PC-BASED ADAPTIVE ROAD TRAFFIC CONTROL SYSTEM*

by

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*This paper is the undergraduate thesis of the authors.

ABSTRACT

This paper is about a PC-based road traffic control system which regulates the flow of traffic based on the data obtained from the sensors. These data are processed and evaluated according to a defined set of rules. The control system then executes the appropriate manipulation of the traffic lights best suited for a particular traffic condition. The designed system is responsive to any flow of traffic such that it reduces abnormal conditions of traffic in any given intersection.

THE PROBLEM

The present traffic controller used in the Philippines is inefficient and unresponsive to the actual flow of vehicular traffic. It fails to regulate the in and out flow of vehicles resulting to abnormal traffic conditions. During times of heavy traffic volume for instance, the present traffic controller cannot prevent clogging from happening. It has no way of knowing whether receiving ends of the intersection have exceeded their capacity and can no longer accept more vehicles at the present moment. It cannot cut off its signal timing to reduce the likelihood of having a clogged intersection. This illustrates that the current system has a problem of keeping the intersection open. It only considers the approaching traffic and disregards the receiving end. Streams with already full receiving ends are still being issued with green light. As a result, it fills up the intersection and blocks the movement of vehicles of the next stream. For cases which involve two movements, such that there is a movement of cars from north to south of the intersection and another movement of cars from south to north of the intersection, the controller cannot issue a red signal to any of the movement while maintaining the other movement in green signal. Such a case happens when only one receiving end of a two-movement phase clogs.

There exist also the problem of servicing the demand in the intersection. This happens when the controller issues a green signal to a section of the intersection where there are no vehicles. Likewise, this happens when the controller continues the elapse of the green time even though there is no vehicular movement in the intersection. In these cases, the controller is issuing the green signal to where there is no demand for it. This means either skipping or cutting of the green time or extending of the green time.

THE SOLUTION

As stated, the problem lies in keeping the intersection open at all times and issuing green signal to deserving streams. It seems to be that traffic enforcers are still needed simultaneously with the present traffic controller. But again, traffic aides are not present during heavy traffic conditions most of the time. If only the traffic controller can "see" what is happening at the intersection, if it can only "think" of what it can do when the traffic becomes abnormal, and if it can "act" immediately, then the problem can be solved. What is needed is a traffic controller that is fully actuated in any given traffic condition which the project is all about.

FEATURES

1. It issues green signal to directions only with vehicles at the approach and whose receiving (exit) ends are not clogged. If the next phase is north-to-south and south-to-north, and the north-to-south direction is clogged; only the south-to-

north direction would be issued with the green signal. Once the clog is gone, the north-to-south direction would be issued with the green signal depending on the green time left for that phase.

2. It cuts off the green time whose receiving ends become clogged. In order to avoid the intersection of being blocked, a red signal is issued at the clogged direction.

3. It extends the green time of the current phase while it is not clogged and have vehicles, and while all the other directions are clogged. Only directions which are able to pass through is given the priority since it will not block the intersection. If the clogged direction is allowed to have a go signal, the intersection will eventually not be opened.

4. It skips a phase when necessary. If the direction/s of the next phase is/are both clogged, it is skipped because otherwise traffic jam would result. Instead, a phase with unclogged direction/s and vehicles is given the go signal.

5. It issues a red signal to all directions when all receiving ends are clogged. Once this condition happens, an all red signal is applied until it finds an opening.

6. A Manual Controller is provided in extra-ordinary instances. Unlike the present manual controller, the operator can also skip a phase when that phase is clogged. Thus, he has no choice but to pass through that phase before electing to go to the appropriate phase. In this new Manual Controller, he can directly jump to the desired phase.

7. It can also determine the required green time for a given intersection through the use of Webster Formula.

8. It can monitor the vehicular volume passing through the intersection.

9. It issues an all red signal when it detects no presence of vehicles in the intersection.

10. The system's fully actuated feature can be turned off. The system neglects data from its sensors, making it a pre-timed signal control system.

11. The system can be manually controlled through the PC keyboard. Keys are defined to skip, provide an all red or flashing yellow signals.

12. It allows time programming. Certain plans, sets of timing and phase movements, can be assigned to certain time of the day or the day of the week, which the system uses.

METHODOLOGY

The project is broken down into three major parts. These include traffic engineering considerations, software and hardware design and implementation. The approach to the project

would start in the study of the basic concepts of traffic engineering. Traffic variables, limits and data dictate the software and hardware design. Moreover, these would help in the determination of the proper layout for the sensors.

The software design starts with the definition of the data and variables to be processed by the computer, basing on traffic signal control protocols. The algorithm will then be generated. This will be translated into the C programming language. The adaptive characteristics of the traffic control system and its general application to basic types of intersection are embedded in the software. For the hardware design, it is dictated by the software that will manipulate it. The hardware components are connected to the PC which is used as a road traffic controller. The overall system is applied to a certain intersection. Such an application maybe presented through a typical model of an existing intersection. Likewise, one can present the prototype through the use of computer simulation. In this case, data gathered from chosen intersection will be regenerated and simulated by the computer. Furthermore, the project can be implemented in an actual intersection.

THE PROTOTYPE DESIGN OVERVIEW

The prototype design is divided into 9 major functional modules namely: (1) PC, (2) Interface Card, (3) Address Decoder, (4) Timer Circuit, (5) Vehicular Light Decoder, (6) Pedestrian Light Decoder, (7) Manual Controller, (8) Sensors and (9) Lights. The PC is used to control and monitor 4 modules: Vehicular Light Decoder, Pedestrian Light Decoder, Timer Circuit, and Sensors. These modules are accessed by the Address Decoder module which is then linked to the computer through the Interface Card. The purpose of the Vehicular Light Decoder and Pedestrian Light Decoder is to manipulate the data that would control the vehicular and pedestrian lights respectively. The appropriate green time is clocked by the Timer Circuit which is then being polled by the PC until the time is finished. The Sensors detect the presence, clogging, and traffic volume in the intersection in which the PC also polls. Finally, the Manual Controller is used only as a back-up controller in extra-ordinary instances.

The written software dictates how the hardware part of the system works. It includes programs for using the Webster formula, input of traffic design, test of the hardware of the system and likewise the control of the system.

SYSTEM APPLICATION

The traffic control system is of a general type being adaptive to all types of intersection. It can be installed for use in a Y-type or X-type of intersection. Its hardware is of a general design and the software provides for the adaptive character of the system. It can be actually interfaced to existing traffic control systems. It can be readily setup to replace the existing local controllers.

Designing the system for a certain application includes a hardware and software setup. The setup depends upon the intersection to which the system is to be applied. Before any signalization of intersections, field surveys are done in order to determine if the intersection merits a traffic control system. Actual on-site observation is done to count the number of vehicles flowing through each stream in the intersection. These counts provide for the data needed to calculate if the intersection requires signalization and determine the optimum number of phases and the sequence of movements and likewise the green times. There are a number of methods to

accomplish this. One is the Webster method. Computations using this method is usually done manually. The system's software has already provided a program for such method, to aid in the first step in the design of the traffic control system. Volume counts gathered from the field are loaded into the program, this includes also the corresponding phase movements. The program will compute for the green times. These results can be saved to a file to be used for the design of the control system.

The use of the Webster program can be skipped if for example the designed green times and phase movements are already determined. The input program is then executed where traffic data are loaded. The following are the required traffic data to be defined:

1. *number of plans*. This include sets of cycles to be used for intersection at certain times of the day or the week.

2. *number of phases and corresponding movements*. The number of phases for the plan is set, defining the vehicular and pedestrian movements for each phase. The reference intersection is of an X-type, with a North-South-West-East direction. For the actual intersection in the reference intersection. Then phase movements are defined.

3. *green time*. This is the time duration in seconds for each phase defined. The data can be loaded from the results from the Webster program, or directly defined by the user

4. *interval timing*. These are the time periods in seconds for the all red and yellow condition.

5. *other timing parameters* [in seconds] such as:

    a. the time when the flashing walk signal is issued
    b. the time when the extension is to be issued, that is extending of the green time
    c. the time duration of the extension
    d. the number of extensions to be given
    e. the number of skips to be issued, sets the limit for skipping of phases where default settings are given.

6. *sensor initialization*. The sensors to be installed are defined which include those for clogging, presence and vehicle counting. The sensors provide for the full actuation of the system. Data from these sensors are processed based from a set of rules defined in the control program.

7. *time programming*. Plans can be set and programmed at certain times of the day or day of the week.

The traffic data is to be saved to a file for use with the control program. The control program requires this file containing the design in order to control the hardware setup. When loaded, the PC then controls the traffic lights based from the designed file. In its operation, one can also

manipulate the traffic lights through the keyboard. Through user-defined keys, one can set on or off the full actuation of the system, or skip or extend green times, or issue an all red or flashing yellow signals.

SYSTEMS ADVANTAGE

PC CONTROL

The PC has an edge over the microprocessor-based controller. One advantage of the PC is the programming flexibility. The system through the PC can be readily and easily programmed. One can easily change the design of a certain intersection just by loading another file containing another set of traffic data. Aside from this, one can program the system right there and then in the intersection. Actually, the software provides the instruction for the PC on how to manipulate the system. Features such as skipping, extension and the like can be easily incorporated through simple re-programming of the software. Following this, a set of rules are actually defined in the source code which are used in the processing of data from the sensors. The rules can be readily changed in order to suit the intersection.

The PC provides also the display of the conditions in the intersection. One can monitor the presence and clogging of vehicles through the PC display. The display covers the conditions of the traffic lights, the date and time, the green time, the current phase movements, and likewise the conditions of the sensors. From the display, the user can also manipulate the traffic lights through the keyboard if any abnormal condition is seen through the monitor.

The PC actually makes the system adaptive to all types of intersection and likewise to the flow of vehicles in the intersection.

MANUAL CONTROL

The system is provided for with a manual controller. In cases where the PC would breakdown or the traffic system requires the manipulation by traffic aides, the manual controller comes in. Compared to existing traffic controllers, the systems' manual controller allows the manual selection of phase to be executed. Likewise, one can jump from one phase to another. Phase movements in the manual controller can also be programmed.

UPGRADE

The system can be easily upgraded to provide for a more efficient regulation of traffic flow in intersections. One can write a better algorithm for the software. It is simply the software that is to be changed. Or if one is to consider a network of intersections, the system can be designed to control more than one intersection. Likewise, one can use higher PC system to provide faster processing and control.

CONCLUSION AND RECOMMENDATIONS

A PC-based road traffic control system is an alternative approach best suited to Philippine traffic conditions. This prototype system is responsive to the actual flow of traffic in a typical isolated intersection.

The design concentrated on gathering data from the field by using ultrasonic sensors as one of the major means of data gathering. The data collected were processed according to a set of defined rules to be able for the system to adopt itself to traffic conditions. The objective of doing this was to reduce
the waiting time of the arriving cars and at the same time prevent the intersection from getting clogged. Many considerations were made for the system to become flexible. First is the manual controller, its purpose was to take over the system in case of extraordinary instances. Secondly, additional ports were provided for future considerations.

It is highly suggested that the following recommendations should be considered for the future development of the system.

1. In the design, further studies can be made on trying to control more than one controller of the same nature using the PC.

2. In the software department, the artificial intelligence should further be enhanced and developed to provide better decision-making on the part of the computer.

3. The sensors employed in the design is for demonstration purposes only. However, the circuity for acquiring the data from the sensors. It would be advisable to further continue the research on other sensors like the ultrasonic, infrared, inductive loop and other transducers that serve the same purpose.

4. The system was designed to best serve an isolated intersection. However, it can also be adopted to other types of intersection.

5. Provisions can be made for incorporating pedestrian signal buttons. This can be done by reserving one of the sensor ports.
