Density Based Traffic Control System and Green Light Transition Time Estimation using Image Processing

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I.

Abstract

Traditionally, equal weightage has been given to the traffic signals to undergo transitions at each side of the junction. In metropolitan cities, this system would give rise to tremendous delay effect which is discomfort to the commuters. Traffic congestion affects the daily routine of passengers and in the long run there will be a declination in productivity if such situation is not addressed effectively. If an Ambulance, unfortunately got stuck in the middle of congested road, any further delay can endanger the life of the patient and many such cases require intelligent, powerful and reliable traffic control system. With the emerging technology such as advanced version of Microcontrollers, Sensors, etc., the smooth functioning of traffic signal system can be attained. For instance, in the density based traffic control system, the interface between IR Sensors and Microcontrollers System on Chip (SoCs) keeps track of vehicle's density across the lane. The microcontroller in response to sensor's output generates the control signals to alter the traffic signals accordingly. During each transition phase, the Voice Recognition (VR) modules installed on different lanes sense the emergency vehicle's siren and thus temporarily allow passage to such vehicles by turning the signal "green" for the corresponding lane, while others being remained at "red".

Using Image Processing analysis, the exact count of vehicles can be visualized in the GUI Tool (created using MATLAB®) and the green light timings for the "consecutive turns" can also be estimated. Due to globalization, the vehicle density is increasing year-by-year, hence we took the motives to propose an improvement in the existing system. We have included larger number of sensors for accuracy as well. In future, we will interface the Image Processing result and the embedded part (the one with separate program running on micro-controller) to get accurate timings to switch to different lanes and circumvent delay issues.

Keywords - *ATmega2560, Infra-Red (IR) Sensors, Edge detection (Image Processing), GUI (Graphical User Interface).*

II. I. INTRODUCTION

Vehicle density [1] at any traffic junction is a probabilistic event [2], hence it becomes complex to monitor their counts at a given time. However, the objective of traffic research is to regulate or smoothen out the flow of traffic in order to suppress the unintentional delays and deliver comfort experience to commuters. Though there are many existing models/methods available to control the traffic signals using IR sensors and the micro-controller, but we felt "incorporating/*embedding* the so-called "density [3] mode" into the "normal/traditional mode" will surely change the way the traffic control [4] system operates." In this research, we have tried to emphasize this effect, and the algorithm used can be made compatible to multiple junctions by modifying (manually) just one section of code (say a control function). Secondly, the VR module installed on each and every junction can handle the emergency situations by diverting the normal transitions of traffic signals into "emergency-mode". For convenience, the setup of the proposed system is shown in Fig 1.

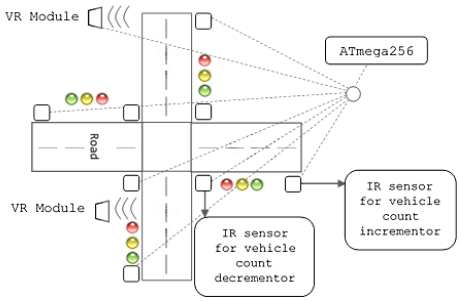

Fig 1: Proposed system architecture

Using image processing [5], the misinterpretation issues in vehicle's count can be addressed effectively. The Image Processing part offers parameters such as percentage match, vehicles count and green light timings, as discussed in design and development section. In future, the correlated version of embedded and image processing part will surely provide "All-in-One" support for traffic research. Notice the position of IR sensors, the one at the extreme end of the road counts the vehicle entry and the other near the traffic post decrements the vehicle's count. Though the logic can be achieved using single sensor but for accuracy

and reliability we have made use of two sensors. The VR module alerts other junctions in case it detects the siren of emergency vehicles. By storing the vehicle's count in memory location and using "dynamic-comparison of values of counter variables", the traffic light signal transition can be controlled by IR sensor output through the micro-controller.

II. ALGORITHM AND SYSTEM DEVELOPMENT

The data flow graph depicting the whole setup is illustrated in Fig 2.

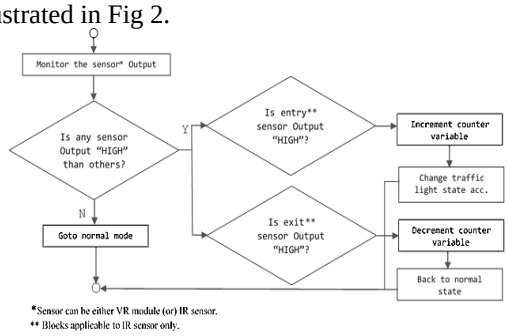

Fig 2: Data Flow Graph

Since the vehicle entry and exit are statistical events, it becomes difficult to design the algorithm that would cater the need. We have carefully considered various aspects that could occur in real-time scenario, hence we dwell to a great depth to incorporate density mode within the normal mode of operation and vice-versa. Besides, we were also able to add the feature called "resume-transition-mode" whereby the traffic signal transition "resumes" from where it was disturbed (due to density on the other lane). Despite these strong algorithms, the IR sensor miscounts the vehicle density in case the vehicles are travelling at the same speed near the junction. To prevent that from happening, we have migrated to the Image Processing Analysis (as explained in the Software section) to count the vehicles (at a particular time) more accurately. Hence in future, the combined version of the aforementioned algorithm can be implemented for imparting the full-fledged traffic-control system. Various components utilized in the construction of ideas are briefly discussed. These major hardware components include –

A. IR sensor

IR [6] transmitter looks like an LED. This IR transmitter always emits IR rays from it. The operating voltage of this IR transmitter is 2 to 3V. These IR (Infra-Red) rays are invisible to the human eye. But we can view these rays through camera. IR receiver receives IR rays that are transmitted by IR transmitter. Normally IR receiver has high resistance in order of Mega Ohms. When it is receiving IR rays the resistance is very low. The operating voltage of IR receiver is also 2 to 3V. We have to place these IR pair in such a way that when we place an obstacle in front of this IR pair, IR receiver should be able to receive these rays. When we give the power, the transmitted IR rays hit the object and reflect back to the receiver.

B. ATmega2560 based Arduino Mega

The Arduino Mega 2560 is a micro-controller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. The program for control logic (refer data flow graph) is developed using Arduino IDE (explained in software section).

C. Voice Recognition Module

This module could recognize voice. It receives configuration commands or responds through serial port interface. With this module, we can control the traffic signals by capturing siren of emergency vehicles. This module can store 15 pieces of voice instruction. Those 15 pieces are divided into 3 groups, with 5 in one group. First we should record the voice instructions group by group. After that, we should import one group by serial command before it could recognize the 5 voice instructions within that group. If we need to implement instructions in other groups, we should import the group first. This module is speaker independent. The key parameters of this module are:

- Voltage: 4.5-5.5V
- Current: <40mA
- Digital Interface: 5V TTL level UART interface
- Analog Interface: 3.5mm mono-channel microphone connector + microphone pin interface
- Size: 30mm x 47.5mm
- Recognition accuracy: 99% (under ideal environment)

III. EXISTING MECHANISM VS. PROPOSED MECHANISM

A. Existing System Introduction

In present, vehicular traffic is increasing throughout the world, especially in large urban areas. As the number of road user's increase constantly and current resources & infrastructures being limited; a smart traffic control will become a very important issue in the future. These needs have led to an ever increasing demand for an "intelligent" traffic control system. Therefore, optimization of traffic control to better accommodate this increasing demand is needed. Our project will demonstrate the optimization of traffic lights in a city using wireless sensors. Traffic light optimization is a tough problem. With multiple junctions, the complexity increases as the state of one light node influences the flow of traffic

towards many other nodes. We proposed a traffic light controller that allows us to control and study different situations of traffic density. We sense the density of traffic using infra-red sensors. The key role behind the implementation of the "Traffic density based light control system" is to make use of an AT89C51 controller which performs processing of the real time data provided by the infra -red sensors, eventually controlling the traffic flow via the LED traffic lights. The summary of the existing system can be illustrated by the following four cases:

i. **Case 1**: In this case the density is highest on the road 1 due to the presence of object on road 1.The higher density will cause the green light on road 1 will go green while red light will occur for road 2, road 3 & road 4.

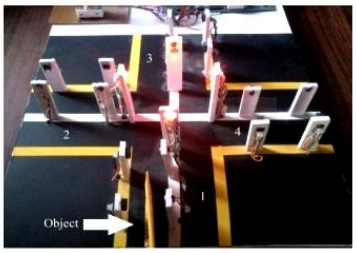

Fig 3: Case 1 scenario

ii. **Case 2**: In this case density occurs at road 2 resulting in the green light to go green on road 2 and remaining road 1, road 3 &road 4 has red lights.

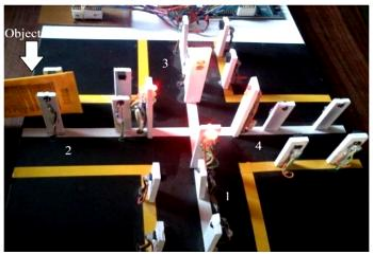

Fig 4: Case 2 scenario

iii. **Case 3**: In this case density occurs at road 3 resulting in the green light to go green on road 3 and red light occurs for road1, road2 & road4 respectively.

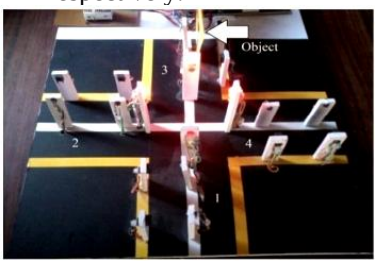

Fig 5: Case 3 scenario

iv. **Case 4**: In this case density occurs at road 3 resulting in the green light to go green on road 3 and red light occurs for road1, road2 & road4 respectively.

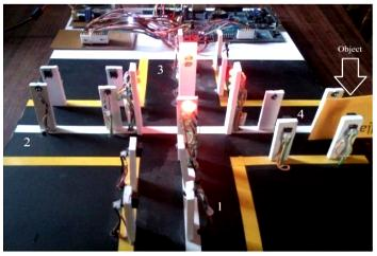

Fig 6: Case 4 scenario

"However, this system has no emergency support and neither has it offered the resume capability. Also, in the proposed system we have incorporated both the normal and density mode within the single system."

Disadvantage of Existing System

- Traffic signal is controlled by using microcontroller with the concept of timing control
- The timing control of traffic has many disadvantages
- Low efficiency
- Not reliable
- Automatic monitoring is impossible

The contending parameters of the existing and proposed system are tabulated below.

TABLE 1: Existing Method vs. Proposed Method summary

Parameters	Existing System	Proposed System
Normal Mode	✓	✓
Density Mode	✓	✓
Normal + Density mode	X	✓
Resume capability	X	✓
Emergency mode	X	✓
Image Processing Analysis	X	✓

Advantages Of Proposed System

- Controls the traffic signal according to traffic priority and passage for emergency vehicles using VR module.
- Processor driven system [7].
- Two sensors per lane to sense vehicle's presence accurately.
- 80% automated.
- Low computational requirements.
- Faster recognition of events.
- High Efficiency.
- Simple technique used.
- Image Processing available!

IV. SOFTWARE

A. A. Arduino IDE

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the

programming language Java. It originated from the IDE for the languages - *Processing* and *Wiring*. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".

The Arduino IDE supports the languages C and C++ using special rules to organize code. The Arduino IDE supplies a software library called Wiring from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consist of two functions that are compiled and linked with a program stub *main()* into an executable cyclic executive program:

- *setup()*: a function that runs once at the start of a program and that can initialize settings.
- *loop()*: a function called repeatedly until the board powers off.

After compiling and linking with the GNU tool chain, also included with the IDE distribution, the Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware.

B. Image Processing

In image processing analysis, we have four components/panes for different images of four lanes of a traffic junction. The first pane is for reference image, which is a fixed image (though can be altered using browse button provided) and this image contains maximum of vehicle density across any one of the lanes of the junction. Once the end user has loaded the images of 4-lanes, he/she can use sobel edge-detection technique (or) opening (morphological operation) technique to count the vehicle density on all the different images, which have been uploaded to the GUI (Graphical User Interface). Once the edge detection process is complete, the "match" button reveals the percentage match values and the green light transition time for the next consecutive turns are also displayed. The screen-shots of program are illustrated as shown:-

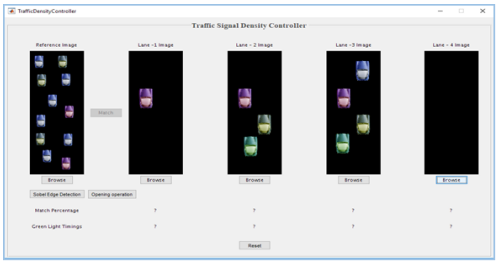

Fig 3: Before opening and closing operation

Fig 4: After opening and closing operation

V. CONCLUSIONS

Thus the implementation of algorithm and evaluation of density based traffic control system under simultaneous mode of operation (normal + density mode or emergency mode) [8] was successfully carried out and we also tried to establish the resume feature [9] which has significantly reduced the delay effects. Also, the Image Processing Analysis was successfully carried out for various combinations of images and outputs were found to be 90% accurate. In future, we have decided to merge both the embedded and image processing part for making decision process extremely reliable and accurate.

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