SMART TRAFFIC SIGNAL CONTROL

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ABSTRACT

Due to the rapid increase in the number of vehicles traffic congestion is a severe problem in most of cities across the world and it has become a nightmare for the citizens. Our project aims at reducing traffic congestion and unwanted long-time delay during the traffic light switchovers especially when the traffic is very low. It is designed to be implemented in places near the junctions where the traffic signals are placed, in order to reduce the congestion in these junctions. It keeps track of the vehicles in each road and accordingly adjusts the time for each traffic light signal. The higher the number of vehicles on the road the longer will be the time delay allotted for that corresponding traffic light signal. The microcontroller board used in this project is Arduino nano and Standard red, yellow, and green lights are controlled by the Arduino. The system contains 2 IR sensors that are mounted on either side of the road. It gets activated and receives the signal as the vehicles pass close by it. Depending on the signal received from IR sensors, Arduino calculates the delay time for each signal. In every unit of traffic light, 2-digit seven-segment display is used along with two 74HC595 serial to parallel shift resistors. These shift registers receive serial data from Arduino nano and give parallel data to 7 segment displays to show the timing. The complete system is powered through 5V, 2Amp power adapter.

Keyword: - *Transportation, Automation, Traffic Management, Smart City, Arduino nano,*

1. INTRODUCTION

Traffic congestion is a pervasive issue in urban areas around the world, significantly impacting daily commutes, increasing travel time, and contributing to environmental pollution. As the number of vehicles on the road continues to rise, traditional fixed-time traffic signal systems are becoming increasingly inadequate. These systems fail to adapt to varying traffic conditions, often leading to inefficient traffic flow and exacerbated congestion during peak hours. To address this challenge, our project aims to develop a density-based dynamic traffic signal control system. This innovative solution leverages real-time traffic data to optimize signal timings, thereby improving traffic flow and reducing congestion. The core of our system is an Arduino Nano microcontroller, which processes input from infrared (IR) sensors strategically placed on either side of the road. These sensors detect vehicle presence and calculate traffic density, enabling the microcontroller to dynamically adjust traffic light intervals. By transitioning from a fixed-time to a density-based traffic signal control, our system offers several advantages. It enhances efficiency by reducing unnecessary waiting times at traffic signals, improves road safety by preventing bottlenecks, and contributes to environmental sustainability by decreasing vehicle emissions due to idling. This project represents a significant step towards smarter, more responsive urban traffic management, providing a scalable and cost-effective solution adaptable to various city infrastructures. In the following sections, we will delve into the components and working principles of the system, outline the implementation steps, and discuss the anticipated benefits and potential challenges of deploying this technology in real-world scenarios.

2. LITERATURE SURVEY

Table 1: Literature Survey:

Sr.No.	Auther & Title	Published in	Explanation
1	Anam Firdous; Indu; Vandana Niranjan,	2020 8th International	In order to reduce the time and complexity, a system that has to be combine the existing technology with artificial

	"Smart Density Based Traffic Light System"	Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO),	intelligence to think themselves. This newly developed project will enable the traffic light to switch from red to green based on traffic density. This paper is concerned with the development and implementation of Sensor based Traffic Light System with Dynamic Control which in turn reduces the Average Trip Waiting Time (ATWT). It consists of IR sensors, Low Power embedded controllers, comparators and storage device.
2	Islam Mohammad Albatish; Samy S. Abu-Naser, "Modeling and Controlling Smart Traffic Light System Using a Rule Based System"	2019 International Conference on Promising Electronic Technologies (ICPET),	This study takes benefit of one of the Artificial Intelligence (AI) fields which is Expert System (ES) and which can be called Rule-Based System (RBS). The researchers designed a new expert system called Traffic Lights Expert System (TLES). TLES uses rule base as the knowledge representation and the evidential reasoning as the inference engine. This system can allocate the suitable dynamic cycle time at the intersections. The system is connected to the hardware design to control the traffic lights and monitor congestion levels at the intersection using Arduino and Infrared Radiation (IR) sensors.
3	L. Paul Jasmine Rani; M. Khoushik Kumar; K. S. Naresh, "Dynamic traffic management system using infrared (IR) and Internet of Things (IoT)"	2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM)	This project plan to provide a automated IR-sense based solution that makes traffic signals to shift the lights (red/yellow/green) dynamically. We plan on implementing the project for one junction "Proof-of-Concept" for this paper, which includes traffic lights, IR-sensors, Wi-Fi transmitter and Raspberry Pi microcontroller. The sensed data gathered from IR sensor is transmitted by the Wi-Fi transmitter which is received by the raspberry-pi controller. Based on this compilation it dynamically shifts time of the red signal and the user gets an intimation of status of the signal on his way. The Raspberry Pi controller works as a central console, it determines which sideways of the road signal is to get open or close. The central console gathers all the data from sensors and stores it in the cloud which intimates traffic status to a mobile device.
4	Bilal Ghazal; Khaled ElKhatib; Khaled Chahine; Mohamad Kher, "Smart traffic light control system"	2016 Third International Conference on Electrical, Electronics, Computer Engineering and their Applications (EECEA)	Conventional systems do not handle variable flows approaching the junctions. In addition, the mutual interference between adjacent traffic light systems, the disparity of cars flow with time, the accidents, the passage of emergency vehicles, and the pedestrian crossing are not implemented in the existing traffic system. This leads to traffic jam and congestion. We propose a system based on PIC microcontroller that evaluates the traffic density using IR sensors and accomplishes dynamic timing slots with different levels. Moreover, a portable controller device is designed to solve the problem of emergency vehicles stuck in the overcrowded roads
5	Y M Jagadeesh; G.	2015 International	This paper is concerned with the development and

	Merlin Suba; S Karthik; K Yokesh, "Smart autonomous traffic light switching by traffic density measurement through sensors"	Conference on Computers, Communications, and Systems (ICCCS),	implementation of Sensor based Traffic Light System with Dynamic Control which in turn reduces the Average Trip Waiting Time (ATWT). It consists of IR sensors, Low Power embedded controllers, comparators and storage device.

3. NEED OF PROJECT

Conventional traffic lights are time-based. Due to this even if there is no vehicle waiting in the lane, lights turn green sequentially. This keeps vehicles in other lanes waiting unnecessarily. So to answer this issue, a sensing system is needed that will sense the traffic on the road and allot more or less time for a particular lane depending on traffic density.

4. OBJECTIVES OF PROJECT

The main purpose of this project is, if there will be no traffic on the other signal, one shouldn't wait for that signal. The system will skip that signal and will move on to the next one. The major objectives of the project are:

- Reduce the waiting time at a traffic signal
- Reduce the traffic with better time management
- Make dynamic time control possible 24x7

5. BLOCK DIAGRAM

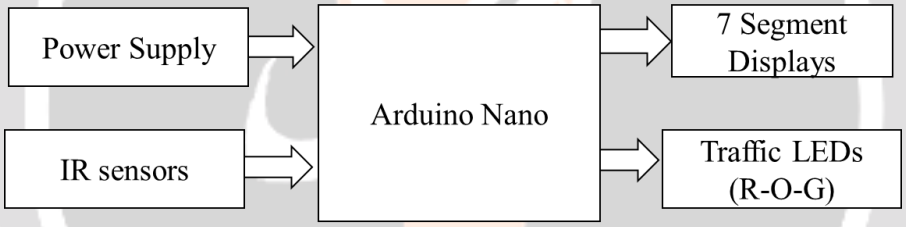

Fig -1: Block Diagram of System

5.1 Components used:

- Arduino Nano: The microcontroller used to process data from sensors and control the traffic lights.
- IR Sensors: Infrared sensors will be placed on either side of the road to detect vehicle presence.
- Traffic Lights: Standard red, yellow, and green lights controlled by the Arduino.
- 7segment display: used to display traffic time calculated by Arduino.
- Power supply is used to power up the complete system.

5.2 Working Principle

- Traffic Density Detection:
  The IR sensors will detect the presence of vehicles by sending and receiving infrared signals. As vehicles pass between the IR transmitter and receiver, the sensor detects the interruption in the IR beam.
- Data Processing:
  The Arduino Nano collects data from the IR sensors. The microcontroller processes this data to determine the density of traffic on each road segment.
- Dynamic Signal Timing:
  Based on the traffic density data, the Arduino adjusts the timing of the traffic lights. For example, if a road segment has a higher density of vehicles, the green light will stay on longer to allow more vehicles to pass through. Conversely, if there is low or no traffic, the light will switch to red quicker.

6. SYSTEM DESIGN

6.1 Circuit Diagram

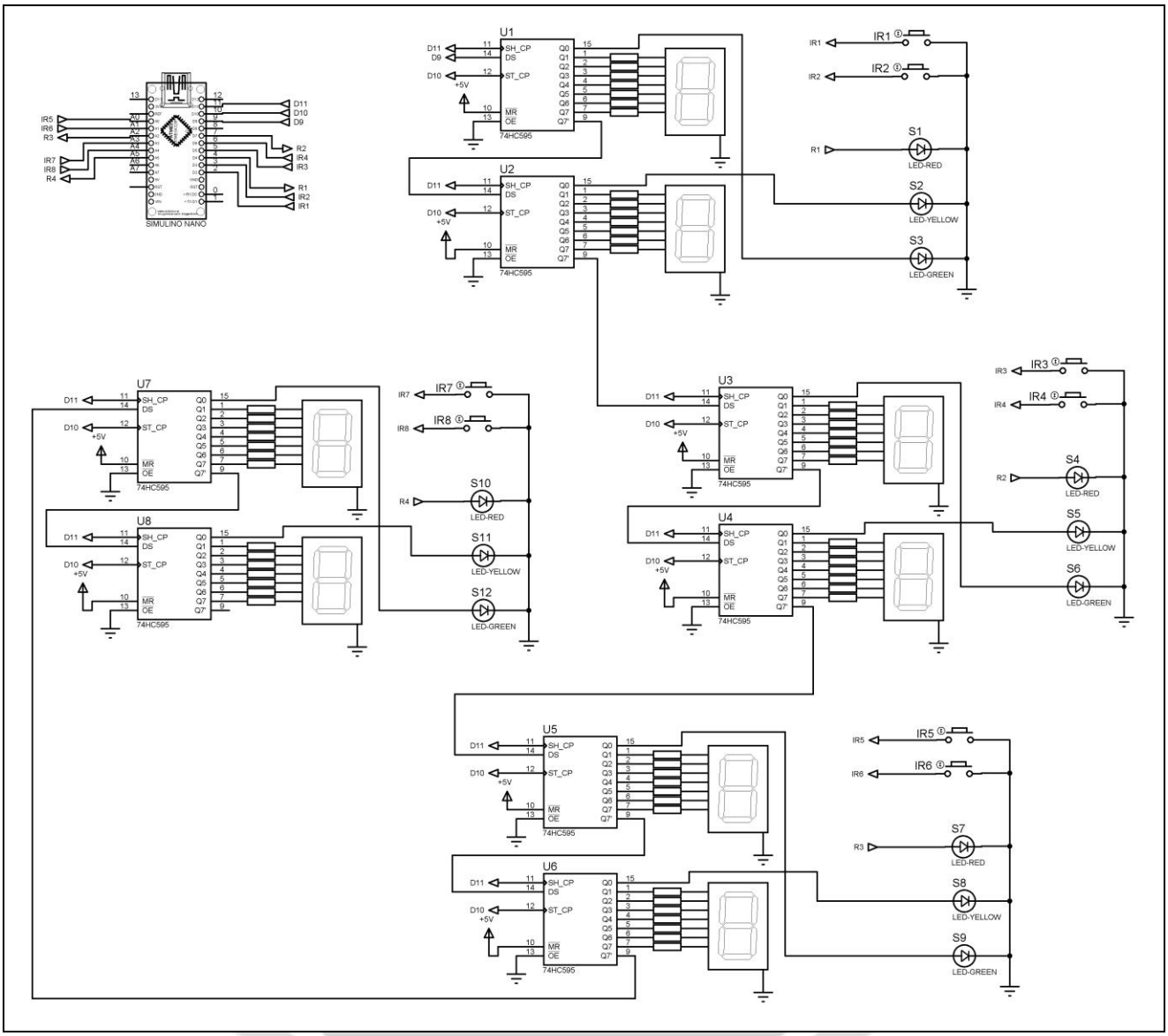

Fig -2: Circuit Diagram of System

6.2 Implementation Steps:

- Setup and Calibration:
  Mount the IR sensors on either side of the roads where traffic density needs to be measured. Connect the sensors to the Arduino Nano and ensure they are properly aligned to detect vehicle movement accurately.
- Programming the Arduino:
  Write a program that reads inputs from the IR sensors and calculates the traffic density. Implement a control algorithm that adjusts the traffic light timings based on real-time traffic data.
- Testing and Optimization:
  Test the system under various traffic conditions to ensure it accurately detects vehicle density and adjusts the signal timing appropriately. Fine-tune the sensor sensitivity and the timing algorithm to optimize performance.

6.3 PCB Layout Design

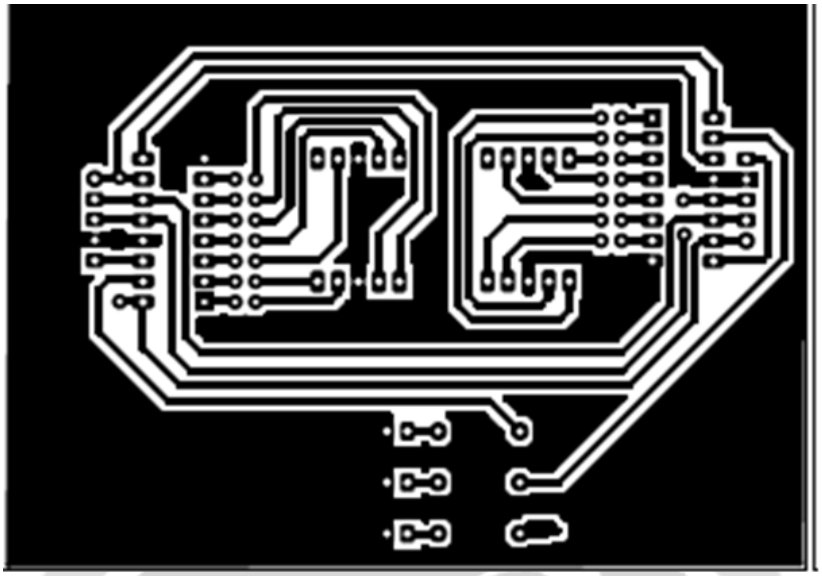

Fig -3: PCB Layout of System

7. RESULTS

Fig -4: Hardware Implementation of Prototype

Final System Specifications:

- System supply required: 5V DC, 2Amp
- Controller board used: Arduino Nano
- 2 digit 7 segment display to show time
- Standard red, green and orange LED indicators on traffic light
- 3 level traffic detection with 2 sensors in every lane
- Range of IR sensors used: 2-6cm Adjustable.
- Default low green time to avoid confusion and maintain sequence.

- Traffic density measurement and delay time calculation in every cycle
- Easy to replace traffic light module

The implementation of this system promises numerous benefits, including reduced waiting times at traffic lights, smoother traffic flow, and decreased vehicular emissions due to reduced idling. These improvements can lead to enhanced commuter experiences, better road safety, and a positive environmental impact by lowering the carbon footprint associated with traffic congestion.

Moreover, the scalability and cost-effectiveness of this solution make it a viable option for various urban settings, allowing cities to retrofit existing traffic signal infrastructures without extensive overhauls. The flexibility of the Arduino-based platform also provides opportunities for further enhancements and integrations with other smart city technologies, such as real-time traffic monitoring and emergency vehicle prioritization.

8. ADVANTAGES

Efficiency: Reduces waiting time at traffic signals by adapting to real-time traffic conditions.
Scalability: Can be implemented in various urban settings with different traffic volumes.
Cost-Effective: Uses relatively inexpensive components and can be retrofitted to existing traffic light systems.

9. LIMITATION

Sensor Accuracy: Ensuring the IR sensors are not affected by environmental factors such as rain, fog, or direct sunlight.
System Reliability: Maintaining consistent performance and handling hardware failures or malfunctions.

10. CONCLUSION & FUTURE SCOPE

The density-based dynamic traffic signal control system developed in this project addresses the pressing issue of urban traffic congestion with a smart, adaptive approach. By utilizing an Arduino Nano microcontroller and IR sensors to measure real-time traffic density, our system can dynamically adjust traffic light timings to optimize vehicle flow through intersections. This innovation offers a significant improvement over traditional fixed-time traffic signal systems, which often fail to respond to fluctuating traffic conditions effectively.

Despite the challenges posed by sensor accuracy and system reliability under different environmental conditions, our project demonstrates that with proper calibration and robust programming, these issues can be effectively managed. Future work can focus on refining the sensor technology, improving the algorithm's responsiveness, and conducting extensive field tests to ensure optimal performance in diverse traffic scenarios.
In conclusion, this project represents a forward-thinking step in urban traffic management, paving the way for smarter cities with more efficient, responsive, and sustainable traffic control systems. By harnessing the power of real-time data and automated control, we can significantly alleviate the burden of traffic congestion and contribute to more livable urban environments.

11. REFERENCES

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[2] Islam Mohammad Albatish; Samy S. Abu-Naser, “Modeling and Controlling Smart Traffic Light System Using a Rule Based System”, 2019 International Conference on Promising Electronic Technologies (ICPET), 2019.
[3] L. Paul Jasmine Rani; M. Khoushik Kumar; K. S. Naresh, “Dynamic traffic management system using infrared (IR) and Internet of Things (IoT)”, 2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM), 2017.
[4] Bilal Ghazal; Khaled ElKhatib; Khaled Chahine; Mohamad Kher, “Smart traffic light control system”, 2016 Third International Conference on Electrical, Electronics, Computer Engineering and their Applications (EECEA) 2016
[5] Y M Jagadeesh; G. Merlin Suba; S Karthik; K Yokesh, “Smart autonomous traffic light switching by traffic density measurement through sensors”, 2015 International Conference on Computers, Communications, and Systems (ICCCS), 2015