JSS Mahavidyapeetha

**JSS SCIENCE AND TECHNOLOGY UNIVERSITY
MYSURU-570006**

B.E. Electronics and Communication Engineering
2022-2023

OPTIMIZING TRAFFIC DENSITY Via IR SENSORS

Submitted by

Name	USN
Pranjal Singh	01JST20EC071
Pratham N Prabhu	01JST20EC073

Submitted in partial fulfilment of the requirement of academic event in

20EC69L Design and Implementation Lab

Lab Coordinators:	Dr Sudarshan Patilkulkarni
	Dr A Thyagarajamurthy
Faculty in Charge	Dr M G Veena
	Prof. D R Pavithra

**SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
MYSURU-570006**

Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Preamble

Traffic organization has the objective to continually improve traffic framework and guideline. As the quantity of vehicle clients always increments and assets given by current frameworks are constrained, clever control of traffic will turn into a point of centre later on. Staying away from congested roads is advantageous to both condition and economy. In our exploration we centre and 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. Fixed control on traffic is fundamentally not control as per the thickness i.e., density, yet so to speak programming which is as of now fixed in the framework. This paper proposes a keen framework utilizing Arduino for actualizing it in the city. Traffic congestion is a pervasive issue in urban areas, leading to delays, increased fuel consumption, environmental pollution, and reduced quality of life for commuters. Traditional traffic control systems, which rely on fixed time intervals or preprogrammed signal timings, may not be efficient in dynamically managing traffic flow based on real-time conditions. To overcome these limitations, a density-based traffic control system that utilizes infrared (IR) sensors has emerged as a potential solution. A density-based traffic control system uses IR sensors to accurately detect and measure vehicle density at intersections. These sensors can detect the presence of vehicles regardless of their size, shape, or colour, and can operate in various weather conditions. The system processes the data from the IR sensors in real-time, allowing for continuous monitoring of vehicle density at intersections. It then makes intelligent decisions on adjusting traffic signal timings based on the detected vehicle density, leading to more effective traffic management and reduced congestion. However, there are challenges to be addressed in the development of a density-based traffic control system using IR sensors. These challenges include ensuring accurate and reliable detection of vehicles, real-time data processing, adaptability and scalability to different types of intersections, integration with existing traffic infrastructure, and cost-effectiveness and feasibility. Previously different techniques had been proposed, such as edge detection, induction loop etc. to acquire traffic date which had their fair share of demerits. In recent years, image processing has shown promising outcomes in acquiring real time traffic information using CCTV footage installed along the traffic light. Different approaches have been proposed to glean traffic data. Some of them count total number of pixels, some of the work calculate number of vehicles. These methods have shown promising results in collecting traffic data. However, calculating the number of vehicles may give false results if the intravehicular spacing is very small (two vehicles close to each other may be counted as one) and it may not count rickshaw or auto-rickshaw as vehicles which are the quotidian means of traffic especially in South-Asian countries. And counting number of pixels has disadvantage of counting insubstantial materials as vehicles such as footpath or pedestrians. Overcoming these challenges and developing a robust density-based traffic control system using IR sensors would contribute to mitigating traffic congestion, improving traffic flow, and enhancing the overall efficiency of urban transportation systems.

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-

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 Problem Statement

Urban traffic congestion is a pervasive problem that causes delays, increased fuel consumption, environmental pollution, and reduced quality of life for commuters. Traditional traffic control systems often rely on fixed time intervals or pre-programmed signal timings, which may not be efficient in dynamically managing traffic flow based on real-time conditions. In addition, these systems may not be effective in accurately detecting the presence of vehicles, especially during off-peak hours or in adverse weather conditions. To address these limitations, there is a need for a density-based traffic control system that utilizes infrared (IR) sensors to accurately detect and measure vehicle density at intersections.

1.4 Objectives

(i) To design and build a circuit with IR sensor and Arduino to detect density of vehicles and control traffic signal lights.

(ii) To optimize time efficiency by ensuring lighting turns on according to the density present at that moment.

(iii) To reduce accidents and increase safety at inter junctions.

(iv) To evaluate practical applications and demonstrate the potential of using hardware components for automated systems.

Chapter 2

Design and Methodology

2.1 Block Diagram

Arduino Mega 2560 is the main heart of this traffic system. The density of traffic on the road is detected using IR sensors, and Arduino will continuously read data from it. As we developed a four-way junction traffic control system. We used eight IR sensors, where two IR sensors are placed on each lane. An external power supply is given to Arduino through a USB cable. RF receiver is connected to Arduino, as it acts as a signal interruption to the ongoing system, which is used to receive the signals from the RF transmitter and give as input to Arduino. It indicates that there is an arrival of an emergency vehicle. The Buzzer will make a buzz sound when there is an arrival of an emergency vehicle. A Battery is used as a power supply to the RF transmitter. Figure 2.1 displays the fundamental block diagram.

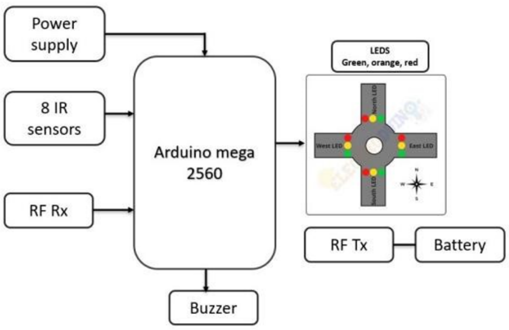

Figure 2.1: Block Diagram

2.2 Hardware requirements

2.2.1 IR Sensor

An IR (Infrared) sensor shown in Figure 2.2 is an electronic gadget which can be utilized to detect certain parameters of its surroundings by either producing or identifying radiations. It can likewise quantify warmth of an item and recognize movement. It utilizes the infrared light to detect protests before them and guide or theory their separation. This framework comprises of 6 IR sensors as a locator of intersections.IR transmitter resembles a LED. This IR transmitter dependably produces IR beams from it. The working voltage of this IR transmitter is 2 to 3v. These IR (infrared) beams are undetectable to the human eye. Be that as it may, we can see these IR radiations through camera. IR transmitter transmits IR beams that are gotten by IR collector. By and large IR recipient has high opposition in the request of mega ohms however when it is getting IR beams the obstruction is low. The working voltage of IR collector likewise 2 to 3V. We need to put these IR pair so that when we place an impediment before this IR pair, IR collector ought to most likely get the IR beams. At the point when control is provided, the transmitted IR beams hit the article and reflect back to the IR recipient.

Figure 2.2: IR 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. The serial ports are labeled as Serial, Serial1, Serial2, and Serial3.

• 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

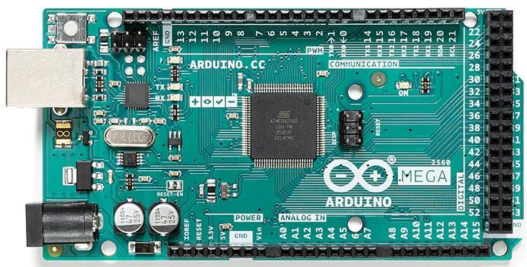

Figure 2.3: Arduino Mega

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.

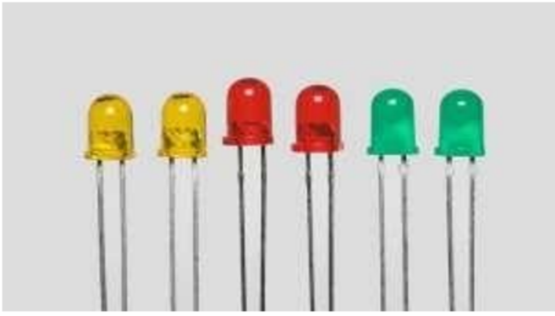

Figure 2.4: LEDs

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

The model takes a shot at the guideline of changing the deferral of Traffic signals dependent on the number of vehicles going through an appointed segment of the street. There are eight sensors put at four sides of a four-way street which checks the number of vehicles going by the region secured by the sensors. Here we are utilizing IR sensors supplanting the traffic control framework to plan a thickness-based traffic flag framework. IR sensor contains an IR transmitter IR collector (photodiode) in itself. This IR transmitter and IR beneficiary will be mounted on similar sides of the street at a specific separation. As the vehicle goes through these IR sensors, the IR sensor will recognize the vehicle and will send the data to the microcontroller. The microcontroller will check the number of vehicles, and give the sparkling time to LED by the thickness of vehicles. The path or street which has a higher thickness, at that point the LED will sparkle for higher time than normal or the other way around. The traffic lights are at first running at a fixed deferral of 1000 milliseconds, which thus creates a postponement of 30000 milliseconds in the whole procedure. This whole implanted framework is put at that intersection. The microcontroller is interfaced with LEDs and IR sensors. The all-out number of IR sensors required is 8 and LED modules(consisting of 3 LEDs in each) are 4. In this manner, these are associated with any two ports of the Arduino.IR sensor module comprises of an IR transmitter and an IR beneficiary. At the point when the sensor finds any article vehicles the, the comparator yield goes low else it gives high voltage, for example, +5v or 3.3v. The external power supply is given to Arduino mega 2560 through a USB cable which operates at 5 volts. The eight IR sensors are connected to Arduino from pin 2 to 9. 5 volts of supply voltage is given to each IR sensor from the Arduino 5v pin. The 4-traffic modules having each of red and green LEDs are connected to Arduino from pin 14 to 21, which acts as communication pins of Arduino.

2.4.1 Design Equations

1. Transformer Design Equations:
a) Turns ratio (N) calculation:
N = Vprimary / Vsecondary = 230 / 12 19.17 (rounded to the nearest integer, so N = 19)

b) Maximum secondary current (Isecondary$_{m}ax)calculation:$
$Isecondary_{m}ax = Secondarycurrentrequirement = 500mA = 0.5A$

2. Rectification and Smoothing Equations:
a) Peak rectified voltage (Vpeak$_{r}ectified)calculation:$
$Vpeak_{r}ectified = 1.414 * Vsecondary = 1.414 * 12 = 16.97V(roundedto17V)$

b) Ripple voltage (Vripple) calculation:
Assuming a desired ripple voltage of 1Vripple = (Iload * T) / (C * Vpeak$_{r}ectified)$
$Let'sassumeT = 10ms(half - cycleof50HzAC), andVripple = 0.01 * 12 = 0.12V$
$Substitutingthevalues:$
$0.12 = (0.5 * 0.01)/(C * 17)SolvingforC:$
$C0.029F(roundedtothenearestmicrofarad, soC = 29F)$

3. Voltage Regulation Equations:
a) Dropout voltage (Vdropout) calculation:
Let's assume a typical linear voltage regulator with a dropout voltage of 2V. Vdropout = Vinput - Voutput = 17 - 12 = 5V

b) Power dissipation calculation:
Pregulator = (Vinput - Voutput) * Iload = 5 * 0.5 = 2.5W

4. Output Filter Equations:
a) Smoothing capacitor (C) calculation:
Using the previously calculated values, C = (Iload * T) / (Vripple * Vpeak$_{r}ectified)(0.5 * 0.01)/(0.12 * 17)0.024F(roundedtothenearestmicrofarad, soC = 24F)$.

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

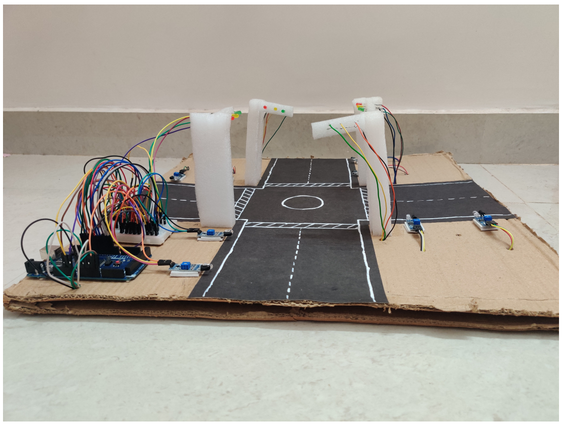

Figure 3.1: Demo model when power supply is switched off

The project consists of eight IR sensors, LEDs, Arduino Mega. The IR sensors are responsible for sensing the traffic density. Two IR sensors are placed on each road in a 4-way junction to detect the density of the vehicles on the road. All the sensors' data is collected by Arduino Mega 2560 which operates at 5 volts. The external power supply can be given to the board either from the DC power jack which takes 7-12 volts or through the USB connector which takes 5 volts. When both the IR sensors on the road detect traffic then that road is considered of having heavy traffic and a green signal is given to that road and a red signal is given to the remaining 3 roads. Initially, the system is timer-based, the signal will be varied on each road in a cyclic order after the fixed time interval. As two IR sensors are placed on each road, if both the sensors detect traffic then only it is considered as heavy traffic and the traffic signal will turn green. If the traffic is up to only 1 sensor, then it is not considered as heavy traffic.

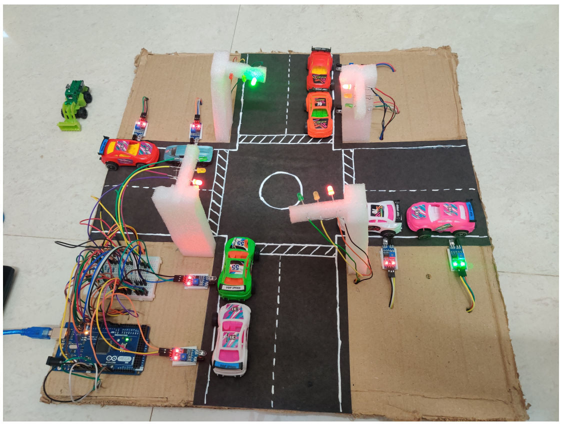

Figure 3.2: Demo model when power supply is switched on

Chapter 4

Conclusion

4.1 Advantages and Limitations

4.1.1 Advantages

- Real-time Traffic Monitoring: IR sensors can provide real-time data on traffic density, allowing traffic management systems to have accurate and up-to-date information for optimizing traffic flow.

- Cost-Effective Solution: Compared to other traffic monitoring technologies such as cameras or radar systems, IR sensors are generally more affordable to install and maintain. This makes them a cost-effective option for traffic management applications.

- Non-Intrusive Detection: IR sensors operate without physical contact with vehicles, making them non-intrusive and less disruptive to traffic. They can be installed discreetly and do not require any special equipment to be installed on vehicles.

- Weather-Resistant: IR sensors can work reliably in various weather conditions, including rain, fog, and low light situations. This ensures consistent data collection even in challenging environments.

- Versatile Deployment: IR sensors can be deployed in various locations, such as intersections, highways, and toll booths. Their flexibility allows for customization based on the specific traffic management needs of different areas

4.1.2 Limitations

- Limited Detection Range: IR sensors typically have a limited range of detection. This means they may not capture traffic conditions beyond their designated coverage area. Multiple sensors may be required to cover larger areas effectively.

- Vehicle-Based Detection: IR sensors primarily detect vehicles based on their heat signatures. This means they may not accurately detect other road users such as pedestrians or cyclists. Additional sensor technologies may be necessary to account for different modes of transportation.

- Line-of-Sight Requirement: IR sensors rely on a clear line of sight to detect vehicles. Any obstructions, such as tall buildings or vegetation, can hinder their effectiveness. Careful placement and consideration of potential obstructions are necessary for optimal performance.
- Calibration and Maintenance: IR sensors require regular calibration and maintenance to ensure accurate and reliable performance. Dust, dirt, or misalignment can affect their ability to detect vehicles accurately. Routine upkeep and monitoring are necessary to maintain their functionality.
- Limited Data for Traffic Analysis: While IR sensors can provide valuable real-time data on traffic density, they may not capture detailed information about traffic patterns, origins, or destinations. Additional data sources and analytics may be needed for more comprehensive traffic analysis.
- Privacy Concerns: Since IR sensors detect vehicles based on their heat signatures, there may be privacy concerns related to the collection and use of this data. It is crucial to implement appropriate data anonymization and privacy protection measures when deploying IR sensor-based systems.

4.2 Future Work

In terms of future work, here are a few ideas to consider:

4.2.1 Advanced Data Analytics:

Enhance the data analysis capabilities of the IR sensors by employing advanced analytics techniques. This can involve applying machine learning algorithms to identify patterns and trends in traffic flow, predict congestion hotspots, and optimize signal timing accordingly.

4.2.2 Integration with Smart Traffic Systems:

Integrate the IR sensors with existing or emerging smart traffic management systems. This integration can enable real-time data sharing and coordination between different traffic control devices, such as traffic lights, variable message signs, and surveillance cameras. The IR sensors can provide valuable input to these systems, helping to improve overall traffic flow.

4.2.3 Adaptive Traffic Control:

Develop adaptive traffic control algorithms that utilize the data collected from IR sensors. These algorithms can dynamically adjust traffic signal timings based on the real-time traffic conditions detected by the sensors. By adapting to changing traffic patterns, these systems can optimize traffic density and reduce congestion.

4.2.4 Connected Vehicle Technology:

Explore the potential of integrating IR sensors with connected vehicle technology. By equipping vehicles with IR sensors and enabling communication between vehicles and infrastructure, it becomes possible to exchange real-time traffic information. This information can be used to optimize routing decisions, prevent traffic bottlenecks, and enhance overall traffic efficiency.

4.2.5 Networked Sensor Deployment:

Consider deploying a network of interconnected IR sensors throughout an entire road network or city. By strategically placing sensors at key intersections and along major traffic corridors, a comprehensive view of traffic density can be obtained. This data can be used to identify congestion patterns, plan infrastructure improvements, and optimize traffic flow across the entire network.

4.2.6 Multi-Modal Traffic Optimization:

Extend the application of IR sensors beyond automobiles to include other modes of transportation, such as pedestrians and cyclists. By detecting and analyzing the movement patterns of all road users, traffic management systems can better understand the interactions and conflicts between different modes. This knowledge can be used to optimize traffic flow and improve safety for all users.

4.2.7 Energy Efficiency Considerations:

Explore ways to optimize the energy consumption of IR sensor networks. This can involve developing energy-efficient sensor designs, implementing power management strategies, or utilizing renewable energy sources to power the sensors. Minimizing the energy footprint of the sensor network can make it more scalable and sustainable in the long run.

Bibliography

[1] N. C. Maduka, I. I. Ajibade, M. Bello "Modelling and Optimization of Smart Traffic Light Control System" IEEE Nigeria 4th International Conference on Disruptive Technologies for Sustainable Development 2022. .

[2] Sireesha Amaraneni, Adarsh Rao Akula, S Srikanth "Automated Adaptive IR based Traffic Control" IEEE Proceedings of the Seventh International Conference on Communication and Electronics Systems 2022.

[3] Naga Harsha.J, Nikhil Nair, Sheena Mariam Jacob, J.John Paul, "Density Based Smart Traffic System with Real Time Data Analysis Using IoT" Proceeding of 2018 IEEE International Conference on Current Trends toward Converging Technologies, Coimbatore, India 2018.

[4] W.A.C.J.K. Chandrasekara, R.M.K.T Rathnayakay , L.L.G Chathurangaz "A REALTIME DENSITY-BASED TRAFFIC SIGNAL CONTROL SYSTEM" 978-1-6654-1475- 3/20 IEEE 2020

[5] Taqi Tahmid, Eklas Hossain "Density Based Smart Traffic Control System Using Canny Edge Detection Algorithm for Congregating Traffic Information." 3rd International Conference on Electrical Information and Communication Technology 2019

[6] Wang, J, Xu, J, Sun, J "A smart traffic control system based on infrared sensors and wireless networks Sensors", 17(4), 787, 2017.

[7] Gupta, A, Kumar, A, Kumar V. "Intelligent traffic control system using IR sensors and machine learning algorithms". 11th International Conference on Computing, Communication and Networking Technologies 2020.

[8] Jiao B, Han X, Li J. "Smart traffic control systems using infrared sensors". Applied Sciences, 9(24), 5369, 2019.

[9] Reddy, S. K, Suresh, S, Srinivasulu, D. "Density-based traffic control system using IR sensor". International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, , 5756-5761, 2019 .

[10] Yu W, Li X, Li B, Li W., Li Q. "A smart traffic control system based on infrared sensors and fuzzy logic". Journal of Advanced Transportation, 49(5), 575-588, 2018.