Prototype Implementation of Density Based Traffic Light Control System

Using NI LabVIEW and NI myDAQ

RAJKUMAR L BIRADAR1, PHANINDRA REDDY K2, GIRLJA VANI G3

1Associate Professor, Dept of E&TM, GNITS, JNTU, Hyderabad, India, E-mail: rajkumar_lb@yahoo.com.
2Assistant Professor, Dept of E&IE, RYMEC, Ballari, India, E-mail: phanindrareddyk@gmail.com.
3Assistant Professor, Dept of E&CE, RYMEC, Ballari, India, E-mail: vanigirija@yahoo.co.in.

Abstract: As most metropolitan areas face high traffic volumes especially during rush hours as more and more vehicles join the roads. The conventional approach of controlling the traffic signals with the fixed timer interval for each road is ineffective, if the traffic is unevenly distributed. This causes inefficient usage of the resources. To address the traffic menace and allow better usage of the resources, there is a need to introduce the state-of-the-art technology and other innovative techniques to the Traffic Transportation System. One such intelligent technique is to control the time interval of the traffic signals based on the measurement of the traffic density using pattern matching technique. This proposal would offer better road utilization and improve the traffic management in rapidly growing cosmopolitans and metropolitans.

Keywords: Traffic Light Control, Pattern Matching, myDAQ, LabVIEW.

I. INTRODUCTION

In the recent years, it is no doubt that the traffic congestion has been a serious problem in the metropolitan and the urban areas as the commuters tend to miss the schedule, arrive late at work, degrading the urban road traffic acoustic environment and has also been a severe concern as it contributes to about 25% of the total green house gases [1]. The ratio of passengers to vehicles is ever increasing, since the cost of the car is more affordable for an average consumer than it was some years ago, as the public transport system is mostly unreliable and the society is becoming more mobile as most of the public willing to commute by cars. Traffic congestion also costs indirectly to the companies, as workers arrive late to their work places resulting in loss of money, productivity from workers, trade opportunities are lost and the delivery are delayed. It is clear that there isn’t a single solution to this crisis, given the complexity of its causes. The possible solutions to the congestion problems might be putting in place the state-of-the-art infrastructure, expanding the existing roads and providing the alternate route. Addition of new infrastructure facilities is not only time consuming but also would cost a lot to the local bodies and to the State Government.

The latter idea of expansion and providing new alternate route seems unrealistic as most cities aren’t properly planned and have occupied their fullest capacity. A more feasible solution is to embed intelligence into the Traffic Transport Systems. There exist different types of systems used for solving the traffic congestion viz., Fuzzy Expert System, Artificial Neural Network, An Intelligence Decision-making system for Urban Traffic-Control [2]. The proposed idea uses pattern matching in detecting the vehicles and estimating the number of vehicles and then control the traffic lights timer interval based on the estimate. National Instrument’s LabVIEW is the preferred choice of the programming language as it has wide range of predefined library functions and other tools that makes the graphical programming that makes the application development easier. The application developers can combine the power of LabVIEW software with modular, reconfigurable hardware to overcome the ever-increasing complexity involved in delivering measurement and control systems on time and under budget.

II. DESIGN OBJECTIVE

The present microcontroller based traffic control system uses a fixed time slice to schedule the traffic lights. They have predefined cyclic time controlled by a program running on a microcontroller computer based on pre-assumed average traffic conditions. This kind of approach does not consider the real time traffic dynamics and significant amount of time is wasted by presenting a green signal for a fixed time on a less congested road or on the empty road as compared to a more congested one. The considerations of the advanced techniques like the Fuzzy Systems, Artificial Intelligent Systems, and The Neural Network Systems in the Intelligent Traffic System might offer a reasonable solution to the problem, however the system design is complex and possible solutions tends to be time consuming. Therefore the design and implementation of the system using the effective graphical system design approach; the NI LabVIEW would be highly beneficial as it offers Reduced time to prototype, Reduced time to market, Smoother technology transfer process, Protection of intellectual property, better/faster prototyping, hardware-in-the-loop (HIL) simulations, User friendly, Graphical Programming Language and several such features. This has been the motivation to design and develop the system using the LabVIEW software.
RAJKUMAR L. BIRADAR, PHANINDRA REDDY K. GRIJIA VAN G

III. METHODOLOGY

This section focuses on the design of the Density based traffic light control system using LabVIEW. The system design considers the uneven distribution of traffic on the roads. The block diagram of the system is as shown in the fig.1 and the flowchart is as shown in fig.2. The brief working of the system is explained below:

Phase 1: Initially image acquisition is acquired using the USB camera. First image of the road is captured by rotating the servo motor at 90°, 0° and -90°. Accordingly, the images are acquired; this image is then fed to a computer where the processing on the image is done by the application program developed using the LabVIEW.

Phase 2: This image, which is fed to the computer installed with LabVIEW, uses vision acquisition and pattern matching to detect the vehicles by comparing the acquired image with the template using the pattern matching technique.

Phase 3: After estimating the number of vehicles and calculating the time interval for the traffic light, the control data is given to the traffic lights using an interfacing device (myDAQ), and the same procedure is repeated to all the roads.

III. THE SYSTEM IMPLEMENTATION

The overall implementation of the Density based Traffic Light Control System is described under the two sections as follows:

A. Software Section

The entire application program is developed using the LabVIEW graphical programming language. The basic constructs used in the application development are [3]:

- IMAQ Functions
- Vision Acquisition Functions
- IMAQ Match Color Pattern function
- while loop structure
- Flat Sequenced Structures

Fig.1. Block diagram of Density Based Traffic Light Control System.

Start

Initialization

Rotate Camera to Road 1 (Servo Angle 90°)

Road 1 Image Acquisition & Density Estimation

Rotate Camera to Road 2 (Servo Angle 0°)

Road 2 Image Acquisition & Density Estimation

Rotate Camera to Road 3 (Servo Angle -90°)

Road 3 Image Acquisition & Density Estimation

Traffic Signal Timer Control

Stop

Fig.2. Flowchart of the Density Based Traffic Light Control System.

The upper half of the fig.3 shows the graphical code for initializing the reading the RGB image using IMAQ Create function, which is responsible for creating a temporary memory for the template image (a red rectangular marking on the vehicles used for density measurement), that is read by IMAQ Read Image And Vision Info. The lower half of the fig.3 shows the graphical code for initializing the Servo Motor. A Temporary memory is created by the DAQmx Create Task.vi to store the configurations. Now the task available in the memory is ready to run upon the execution of DAQmx Start Task.vi, hence allowing the interactions to control the Servo Motor.

Fig.3. Initialization of USB Camera and Servo Motor.
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Fig. 4. Setting the Servo Motor Angle of rotation.

The above fig. 4 shows the graphical code used to set the position of the USB camera mounted on the arm of the Servo Motor. The Servo Motor Angle of rotation is controlled by generating the PWM signals of appropriate ON time by converting the angle of rotation in degree into its equivalent ON time. The same code snippet is repeated for two more roads with appropriate “Camera Positioning Angle (deg)” as shown in the table below:

<table>
<thead>
<tr>
<th>Road No.</th>
<th>Camera Positioning Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road 1</td>
<td>90</td>
</tr>
<tr>
<td>Road 2</td>
<td>0</td>
</tr>
<tr>
<td>Road 3</td>
<td>-90</td>
</tr>
</tbody>
</table>

TABLE 1: Camera Position for Each Road

Fig. 5. Vehicular Density Estimation using Image Acquisition and Pattern Matching.

The fig. 5 shows the graphical code that estimates the traffic density, by capturing the image of the road using Vision Acquisition and detecting the vehicles by searching the red rectangular template on top of the vehicle using IMAQ Match Color Pattern function. The same code snippet is repeated to estimate the traffic density for all the roads. After the estimation of the traffic density of all three roads, the next phase is to appropriately control the traffic signals.

Fig. 6. Traffic Signal Control for all three roads.

The above fig. 6 shows the graphical code from frame 6 to frame 12 of the sequence structure to control the traffic signals by calculating the time for the vehicular flow based on the traffic estimate. Calculation is done by considering two seconds of average time to cross the signal as shown in the code as 2000ms. Thus, the traffic signal control operation is repeated forever is shown in the system flow diagram. As shown in the fig. 6, a pair of DAQmx Assistants is used in each of the flat sequence structure. The upper DAQmx assistant corresponds to myDAQ1 and the lower DAQmx assistant corresponds to myDAQ2.

B. Hardware Section

The implement the system prototype the following hardware devices/ components have been used:
- NI myDAQ (2 No’s)
- Servo Motor
- USB Camera
- LED’s

NI myDAQ: The National Instruments myDAQ [4] is a portable data acquisition (DAQ) device that students can use to design control, robotics, and mechatronics systems. The pinouts, connectivity information, specifications of the NI myDAQ is shown in the fig. 7.

Servo Motor: The servo motor is used to rotate the mounted camera on top of at 90°, 0° and -90° for “Road 1”, “Road 2” and “Road 3” respectively, to capture the images of the respective roads. The Rotation of the motor is controlled by the counter (DIO3) of myDAQ, which generates the appropriate PWM signals for the above mentioned angles.
USB Camera (HD 720p): The camera sequentially acquires the images of all the three roads and sends them to the computer for further processing.

Light Emitting Diodes (LED’s): Three different color LED’s are used to represent the traffic signal whose operations are controlled by the nine digital lines (DIO’s) of the myDAQ’s.

IV. RESULTS

The fig.8 shows the Prototype Implementation of the Density Based Traffic Light System containing the USB camera on the top mounted on the servo motor. The figure also shows the traffic signals and the toy cars placed on all the three roads. The camera rotates at angles 90°, 0°, -90° to acquire the images of the roads and estimates the number of vehicles and calculates the approximate time (assuming 2seconds/vehicle) for to the traffic flow at the junction. The fig.9 shows the front panel (result panel) of the application program from the LabVIEW environment with a Green LED “ON”.

V. CONCLUSION AND FUTURE SCOPE

The prototype is designed such that the traffic timer signal intervals depend on the density of the vehicles present on the road. This reduces the waiting time of vehicles waiting on other roads and also reduces the fuel consumption. Furthermore, if the road is empty i.e. if no vehicles are present on the road, then that road is signaled red till the vehicles presence is detected.

VI. REFERENCES