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Research Article

Fleet Management using Smart Technology

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Abstract

This report details the development of a prototype system designed to manage traffic at intersections using smart technology. The main goal of the project is to create a system capable of detecting vehicles and managing traffic signal lights in real-time. In the final version, the system will use sensors installed on a device to detect vehicles and adjust traffic lights accordingly. At the prototype stage, however, the focus is on a simplified model where traffic lights are controlled using an Arduino or PCB. In this setup, digital counters simulate traffic by recording the number of vehicles on each road.

The physical environment we created for this prototype replicates a typical intersection. Traffic lights change based on the counts from these digital counters, which helps us understand how traffic signals can be dynamically managed. This hands-on approach provides a clear demonstration of how such a system can operate and lays a solid foundation for future developments. Ultimately, the aim is to enhance traffic management and fleet efficiency by integrating smart technology that can respond to real-time traffic conditions, reducing congestion and improving the flow of vehicles.

Keywords: Arduino, Prototype, Internet of Things, Smart Technology, Vehicles

INTRODUCTION

Traffic lights, or traffic signals, are devices placed at road intersections, pedestrian crossings, and other locations to control the flow of traffic. They use a system of coloured lights (red, yellow, and green) to indicate when vehicles should stop, prepare to stop, or proceed. The first electric traffic light was installed in 1914 in Cleveland, Ohio. Since then, traffic lights have become a key part of modern road networks, significantly streamlining traffic flow. By organizing the movement of vehicles and pedestrians, traffic lights help reduce the likelihood of accidents and improve safety at intersections. They also aim to minimize traffic delays by managing the sequence and timing of the lights based on fixed schedules or, in more advanced systems, real-time traffic conditions. Despite their effectiveness, traditional traffic lights still face challenges, especially in handling variable traffic patterns and coordinating with nearby intersections. This is why ongoing advancements in traffic light control systems are crucial for enhancing traffic management in our increasingly congested cities [1-2].

Traffic light control systems are used a lot to manage how cars move through road junctions. Their main goal is to keep traffic flowing smoothly. But making multiple traffic lights at nearby intersections sync up is tricky because there are so many different things to think about. Regular systems don't handle changing traffic flows very well. Plus, they don't account for how traffic lights at different intersections affect each other, or how traffic can change over time. They also don't handle accidents, emergency vehicles passing through, or pedestrian crossings well. This often results in traffic jams and congestion. To fix this, we're proposing a system that uses IR sensors, and possibly GPS data under the control of a microcontroller to measure traffic density with IR sensors and adjust the timing of the lights dynamically. We've also designed a portable controller to help emergency vehicles get through crowded

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roads.

Therefore, it has become quite important for us to improve and upgrade our old technologies and integrate the smarter solutions to achieve the varying benefits it proposes [3-7].

PROPOSED MODEL – SMART TRAFFIC SIGNAL

We humans have realized, that the transportation is the one of the most important factor when it comes to growth of a country, time after time has it come to our mind, the need of a smoother transportation channels, from the establishment of hand carts to the most advanced aircrafts, But with every idea and concept comes its saturation, hence the need for an alternate improvement comes into play to improve the main goal, and that's where the traffic signals come. But further improvements require smarter technologies, which are fast, smart, dynamic, cost efficient, and much more capable to handle more difficult and demanding situations.

A smart traffic signal system offers several cutting-edge features that make it much more efficient than traditional setups. First off**,** real-time traffic detection uses sensors at intersections to continuously monitor vehicle flow and send this data to a central control system. With this data, the system can perform dynamic signal control, adjusting the timing of traffic lights based on actual conditions. For example, it can keep green lights on longer for busy roads or shorten red lights where there's less traffic. Another great feature is adaptive energy management**,** which helps save energy by dimming or even turning off lights during low traffic periods and uses predictive analytics to optimize energy use according to expected traffic patterns. Emergency response integration is also a big plus, allowing the system to prioritize emergency vehicles by clearing intersections or creating green corridors for them. Additionally, the system utilizes data analytics for optimization to analyse past and current traffic data, continually refining signal timings to make traffic flow smoother and reduce congestion. By adopting these smart features, cities can improve traffic management, lower environmental impacts, and enhance the commuting experience for everyone [6-9].

Proposed Solution: -

1. Real-time Traffic Detection: Sensors installed at intersections can detect the vehicles and monitor traffic flow continuously. This data will then be transmitted to a central control system.
2. Dynamic Signal Control: Using this real-time data, smart traffic signals can adjust their timing dynamically. For instance, signals can extend green lights for roads with heavier traffic or shorten red lights for less congested intersections.
3. Adaptive Energy Management: During periods of low traffic, signals can dim or switch off lights to conserve energy. They can also use predictive analytics to optimize energy usage based on anticipated traffic patterns.
4. Emergency Response Integration: Smart signals can prioritize emergency vehicles by clearing intersections or adjusting signals to provide a green corridor.
5. Data Analytics for Optimization: The setup can study past and current traffic info to always improve how long signals stay on, making traffic smoother and cutting down on jams.

By integrating smart technology into traffic signal systems, cities can achieve more efficient traffic management, reduce environmental impact, and enhance the overall commuting experience for residents and visitors alike [10].

Getting to a fully smart traffic signal system is going to be tough and won't happen overnight. There are a lot of hurdles, like installing sensors, making sure they send accurate data, and getting that data to a central control system. Plus, figuring out how to adjust signal timings dynamically in real-time needs solid algorithms and constant tweaking. It's also tricky to set up energy-saving features and make sure emergency vehicles get through intersections smoothly without getting stuck. So, we'll take it step-by-step by starting with smaller, simpler models focusing on key features. For instance, we might first put sensors at a few intersections and work on fine-tuning how we adjust the signals based on traffic flow. Once that's running well, we can add in energy management and emergency response features. Each step will involve testing and improving based on what we learn. By rolling out these features gradually, we can handle the challenges bit by bit and eventually build a fully smart system that really makes traffic management better and helps everyone have a smoother commute.

PROTOTYPE -

In the passages leading to this section, we discussed how the final product will be efficient and described how the main device will function. However, landing on the final product is a long walk, with multiple milestones, and multiple versions/prototypes. Before we get to the finish, we need to start from the bottom, incorporate important features and advance from there through multiple versions.

In the first prototype of our smart traffic signal project, we have created a model that reflects key features of the final system: real-time traffic detection, dynamic signal control, and adaptive energy management.

- To see how traffic flows, we use digital counters that show how many cars are on the roads. These counters tell us how busy an intersection is by counting vehicles.
- We then show how traffic lights can change in real-time using small LED lights. These LEDs adjust when they change colour based on the counts from the digital counters. For example, if a road has lots of cars according to the counters, the green light stays on longer. This is like how the final system will work, adjusting signals based on real traffic.
- For saving power, the prototype also shows how lights can get dimmer, blink, or turn off when no cars are detected for a while. This cuts down on energy use during quiet times, such as late at night, just like the final system will do.
- This prototype effectively shows how smart traffic lights can manage real traffic efficiently and save energy, giving us a solid foundation for future development. 3D view of PCB (Arduino Based) is sown in figure 1.

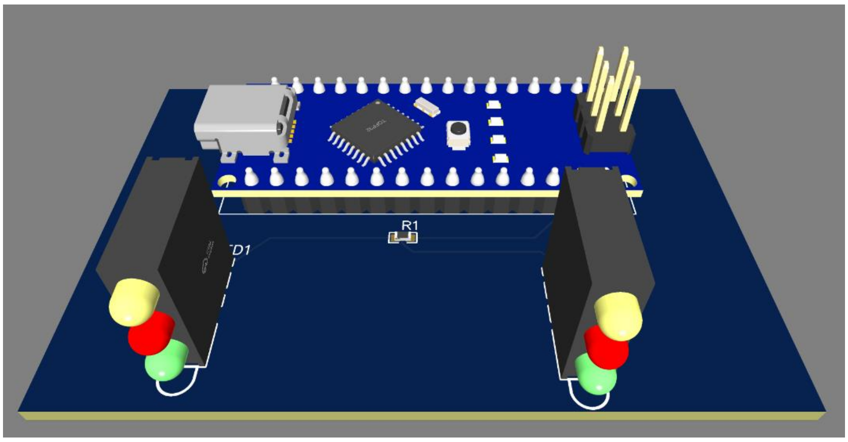

Figure 1. – 3D view of PCB (Arduino Based)

For the initial phase of creating a smart traffic signal prototype, we needed various hardware components and tools to set up and run the model effectively. Here's a list of the key items:

Hardware Components

1. Arduino Board
    a. Purpose: The main microcontroller used to control the LEDs based on input from the digital counters.
    b. Example: Arduino Uno
2. LED Lights
    a. Purpose: Represent traffic signals in the prototype.
    b. Types: Red, yellow, and green LEDs
3. Digital Counters

   a. Purpose: Simulate vehicle counts and provide input to the Arduino.
   b. Example: 7-segment display or similar counter module
4. Resistors
   a. Purpose: Limit current to the LEDs to prevent them from burning out. -Types: Typically, 220 ohm or similar, depending on your LED specifications
5. Breadboard
   a. Purpose: Used to prototype circuits without soldering.
   b. Example: Standard-sized breadboard
6. Jumper Wires
   a. Purpose: Connect components on the breadboard and link them to the Arduino.
   b. Types: Male-to-male, male-to-female, and female-to-female
7. ICs (Integrated Circuits)
   a. Purpose: For any additional logic or control functions needed (if applicable). - Example: Timer ICs like the 555, or logic ICs like the 7400 series
8. Power Supply
   a. Purpose: Provide power to the Arduino and other components.
   b. Example: USB power adapter or battery pack for Arduino
9. Cables and Connectors
   a. Purpose: For powering and connecting various components.
   b. Example: USB cables, power connectors
10. Enclosure/Model Base
   a. Purpose: A base or box to hold and organize the components neatly.
   b. Example: Small plastic or cardboard box

The 3D Top/Bottom View of PCB (Arduino Based) is shown in figure 2.

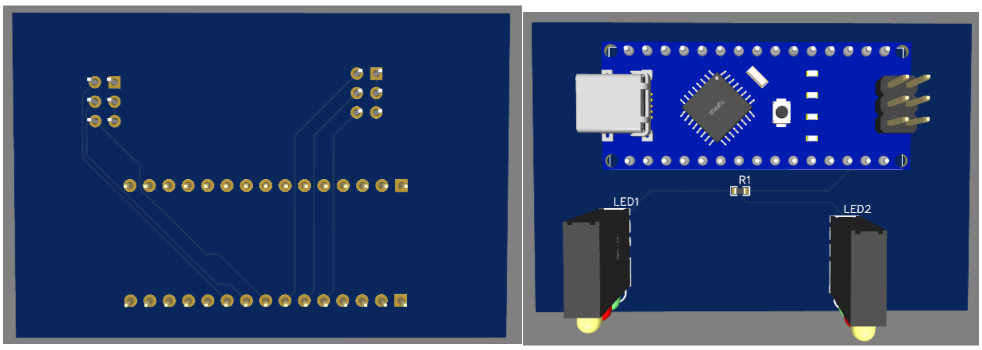

Figure 2 – 3D Top/Bottom View of PCB (Arduino Based)

Software Skills and Tools

1. Arduino Programming
   a. Skills Needed: Basic knowledge of C++ or Arduino-specific syntax.
   b. Tools: Arduino IDE (Integrated Development Environment)
2. Circuit Design
   a. Skills Needed: Understanding of basic electronic circuits and components.
   b. Tools: EasyEDA and visualizing circuits
3. Embedded Systems
   a. Skills Needed: Knowledge of microcontrollers and how to interface them with sensors
   b. Tools: Familiarity with libraries for handling input/output on the Arduino
4. Basic Troubleshooting
   a. Skills Needed: Ability to diagnose and fix issues in both hardware and software.
   b. Tools: Multimeter for checking connections and voltages
5. Simulation and Testing
   a. Skills Needed: Skills to simulate and test the setup before deployment.
   b. Tools: Proteus or other simulation software (optional but helpful)

6. Documentation
    a. Skills Needed: Keeping track of your design, code, and troubleshooting steps.
    b. Tools: Markdown editors or word processors for writing documentation

By having these hardware components and software skills/tools, we were well quipped to build, program, and test our smart traffic signal prototype effectively.

FUNCTIONING

The device was programmed using an Arduino Uno Board, for the initial prototype, and the following figure displays the schematic is shown in figure 3.

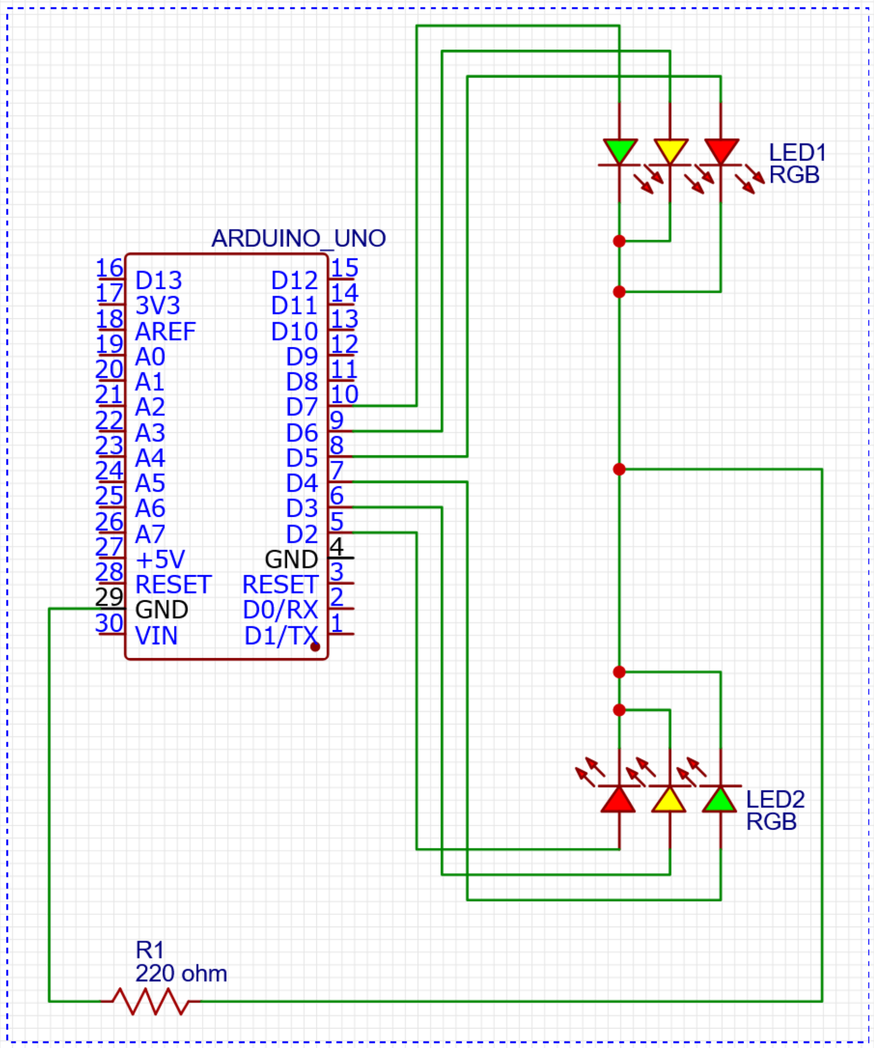

Figure 3. – Schematic of Prototype

This Figure 3. shows, the pins from D2 (pin 5) to D7 (pin 10) were used to connect to the RGB LEDs and they were all connected in parallel to each other, while the resistor (220ohm) was connected in series to all these pins.

The flow chart of the prototype is as follows, which display how the flow the program and its functioning will behave.

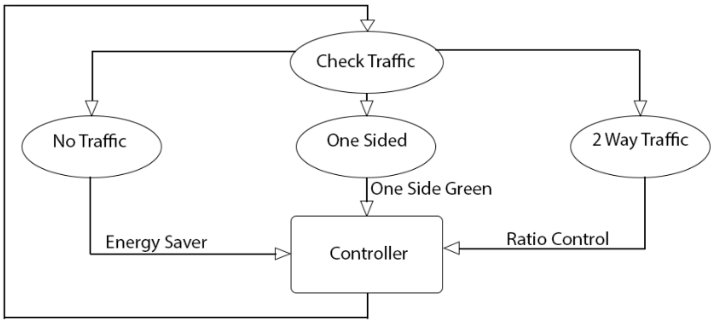

Figure 4. – Flow Chart of proposed system

This Flow chart (Figure 4) explains the situation very well, the device is kept powered (however the traffic signal is powered, or possibly solar powered), and the device checks for traffic via sensors at stage 1. Following this this it determines the which method to opt for, No traffic, One Sided Traffic, or 2 Way Traffic. For No Traffic, the device is managed to conserve signal power. This feature specifically helps in times of less crowd.

Following this we have one side control, where the green signal is turned ON permanently, till traffic is cleared, or when traffic from another lane also appears. This allows for traffic management when traffic Is not present on the alternate lane, it significantly improves the time, and efficiency for such a case as no green signal time is spent on the empty lane.

For the third case, when both lanes have traffic, in this scenario, the sensors play an important role, they are used for detecting, analysing, comparing traffic among both the lanes, and according to the traffic ratio, the green lights and red lights are managed. Here the aim is not preserving time on a large scale, but rather on an individual level, ensuring no individual must wait more than the other, and all traffic is treated equally, and the burden is distributed among the entire crowd.

RESULT

With the device out of the way, the Output is the primary concern. We have listed below the programming spent into making this possible, it describes all the 3 possible states of the 2-way traffic signal management, The results for each are aimed to achieve the same goal, that is to clear the traffic, but the difference arises, on what the importance is given to while achieving that aim.

For The first case, where there is no traffic, this importance is given to energy saving, as described earlier, the device controls the traffic signals red light by either turning it off, or blinking the red light to save energy, another workaround is to set brightness to low. Alternatively, it could be a mix of the above stated methods, i.e dimming the lights while blinking it.

The second, scenario is when there is traffic only one side of the intersection. Here the traffic signal is made to display green light for as long as either the traffic gets cleared, or some traffic appears on the other side the intersection. Here our device is made useful, by not wasting any green light time on an empty lane.

The third case is the most complicated, and this is the case when the device is focused to manage the heavy traffic flow as smoothly as possible. In this case multiple goals can be achieved while controlling the traffic flow. The first being energy saving and most efficient which allows the traffic from either side to flow for the longest period before altering the signal. The second case is when the signal is quickly changed, here the traffic keeps moving, the overall frustration is lower, but this is highly inefficient since, there is more yellow signal time, and riskier since it can cause confusions. The third case is when the traffic is analysed, and the green and red lights are controlled so that every car must wait almost equal time as everyone else. The third approach is most reasonable, and it’s based on the ratio of traffic on both sides. This is not only morally right but also maintaining it such that both the lanes get almost equally traffic free

CONCLUSION

1. What is IoE?

To wrap up, IoE (Internet of Everything) is all about connecting people, processes, data, and things into one big network. This helps devices talk to each other and share data, making decisions smarter and everyday tasks easier. It's about making everything work together better, from gadgets to systems, which helps in saving time and improving efficiency.

2. Regions for Integration of IoE

In short, IoE can be used in a lot of places like smart cities for managing traffic and energy, healthcare for checking on patients remotely, retail for better inventory tracking, and farming for more accurate crop monitoring. Each area uses IoE to get real-time info and automate stuff, which makes everything run smoother and cheaper.

3. Traffic Signals – Working, Issues, Efficiency, Workaround

In conclusion, traditional traffic signals usually stick to fixed timings and can't adapt to real-time traffic, causing delays and wasting energy. Our smart system uses real-time data to adjust signal timings based on actual traffic, which helps cut down congestion and save power by only using signals when needed.

4. Fleet Management Device Final Product Aim

The goal for our Fleet Management Device is to use IoE to keep track of vehicles in real-time. This means we can plan routes better, cut down on costs, and keep the fleet running smoothly by knowing exactly where each vehicle is and how it's doing, making fleet management quicker and more efficient.

5. Prototype – Aim, Environment, Devices, Tools Used

To sum up, our first prototype shows how smart traffic signals can work by using LEDs for lights and digital counters to track traffic. We built it with an Arduino, which helps the lights change based on how much "traffic" we detect, showing that dynamic adjustments can improve traffic flow and save energy, setting us up for the full system later.

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