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A Review Paper on Smart Traffic Light Control System

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ABSTRACT: The traffic issue is very complex owing to the participation of many variables. First, traffic flow is affected by the time of day, with peak hours generally being in the morning and afternoon; by the days of the week, with weekends showing the least amount of traffic and Mondays and Fridays showing dense traffic oriented from cities to their outskirts and backwards; and by the season, with holidays and summer showing the most traffic. Traffic light control systems are often used to monitor and regulate the flow of vehicles at intersections. They want to ensure that vehicles move smoothly along transportation corridors. However, considering the numerous factors involved, synchronizing several traffic signal systems at nearby junctions is a difficult issue. Variable flows approaching intersections are not handled by traditional methods. Furthermore, the current traffic system does not include mutual interference between neighboring traffic signal systems, disparities in automobile flow with time, accidents, emergency vehicle passage, and pedestrian crossing. As a result, there is a traffic bottleneck and congestion. We present a system based on a PIC microcontroller that uses IR sensors to assess traffic intensity and implements dynamic time slots of varying intensities. Furthermore, a portable controller device is being developed to address the issue of emergency vehicles being trapped on congested highways.

KEYWORDS: Direction, Dynamic, Road, Sensor, Traffic Light.

1. INTRODUCTION

Traffic lights, which have been in use since 1912, are signaling devices used to regulate traffic flow at road junctions, pedestrian crossings, rail trains, and other places. The green light enables traffic to continue in the specified direction, the yellow light advises cars to prepare for a brief halt, and the red light prevents any traffic from continuing [1].

Many nations are now dealing with traffic congestion issues that are wreaking havoc on city transportation systems and posing significant challenges. Despite the fact that automated traffic systems have replaced traffic cops and flagmen, optimizing severe traffic jams remains a significant challenge, particularly with many junction nodes. The fast growths in the number of cars on the road and the ever-increasing number of road users are not supported by improved infrastructures with enough resources. Construction of additional highways, the implementation of flyovers and bypass roads, the creation of rings, and road repair were all partial answers [2], [3].

Second, the present traffic signal system uses hardcoded delays, in which the light transition time slots are set on a regular basis and are not affected by real-time traffic flow. The third issue concerns the status of one light at a junction that has an impact on traffic flow at other intersections. Furthermore, the traditional traffic system ignores the effects of accidents, construction, and breakdown vehicles, all of which exacerbate traffic congestion. Furthermore, a critical problem is the seamless movement of higher-priority emergency vehicles such as ambulances, rescue vehicles, fire trucks, police, and VIPs through junctions, which may get

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trapped in the throng. Finally, people who cross lanes have an impact on the traffic system [4], [5].

In large cities and cities in which the metropolitan area has a percentage of its infrastructure and economy centered around an airport, a large percentage of the population travels the streets. Traffic jams are frequent and contribute to lower efficiency in people's work. The objectives of airport and surface transportation planning objectives are to ensure maximal access to airports and business sites with minimal time and cost. The time and cost of connectivity supersede space and distance as the primary planning metrics. It is not the speed, but the time required for firms to connect to their suppliers, customers, and enterprise partners that is important. Synergy between airports and urban development is necessary for sustainable development, such as through improvement of the urban surface transport capacity. To deal with this problem, the most natural solution is to build new roads, but this is generally unfeasible in urban areas due to the presence of existing buildings, which makes the construction of these new roads very expensive or even impossible. Hence, traffic density keeps increasing at an alarming rate in major cities, which calls for the development of intelligent traffic light control to replace the conventional manual and time-based methods.

To ease this problem and improve mobility, safety, and traffic efficiency, many countries are improving their existing transportation systems. Traffic signal control systems can be either static or dynamic. In static systems, the predetermined timing of the signal is optimized using historically measured data. However, such systems are not able to predict or adapt to changes in demand. Moreover, they do not deal well with accidents and other disturbances. When dynamic systems are used, traffic signal timing is adapted to the current conditions, which are measured from sensors. This leads to better traffic control (TC). Large cities usually implement a traffic monitoring system. A large number of sensors are deployed under the pavement. TC central receives all of the information and controls the traffic accordingly. The necessity of a large cabling infrastructure usually limits their use to central areas. Currently, wireless sensor devices are becoming less and less expensive, which enables the rapid expansion of monitoring system structures.

Hence, the sensor market has become larger, which allows the connection of more sophisticated sensors. The usage of radar sensors or digital cameras has been increased in order to allow the measurement of car speeds as well as general variables, such as the quantity of cars on the road to be measured in order to inform drivers directly and avoid congestion. TC systems have evolved to provide better traffic management. Intelligent Transport Systems (ITSs) are applications that provide innovative services for traffic management. ITS provide users with better information to allow smarter, safer, and more coordinated use of ITS infrastructures. In this paper, the authors combine ITSs with wireless communication technology (WCT) systems that are easier to install and more easily expandable to areas outside the city center.

To relieve severe traffic congestion, decrease traffic volume and waiting time, reduce total travel time, maximize vehicle safety and efficiency, and extend the advantages in the health, economic, and environmental sectors, the traditional traffic system must be updated. This article presents a simple, low-cost, real-time smart traffic light control system with the goal of eliminating many flaws and improving traffic management. The system is controlled by a PIC microprocessor, which monitors traffic volume and density flow using infrared sensors (lR) and adjusts the lighting transition slots appropriately. Furthermore, using XBee transceivers, a handheld portable device connects wirelessly with the traffic master controller to execute the

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necessary subroutines and enable emergency vehicles to pass through the junction smoothly [6], [7].

1.1. System of Intelligent Traffic Control:

The development of intelligent traffic control systems is a hot subject in academia. To address this stressful issue, researchers from all around the globe are developing novel methods and technologies. To estimate the car waiting time at a junction, the number of cars in the waiting queue, the extension of the waiting cars along the lane, the optimal timing slots for green, yellow, and red lights that best fit the real and verifiable situation, and the efficient combination of routing, models based on mathematical equations are used. Indeed, the reciprocal interdependence between adjacent crossings needs a convoluted formulation including many factors. These characteristics are unintentional, dangerous, and reliant, and the worst part is that they vary with time. As a result, it's almost difficult to come up with a dynamic, consistent, and practical answer. Researchers from many fields are working together to find practical solutions to traffic congestion. As a result, various methodologies are constantly proposed in the literature, and many techniques are implemented, taking advantage of microcomputer technological advances, newly manufactured devices and sensors, and innovative algorithms that model the complication of traffic lights as accurately as possible [8]–[10].

IR sensors are used in a variety of traffic systems. On each side of a road, the IR transmitter and receiver are installed. The system is triggered and the vehicle counter is increased when an automobile passes between the IR sensors on the road. The gathered data on the traffic density of the various roads at a junction is evaluated in order to dynamically adjust the green light delays at the lane with the highest traffic flow. PIC microcontrollers or even PLCs may control the whole system.

They are supplemented by RF emitters that transmit warning signals to RF transceivers positioned at every traffic light intersection to notify the traffic system of the approach of emergency vehicles near the junction. In order to create a specific path for emergency vehicles, the traffic signal triggering sequences are changed accordingly. Other researchers connect with traffic light controllers and transmit preemption signals using the Global Positioning System (GPS). The ambulance was equipped with both an RF module for communicating with the traffic light controller and a GSM module for reporting the patient's condition to hospital doctors and receiving messages about the type of therapy or first aid recovery that should be performed on the injured patient.

Many studies use image processing methodologies to estimate traffic density. However, these methods require the collection of excellent pictures, the quality of which is weather-dependent, particularly in the rain and fog. Other academics utilize complex algorithms like fuzzy logic and evolutionary algorithms to simulate the different phases of traffic. The majority of published papers are focused on a single junction or crossroads, and the impact of other junctions is not considered. As a result, the situation gets more complex and reliant. More work has to be done to complete the modeling, monitoring, and control of many synchronized junctions.

1.2. System Development:

The smart traffic light management system corresponds to a junction of four monodirectional roads in the fun of "+." First and foremost, we want to look into the technologies of current

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systems and choose the most suitable gadgets to use. We also attempt to put the suggested integrated design, which includes architecture, hardware, and software, to the test. The proposed traffic light system will be extended to a bidirectional "+" junction with different route configurations as the next stage. The control of traffic light systems for several nearby bidirectional roadways is the focus of our study.

1.2.1. Configurations of traffic lights:

Two configurations are shown in the proposed smart traffic signal system: the first enables vehicles to flow from road 1 forward to road 3 as well as turn right to follow road 4, while the second allows cars to travel from road 2 straight toward road 4 or shift to the left to follow road 3.

The placement of vehicles as they transition between roadways takes pedestrian crossings into account. The statuses of the traffic lights designated A, B, L, and R during the two configuration modes. The language used is divided into three categories: traffic lights, color lights, and states. A-G ON, for example, indicates that the green light of traffic signal A is turned on. The initial configuration's phase I corresponds to the activation of the green light of traffic lights A and R when vehicles parked on road 1 are crossing the junction. Phase II corresponds to the stop position warning, in which only the yellow light of traffic signal A illuminates for 5 seconds. The red lights of traffic signals B and L are turned on in this arrangement. The light illuminations are inverted in the second arrangement.

1.2.2. Infrared sensors and density traffic lights:

The transition time slots are set inside the coding, which is a significant flaw in current traffic signal systems. When traffic congestion is only visible from one way, a comparable approach fails to address the problem. Employees from the periphery drive to the city center in the morning and return home in the evening, causing this condition to be commonly observed in many cities. Furthermore, the green light activation should be prolonged or decreased depending on whether the flow of vehicles approaching the junction roadways rises during peak traffic hours or drops at night.

To detect the passing of vehicles, IR transceivers placed on each side of highways are employed. The IR transmitter sends out a 38 kHz square wave signal that is received by the IR receiver attached to the traffic master controller but is not activated. The system is triggered when a vehicle passes between the IR transceivers. The traffic master controller evaluates this activation process and adjusts the vehicle density counter accordingly. The data is then processed by the traffic master controller, which is controlled by a PIC microcontroller. The regular mode, the traffic jam mode, and the gentle traffic mode are the three lighting transition slots that are recommended. The transition between these three modes occurs in real time and is dynamic. In reality, the number of vehicles counted in phase I of a particular configuration has a direct impact on the green light duration in phase I of the following configuration. The regular, jam, and gentle modes of traffic each have three time slots of 30, 50, and 15 seconds. The coding determines these levels, which the program may change. Each configuration's phase I in normal mode is 30 seconds long. If, on the other hand, road 1 has heavy traffic and road 2 has little traffic, the first configuration's phase I will last 50 seconds. The second configuration's phase I will last 15 seconds.

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The vehicles on road 1 are going to their destinations while the cars on road 2 are piled and parked in the initial arrangement. In addition, when phase II of the first configuration begins, the IR sensor on road 1 starts counting the vehicle from zero.

1.2.3. Vehicles in case of an emergency:

One of the major issues with the traffic signal system is the movement of emergency vehicles through road intersections as higher priority vehicles. Ambulances, rescue vehicles, fire trucks, police officers, and VIPs are examples of emergency vehicles that may get trapped in traffic. This problem may result in a variety of issues, including patient harm, vehicle accidents, fires, robberies, and a variety of other important circumstances. It is critical to put in place a strategy to address this problem.

To command the traffic master controller, a handheld portable device at the traffic officer's disposal is suggested. The portable controller may, in fact, be modified to be placed on emergency vehicles or used in traffic control centers. Two push buttons labeled EA and EB help support the portable gadget. When an emergency vehicle approaches the junction from the direction of traffic light A, or from road 1, the EA button is depressed. The phase I of the first configuration is established as a result of this operation, and the green light timing slot shines indefinitely to provide the stacked vehicle enough time to pass through the junction. The EA button is then pushed once more to revert to normal mode, with the yellow light of traffic light A flashing for 5 seconds to alert cars that traffic light B is about to be activated. The mechanism is automatically activated and starts the second configuration if the elapsed time exceeds 4 minutes and the EA button is still operational for a variety of reasons. A similar procedure is achieved by pressing the EB button on the traffic light B. When both buttons are pushed at the same time, button EA takes precedence.

2. DISCUSSION

The author has discussed about the traffic lights, the issue of traffic lights is clearly a major concern for citizens and governments. The economic, health, financial, and environmental domains are all affected by the low efficiency of traditional traffic systems. Trouble with the transportation system and poor monitoring can lead to car accidents, traffic jams, and road congestion, putting a strain on businesses and workers. Technology advancements and the miniaturization of control devices, appliances, and sensors have enabled the development of sophisticated smart and intelligent embedded systems to solve human problems and improve lifestyles. Our smart traffic light control system aims to contribute to the scientific community by implementing innovative hardware and software design systems to improve existing traffic light systems and manage the flow of automobiles at intersections.

A traffic light controller manages the traffic lights of a "+" junction of mono directional roads in the proposed smart traffic system. Using infrared sensors installed on both sides of the roads, the system can estimate traffic density. Based on this data, the green light time will be extended to allow a large flow of cars in the event of a traffic jam, or reduced to avoid unnecessary waiting time when no cars are present on the opposite route. A portable controller is included in the system for emergency vehicles stuck in traffic. The portable controller triggers the traffic master controller to emergency mode and provides an open path until the stuck emergency vehicle traverses the intersection via secure communication using the XBee wireless system.

3. CONCLUSION

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The author has concluded about the traffic lights, to ensure complete validation of its operations and functions, the designed system is implemented, realized electronically, and tested. The current design can be aided by monitoring and controlling a double-road intersection. Future enhancements could include a pedestrian crossing button, delay timing displays, and car accident and failure modes, among others. In order to achieve complete synchronization, the integration of different traffic controllers at several junctions will be investigated in the future. To better understand the traffic flows between the intersections, traffic data can be recorded and downloaded to a computer platform, where statistical data analysis studies can be applied to better understand the system performance. Finally, solar panels may be used to power traffic light controllers, reducing grid electricity usage and enabling green energy operations.

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