Development of Real-Time Traffic Management System

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Abstract: This paper introduces a real time traffic control system would be created for each traffic light at an intersection on Yangon-Insein road. This research paper presents also a dynamic time contribution schemes based on volume of IR sensors according to the traffic congestion condition. The IR sensors are used to sense and count the vehicle volume and programmable logic controller (S7-300, Siemens PLC) based routing algorithm is programmed for excellent traffic control system. Sensor based routing algorithm is considered and enhanced upon the traffic signal flow of existing traffic point at Thamine junction. To manage the traffic congestion, the alternative ways and traffic instruction monitoring boards are considered for heavy traffic jams at two road portions. A prototype model for a tested traffic light is simulated. The simulation outputs are achieved by SIMATIC Manager simulation software.

Keywords— Traffic Algorithm, Vehicle Volume, Traffic Control System, IR Sensors, S7-300 Siemens PLC

I. INTRODUCTION

Vehicular traffic is continuously increasing around the world, especially in large urban areas. Traffic is becoming one of the important problems in our society, which is possible to be resolved by this proposed system that is the development of real-time traffic management system with traffic flow control algorithm. The application area for this proposed system is Yangon-Insein Road. According to the control algorithm, the system can control the traffic congestion and help to improve the traffic situation. Thus, the proposed system may become a major concern to transportation specialists and vehicle traffic control. The existing methods for traffic management, surveillance and control are not adequately efficient in terms of performance, cost, maintenance and support. This work efficiently manages new traffic flow control algorithm for four bounds junction in particular, it presents sensor-based traffic flow control PLC algorithm using enhanced concept for controlling the traffic flow sequences on that road. This system is dynamically adaptive to traffic conditions on both single and multiple intersections.

II. METHODOLOGY

The model of dynamic signal time contribution algorithm for traffic control system created by program instructions based S7-300 Siemens PLC. It consists of six components.

A. SIMATIC S7-300 Siemens PLC

SIMATIC S7-300 Siemens PLC is the modular mini PLC system for the low-end and mid performance application ranges. It works with a comprehensive range of modules for optimum adaptation to the automation tasks the mid-range family of the microcontroller devices. It is used to control the traffic signal light program in four bound junctions on the roads. The S7-300 is a modular design and all modules are open component. All of the S7-300 modules are contained in housings protected to IP 20, i.e. they are encapsulated and can be operated without a fan. Several S7-300s can communicate together with other SIMATIC S7 PLCs via PROFIBUS bus cable [1].

B. Languages of PLC

To implement the flow chart of the system, an application program is written by the ladder diagram format [2].

C. SIMATIC Simulation Software

As of STEP 7 V5.5 SP3, a new import interface is implemented for the mechatronic concept designer and for PLC open-compliant XML files for the "S7-GRAPH" optional package [3].

D. IR Sensors

The medium range infrared sensor IR-TR-10 offers simple, user friendly and fast obstacle detection using infrared; it is non contact detection. The implementations of modulated IR signal immune the sensor to the interferences caused by the normal light of a light bulb or the sun light [4].

E. Kind of Traffic Lights

Four kinds of traffic lights are considering at each traffic points in this proposed system. They are

1. Green light for through (Thru) movement,
2. Yellow light for through (Thru) movement and left turn (Left) movement,
3. Green light for left turn (Left) movement, and
4. Red light.

F. Sensor Location

There are three sensors per lane to sense and count the vehicles density for through (Thru) movement and left turn (Left) movement on each bound [5]. These sensors are put beside of the road and the first level sensor starts 164 feet or 50 meter distance from the stop line of traffic junction. The next sensors are located consequently every 164 feet or 50 meter distance [6].

III. SYSTEM DESIGN AND IMPLEMENTATION

The design and implementation of this traffic control program can be considered into six main parts:

A. Collection of Traffic Information at Thamine Junction

To develop traffic management system, firstly traffic information data collection is made. The routing algorithm is considered upon the existing intersection turning movement volume data and numbers of count vehicles at Thamine junction on the multiple counting periods of days. The collected turning movement volume data at Thamine junction are shown in Table 1 and Table 2.

Table 1: Turning Movement Volume Data at Thamine Junction

<table>
<thead>
<tr>
<th>Bound and Time (25.12.2015)</th>
<th>South Bound (Insein)</th>
<th>North Bound (Kamaryut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement</td>
<td>T</td>
<td>L</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>62</td>
</tr>
</tbody>
</table>

T = Through or straight movement; L = Left turn movement; R = Right turn movement.
It mainly calculates the green-light time for straight forward or through (Thru) movement and left turn (Left) movement on three lanes at four bounds junction according to the return values from the sorting_Thru function and Sorting_Left function in “East-West” subroutine for east-west bound in main control program. The operation of “South-North” subroutine for south-north bound is similar to the “East-West” subroutine.

E. Operation Description of South-North Subroutine

The calculation of green-light signal timing is explained by letting south-north bound as an example. The maximum allowed capacity of three IR sensors may be between 15 and 40 no. of cars. The south sensors are E1, E2, E3 and north sensors are C1, C2, C3 are for left turn (Left) movement. The maximum numbers of cars (MAX_Thru) for through (Thru) movement are achieved by “Sorting_Thru” sorting program. Then, the green-light time for through (Thru) movement with five seconds tolerance is calculated by Equation 1.

\[ T_{G-Thru} = (\text{MAX}_{-\text{Thru}} \times 3) + 5 \]  

Similarly, south sensors D1, D2, D3 and north sensors C1, C2, C3 are for left turn (Left) movement. The maximum number of cars (MAX_Left) for left turn (Left) movement is achieved by “Sorting_Left” sorting program. Then, the green-light time for left turn (Left) movement with five seconds tolerance is calculated as Equation 2.

\[ T_{G-Left} = (\text{MAX}_{-\text{Left}} \times 3) + 5 \]

Therefore, the red light ON time of east-west bound is equal to the sum of the green-light time for through and left turn movements of north-south bound with added two times of yellow-light time as an Equation 3.

\[ T_{RED} = T_{G-Thru} + T_{G-Left} + 4 \]

The meanings of the terms are illustrated in above equations as follows.

- \(T_{G-Thru}\) = green-light time for through movement (s)
- \(T_{G-Left}\) = green-light time for left turn movement (s)
- \(T_{RED}\) = red-light time (s)
- \(T_{Y}\) = yellow-light time = 2 second
- \(\text{MAX}_{-\text{Thru}}\) = maximum no. of cars for through movement
- \(\text{MAX}_{-\text{Left}}\) = maximum no. of cars for left turn movement

The overall system flowchart is shown in Fig. 1. It consists East-West subroutine and South-North subroutine. Two subroutines are operated regularly and alternatively by regular electricity “ON” condition. If the electricity is breakdown, the traffic flow is controlled by direction of traffic police. When the electricity is turn on again, program restarts to run “East-West” and “South-North” subroutines after generating 10 seconds red light “ON” as a program start situation.

C. Sorting_Thru Function and Sorting_Left Function

The purpose of this two functions are to sort the maximum number of vehicles counted of six IR sensors by descending order. These functions have a return value MAX_Thru and MAX_Left as maximum number of cars for through and left turn movement respectively. They are composed in their subroutines.

D. East-West Subroutine and South-North Subroutine

The purpose of this two subroutines are to run alternatively and to set traffic light signal timing based on number of vehicles counted by IR sensors.

Table 2: Turning Movement Volume Data at Thamine Junction

<table>
<thead>
<tr>
<th>Bound and Time (25.12.2015)</th>
<th>East Bound (Kyetwine)</th>
<th>West Bound (Bayintnaing)</th>
<th>Movement</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>19:45~20:00</td>
<td>20:15~20:30</td>
<td></td>
<td>T</td>
<td>87</td>
</tr>
<tr>
<td>T</td>
<td>L</td>
<td>R</td>
<td>L</td>
<td>43</td>
</tr>
<tr>
<td>Thru</td>
<td>Left movement</td>
<td></td>
<td>R</td>
<td>65</td>
</tr>
</tbody>
</table>

T = Through or straight movement; L = Left turn movement; R = Right turn movement.

Table 3: Comparison Results between the Existing System and the Proposed System

<table>
<thead>
<tr>
<th>Real-Time Start from 5 p.m. (min:sec)</th>
<th>Existing System</th>
<th>Proposed System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green_Thru Light ON</td>
<td>Green_Left Light ON</td>
</tr>
<tr>
<td>from to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:00 to 01:00</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>01:00 to 01:20</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>01:20 to 02:40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02:40 to 03:40</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>03:40 to 04:00</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>04:00 to 05:20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05:20 to 06:20</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>06:20 to 06:40</td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 1: Flow chart of overall system

The overall system flowchart is shown in Fig. 1. It consists East-West subroutine and South-North subroutine. Two subroutines are operated regularly and alternatively by regular electricity “ON” condition. If the electricity is breakdown, the traffic flow is controlled by direction of traffic police. When the electricity is turn on again, program restarts to run “East-West” and “South-North” subroutines after generating 10 seconds red light “ON” as a program start situation.
The comparison results between the existing system and the proposed system shown in Table 3 and Table 4.

These data in Table 3 are collected at north bound of Thamine junction in the evening on 24.4.2016 by collecting manually. The data in Table 4 are achieved from simulation result. These two tables are assumed on same duration of red-light time.

According to these Tables, all 73 no. of cars for through movement requires six minutes and 20 seconds long to pass this junction by the existing system. In the proposed system, not only 45 no. of cars take two minute and 20 seconds but also all 73 no. of cars required six minutes and 30 seconds duration to pass this junction.

Next, all 25 no. of cars for left turn movement requires six minutes and 40 seconds long to pass this junction by the existing system. For the proposed system, all these 25 no. of cars take three minutes and 40 seconds duration to pass this junction.

Furthermore, the proposed system adjust the traffic jam of two bounds (as an example: east and west bound) and set the signal timing depends on the maximum number of vehicles of that two bounds. So, the proposed system is more efficient traffic management system than the existing traffic control system, gained less waste time, greater smooth traffic flow and quick service for all road users. Can easily set the signal timing w.r.t traffic jam, Net, driver and road users can easily estimate their departure time to pass the junction depend on their position according the sensors’ position. All drivers and all passengers obtain extra time benefits individually. If people use this road more time, they will save their more private time and they can do their improvement. All road users will arrive in time or on time at their work.

No waste time for no cars condition due to the two green-light time are depend on no. of vehicles. In this condition, traffic control flow is running with minimum constant period 29s-2s-14s-2s-47s timing.

### IV. SIMULATION RESULT

All the codes have been tested and simulated by using SIMATIC Manager simulation software. This simulation results are successfully completed. The simulation results for south-north subroutine at initial condition and through movement running condition are illustrated in Fig. 3 and Fig. 4. As shown in Fig.3 and Fig.4, Timer 7, Timer 8, and Timer 9 are stored and displayed for the green-light time T_{G,Thru}.

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Next, Timer 10, Timer 11, and Timer 12 are stored and displayed for the green-light time TG_Left.

And then, Timer 13, Timer 14, and Timer 15 are stored and displayed for the red-light time TRED-E/W. Furthermore, the maximum number of vehicles are stored in both Counter 5 and Counter 6 for through movement and Counter 7 and Counter 8 for left turn movement.

**CONCLUSIONS**

In this paper, the traffic signal time control flow algorithm which controls the traffic light of any four bounds junction is presented. It is S7-300 Siemens PLC based control program.

The maximum number of cars MAX_Thru and MAX_Left are return values of Sorting_Thru and Sorting_Left function may be 15 to 40 due to sensor’s distance of each other. Therefore, the TG_Thru and TG_Left may be greater than 99 seconds. So, TRED is examined two times of the logical decision for greater than 99 seconds to complete programming concept because TRED is equal to the sum of TG_Thru and TG_Left.

So, the proposed system is most reasonable and reliable algorithm for both one way, two ways, or multiple ways of roads and unidirectional lane or bidirectional lane of any traffic lights.

**Acknowledgments**

The author wishes to express her gratitude to Dr. Aye Myint, Rector of Yangon Technological University, for his encouragement. The author is deeply grateful to her supervisor, Dr Yu Yu Lwin, Associate Professor and Head, Department of Electronic Engineering, Yangon Technological University, for her willingness to share her ideas and helpful suggestions. The author is very thankful to U Thant Zin Win,
Lecturer, Department of Electronic Engineering, Yangon Technological University, for his valuable support and help.

The author greatly expresses her thanks to all persons will contribute in different ways to support in preparing this paper.

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