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Design of Dynamic Traffic Signal Control System

Shabnam Sayyed
Department of Computer Engineering, BSIOTR(W)

Prajakta Date
Department of Computer Engineering, BSIOTR(W)

Richa Gautam
Department of Computer Engineering, BSIOTR(W)

Gayatri Bhandari
Department of Computer Engineering, BSIOTR(W)

Abstract

Traffic lights are source of signalling device for road junctions. Traffic light controllers are programmed to assign timely directions to road users in Red, Yellow and Green. Present Traffic Light Controllers are based on microcontroller.TLC have limitations as it uses pre-defined hardware, which functions according to program that does not have flexibility of modification on real time basis. As the numbers of road users' increases, resources provided by current infrastructures are limited, thus control of traffic becomes very important. To mange traffic flow, introduction of new technique ***'Dynamic Traffic Signal Controller'*** *emerged. Thus, optimization of traffic light switching; controls road capacity traffic flow and prevent congestions. The unique aspect is that web application is provided over mobile phones to road users who wish to access the traffic management application for traffic news. The application displays the traffic status. The proposed system has simple architecture, ease of implementation and user friendliness.*

1. Introduction

Presently, modern lifestyle consists of fast and rapid transport mediums which play a vital role in economic development for any nation. All developed nations have a well developed transportations system with efficient traffic control on road, rail and air. Transportation of goods, industrial products, manpower and machinery are the key factors which influence the industrial development of any country [1]. Also, the drastic/rigorous changing condition of road traffic is rising as a serious problem for people to move, infrastructure wise and as nation's economic point of view. Hence traffic congestion leads to long waiting hours along with fuel and money wastage. So, the Traffic management on road is crucial to reduce these problems. Now, control and management of city traffic has become a major problem in many countries even though Regional Traffic Office has found solutions to overcome these traffic issues. One way to improve traffic flow and safety of current transport system is to apply automation and intelligent control methods to road infrastructure [1]. Also, measures like new roads, flyovers, ring roads, city trains are applicable for traffic management. But as the number of road users increase and resources provide by current infrastructures are limited dynamic control of traffic is need of hour.

The drawbacks of the traditional traffic light controller are highlighted below:

Heavy Traffic Jams

Under ordinary conditions when the traffic lane waits for the green light, time setting is same and fixed. With increasing number of vehicles on roads has substantially increases congestion. This is observed usually at main junctions in morning, office hours and after office hours. Hence the main effect of this increases the waiting time of people on road. Thus a solution for this matter can be given by different delays

to traffic lanes which is called as normal mode operation [1].

No traffic, but need to wait

At certain junctions even if there is no traffic when the traffic light remains red the road users have to wait until the light turns green. And if rule is broken fine has to be paid [4]. The solution of this problem is by developing the system which detects traffic density on each road and then sets signal timing accordingly along with synchronization of the adjacent junction's traffic signal.

Emergency car case (one or more than one)

During traffic jam an emergency vehicle like ambulance, fire brigade, police are stuck and have to wait for the traffic light to turn green. Hence this critical problem may further complicate that costs human life. So solution to this problem can be given by having priority for emergency vehicle to flow rapidly through the traffic while other vehicles are instructed to be still (i.e. traffic signal light is red).

Inadequate traffic information to users

Present conventional traffic system fails to provide traffic status about congested roads, alternate routes etc. A remedy for this issue is to design a user web application to road users who shall access the URL of the web application.

The dynamic traffic signal controller is introduced in this project with efficient functions and hardware interface. The traffic jam will be reduced by increasing green signal time for busy lanes and decreasing red signal time for non busy roads. In other words dynamic signal switching can be achieved by when vehicle density of the four way junction road is known. Secondly, traffic news is provided through the website design for users ease. Therefore, improvement of town traffic condition is largely dependent on the modern ways of traffic management and control. Advanced traffic signal controllers and control system contribute to the improvement of the traffic problem.

2. Literature Survey

Nowadays, vehicles on road are increasing each day like growing cities of this world. Traffic Management on road has become the need of hour in today's urban lifestyle. Efficient techniques are needed to reduce travel time, usage of money, fuel and waiting hours along with gamut of other problems too. Thus need arises for simulating and optimizing current system for the traffic controllers to better accommodate this increasing demand by road users around the world. Traffic lights are commonly used devices to regulate roadway intersection traffic with a view to both safety and smoothness of vehicle flow, for generations where it is still considered the best practices [2]. Various methods and approaches are suggested in literature for solving the traffic control problem. It includes rule based learning to the modern fuzzy and neural network approaches. In this section, the various solutions to the traffic control problems suggested in the literature are discussed, along with their merits and demerits [1].

Since the traffic light was invented ages ago, there have been significant revolutions lined down in various aspects about same. The most common revelation which we can visualize is the displays of traffic light itself. The other revolution which is being enhanced and improved is the traffic light controllers [2]. The various traffic congestion problems and solutions suggested in literature are as follows:

2.1. Expert System

An expert system uses the set of rules to decide the next action. In traffic Light control such an action can change some of control parameters that means the totally new system implementation required. Findler and Stapp describe a network of roads connected by traffic light-based expert systems [5]. For each traffic light controller, the set of rules can be optimized by analyzing how often each rule fires, and the success it has. The system could even learn new rules. Researchers have shown that their system could improve performance, but they had to make some simplifying assumptions to avoid too much computation.

2.2. Prediction Based Optimization

Prediction based optimization based Traffic Light Controller was described by Tavladakis and Voulgaris (1999). In this system, Measurements taken during the current cycle are used to test several possible settings for the next cycle and the setting resulting in the least amount of queued vehicles is executed. Since it only uses the data of one cycle, it could not handle strong fluctuations in traffic flow well. The system seemed highly adaptive. In this case, the system would adapt too quickly, resulting in poor performance [1] [5].

Liu introduce a way to overcome problems with fluctuations. Traffic detectors at both sides of a junction for vehicle identification are used to measure delay of vehicles at a junction. This is projected to an estimated average delay time using a filter function to smooth out random fluctuations. The control system tries to minimize not only the total delay, but the summed deviations from the average delay as well. Since it is no longer beneficial to let a vehicle wait for a long time, even if letting it pass would increase the total waiting time, this introduced a kind of fairness [6].

2.3. Fuzzy Logic

Fuzzy Logic Traffic Light Controller described by Tan (1995). The fuzzy logic controller determines the time that the traffic light should stay in a certain state, before switching to the next state. The order of states is predetermined, but the controller can skip a state if there is no traffic in a certain direction. The amount of arriving and waiting vehicles are quantized into fuzzy variables like many, medium and none. In experiments the fuzzy logic controller showed to be more flexible than fixed controllers and vehicle actuated controllers, allowing traffic to flow more smoothly, and reducing waiting time. A disadvantage of the controller seems to be its dependence on the preset quantification values for the fuzzy variables.

They might cause the system to fail if the total amount of traffic varies. Furthermore, the system was only tested on a single junction. Lee et al. studied the use of fuzzy logic in controlling multiple junctions [5]. Choi et al. also use fuzzy logic controllers, and adapted them to cope with congested traffic flow. Comparisons with fixed fuzzy-logic traffic light controllers indicated that this enhancement can lead to larger traffic flow under very crowded traffic conditions [1]. However in the most complicated cases where the numbers of lanes are large and may be not only one but more road intersections and railroad take part, it does make sense to use fuzzy methods containing hierarchy and apply interpolation to decrease the complexity [5].

2.4. Reinforcement Learning

Reinforcement learning for traffic light control had first been studied by Thorpe. The system designed, used a traffic light-based value function. Thorpe used a neural network for the traffic-light based value function which predicts the waiting time for all cars standing at the junction. This means that Thorpe's traffic light controllers have to deal with a huge number of states, where learning time and variance may be quite large. Furthermore, a somewhat other form of RL, SARSA (State-Action, Reward-State Action) was used with eligibility traces and others used a model-based RL [5].

2.5. Using Magneto-Resistive Sensors

Author Cai Bai-gen et.al. (2009) designed a vehicle detection system based on magneto-resistive sensor composed by wireless traffic information collection nodes which are set on two sides of road to detect vehicle signal. The magneto-resistive sensor is costly and maintenance cost of the system will be more if the system fails [3].

An intelligent traffic light monitoring system using an adaptive associative memory was designed by Abdul Kareem and Jantan (2011). The research was motivated by the need to reduce the unnecessary long waiting times for vehicles at regular traffic lights in urban area with 'fixed cycle' protocol. To improve the traffic light configuration, the paper proposed monitoring system, which was able to determine three street cases (empty street case, normal street case and crowded street case) by using small associative memory. The experiments presented promising results when the proposed approach was applied by using a program to monitor one intersection in Penang Island in Malaysia. The program could determine all street cases with different weather conditions depending on the stream of images, which were extracted from the streets video cameras [5].

The efficiency of the traffic light in the queue model however, was affected by the occurrence of unexpected events such as the break-down of a vehicle or road traffic accidents thereby causing disruption to the flow of vehicles. Among those techniques based on the queue model was a queue detection algorithm proposed by Fathy, M. and Siyal, M. Y. (1995). The algorithm consisted of motion detection and vehicle detection operations, both of which were based on extracting the edges of the scene to reduce the effects of variations in lighting conditions. A decentralized control model was described Jin & Ozguner (1999). This model was a combination of multi-destination routing and real time traffic light control based on a concept of cost to- go to different destinations [5].

3. Proposed Model

The primary objective of this project is to design a user interface program and implement hardware for dynamic traffic light control system that is suitable for real life implementations. The project implementation

also aims to have efficient and safe traffic flow control along with reduced waiting time at signal junction, priority for emergency case, heavy traffic jams and provision of information to road users instantly. The traffic jam will be reduced by increasing the green signal time on busy road and decreasing the red signal time on non busy road. Infra Red–Light Emitting Diode (IR-LED) transmitters and receivers are used to measure the traffic flow [1]. The proposed Dynamic Traffic Light Control (DTLC) operations have Infrared Sensors mounted on road to detect frequency of the vehicles. The presence or absence of a vehicle is sensed by the sensor assembly mounted on each road, which acts as an input to the DTLC unit. This input signal indicates the density of vehicles on each road. In this system the basic operations are implemented using Microcontroller89c51AT.

The heart of the system is microcontroller AT89c51. For communicating with the external signals, additional ports like computer links and pull up array are used. The DTLC unit generates output signals for Red, Green and Yellow Signal and monitor their timings taking into consideration the length of vehicles on each road [1]. The information as input to microcontroller will be given in form of already prepared database entries for typical model working, which would determine vehicle density on each lane. Therefore, the on and off signal time at the four junctions will be calculated by the microcontroller.

The figure 3 i.e. pictorial representation of dynamic signal time evaluation gives the clear concept of how the dynamic time objective can be implemented. A very important point is that time allocation to each lane is done as per the threshold value taken. In an emergency consider figure 1, if an emergency vehicle is passing through the route ABC, the signals on those junctions which are along this route will be immediately made red to stop other vehicles. This is a very useful feature in case of emergency.

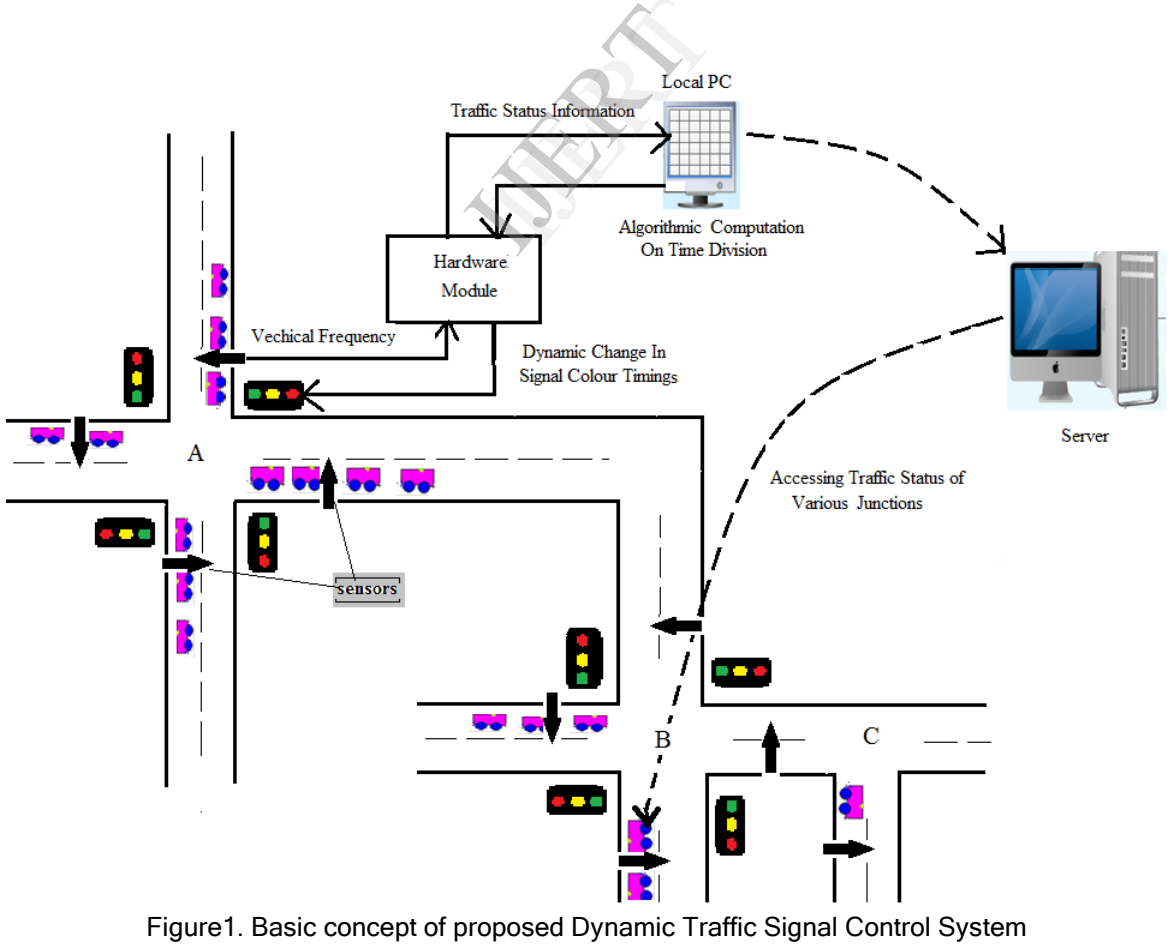

Figure1. Basic concept of proposed Dynamic Traffic Signal Control System

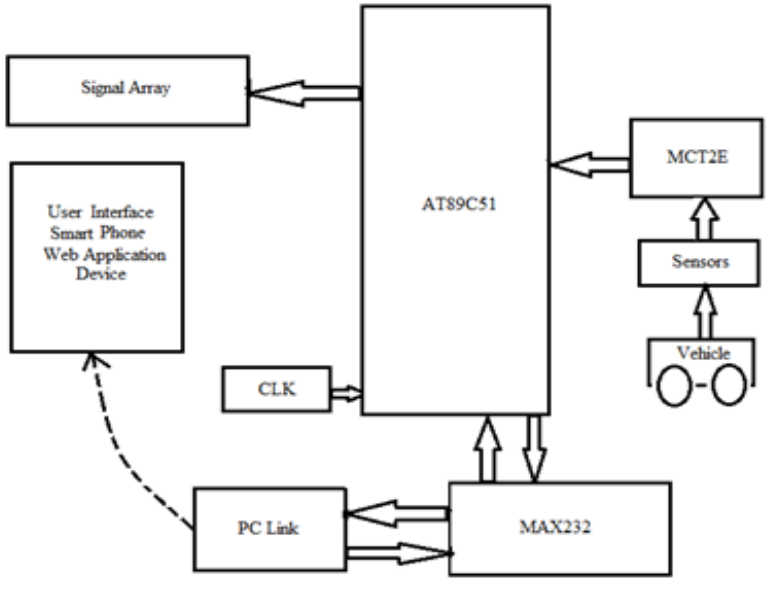

Figure2. Block Schematic of Dynamic Traffic Control System

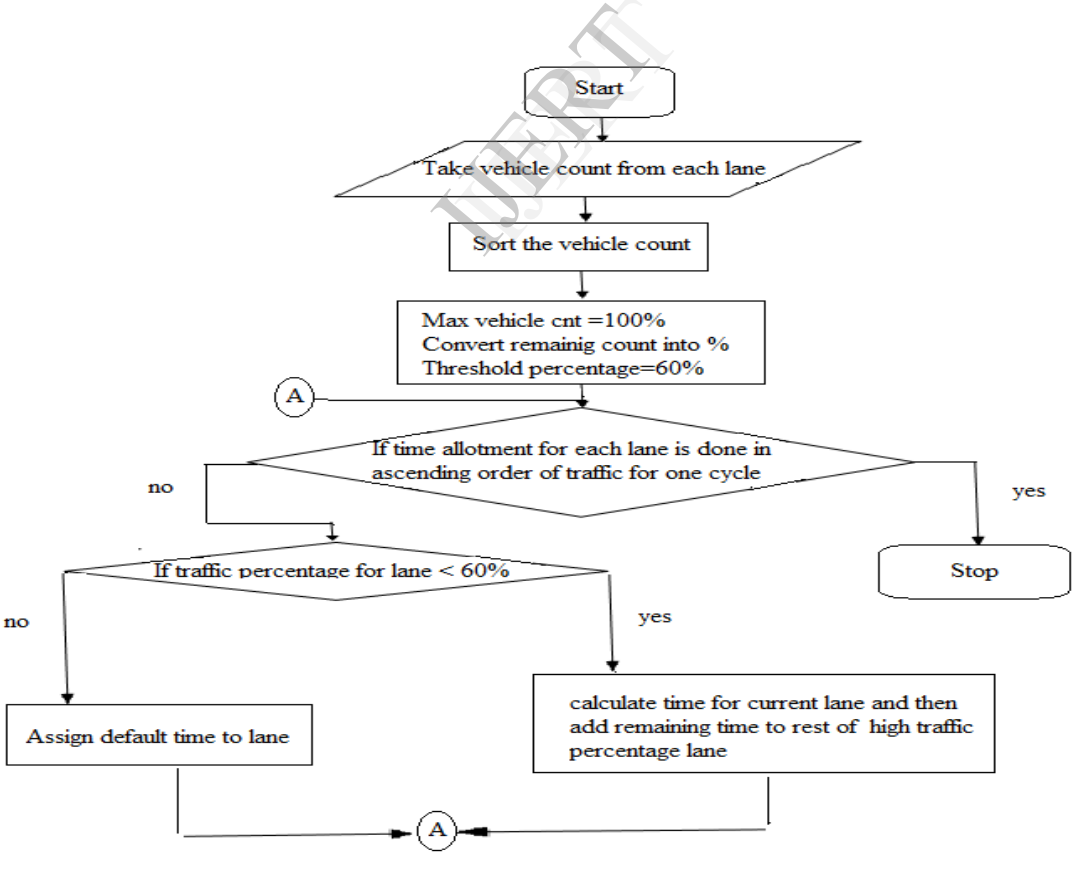

Figure3. Flowchart for Dynamic evalution of Signal time

4. Conclusion

The optimization of city traffic scenario is an important issue to be considered. Hence modern techniques of traffic management contribute to optimization of traffic problem. The dynamic traffic signal controller is introduced in this project having specific functions along with hardware interface. The first part is designing of program which consists of data collection, sorting, calculation of percentage and therefore automatic evaluation of signal time. After that the second part is web application which is designed to provide traffic alerts for road users and take measures to avoid congestion. So problems such as wastage of fuel, emergency case could be overcome through this proposed system. This system aims at saving a large amount of waiting hours caused by traffic deadlocks, where control can save time and property.

5. References

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