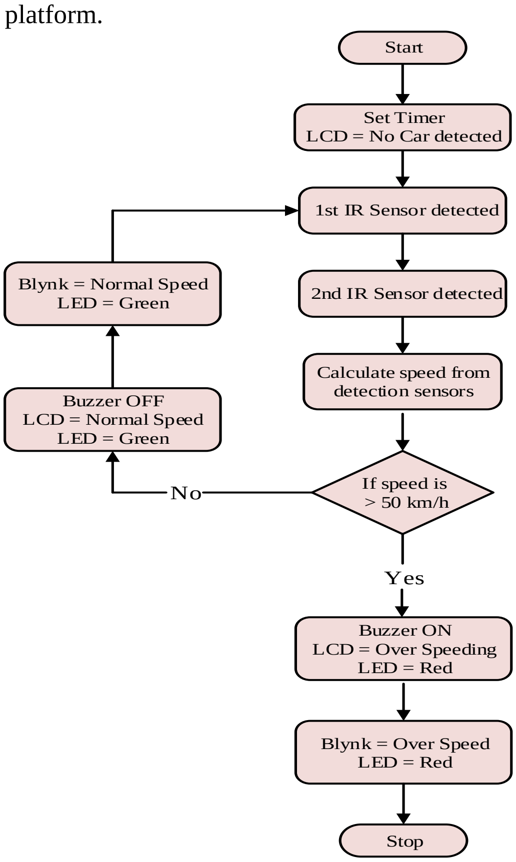

Figure 7. The program code flowchart

Blynk is an innovative platform that simplifies the creation of interfaces for managing and overseeing hardware projects through your iOS or Android device [16]. It also serves as a smartphone application, granting users the ability to supervise and control their self-designed Internet of Things (IoT) devices. Blynk boasts the capability to remotely manage devices like Raspberry Pi. With its user-friendly interface, users can swiftly create graphical interfaces by effortlessly dragging and dropping widgets, along with performing basic programming tasks directly on their mobile devices. In the context of this project, Blynk will be utilized to establish a monitoring function, including an LCD display and two LED indicators. These components will convey information to the user regarding whether the vehicle's speed is within the normal range or exceeds it, all accessible via their smartphone. Figure 8 illustrates Blynk Application network.

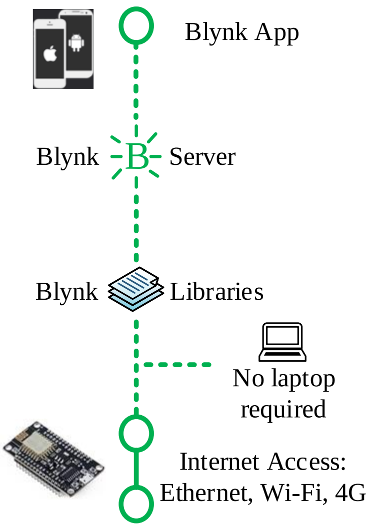

Figure 8. Blynk Application [17]

III. RESULT AND ANALYSIS

Once the requirements have been successfully met, the speed sensor detection system becomes ready for use. The primary function of this project is to compute the speed of vehicles passing through it. At system start up, when no vehicles are detected, the LCD display will indicate "No car detected" as its output. This result is shown in figure 9.

Figure 9. Screenshot of LCD display "No car detected."

Next, every time a vehicle crosses the first IR sensor, it waits for the vehicle to reach the second IR sensor to perform the speed calculation. This speed calculation is executed in real-time and presented to the user in kilometers per hour (km/h). Both the first and second sensors are activated by passing vehicles, and the NodeMCU ESP8266 continuously computes the vehicle's speed [18], v, using the formula,

$$v = \frac{s}{t}\,; \tag{1}$$

where: s = Vehicle distance
t = Time

then with the results displayed on the LCD screen. This feature ensures that the speed is automatically calculated and readily available for monitoring. Figure 10 illustrates a vehicle traveling at a normal speed, while Figure 11 displays a vehicle that is speeding.

Figure 10. Screenshot for LCD display the "Normal speeding"

Figure 11. Screenshot for LCD display the "Over speeding"

Another important feature integrated into this project is the ability for users to effortlessly monitor the speed sensor detection using a smartphone. Users can conveniently track vehicle speeds through the Blynk application. Within the Blynk application, users can ascertain the presence of vehicles and their respective speeds, categorized as either "Normal speeding" or "Over Speeding." To enhance user awareness regarding vehicle speeds detected, the Blynk application interface is equipped with green and red LEDs. The green LED indicates "Normal speeding," while the red LED signifies "Over Speeding." This additional visual indicator ensures users are promptly informed about the status of the passing vehicle's speed, enhancing their sensitivity to potential over speeding incidents. The displays result at the smart phone demonstrates in figure 12.

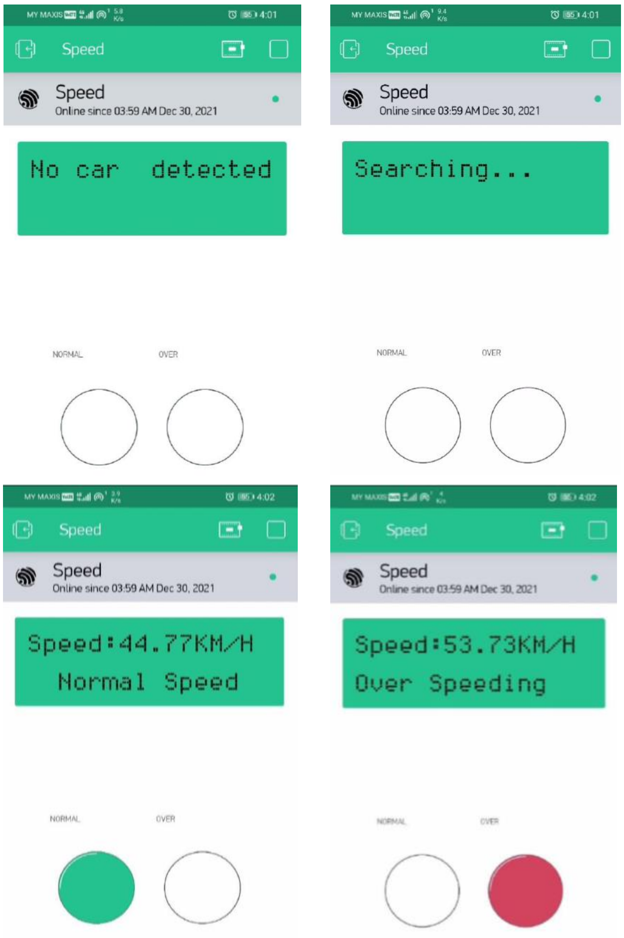

Figure 12. Screenshot for Blynk application interface

The next experiment aimed at assessing system functionality across varying distances between IR sensor 1 and IR sensor 2. In this experiment, three distinct distances were established: 0.5 meters, 1 meter, and 1.5 meters. For each of these distances, five attempts were made to evaluate the system's performance. Success was determined if the vehicle was detectable at a reasonable speed, while an unsuccessful outcome was defined by the vehicle being undetectable or displaying an unreasonable speed (either too slow or excessively high). The detailed analysis of the results can be found in Figure 13.

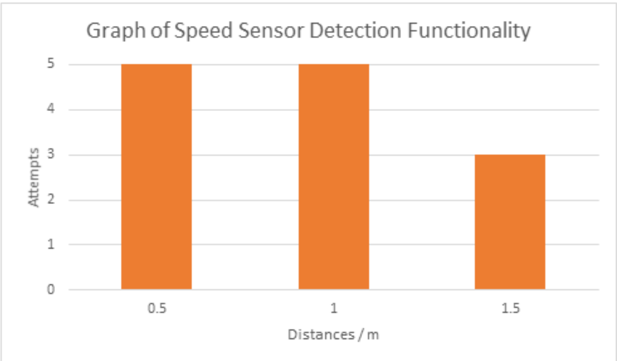

Figure 13. Graph of speed sensor detection functionality

The graph reveals that the spacing between the two sensors plays a crucial role in the accuracy of vehicle detection. When the distance exceeds 1 meter, there is a notable increase in the detection error rate by approximately 40%. However, within the range of 0.5 meters to 1 meter, a 100% success rate in detection was achieved. While this experiment was relatively brief, it underscores the importance of determining an optimal sensor distance, particularly in scenarios involving varying vehicle speeds. As part of future work, it is advisable to conduct experiments aimed at identifying the ideal sensor distance, which is expected to fall within the range of 0.3 meters to 1.2 meters. Additionally, further analysis should encompass different types of sensors, environmental conditions, a wide range of vehicle speeds, and circuit design considerations.

IV. DISCUSSION AND CONCLUSION

This project possesses the potential to assist authorities in addressing speeding violations and reducing the occurrence of road accidents in Malaysia by promptly addressing road users who breach traffic regulations. The utilization of a simple speed sensor detection system employing IR sensors is further enhanced by its integration with the Blynk application. This integration allows for remote monitoring via smartphones, placing authorities in a state of readiness to take necessary actions. The objective of implementing the Automated Enforcement System (AES) is to curtail the frequency of car accidents resulting from speed violations through fines imposed on speeding vehicles. However, AES has yielded fewer effective results in reducing accident rates and incurs significant costs due to expensive equipment and the need for professional installation. Simultaneously, road offenses persist because authorities cannot take immediate action at the scene to penalize traffic rule violators or issue warnings to encourage more cautious driving. Integrating this project with the Blynk app for monitoring purposes simplifies and enhances the effectiveness of authorities' actions against traffic violations. Lastly, the incorporation of hardware indicators like LEDs or buzzers in the speed sensor detection system serves to alert users promptly in the event of a speeding violation by other road users.

ACKNOWLEDGMENT

The authors would like to acknowledge the Centre for Telecommunication Research & Innovation (CeTRI), Universiti Teknikal Malaysia Melaka (UTeM). This research is supported by the Ministry of Higher Education Malaysia (MOHE).

REFERENCES

[1] R. Sarani, S. A. S. M. R and W. S. Voon, “Malaysian road fatalities prediction for Year 2020,” Journal of the Autralasian College of Road Safety, vol. 27, no. 2, pp. 18-22, 2016.

[2] S. Karmakar, S. Pallob, S. Dutta, S. R. Chaudhuri and S. Biswas, “Internet of things (IoT) based smart health monitoring system,” International Journal for Research in Applied Science and Engineering Technology, vol. 9, no. 7, pp. 1733-1737, 2021.

[3] M. P. Sharma and M. P. Kantha, “‘Blynk’ cloud server based monitoring and control using ‘nodemcu’,” International Research Journal of Engineering and Technology, vol 7, no. 10, pp. 1362-1366, 2020.

[4] T. Jing, X. Li, W. Cheng, Y. Huo and X. Xing, “Speeding detection in rfid systems on roads,” in Proc. of International Conference on Connected Vehicles and Expo (ICCVE), 2013, pp. 953-954.

[5] X. Li, W. Cheng, Y. Huo and X. Xing, "RFID technology applied in highway traffic management," in Proc. of International Conference on Optoelectronics and Image Processing, 2010, pp. 348-351.
[6] K. S. Kaushitha, K. Prajna, K Kavana, Akshatha and N. R. Sharathchandra, "A literature review paper on different techniques used in vehicle over speed detection," International Journal of Engineering Research & Technology (IJERT), vol. 8, no. 2, pp. 1-3, 2019.
[7] S. M. Malik, M. A. Iqbal, Z. Hassan, T. Tauqeer, R. Hafi and U. Nasir, "Automated over speeding detection and reporting system," in Proc. of 16th International Power Electronics and Motion Control Conference and Exposition, 2014, pp. 1104-1109.
[8] S. L. Jeng, W. H. Chieng and H. P. Lu, "Estimating speed using a side-looking single-radar vehicle detector," IEEE Transactions on Intelligent Transportation Systems, vol. 15, no. 2, pp. 607-614, 2014.
[9] N. Teed, A. K. Lund and R. Knoblauch, "The duration of speed reductions attributable to radar reduction," Accident, Analysis and Prevention, vol. 25, no. 2, pp. 131-137, 1993.
[10] L. Kumar, "Vehicle speed detection system using ir sensor," Journal for Research in Applied Science and Engineering Technology, vol. 8, no. 5, pp. 1563-1567, 2020.
[11] S. M. Paing, S. S. Y. Mon and H. M. Tun, "Design and analysis of doppler radar-based vehicle speed detection", International Journal of Scientific & Technology Research, vol. 5, no. 6, pp. 145-148, 2016.
[12] L. Y. Mon and K. K. Saw, "Design and construction of speed detection system for vehicles", International Journal of Trend in Scientific Research and Development, vol. 3, no. 3, pp. 803-805, 2019.
[13] A. S. Ismailov and Z. B. Jo'rayev, "Study of arduino microcontroller board," 'Science and Education' Scientific Journal, vol. 3 no. 3, pp. 172-178, 2022.
[14] Y. B. Badamasi, "The working principle of an arduino", in Proc. of 11th International Conference on Electronics, Computer and Computation (ICECCO), 2014, pp. 1-4.
[15] K. Kumar, P. Chandrakant, S. Kumar and K. Kushal, "Vehicle speed detection using corner detection," in Proc. of 5th International Conference on Signal and Image Processing (ICSIP), 2014, pp. 253-258.
[16] M. Todica, "Controlling Arduino board with smartphone and blynk via internet," Preprint, 2016, doi: 10.13140/RG.2.2.23956.30080.
[17] How2Electronics, "Blynk Application". Accessed: Dec. 14, 2023. [Online.] Available: https://how2electronics.com/?s=blynk+application.
[18] M. Vutturi, S. Palle and S. Bonala, "Automatic speed detection and reporting system using arduino," International Journal of Scientific Engineering and Research, vol. 8, no. 1, pp. 1-4, 2018.