Traffic Light Pre-emption control System for Emergency Vehicles

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Abstract—Emergency vehicles such as ambulances, fire fighting vehicles and police force vehicles are required to reach their destination as quickly as possible. One of the most important delays is the time that is consumed in intersections with these traffic lights, especially when their intersections are highly congested. In this paper we discuss the design and implementation of an automatic pre-emption traffic control system that ensures to give preferences to all the emergency vehicles.

Index Terms—Emergency vehicle, pre-emption, voice sensors, Delay, Congestion, Microcontrollers.

I. INTRODUCTION

Traffic congestion is increasing day by day and pre-emption of emergency vehicles have become a necessary concept in today’s life. Traffics in urban places and traffic emergencies are one of the biggest issues of the society. They should handle this in an efficient manner realizing the emergencies and the need for emergency vehicles to pass thorough.

II. TECHNICAL BACKGROUND

The existing systems focuses on the problem of adaptive traffic light control uses real-time traffic information collected by a wireless sensor network (WSN) sequence and length of traffic lights and then accordingly the traffic will be detected. This algorithm considers a number of factors such as traffic volume, waiting time, vehicle density, etc., after which green light sequence will be determined. Intelligent transportation systems (ITSs) are automatic road traffic management systems that manage road traffic with the intention of improving traffic safety and minimizing the energy consumption of vehicles running on the roads. An ITS consists of four subsystems (i) a surveillance system (ii) a communication system (iii) an energy efficiency system and (iv) a traffic light control: fixed-time, actuated system. Most probably the current traffic light control systems use any one of three control approaches, or adaptive. All these cases have the same goal, to maximize safety, speed, and energy efficiency or minimize waiting time, number of vehicle stops. So far as we know, most existing work use a fixed sequence for traffic lights control, that takes an average waiting time and number of vehicle stops as the objective. However, they pay little attention to traffic flow’s characteristics and special traffic circumstances, for emergency vehicles such as ambulance or fire engine. The algorithm uses traffic information that is detected to determine the sequence and length of traffic lights. This algorithm is executed in three steps: Detection of Vehicles, determination of green light and determination of light length. Nowadays the traffic preemption systems use line-of-sight-based systems, sound-based systems, GPS-based systems, radio-based systems or sensor-based systems. The above implementations undergo several drawbacks e.g. the need for a special device is to be installed at every Emergency vehicle, visual obstructions in line-of-sight based systems or bad atmospheric conditions.

A. Other Systems

For urban traffic emergencies rapidly handled, with help traffic management -synthetic information system and the computer network and application platform, such as GIS, based on the structure of B/S (browser/server) and C/S (client/server) and by integrating with systems such as GPS, traffic guidance system, traffic monitoring system, 122 police call system, synthetic inquiry System and WEB publishing system, which helps in handling urban traffic emergencies. Initially the urban traffic situation is analyzed countermeasures are created and stored in the countermeasure database the situation is analyzed by (for example monitoring video, traffic data, alarm audio etc.)After these emergency measures police men are informed and they immediately dispatch traffic situations that will be controlled manually.

Some of the currently used traffic light pre-emption systems can be classified based on its operation as:

1- Optical systems:

This system which utilize coded infrared or visual light transmissions from the emergency vehicle to the traffic light in
the intersection for the path clearance before its approach. For example to these systems include OPTICOM, MIRT and TOMAR/SRTOBECOM.

2- Sound based systems:
This system detects the sound from the siren on the emergency vehicle and clears the path in the intersection. This is done with the use of directional microphones to determine the direction of travel to the intersection. We can take the example as, SONEM 2000 and EPS-II.

3- Radio controlled systems:
In an emergency vehicle, a control button is pressed to initiate the special timing plan for signals along a selected route. Nearly ten intersections could be specified and controlled along the path of travelling. Each pre-determined route has a specific button to activate it. BLISS system is an example for a radio controlled systems.

4- GPS based systems:
These systems require communications and different software equipments to determine the location, direction and speed of the emergency vehicle and also the information that is used to determine which traffic light should be pre-empted. Once the decision is made, an application in the control centre activates or deactivates the desired traffic light accordingly.

5- Sensor-based systems:
These systems control the operation of traffic light with a particular algorithm. Low frequency transponders mounted on vehicles are detected by appropriately placed standard pavement loop detectors connected to a special amplifier.

6- A Novel CAM based systems:
A novel traffic light pre-emption algorithm is proposed based on processing part of the Cooperative Awareness Messages (CAM) already defined in the so-called European Intelligent Transportation System (ITS) communication architecture. In this architecture the information used for the network maintenance and other high-level applications are periodically broadcasted by the networking layer encapsulated in CAM’s using IEEE802.11p WAVE wireless technology at a rate of 2 messages per second and a carrier frequency of 5GHz. The proposed CAMTLP procedure utilizes both the CAM spatial and angular information along with the parameters describing the traffic light environment.

7- Systems using acoustic sensors:
This system uses acoustic sensor linked to the pre-emption system. Systems like this override the traffic signal when a specific pattern of wails from the siren of an emergency vehicle is identified. The most advantageous part of this system is that they are fairly inexpensive to implement it in our existing traffic signals and also the ability to use siren which is already installed in emergency vehicles – thus avoiding the need for installing any special equipment. But the complicated part is that the sound waves from the siren can be easily reflected by buildings and other large vehicles present at or near the intersection and this reflected wave may trigger a preemption event in the wrong direction. Yet another disadvantage is that the acoustic sensors can sometimes be sensitive enough to activate the preemption for a siren from too far away or from other unauthorized vehicle with a horn exceeding 120 dB

All these systems offered many solutions to the problems from different perspectives. But still other problems are yet to be solved attached to various traffic light pre-emption systems. For example; the narrow range of communication for these systems and decision time based on that range, the repeatedly and unwanted waiting times for other vehicles’ drivers on intersections for the emergency vehicle to pass through and the effect of congested roads, especially during rush-hours, on various pre-emption systems.

B. Comparison of Technologies.

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Optical systems</th>
<th>Line of Sight System</th>
<th>Radio System</th>
<th>GPS</th>
<th>Sensor system</th>
<th>Acoustic System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated Emitter Required?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Susceptible to Electronic Noise</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Interference?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Clear Line of Sight Required?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>AFFECTED BY WEATHER?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>POSSIBLE PREAMPTION OF OTHER APPROACHES</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>POSSIBILITY OF ILLEGAL TRIGGERING OF PREEMPTION</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>CENTRALIZED TRAFFIC SIGNAL</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

C. Systems using ITS
The intelligent transport system works by using sensors of the emergency vehicles that are detected and controller switches to green until the vehicle crosses the intersection and also providing red light to conflicting approaches in this infra red sound based radio based emitter detector is used. They use technical approaches that are based on advanced communication, information and electronics technology for better efficiency of EVP transport. Wireless communication is used to convey the traffic situation but the greatest disadvantage is ambient interference during poor weather conditions. This a mechanism has a centralized server is used to monitor and control all traffic information of emergency vehicles and the shortest path for emergency vehicles to pass by is calculated by the centralized server. The working is as follows, the traffic light phase senses the EV with the help of a
sensor then a pre-emption signal is send and all lights are turned yellow at the pre-emption phase and then accordingly green and red are at the conflict after the transition is out of pre-emption the EV is censored out of detection timing constraints are used are global timing constraints.

III. METHODOLOGY

The automatic traffic light system is that, in case of emergency vehicles like ambulances and fire engines that want to pass by when the signal is red, an automatic voice sensor which is attached to the traffic light that recognizes the siren sound of the emergency vehicles and shifts the red signal to green. This is recognized from 500m distance from the signal. When it is green signaled for the emergency vehicle’s path the other three sides of the traffic is halted. The mechanism that can be used in the sound sensors is that in which the siren sound of the emergency vehicles reaches the maximum level when it is near the signal and then decreases after crossing the signal. When the sensor recognizes the decrease of the siren sound, the normal operation of the traffic light continues.

A. Block Diagram

B. Voice Detection System

The sound of any vehicle is absorbed by the voice IC APR9600 and sent to the microcontroller. As soon as the PIC detects that it is approach of an emergency vehicle the other voice ICs are set to the inactive state for a while till the particular EV passes that IC. It checks whether any of the voice that is absorbed by the voice IC matches with the already saved pattern of the siren. If the pattern matches it will instruct the control system to change the light system accordingly.

C. Control System

The microcontroller used here is PIC16F877A (Peripheral Interface Controller). This controller controls the light system.

D. Light System

When the control system is affirmative for the siren the micro controller checks whether the system is signaled red. If so, it is changed to green and the other signals are changed to red. If the signal is already green it sees to that green signal is resumed till the EV crosses the intersection. At the same time the other three signals are changed to red.

E. Power Supply Design

This 5-15V regulated power supply project has a variable DC voltage range from 5V to 15V. It can provide current supply up to a 400mA. The voltage output is varied by using the potentiometer VR1. Here, the input line power supply is designed for 240VAC. Change the ratings of the varistor to 150VAC and the transformer ratio to 110V/12V, if 110VAC input is used.

Fuse F1 is used for a protection in case if there is any short circuit. Varistor V1 is connected in parallel to the input of the line voltage to clamp the surge voltage from the line to a reasonable level that helps to protect the transformer and other circuitry.

Once the voltage level surge to a high level beyond the ability of the varistor to absorb it, either fuse F1 will burn or varistor V1 will alone burn or sometimes both will burn. If this circuit fails after a period of operation, check whether the fuse and the varistor are still in good condition and if not replace them.

Diodes D1, D2, D3 and D4 are used to rectify the 12VAC voltage to DC voltage. Electrolytic capacitor E1 is used to reduce the ripple of the DC voltage as a smoothing capacitor. The DC voltage is fed to the input of 7805 regulator where the output DC voltage is obtained. Obviously, changing the value of VR1 will change the output also. Capacitor C1 is used to filter out high frequency component from the power supply.
IV. TRAFFIC LIGHT PRE-EMPTION SYSTEM DESIGN

In case when the signal is struck red and the traffic starts getting jammed, at that time if there is an approach of any emergency vehicle, the sound sensor which absorbs all the sound has already a stored frequency of the siren. When this frequency matches with the frequency of the siren sound from the emergency vehicle, the sensor intimates the signal. If the signal is green, there won’t be any changes and the normal operation continues. And if suppose the signal is red, the normal operation shuts down and that particular way is given green and the rest are given red till the emergency vehicle crosses the signal. This is identified by decrement of the siren’s frequency. After which the normal operation of the traffic light system continues.

V. CONCLUSION

The results indicate that this proposed system has an optimum solution for the delay time experienced on the emergency vehicles along the signal by using sound sensors like directional microphones.

REFERENCES


