

Traffic Control System

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ABSTRACT

Due to the rapid growth of cities and the increased number of vehicles on roads, traffic congestion has become a serious problem in today's urban areas. Most of the existing traffic signal systems are still based on fixed timing approaches and do not take into account the real-time traffic conditions. This results in increased waiting times at traffic signals, unnecessary fuel consumption, and environmental pollution. To address these problems, this paper proposes an IoT-based smart traffic light control system that has the capability to adjust traffic signal timings based on the real-time traffic density. Smart sensors installed at road intersections are used to detect the presence of vehicles and estimate traffic load, and an IoT-based controller analyzes the information and decides appropriate green signal times for each lane. Furthermore, the proposed system also offers centralized monitoring of traffic conditions through a web-based interface, enabling traffic authorities to monitor traffic conditions in real time and take necessary actions to alleviate congestion. The experimental results and analysis clearly indicate that the proposed system is effective in reducing average waiting time, improving overall traffic flow, and minimizing vehicle idle time compared to the existing fixed-time traffic signal systems.

Keywords: Traffic Light System, Arduino, Image Processing, Camera, Vehicle counting, Traffic Density

1. INTRODUCTION

Traffic congestion is a persistent problem with existing transportation infrastructure in most modern cities. Unprecedented urban development, population growth, and dependence on private cars have led to an ever increasing burden on the existing road network. Many cities use traditional traffic signals for intersection control. These operate on fixed time schedules which is extremely inefficient for unpredictable and dynamic traffic conditions, especially during peak hours, thus, causing increased vehicle waiting time, fuel consumption, and harmful emission.

With the proliferation of communication and sensing technologies, there is a pressing need for intelligent traffic management systems which are capable of responding dynamically to traffic conditions. The concept of the Internet of Things (IoT) provides a suitable technology to address such challenges with its capability to collect, transmit, and analyze data from connected devices in real-time. It enables a system to sense vehicle presence and traffic load at different intersection lanes, process this information in real-time using the IoT enabled controller, and adapt the traffic signal timing accordingly. This would improve traffic flow efficiency and reduce congestion without large capital investments on infrastructure expansion.

The main goal of this research is to design and develop an IoT based intelligent traffic light control system where the signal timing can be varied based on real time vehicle density at an intersection. Smart sensors at road intersections detect the presence and traffic flow, collect data about it and transmit it to an IoT enabled controller where optimum signal durations for each lane can be decided based on the vehicle density. The system would also support a web-based user interface for remote monitoring of traffic conditions, thus assisting the traffic authorities to take necessary actions upon detection of severe traffic congestions.

This system would contribute to decreasing the average waiting time, minimize the vehicle idle time, increase overall traffic movement through the intersection, and represent a scalable and efficient solution for traffic management, paving the way for intelligent transportation systems and overall smart city solutions.

2. Problem Statement

Due to the rapid growth of population, there is a corresponding increase in the number of vehicles, which has made traffic congestion a major issue of concern in many urban centers. A large number of current traffic intersections use traditional

traffic signals. The operation of fixed-time traffic signals is similar each and every day, regardless of the prevailing traffic conditions. The operation of fixed-time traffic signals is not effective in responding to changes in traffic volume. In some intersections, there is unequal distribution of traffic volume, i.e., some directions may be congested, while others may be less congested. The fixed-time traffic signals allocate equal green time for all approaches, resulting in increased idling, fuel consumption, and emissions. This results in a poor driving experience, especially during peak hours, and increases the probability of accidents.

2. Objective

The overall aim of this work is to design a smart traffic light controlling system based on IoT to efficiently and dynamically control the traffic at the intersection of the roads. This work is going to control traffic signal based on the density and traffic conditions rather than predefined fixed signals.

The specific objectives of the work are:

1. To study about the limitations and drawbacks of existing traffic light control systems and demonstrate the need of adaptive traffic control.
1. To design the system that utilizes smart sensors to gather real-time traffic density from road intersections.
2. To design an IoT-enabled controller that analyzes the collected data and assigns the desired green signal time to the roads.
1. To provide a central control using a web interface for authorities to monitor the traffic and take an action accordingly, in case of traffic jams.
1. The system developed will be able to decrease the waiting time of the vehicles and control the traffic efficiently, leading to a decrease in the fuel consumption and pollution.
1. To design a system which is economical and can be implemented at large scale in smart cities.

4. LITERATURE REVIEW

4.1.Existing modeling approaches for traffic control systems

Traffic control has been studied from two major perspectives in the literature, signal timing optimization based on global system behavior and implementation of traffic control logic within operation frameworks. Initially, traffic control systems were developed to be operate using fixed signal cycles designed to cater for average traffic conditions.

One of the early approaches that is being used in the modeling of traffic control systems is the Finite State Machine (FSM) modeling approach where the dynamics of traffic signals are modeled as finite states and state transitions which are activated by event triggers. FSM models have proven successful in simple intersections but have significant limitations when dealing with complex, distributed systems as they lead to 'state explosion' where the number of states grows beyond reasonable levels to handle.

A further common approach involves optimization using mathematical programming. The logic is centered around optimizing the signal timing for a specific set of objective functions that capture the desired global system performance such as traffic throughput and traffic delay. These models yield optimal solutions but depend heavily on idealized and simplistic traffic assumptions and tend to perform poorly when dealing with real-world traffic flow conditions that are stochastic in nature.

1.2.Advanced Modeling Methods

Due to shortcomings in traditional techniques, various advanced methods to model traffic control system have been developed by researchers. State chart technique, an enhancement of finite state machine by supporting hierarchical decomposition and parallel states, can model traffic system at different abstraction levels and can accommodate large system. Broadcast synchronization is another mechanism which is supported in state chart technique. It has been successfully applied in modeling of manufacturing systems, communication networks, and air traffic control systems.

In recent years, artificial intelligence (AI)-based techniques have been of increasing interest in traffic signal control. A lot of researches adopted methods including fuzzy logic controller, genetic algorithm, artificial neural networks and reinforcement learning to design an adaptive traffic control strategy. Fuzzy logic controllers, with the capability of handling imprecise

sion and uncertainty of traffic data, are among the favorite technique and intelligence methods are more flexible than a rule based system so it can adapt traffic signal control in more intelligent way.

1.1.Real Time Traffic Monitoring and Sensing Real-time traffic monitoring has been recognized as one of the essential functions of intelligent traffic control systems. Various sensing techniques are employed for collecting relevant traffic information at road intersections. Low-cost, easily installed Infrared (IR) sensors are quite popular. The principle of IR sensor is based on a transmitter-receiver pair, which detects a vehicle by receiving the IR signal transmitted by it. As the vehicle passes across, it breaks the IR beam and the detection event can be recorded and used to update the count.

1.2.

Image processing, another widely used technique, involves the usage of cameras and sophisticated computer vision tools, which would provide more information regarding traffic intensity and flow with higher complexity and requirements for high computation ability and lighting condition.

1.1.Emergency Vehicle Congestion Management. To cope with emergency vehicles is one of the most important requirement in present smart traffic system. Multiple research have proposed giving priority to the emergency vehicles such as ambulances, fire trucks, and police cars in order to minimize the response time. A general approach of many proposed system is to provide an alarm signal or pre-emption signal which is sent to neighboring traffic signal controllers by the approaching emergency vehicles.

Most of the GPS system provides real-time location tracking of emergency vehicle to find an appropriate route for the traveling emergency vehicles. It also provide handheld or portable controller for manual control to change traffic lights to emergency modes when they are needed. Some of them also provides interfaces to communicate with traffic control center for smooth and safe passage for the emergency vehicles in the congested regions.

5. Existing System

Currently, the most commonly used method for controlling traffic flow in urban centers is the fixed time traffic signal system. Under this system, the time allocated for the different phases of the traffic signal remains fixed and cannot be adjusted or respond in any way to the traffic conditions at the time. As a result, regardless of the traffic density at an intersection, the different directions are allocated specific amounts of time for green, yellow, and red lights. One major challenge with the current traffic control system is that it does not in any way take into consideration the traffic density on individual roads. For instance, a road with minimal traffic density may still be allocated the standard green light period, while other roads with high traffic density are made to wait for long, thereby creating unnecessary traffic queues. These problems are mainly experienced during peak hours, especially when the traffic density on individual roads is very high. Another major challenge with the traditional traffic control system is that it does not in any way respond or adjust to changes in traffic density on individual roads. The current system also does not in any way prioritize the passage of emergency vehicles, and in most-cases, these traditional traffic control systems are not centrally monitored, which affects the traffic controllers' knowledge of the current conditions.

6. PROPOSED SYSTEM ARCHITECTURE:

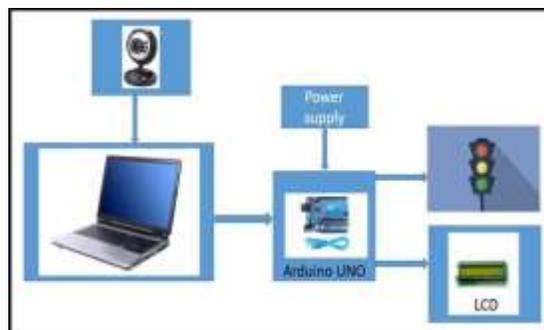


Figure 1: block diagram for traffic light system

The following section presents a block diagram of the proposed smart traffic light control system. The primary aim of this system is to control the traffic signals based on real-time traffic density using image processing techniques in conjunction with a microcontroller. As mentioned, a camera will be installed near a traffic junction, capturing real-time images of the road. The images will be transmitted to a computer system, and image processing algorithms will be applied to identify the presence of vehicles and calculate traffic density for each of the lanes. The highest traffic will be computed for a specific

road. The processed traffic data will be sent to an Arduino UNO microcontroller, which will be used as a central controller. The computer will send a signal to the Arduino UNO, which will be used to control the time period of the Green, Yellow, and Red signals. A power supply will be connected to the Arduino UNO microcontroller, ensuring proper functioning of the system. The power will be transmitted to the microcontroller, which will be used to control the traffic signals. The lanes with the highest traffic will be provided a longer green signal, thereby resolving traffic congestion. An LCD will be interfaced with the Arduino UNO microcontroller, which will be used to display the parameters.

6.1. Hardware module:

- ❖ Arduino UNO.

- ❖ Traffic light (Red, Green and Yellow)

- ❖ LCD.

- ❖ Camera.

- ❖ Power supply.

- ❖ Personal computer or laptop.

1.1. Software module:

- ❖ Arduino IDE.

- ❖ MATLAB.

- ❖ Prolific.

- ❖ Win video (camera).

1. Methodology

1.1. Image Acquisition

Image acquisition is where the system begins. The image, in this case, can be regarded as a two-dimensional function where each point in the image has a brightness associated with it.

However, for a computer to be able to process an image, an image captured using an analog medium must be digitized or translated into a digital form.

1.2. Image Cropping

Image cropping is the next step in processing. Cropping is a technique used by image processing systems whereby a region of interest in an image is identified, with irrelevant areas cropped out. In a traffic system, only a region of interest where there is movement of vehicles is needed, while areas like buildings, trees, and sky, which are not of interest, are cropped out.

1.3. Image Matching

Image matching is used for the identification and detection of the target object in the image by comparing it with the available set of images. The input image is matched with the available set of patterns, and once the image matches, the vehicles and density are calculated.

1.3. Image Scaling

Image scaling is used for resizing the image to the required size for the application. When an image is captured, it may not be in the required size, and resizing may be required for the application.

1.3. Image enhancement:

Image enhancement is a form of image processing wherein tweaks are made to digital images so that their results look good for display or for analysis. For instance, noise reduction can be done so that the key features become easily identifiable. In low-contrast images, the adjacent characters tend to spread out in the background after smoothing. We would like to minimize this spreading of characters before any limit is imposed on the image itself.

1.4. Color detection:

Color detection, as the name itself indicates, is a part of image processing wherein items are identified based on their color. When a given image is being processed, and it consists of different colored objects, and only a specific color object needs to be extracted, then color detection results in a binary image, i.e., only the identified color is displayed as white, and all other areas of the image become black.

1.5. Blob Detection

Blob detection techniques are applied to spot the areas where the intensity or color is different from the other areas of the image. A particular range is set to check whether the area needs to be checked if it falls under that particular range. Otherwise, it is considered to be a noisy image and is eliminated.

1.6. Object counting:

To count the number of objects present in the image, the boundaries of the objects are first identified. The outer boundaries of the objects and the boundaries of the openings present inside the objects are considered to find the number of objects present in the particular area.

1.4. Traffic density:

Next, the number of vehicles present on the road needs to be calculated for the particular area. The signals are processed based on the density of the traffic present on the road. The traffic signal is controlled based on the density of the traffic present in the particular lane or road. Images are captured to change the signal as per the density of the traffic present on the road.

8. **Proposed Algorithm**

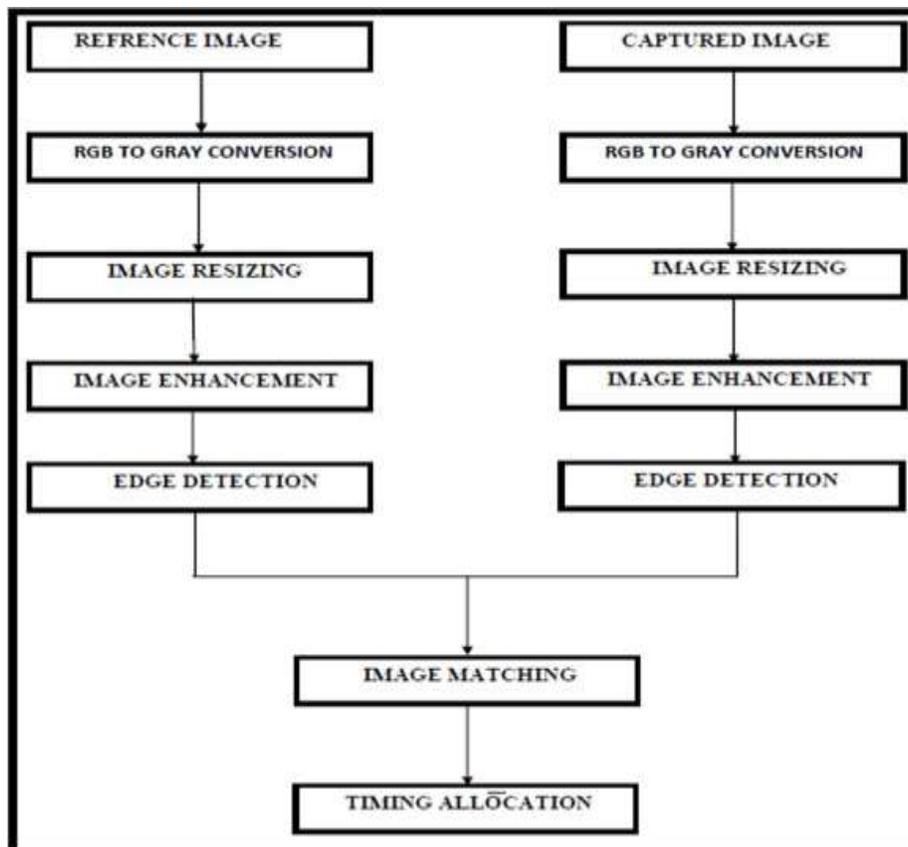


Figure: proposed algorithm for traffic light system

9. Working module

A camera is placed at a busy intersection to monitor the flow of vehicles. The live images from the camera are captured and processed using a computer. The images are then saved in the form of a video. The saved video is then processed further to obtain images, which are then input into the system. To only monitor the road, the images are cropped to remove the unwanted areas around the road. The images are then processed using image enhancement techniques to obtain clear images. The vehicles are detected using pattern matching and color information in the images. The density of vehicles in a particular lane is calculated by determining the number of vehicles in the images.

The density information is then processed using an Arduino UNO microcontroller. The density information from all the lanes is processed using the microcontroller. The microcontroller then determines which lane is congested. The microcontroller then gives a longer green signal to the congested lane and a shorter green signal to the less congested lane. The signals are changed from red to yellow to green using the microcontroller. A change from green to red is made through yellow to avoid chaos in the system. The system also has an LCD display to display the system's status and other relevant information.

This process is continuously repeated to monitor the changes in the traffic system.

1. CONCLUSION

We have proposed a smart traffic light system using IoT technology. The traditional traffic signals, which change after a specific period of time, do not adapt according to the changing nature of traffic. They are not effective in controlling traffic. The traditional signals cause traffic jams, longer halting times, fuel consumption, and pollution. The proposed system will change signals according to the actual traffic density at the intersection.

1. REFERENCES

- [1]. [1]Georgios Vigos, Markos Papageorgioua, Yibing Wangb, “Real-time estimation of vehicle-count within signalized links”, Journal of Transportation Research Part C: Emerging Technologies, Volume 16, Issue 1, pp.18–35, February 2008.