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Density Based Traffic control System Using Ultrasonic sensors

Submitted by

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Contents

List of Figures

Chapter 1

Introduction

1.1 Automated traffic control system

An automatic traffic control system using ultrasonic sensors is a modern solution that aims to efficiently manage and control traffic flow in various settings, such as intersections, road junctions, and pedestrian crossings. This system utilizes ultrasonic sensors, which are devices that emit and receive high-frequency sound waves, to detect the presence and movement of vehicles and pedestrians. The basic principle of this system involves the placement of ultrasonic sensors strategically at key points within the traffic environment. These sensors emit ultrasonic waves that bounce off objects in their range and return to the sensor. By measuring the time it takes for the waves to travel back, the system can calculate the distance between the sensor and the detected object. In the case of traffic control, the ultrasonic sensors are used to detect the presence of vehicles and pedestrians. They can be mounted at various locations, such as on traffic signals, traffic poles, or above roadways. When a vehicle or pedestrian is detected within the sensor's range, the system processes this information and initiates appropriate control actions. For example, at an intersection, the system can detect the presence of vehicles approaching from different directions. Based on the data from the ultrasonic sensors, the system can determine the number of vehicles waiting at each approach and adjust the traffic signal timings accordingly. This helps optimize traffic flow, reduce congestion, and minimize waiting times for drivers. Similarly, at pedestrian crossings, ultrasonic sensors can detect the presence of pedestrians waiting to cross the road. The system can prioritize pedestrian movements by extending the green signal or providing additional crossing time when pedestrians are detected. The automatic traffic control system using ultrasonic sensors offers several advantages. It enhances traffic efficiency by dynamically adapting to the real-time traffic conditions. It improves safety by reducing the likelihood of accidents and conflicts between vehicles and pedestrians. Additionally, it can be integrated with other traffic management systems, such as traffic cameras or centralized control centres, to create a comprehensive and intelligent traffic control infrastructure.

1.2 Literature Survey

This research [1] proposes to develop a smart traffic management system that would ameliorate some difficulties encountered daily by road users on a four-side junction in which traffic flow on each side is only in one direction. The system is based on PIC microcontroller that evaluates the traffic density using IR sensors with dynamic timing slots with different levels. Thereby maintaining smooth and easy flow of vehicles on a four-side junction with traffic flow on each side only in one direction. The proposed paper [2] is real-time information gathering of the traffic and monitoring system is presented to address this issue of road management of traffic. The suggested model is a function of real-time traffic density and in a sequential manner the regulation for clearing time of every lane is given. The method is very hybrid, consisting of a combination of sensor networks. RFID technology is additionally achieved for emergency vehicles besides prioritization and minimization for vehicles. This paper [3] aims to develop a convenient traffic system that allows a smooth movement of cars which will help build a smarter city. In this proposed system Ultrasound Sensors are used along with Image Processing (using live feed from a camera) that works on a Raspberry Pi platform and calculates the vehicle density and dynamically allots time for different levels of traffic. By using Internet Of Things(IoT) real time data from the system can be collected, stored and managed on a cloud. This research [4] proposed an approach to develop an effective real-time density-based traffic light control system. This research consists of two major parts; Image processing model for capture real-time data and ANN model for predicting the results considering real-time data. Identify the best features from gathered data and minimize dimensionality between the features, by principal component analysis (PCA) to train a Neural Network model. This system reduces the average waiting time and increases the efficiency of traffic clearance. New adaptive traffic management also reduces the pollution due CO2 emission and also social and economic problems. In this paper [5], a system to control the traffic by measuring the real time vehicle den- 2 sity using canny edge detection with digital image processing is proposed. This imposing traffic control system offers significant improvement in response time, vehicle management, automation, reliability, and overall efficiency over the existing systems. Besides that, the complete technique from image acquisition to edge detection and finally green signal allotment using four sample images of different traffic conditions is illustrated with proper schematics. This paper [6], proposes a traffic control system that uses IR sensors to detect traffic density and a wireless network to transmit data to a central control unit. The system was tested in a real-world scenario and showed promising results in reducing traffic congestion and improving traffic flow. This paper proposes a design of an automatic, save and efficient traffic flow. This project is to limit the vehicle based on density of the traffic at any junction when it comes to green light. The main problem of the present traffic control system are fixed time interval. Vehicles at the particular junction need to wait for a few minutes until the traffic light turn green to proceed due to the fixed time interval although the traffic at the junction is not so congest. This research [7], proposes a smart traffic control system that uses IR sensors to detect traffic density and machine learning algorithms to predict traffic patterns and adjust traffic signals accordingly. The authors tested the system in a simulation and found that it was able to reduce travel time and fuel consumption. This study contributes in solving this problem by introducing an artificial intelligence-based smart traffic light system using fuzzy logic to ensure the smooth flow of traffic in cities. Research results indicate that smart traffic light management is very crucial in smart cities to reduce their carbon footprint to save the world and save energy. The proposed paper [8], provides an overview of the state-of-the-art in smart traffic control systems that use IR sensors. The authors summarize the main advantages and challenges of using IR sensors for traffic monitoring and control and provide a comprehensive review of the existing literature. proposes a framework that will quantify the traffic upheld the amount of auto thickness of the vehicles inside the street. The control framework offers proficient administration of traffic and dependability above the overall frameworks by effectively utilizing Raspberry Pi pigs as the canter principle. This paper [9], proposes a density-based traffic control system that uses IR sensors to detect the number of vehicles on the road and adjust traffic signals accordingly. The authors tested the system in a simulation and found that it was able to reduce congestion and improve traffic flow. The suggested model focuses on enhancement of traffic light controller in a city utilizing IR sensor and created utilizing Arduino. A smart transportation framework assesses the traffic parameters and streamlines traffic flag to diminish vehicle delays and stop. This paper [10], proposes a traffic control system that uses IR sensors to detect traffic density and fuzzy logic to adjust traffic signals. The authors tested the system in a real-world scenario and found that it was able to reduce travel time and waiting time at traffic signals. By accurately detecting traffic density on roads, the system can optimize traffic flow and reduce congestion. This can result in reduced travel time, fuel consumption, and emissions.

1.3 Objectives

(i) The objective of a density-based automated traffic control system using ultrasonic sensors is to effectively manage traffic flow by dynamically adjusting signal timings based on the density of vehicles at different locations within the traffic environment. This system aims to achieve the following specific goals:

2. Traffic Flow Optimization: By continuously monitoring the density of vehicles at various points, the system can dynamically adapt signal timings to optimize traffic flow. It aims to reduce congestion, minimize waiting times at intersections, and improve overall traffic efficiency.

Chapter 2

Design and Methodology

2.1 Block Diagram

The density-based automated traffic control system utilizes ultrasonic sensors to detect vehicles and calculate their density. The collected data is processed and analyzed to determine optimal signal timings, allowing for dynamic adjustments in traffic signals. This enables the system to optimize traffic flow, reduce congestion, minimize waiting times, and enhance overall road efficiency for a smoother and more efficient transportation experience.

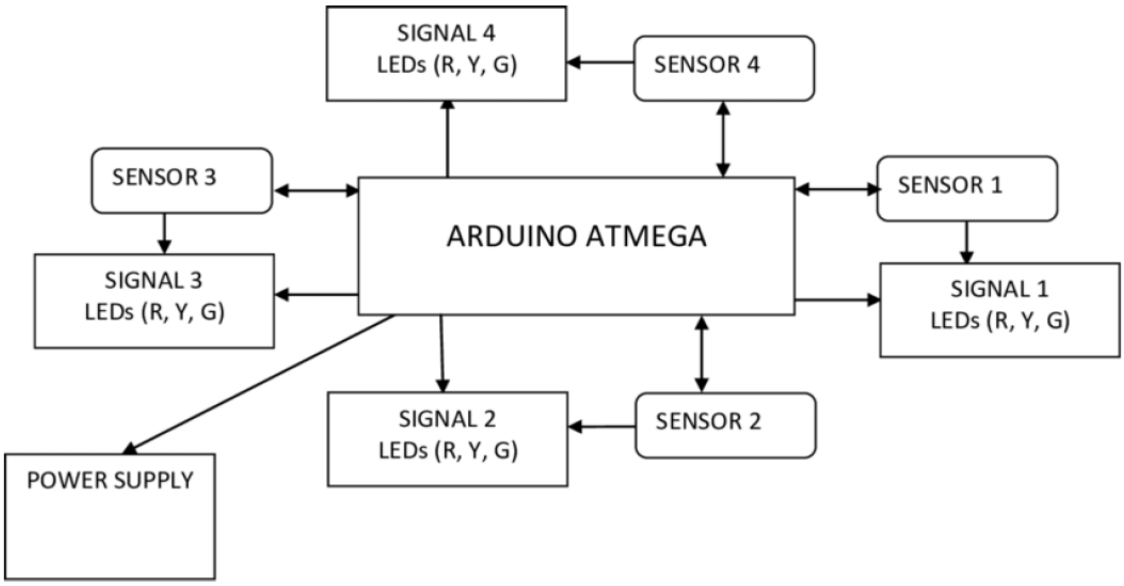

Figure 2.1: Main block diagram

2.2 Hardware requirements

2.2.1 ultrasonic sensor

Ultrasonic sensors are non-contact proximity sensors that use sound waves to detect the presence and measure the distance to objects. These sensors emit high-frequency sound waves and measure the time it takes for the sound waves to bounce back after hitting an object. This information is then used to calculate the distance between the sensor and the object. Ultrasonic sensors have a wide range of applications, including obstacle detection and avoidance in robotics and automation systems, parking assist systems in automotive applications, object detection in industrial manufacturing, and medical imaging in healthcare. They offer reliable and accurate distance measurements, making them a popular choice in various industries due to their versatility and ability to operate in different environmental conditions.

Figure 2.2: ultrasonic sensor

2.2.2 Arduino

In this setup, Arduino Mega 2560 board shown in Figure 2.3 is identical to the Arduino UNO board, however, the Mega 2560 is more powerful. This is an 8-bit microcontroller board based on the ATmega2560. It is utilized for tasks that demand a significant number of input-output pins or high processing power. Because it features 54 digital I/O pins, 15 of which are utilized for PWM output, and 16 analog pins. The digital pins operate at 5 volts. Both an external power supply and a USB connection are options for powering the Mega 2560. The power source is automatically chosen. The two sources of external (non-USB).

1. Microcontroller: The Arduino Mega is built around the ATmega2560 microcontroller, which is an 8-bit AVR architecture-based chip. It operates at a clock speed of 16 MHz and has 256 KB of flash memory for storing the program code.

2. Digital Input/Output Pins: The Arduino Mega has a total of 54 digital input/output pins. Among them, 15 pins can be used as PWM (Pulse Width Modulation) outputs, allowing for control of devices such as LEDs, servos, and motors. The digital pins are labeled from 0 to 53.

3. Analog Input Pins: The board features 16 analog input pins, labeled A0 to A15, which can be used to measure analog voltage levels from sensors or other devices.
4. Communication Interfaces: The Arduino Mega supports multiple communication interfaces, including:
   - Serial: It has four hardware UART (Universal Asynchronous Receiver/Transmitter) serial ports, which allow for communication with other devices using the Serial library.
   - SPI (Serial Peripheral Interface): The board has one SPI interface, which enables communication with SPI-compatible devices like displays, SD cards, and other microcontrollers.
   - I2C (Inter-Integrated Circuit): There is one I2C interface on the Arduino Mega, allowing communication with I2C-compatible devices, such as sensors and displays.
   - CAN (Controller Area Network): The board also supports the CAN protocol, which is commonly used in automotive and industrial applications.
5. Memory: The ATmega2560 microcontroller on the Arduino Mega has 256 KB of flash memory, of which 8 KB is used for the bootloader. It has 8 KB of SRAM (Static Random-Access Memory) and 4 KB of EEPROM (Electrically Erasable Programmable Read-Only Memory).
6. Power Supply: The Arduino Mega can be powered using a USB connection or an external power supply. The board supports a voltage range of 7 to 12 volts for the external power supply. It has a built-in voltage regulator that provides a stable 5V output for powering other components.
7. Operating Voltage: The Arduino Mega operates at 5 volts. However, it can also be powered at 3.3 volts by setting the appropriate voltage on the board and providing a regulated 3.3V power source

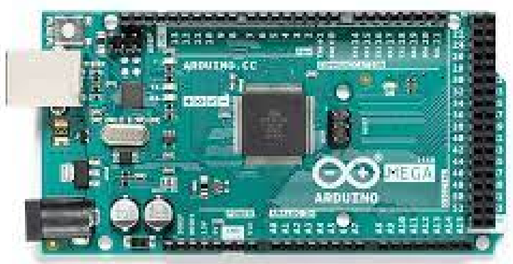

Figure 2.3: Arduino Mega 2560

2.2.3 LEDs

Three LEDs i.e., Red, yellow and green as shown in Figure 2.4 are used as a traffic light indicator which is connected in series with a 1k resistor in the PCB board. All the LEDs are polarised and all its ground wire are connected together.

Figure 2.4: LED

2.3 Software Components

2.3.1 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

2.4 Methodology

- Sensor Placement: Determine the optimal locations for placing the ultrasonic sensors. These sensors should be strategically positioned to cover the desired areas, such as intersections or pedestrian crossings. Consider factors such as visibility, range, and line-of-sight obstruction.

- Ultrasonic Sensor Calibration: Calibrate the ultrasonic sensors to ensure accurate distance measurements. This involves adjusting the sensor parameters and thresholds to match the specific requirements of the traffic control system.

- Hardware Setup: Connect the ultrasonic sensors to the Arduino Mega 2560 microcontroller. The Arduino Mega 2560 provides the necessary processing power and input/output capabilities to interface with the sensors and control the traffic signals.

- Data Acquisition: Write a program on the Arduino Mega 2560 to continuously read the distance measurements from the ultrasonic sensors. This involves utilizing the appropriate libraries and functions to communicate with the sensors and retrieve the distance data.

- Traffic Density Calculation: Use the distance measurements from the sensors to calculate the traffic density at each monitored location. The density can be determined by analyzing the number of vehicles or pedestrians within a certain range of the sensor.

- Traffic Signal Control: Implement the control logic on the Arduino Mega 2560 to control the traffic signals. The microcontroller should be programmed to switch the traffic signals based on the calculated density values and predefined signal timings.

Chapter 3

Implementation and Testing

3.1 Result Analysis

When the power supply is not there , the demo model looks as shown in Figure 3.1

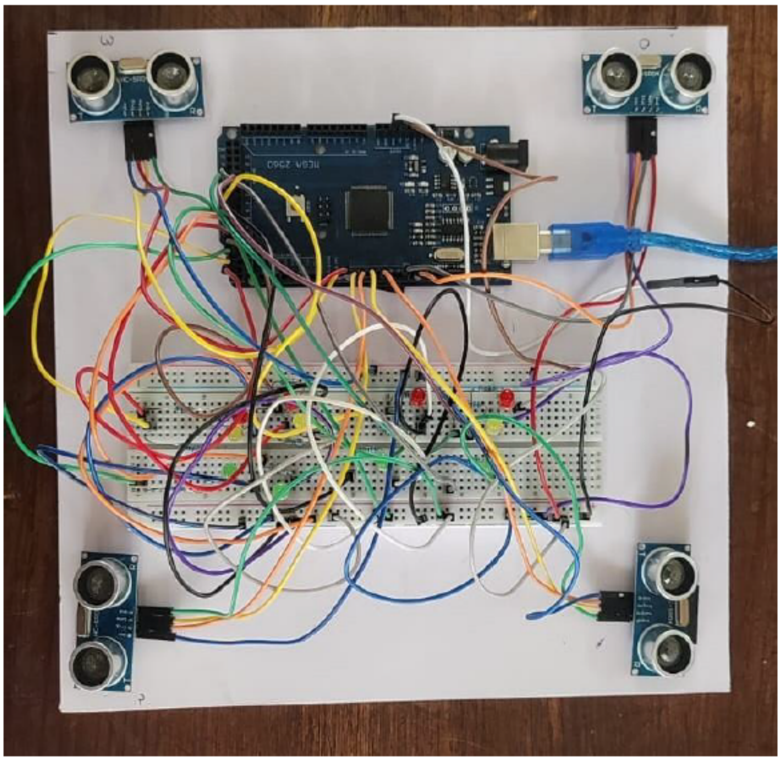

Figure 3.1: When the power supply is not there

This below image represents the scenario in which the density of vehicles is high at the 0 th ultrasonic sensor and the respective green signal is switched on.

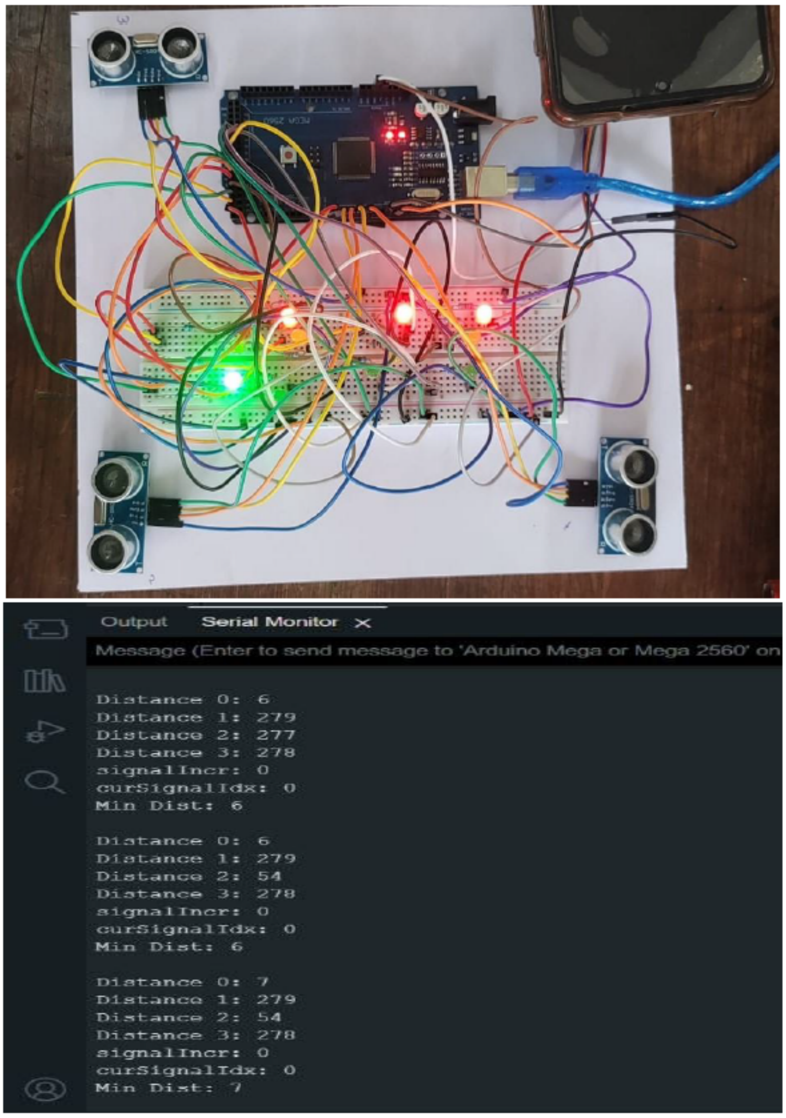

Figure 3.2: density at 0th signal is high

This below image represents the scenario in which the density of vehicles is high at the 3 rd ultrasonic sensor and the respective green signal is switched on.

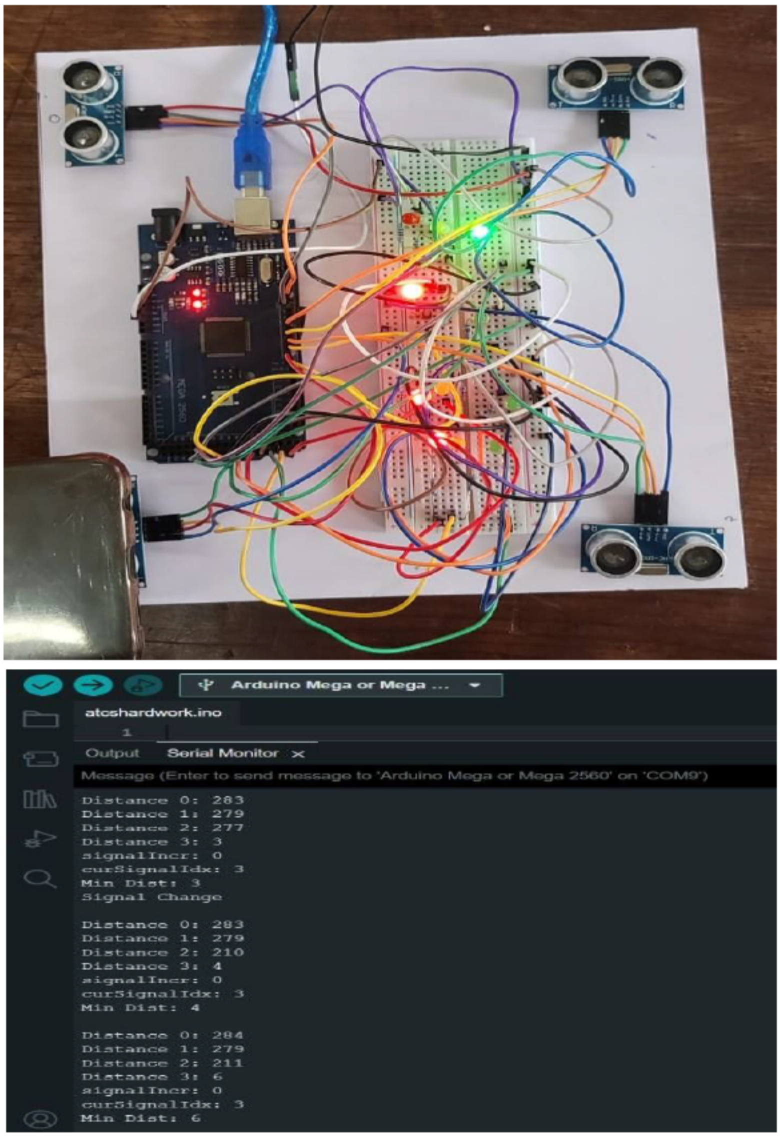

Figure 3.3: density at 3rd signal is high

Chapter 4

Conclusion

In conclusion, the density-based automated traffic control system offers an intelligent and efficient solution for managing traffic flow. By utilizing ultrasonic sensors and advanced data processing algorithms, the system accurately detects vehicle density at various points along the road network. This real-time information allows for dynamic adjustment of traffic signal timings, optimizing traffic flow and reducing congestion. The system's ability to adapt to changing traffic conditions improves overall road efficiency, enhances safety, and provides a smoother commuting experience for drivers. With its potential to minimize waiting times and optimize traffic patterns, the density-based automated traffic control system holds great promise for improving urban transportation systems in the future.

4.1 Advantages and Limitations

4.1.1 Advantages

- Efficient Traffic Flow: The system uses ultrasonic sensors to measure the density of vehicles on the road. By continuously monitoring the number of vehicles present in different lanes or sections, it can adjust signal timings accordingly. This helps in optimizing traffic flow by allocating green signals to lanes with higher vehicle density, thereby reducing congestion and improving overall traffic efficiency.

- Real-Time Monitoring: The system provides real-time data on vehicle density, allowing traffic authorities to monitor the traffic situation accurately. This information can be used to make informed decisions, such as adjusting signal timings, implementing traffic diversions, or deploying additional resources to manage traffic congestion effectively.

- Adaptive Control: Unlike fixed-time traffic signals, the density-based system adapts to changing traffic conditions. By using ultrasonic sensors, it can dynamically adjust the signal timings based on the real-time vehicle density. This ensures that the traffic control system responds to the actual traffic demand, resulting in reduced waiting times for vehicles and improved traffic flow.

- Improved Safety: The system enhances safety by reducing the likelihood of accidents. By continuously monitoring the density of vehicles, it can detect situations where the vehicle density exceeds the road capacity. In such cases, the system can implement measures like extending the red signal duration or controlling the entry of vehicles to prevent overcrowding and potential accidents.

- Cost-Effective Solution: The use of Arduino Mega 2560, an open-source microcontroller platform, in conjunction with ultrasonic sensors, makes the system relatively cost-effective compared to complex traffic control solutions. Arduino Mega 2560 offers a cost-efficient and flexible platform for programming and controlling the traffic control system. The density-based automated traffic control system using ultrasonic sensors and Arduino Mega 2560 offers advantages such as efficient traffic flow, real-time monitoring, adaptive control, improved safety, cost-effectiveness, scalability, and energy efficiency. These advantages make it a promising solution for modern traffic management, contributing to smoother traffic flow and enhanced overall transportation efficiency.

4.1.2 Limitations

- Limited Detection Range: Ultrasonic sensors have a limited range of detection. They can accurately detect objects within a specific distance range, typically up to a few meters. This limitation restricts their effectiveness in monitoring traffic at longer distances, such as on highways or wide roads.

- Sensor Interference: Ultrasonic sensors may experience interference from external sources, such as other nearby sensors or reflective surfaces. In congested traffic environments, multiple sensors operating simultaneously can interfere with each other, leading to false detections or missed detections. Careful sensor placement and signal processing techniques are required to mitigate this limitation.

- Complex Traffic Scenarios: Dense traffic scenarios with complex vehicle movements, such as merging lanes, roundabouts, or unconventional intersections, can pose challenges for a density-based automated traffic control system. The system may struggle to accurately determine the density and prioritize traffic movements in such situations, potentially leading to suboptimal traffic flow.

- System Cost and Maintenance: Implementing and maintaining a density-based automated traffic control system using ultrasonic sensors can be costly. It requires the installation, calibration, and periodic maintenance of numerous sensors at various locations. Additionally, the system may require integration with other infrastructure and technologies, increasing the overall implementation and operational expenses.

4.2 Future Work

- Advanced Data Processing: Enhancing the data processing capabilities of the system can lead to more accurate and efficient traffic control. By incorporating advanced algorithms and machine learning techniques, the system can better analyse the data from ultrasonic sensors to identify patterns, predict traffic conditions, and optimize signal timings accordingly.
- Adaptive Control Algorithms: Developing adaptive control algorithms that can continuously adapt the traffic signal timings based on the changing traffic density can significantly improve traffic flow. These algorithms can consider factors such as time of day, day of the week, and special events to optimize signal timings and reduce congestion.
- Sensor Technology Advancements: Advancements in sensor technology, particularly ultrasonic sensors, can lead to more accurate and reliable detection of vehicles and pedestrians. Improved sensor range, resolution, and sensitivity can enhance the performance of the traffic control system and enable it to handle complex traffic scenarios more effectively

The future work on a density-based automated traffic control system using ultrasonic sensors aims to leverage advancements in technology and data processing to create more intelligent, adaptive, and efficient traffic management solutions. By integrating various elements of smart city infrastructure and adopting a holistic approach, these advancements can contribute to safer, more sustainable, and less congested urban environments

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