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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

SMART ULTRASONIC-BASED TRAFFIC CONTROL SYSTEM

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Abstract: Urban traffic congestion remains a major issue, often worsened by conventional traffic light systems that rely on fixed timers or expensive pressure sensors. In this study, Smart Ultrasonic Sensor-Based Traffic Control System was designed and the prototype circuit of the system was also constructed. The performance of the system was evaluated measuring the distance between the sensor and approaching vehicles. The prototype was developed using the HC-SR04 sensor integrated with an Arduino Uno with LEDs representing traffic lights. Results showed accurate real-time detection and signal adjustment, proving its potential to improve traffic flow and detect lighter vehicles effectively. The sensor was able to detect vehicles within a range of 10 cm with consistent response time, allowing timely signal changes. In conclusion, the project successfully met all objectives, demonstrating that ultrasonic sensors can enhance accuracy and responsiveness in modern traffic systems. This confirms the system's effectiveness as a smart, cost-efficient solution for real-time traffic management.

Keywords: *Arduino Uno, ultrasonic sensor, traffic light*

INTRODUCTION

Traffic signals play a vital role in ensuring safe and efficient traffic flow in urban areas by using a universal color system which are red to stop, green to go, and yellow to prepare to stop. Different types of traffic lights serve specific needs, including fixed-time systems, vehicle-actuated signals, and pedestrian-activated controls (Fei et al., 2023). Although one of the widely used vehicle-actuated system is a pressure sensor-based traffic lights, they have major drawbacks including high installation costs, frequent maintenance needs, and difficulty in detecting lighter vehicles like bicycles and motorcycles (Mick Chan, 2023). To overcome these challenges, this project proposes a Smart Ultrasonic-Based Traffic Control System that utilizes ultrasonic sensors for more reliable, contactless vehicle detection (Frantzen, 2025). This system offers a cost-effective and efficient alternative capable of adapting to real-time traffic conditions. The main objectives of this project are to design a suitable ultrasonic sensor circuit diagram, construct and test a working prototype circuit, and optimize its performance by accurately measuring the distance between the sensor and approaching vehicles to improve responsiveness and traffic management. Using the HC-SR04 sensor integrated with an Arduino Uno, a prototype was developed with LEDs representing traffic lights. In the setup, an Arduino board functions as main microcontroller that can read inputs, processing data and control outputs based on programmed instruction. Simulated vehicle distances tested the system's responsiveness. Results showed accurate real-time detection and signal adjustment, proving its potential to improve traffic flow and detect lighter vehicles effectively.

LITERATURE REVIEW

The integration of microcontrollers like Arduino Uno with ultrasonic sensors has emerged as a cost-effective, simple and efficient solution to address the growing problem of urban traffic congestion. Traditional traffic light systems that operate on fixed schedules often fail to adapt to fluctuating traffic volumes, leading to delays, inefficiencies, and increased commuter frustration. This limitation can be overcome by using ultrasonic sensors such as the HC-SR04, these systems can measure the distance of approaching vehicles, assess traffic density, and dynamically adjust signal timings to optimize traffic flow (Abbas & Ibrahim, 2020; Chavan et al., 2024). They work by sending out sound waves and timing the return of the echo. Calculating lane-wise traffic density and dynamically modifying light durations depend on this sensor-based detection (Pujithsai et al., 2020). With the use of an Arduino Uno and ultrasonic sensors created a density-controlled traffic light system that dynamically modified signal durations in response to the actual traffic density at intersections (Pujithsai et al., 2020). Additionally, they incorporated a feature that enables traffic

controllers to use SMS commands to override routine operations in emergency situations. Abbas and Ibrahim (2020) developed a smart traffic signaling system using ultrasonic distance measurement sensors, demonstrating the system's ability to adjust green light durations based on traffic density. Similarly, Dermawan and Meliala (2022) implemented a fuzzy logic-based traffic light control model using Arduino Mega 2560 and HC-SR04 sensors, allowing for adaptive signal timing in response to varying traffic conditions. Rahman et al (2023) combined Passive Infrared (PIR) motion sensors with ultrasonic sensors to create a traffic light control system that adjusts signals based on vehicle movement and congestion levels. Chavan et al. (2024) designed a traffic control system for a four-lane intersection using Arduino Uno and ultrasonic sensors. The system improved traffic flow by adjusting green light durations and prioritizing congested lanes, reducing manual control and idle time based on simulation results.

The application of Arduino with ultrasonic sensors in traffic light systems has been researched in a number of projects and studies. However, many of these only solve basic detection, ignoring the ways in which sensor placement, accuracy, and distance affect traffic efficiency. These systems frequently lack flexibility and do not fully optimize responses to the presence of vehicles in real time. Moreover, current models hardly ever incorporate intelligent ability to make decisions or test under a variety of conditions. The goal of this project is to improve traffic flow and decrease waiting times by creating a more responsive and optimized system that uses ultrasonic sensors to measure vehicle distance and Arduino to control traffic lights accordingly.

MATERIALS AND METHODS

Materials: Ultrasonic sensor: Detect distance in range, Controller (Arduino Uno), Traffic light (LEDs), power supply (battery/USB power), 220Ω resistors, Jumper wires

Method:

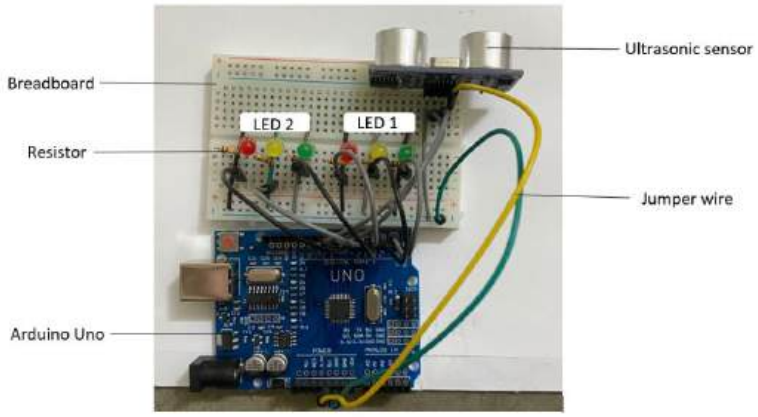


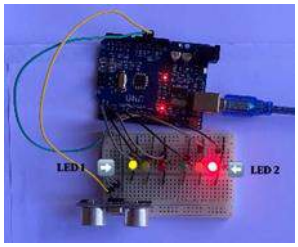
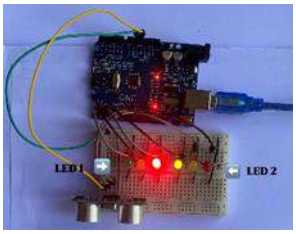
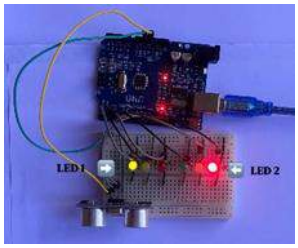
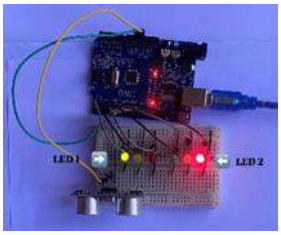
Figure 1. Ultrasonic sensor detection circuit diagram

The design of the ultrasound sensor detection circuit required for the traffic light detection system consisted of an ultrasound sensor such as the HC-SR04, Arduino, breadboard, jumper wires, resistors, and LEDs as shown in Figure 1. In the setup, an Arduino board functioned as the main microcontroller that could read inputs, process data, and control outputs based on programmed instructions. The circuit consisted of two primary components, which were the connection of the HC-SR04 ultrasonic sensor and the connection of six LEDs representing two directions of traffic flow. The ultrasonic sensor HC-SR04 was connected to the Arduino through the following steps: the VCC pin of the sensor was connected to the 5V pin on the Arduino to supply voltage, while the GND pin was connected to the GND pin on the Arduino for ground. Digital pins 8 and 9 on the Arduino were connected to the TRIG and ECHO pins of the sensor, respectively (Dejan, 2015). With this setup, the Arduino was able to transmit and receive ultrasonic signals to detect the distance of an object. Six LEDs represented two traffic light sets (LED1 and LED2). LED1, which represented the opposite direction, consisted of green, yellow, and red LEDs that were connected to digital pins 2, 3, and 4 on the Arduino board. LED2, which represented the lane in front of the sensor, also consisted of green, yellow, and red LEDs that were connected to digital pins 5, 6, and 7. The anode of each LED was connected to a digital pin on the Arduino using jumper wires, while the cathode was connected to GND on the breadboard. To complete the

ground circuit, the GND was connected to the GND pin on the Arduino using another wire. A working prototype circuit design was by using a box as a representation of the road surface. The ultrasound detector was placed beside the road and faced the lane where vehicles were expected to stop. The moment a vehicle entered the range of the sensor, the ultrasonic wave detection began to catch the signal of its presence. This returned signal activated an indicator for data transmission to a microcontroller for further processing. The ultrasound sensor detection range was tested by placing reflective surfaces at different distances to determine the best sensing distance, such as a range below or between 10 cm, which provided an optimal trade-off between sensitivity and accuracy as part of efforts to maximize the functionality of the ultrasound sensor detection system.

RESULTS

Table 1. Distance of the vehicle at ≤10 cm and at >10 cm

Distance of the vehicle (cm)	Traffic light response (LED status)		Sensor detection output (HIGH/LOW)
	Initial	Final	
4			HIGH
6			HIGH
8			HIGH
10			HIGH
14			LOW
16			LOW
18			LOW

DISCUSSION/ANALYSIS

In this prototype circuit, an ultrasonic sensor was used to detect the presence of vehicles at various distances, specifically to control the operation of a traffic light system using Arduino Uno. The measured distances include 4 cm, 6 cm, 8 cm, 10 cm, 14 cm, 16 cm and 18 cm. The sensor was programmed to function only when it detects a vehicle within the range of 10 cm or below, such as 4 cm, 6 cm, 8 cm and 10 cm will the sensor successfully detect the presence of a vehicle as shown in Table 1.

When detection occurs within this range, the sensor will produce a high output signal, which is then sent to the Arduino Uno. Upon receiving this high signal, LED 1 changed from green to red. Once LED 1 fully changed to red, LED 2 changed from red to green, indicating a shift in traffic flow. This process will continue as long as there is still a vehicle present within the detection range (≤10 cm).

However, when a vehicle was positioned beyond the 10 cm detection range, for example, at 14 cm, 16 cm or 18 cm, the sensor will not be able to detect it. In this case, the sensor output will remain low, meaning no signal is sent to the Arduino Uno. As a result, LED 1 remained in its current state and no change in colour. Consequently, LED 2 remained unchanged as the system has not been triggered to proceed with the signal switching process.

In addition, another possible reason was the sensor might fail to detect a vehicle due to improper alignment or positioning of the sensor. If the sensor is not aligned correctly such as being placed at an incorrect angle or outside the direct path where vehicles pass, it may not be able to accurately detect the object even if the vehicle is within the acceptable distance range. This highlights the importance of precise sensor placement and alignment in ensuring reliable detection and overall system functionality.

CONCLUSIONS

In conclusion, all the objectives of the project were successfully achieved. The ultrasonic sensor detection circuit diagram was designed to suit the needs of a traffic light detection system. A working prototype circuit was then constructed and tested, demonstrating the functionality of the designed system. Finally, the performance of the ultrasonic-based smart detection system was optimized by evaluating the distance between the sensor and the approaching vehicle or object, allowing for more accurate and responsive traffic light control. This confirmed the effectiveness of using ultrasonic sensors in improving real-time traffic management systems.

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Setuju.

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