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INTELLIGENT TRAFFIC LIGHT CONTROLLER USING EMBEDDED SYSTEM

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ABSTRACT

Present Traffic Light Controllers (TLC) are based on microcontroller and microprocessor. These TLC have limitations because it uses the pre-defined hardware, which is functioning according to the program that does not have the flexibility of modification on real time basis. Due to the fixed time intervals of green, orange and red signals the waiting time is more and car uses more fuel. To make traffic light controlling more efficient, we exploit the emergence of new technique called as "Intelligent traffic light controller". This makes the use of Sensor Networks along with Embedded Technology. The timings of Red, Green lights at each crossing of road will be intelligently decided based on the total traffic on all adjacent roads. Thus, optimization of traffic light switching increases road capacity and traffic flow, and can prevent traffic congestions. GSM cell phone interface is also provided for users those who wish to obtain the latest position of traffic on congested roads. This is a unique feature of this project which is very useful to car drivers to take an alternate route in case of congestion. The various performance evaluation criteria are average waiting time, average distance traveled by vehicles, switching frequency of green light at a junction, efficient emergency mode operation and satisfactory operation of SMS using GSM Mobile. The performance of the Intelligent Traffic Light Controller is compared with the Fixed Mode Traffic Light Controller. It is observed that the proposed Intelligent Traffic Light Controller is more efficient than the conventional controller in respect of less waiting time, more distance traveled by average vehicles and efficient operation during emergency mode and GSM interface. Moreover, the designed system has simple architecture, fast response time, user friendliness and scope for further expansion.

KEYWORDS- *Intelligent Traffic Light Controller, embedded system, Performance Evaluation, Microcontroller based system.*

A. I. INTRODUCTION

Fast transportation systems and rapid transit systems are nerves of economic developments for any nation. All developed nations have a well developed transportation 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. Mismanagement and traffic congestion results in long waiting times, loss of fuel and money. It is therefore utmost necessary to have a fast, economical and efficient traffic control system for national development.

The monitoring and control of city traffic is becoming a major problem in many countries. With the ever increasing number of vehicles on the road, the Traffic Monitoring Authority has to find new methods of overcoming such a problem [1-4]. The measures taken are development of new roads and flyovers in the middle of the city; building of several ring such as the inner ring road, middle ring road and outer ring road; introduction of city trains such as the light rapid transit (LRT), and monorails; restricting of large vehicles in the city during peak hours; and also development of sophisticated traffic monitoring and control systems. Growing numbers of road users and the limited resources provided by current infrastructures lead to ever increasing traveling times [5, 6].

One way to improve traffic flow and safety of the current transportation system is to apply automation and intelligent control methods to roadside infrastructure and vehicles [7]. Transportation research has the goal to optimize transportation flow of people and goods. As the number of road users constantly increases, and resources provided by current infrastructures are limited, intelligent control of traffic will become a very important issue in the future.

The problems of typical conventional traffic light Controller are mentioned below:

A. Heavy Traffic Jams

With increasing number of vehicles on road, heavy traffic congestion has substantially increased in major cities. This happened usually at the main junctions commonly in the morning, before office hour and in the evening, after office hours. The main effect of this matter is increased time wasting of the people on the road. The solution for this problem is by developing the program which different setting delays for different junctions. The delay for junctions that have high volume of traffic should be setting longer than the delay for the junction that has low of traffic. This operation is calling Normal Mode [8].

B. No traffic, but still need to wait

At certain junctions, sometimes even if there is no traffic, people have to wait. Because the traffic light remains red for the preset time period, the road users should wait until the light turn to green. If they run the red light, they have to pay fine. The solution of this problem is by developing a system which detects traffic flow on each road and set timings of signals accordingly. Moreover, synchronization of traffic signals in adjacent junctions is also necessary [9].

C. Emergency car stuck in traffic jam

Usually, during traffic jam, the emergency vehicle, such as ambulance, fire brigade and police will be stuck especially at the traffic light junction. This is because the road users waiting for the traffic light turn to green. This is very critical problem because it can cause the emergency case become complicated and involving life.

D. Lack of Traffic Information to users

Present traffic systems fail to provide traffic information including congested roads and alternate routes available in case of congestion.

In the proposed Intelligent Traffic Light Controller (ITLC) all these limitations of existing controller are eliminated. The proposed project of 'Intelligent Traffic Light Controller' uses embedded system (microcontroller 89C51) and has advantages of efficient control, GSM Interface to mobile phones and fast response time. The problem of fixed timing traffic light is totally eliminated in this project.

The main objective for this project is to design a program and implement hardware of intelligent traffic light system suitable for real life implementations. This project also aims to design a safe and efficient traffic flow, to assign the right way and minimizes the delay or waiting time at road. The traffic jam will be reduced by increasing the green signal time on busy road and decrease the red signal time in non busy road. The information about congestion on road or possible alternate routes can also be informed to car drivers on demand on his/her GSM mobile phone. Infra Red –Light Emitting Diode (IRLED) transmitter and receivers are used to measure the traffic flow. In short, this project is a real-time, GSM enabled and intelligent Traffic Light Controller

This paper is organized as follows: In section II a brief study of traffic controllers designed in past in literature is presented. The proposed model of ITLC is presented in section III. Design, hardware and software details are explained in this section. Section IV deals with performance evaluation of the proposed system with the conventional fixed time traffic light controllers. Verious Performance measures are discussed in this section. Finally, the paper is concluded in section V, which presents conclusion, commercialization of project and future scope for the proposed system

II. LITERATURE SURVEY

Traffic Management on the road has become a severe problem of today's society. An efficient traffic management techniques are needed to reduce waiting and traveling times, save fuel and money. In order to alleviate the problem, a large number of methods and approaches have been suggested in the literature[10]. 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 presented, along with their merits and demerits.

Traffic Light Controller using an expert system uses a set of given rules to decide upon the next action. In traffic light control, such an action can change some of the control parameters. Findler and Stapp describe a network of roads connected by traffic light-based expert systems [11]. 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. Authors have shown that their system could improve performance, but they had to make some simplifying assumptions to avoid too much computation. Tavladakis and Voulgarisdescribe a traffic light controller using a simple predictor [12]. 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. The system seems highly adaptive. Since it only uses data of one cycle, it could not handle strong fluctuations in traffic flow well. In this case, the system would adapt too quickly, resulting in poor performance. Liu introduce a way to overcome problems with fluctuations [1,13]. Traffic detectors at both sides of a junction and 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 introduces a kind of fairness.

Tan describe a fuzzy logic controller for a single junction that should mimic human intelligence [14]. 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. [15].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 [16].

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 [17].

Taale et al. compare using evolutionary algorithms evolution strategy to evolve a traffic light controller for a single simulated intersection to using the common traffic light controller in the Netherlands (the RWS C-controller). They found comparable results for both systems. Unfortunately they did not try their system on multiple coupled intersections, since dynamics of such networks of traffic nodes are much more complex and learning or creating controllers for them could show additional interesting behaviors and research questions [18].

Reinforcement learning for traffic light control has first been studied by Thorpe He used a traffic light-based value function, and we used a car-based one. 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 controller have to deal with a huge number of states, where learning time and variance may be quite large. Furthermore, Thorpe used a somewhat other form of RL, SARSA (State-Action, Reward-State Action) with eligibility traces and we use model-based RL [19].

Roozemond describes an intelligent agent architecture for traffic light control [20]. Intelligent traffic signalling agents (ITSAs) and Road Segment Agents (RSAs) try to perform their own tasks, and try to achieve local optimality. One or more Authority Agents can communicate with groups of ITSAs and RSAs for global performance. All agents act upon beliefs, desires, and capabilities. No results were presented.

From the above discussion, it is obvious that designing a traffic light controller that satisfies all the criteria simultaneously is a complicated task. Each proposed scheme has certain merits and demerits Nevertheless, considering the common limitations of each listed above [19, 20], there is still a scope of designing a better traffic light controller having improved performance in most of the respects that will work optimally in diversified traffic conditions. One such attempt to propose a new traffic control scheme based on actuated car based approach combined with GSM is made in the research work.

One major common drawback of all schemes mentioned above is that they are applicable to the major crossing of road. The congestion conditions for a particular crossing of road are considered to alleviate the problem at that particular road. Providing traffic controllers at each separate crossing is not going to solve the traffic problem of the city as a whole. An integrated approach incorporating proper synchronization between all related crossings is essential to compute the signaling times of signals. In order to do this a proper communication between each crossing must be established and the proper messages must be given to the drivers of vehicles. For example consider, a congestion occurs on a road which is 10 Km away from a person driving a car towards that road. An intelligent system must inform the person about the happenings and should also inform alternate route to avoid loss of time. In this project, we are implementing to inform the car drivers about congested and alternate routes for rapid transit. Conditions on roads are communicated to car drivers on their personal GSM mobile sets, which will help them to select proper route for minimum delay.

B. III. PROPOSED MODEL

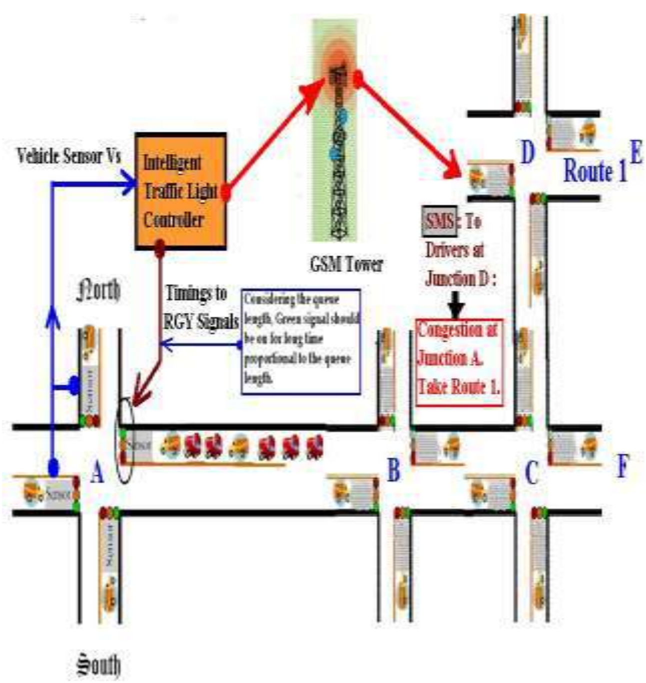
The proposed operations of Intelligent Traffic Light Controller are shown in Figure 1. In this figure the junctions are shown by letters A to F. The Infrared Sensors to detect vehicles is mounted on road. The presence or absence of a vehicle is sensed by a sensor assembly mounted on each road. This acts as an input to the ITLC unit. This input signal indicates the length of vehicles on each road. The ITLC unit generates output signals for Red, Green and Orange Signal and monitor their timings taking into considerisation the length of vehicles on each road. The same information is transmitted to the mobile user which will request for congestion status. If a vehicle driver at junction send sms on GSM mobile phone to ITLC unit, the driver will get message indicting congestion status of road. In this case it will inform that junction A is congested and the best possible route at this instant is Route 1 via junction E. In addition to above, in the emergency mode, for a vehicle like ambulance, fire fighter or police car, the signals are altered for the fast and easy movement of these vehicle. Consider Figure 1, if an emergency vehicle is passing by the route A-B-C-F, the signals on the roads which are crossing this route will be immediately made red to stop vehicles on these routes. This is a very important feature which is very useful in case of emergency.

The basic operation of ITLC can be realized by using embedded system which has advantages of simplicity, user friendly, easily programmable and a facility for GSM mobile interface. In our proposed model the basic operations are implemented using Microcontroller89c51AT. The main reason for selecting this microcontroller is ease of programming, sufficient number of input output lines, manageable size of RAM and ROM and simple architecture. The block diagram of the proposed model is shown in Figure 2. The heart of the system is microcontroller AT89c51. For communicating with the external signals additional ports and multiplexers are used. Additional RAM and ROM are used for storing system program and application program. The block diagram consists of the microcontroller, input switching matrix, serial communication interface, GSM interface, Real Time Clock 1307, Clock circuit, Relay Driver ULN 2003, LED interfacing circuit.

The signals from sensor assembly will be applied to input switching circuit. These input signals from sensors will be in the form of digital signals which corresponds to presence or absence of a vehicle. These digital signals from each lane will be given to the input port of microcontroller, where the microcontroller will determine the length of vehicle at each lane. This information is the input to microcontroller to determine various timing signals. The on and off time of the four junctions will be calculated by microcontroller, in order to keep waiting time minimum. These signals will be applied to two relay drivers which consist of ULN 2003. These relay drivers are level shifters and current amplifiers. The output of relay driver is applied to Red, Green and Orange LED at each junction. IC 24C61 is used for I2C interface. One LCD Display will be provided with each signal. LCD Display is

shown only for prototype mode LCD Display will indicate the contract LED displays are to be used, which will be visible time left for the signal to become green i.e. it indicates the time from a longer distance. a vehicle has to wait at a particular junction. In practice a good

Figure 1 Basic Concept of Proposed Intelligent Traffic Light Controller.



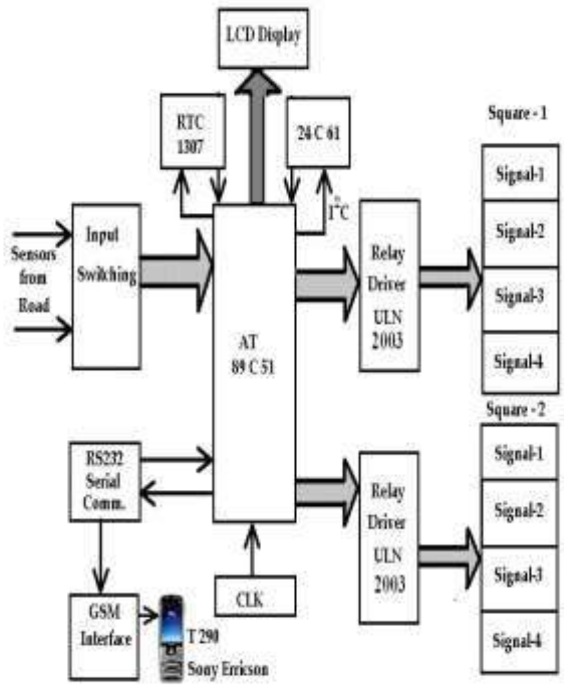


Figure 2 : Block Schematic of Intelligent Traffic Light Controller with GSM Interface.

Microcontroller is programmed using Assembly Language. Separate routines are written for Input section, Relay drivers, LCD Display, GSM interface. All routines are integrated with the main logic of the system which determines the timing interval at each junction.

IV. PERFORMANCE EVALUATION

Performance evaluation criteria used are average waiting time of a vehicle, distance traveled by a vehicle, operation during emergency mode, proper display of time left, signal switching frequency, and satisfactory working of SMS received on GSM Phone. The performance is evaluated with the conventional fixed time traffic light controller. These are mentioned below.

A. Average Waiting time of a Vehicle

This indicates the time period for which a vehicle has to wait on the junction. The scenario is simulated for 50 vehicles. The performance is separately calculated for Fixed Time Mode and Intelligent Traffic Controller. Average waiting time is separately calculated for non busy hours and busy hours. The results of this experiment are presented in Figure 3. This clearly indicates that the average waiting time is less for Intelligent Traffic Light Controller during busy (Peak hours) and non-busy hours. This is because, the intelligent traffic light controller takes into account the physical presence of vehicles and queue length of vehicles for deciding signal timings. This indicates the proposed model saves time to a large extend.

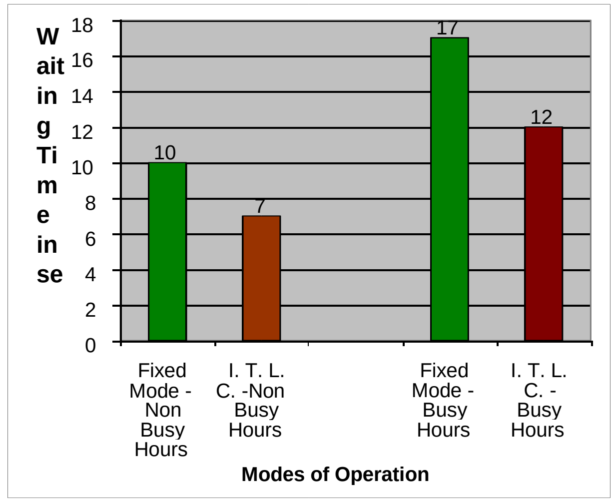


Figure 3 Average Waiting Time of a Vehicle at a Junction.

B. Distance Traveled by Vehicles

This is the total distance traveled by vehicle from its source to destination. For evaluation purpose a variable distance is considered at various routes on the road and the distance traveled by each vehicle is calculated and average is computed for 50 vehicles. Figure 4 shows the result. The total distance traveled in case of Fixed Time Traffic Light Controller and the Intelligent Traffic Light Controller is calculated independently for comparison. This indicates that distance traveled in case of intelligent traffic light controller is more as compared with the Fixed Time Traffic Controller.

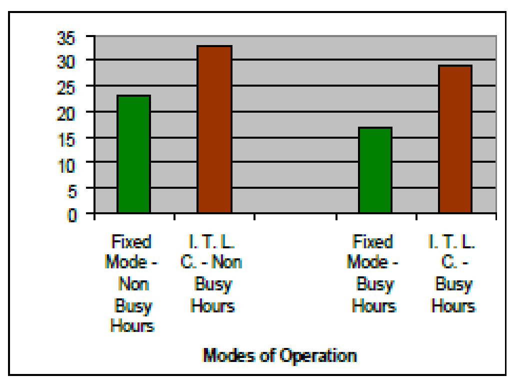


Figure 4 Average Distance Traveled by Vehicles

C. Emergency Mode

In case of arrival of Emergency Ambulance or Fire Bridge or Police Vehicle, emergency mode is activated and appropriate signals are generated for the particular junctions. It is observed that this mode of operation is working satisfactory and the vehicles on crossing the route of emergency vehicle gets an alert and Red Signal till emergency vehicle passes by its route. This feature is very useful for metropolitan cities in case of such emergency.

D. Signal Switching Frequency

In case of Intelligent Traffic Controller this switching frequency will be more as compared with Fixed Time Traffic Controller. The graph of Signal Switching Frequencies is shown in Figure 5. It indicates that the switching frequency of signals in Intelligent Traffic Mode is more. It is quite obvious that intelligent traffic light controller operates on feedback of queue length of vehicles hence it is operated frequently. So it is a dynamic System.

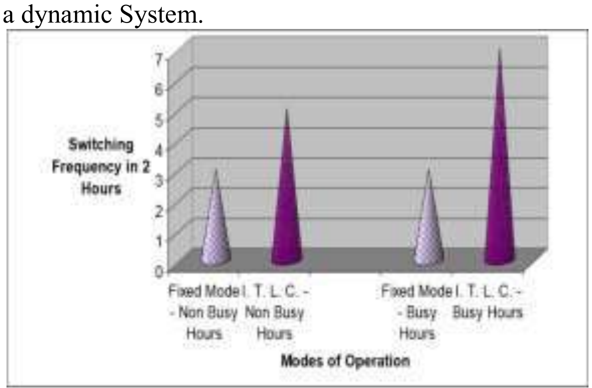


Figure 5 Switching Frequency of Green Signal for 2 Hours Duration.

V. CONCLUSION

The 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. The intelligent of traffic signal controller is introduced in this project with powerful functions and hardware interface. This project has two major phases. The first stage is to design a program, which consists of reading, research, planning and designing a program. Design a traffic light using the state machine is very difficult compare to design using the logic gates. Microcontroller Assembly Language was chosen to write a program code for simulation only to get a timing diagram. After that, second phase is to continue with the hardware implementation using the gate logic and the interface light is using LED. The blinking is depending on the state machine transition. GSM Interface is also provided for sending traffic alerts signals for drivers on road and precautions be taken not to indulge in traffic congestion. It is observed that the proposed Intelligent Traffic Light Controller is more efficient than the conventional controller in respect of less waiting time, more distance traveled by average vehicles and efficient operation during emergency mode and GSM interface. Moreover, the designed system has simple architecture, fast response time, user friendliness and scope for further expansion.

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