A Novel Approach for Automatic Control of Road Traffic Congestion using Image Mosaicking Technique

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Abstract-- As the major problem of urban and developed cities is spreading of traffic congestion day by day. For which, there is a pressing need of advanced technology to provide reliable results with improvement of the state of the art of traffic control mechanism. As on date, Traffic problems are increasing with a higher rate around the world because of the number of vehicles are increasing by leaps and bounds besides the resources available with the current infrastructure are limited. Now as existing methods to solve traffic congestion problem, the manual identification of control points and tedious several automatic techniques have been developed. But these all techniques may be time consuming. So this paper discuss, amethodology named “Structured System Analysis” to analyze the existing traffic congestion problem and designing a new model by using image mosaicking techniques.

This paper proposes a new approach for dynamic and automatic traffic light control system using image mosaicking techniques. Generally Image Mosaicking is a method of assembling multiple overlapping images of the same scene into a larger image. In this proposed model, Image registration is an important operation in remote sensing applications that basically involves the identification of many control points in the image. Finally in this paper, we will identify the problems with current traffic control system and then we will design and analysis to a new effective system.

Keywords-- Image mosaicking, Traffic congestion, Artificial Neural Network, An Intelligence Decision-making system for Urban Traffic-Control (IDUTC), Fuzzy Expert System.

I. INTRODUCTION

Due to increasing the number of vehicles, Traffic congestion is a severe problem in many modern and developed cities. To travel to different places within the city is becoming more difficult for the travellers in traffic. Due to these problems, people lose time, miss opportunities, and get frustrated etc. i.e. Traffic congestion directly impacts the companies/industries to nation’s growth; because due to traffic congestion, there is a loss in productivity from workers, trade opportunities are lost, delivery gets delayed, and thereby the cost goes on increasing i.e. all of the above mentioned factors leads to a bad impact on the economy of a country.

So to solve traffic congestion problem, we have to need to build new facilities and infrastructure, but at the same time, it should be smart also. The only disadvantage of making new roads on facilities is that it makes the surroundings more congested nothing else. So for this reason, we need to change the system to improve traffic congestion rather than making new infrastructure twice. The developed registration system is a full-featured application intended for operational use by beginners as well as by advanced users.

Therefore many countries are working to manage their existing transportation systems to improve mobility, safety and traffic flows in order to reduce the demand of vehicle use. By enhancing public transport, traffic signal improvements, route guidance systems and incident management, congestion can be improved greatly from the statistical analysis of US department of transportation in 2007[1, i.e. it has been found that half of the congestion caused is due to the recurring congestion. Generally these congestion problems are recurring congestion problems are caused due to the poor guidance of travellers and other half of the congestions are due to the non-recurring congestions which are due to work zones, traffic incidents, and weather on special events. Non-recurring events dramatically reduce available capacity and reliability of the entire transportation system (TS). The researches done on these goals would be started by stating about the simulation model created by Schaefer, Upchurct et al. (1998) which evaluated the freeway lane control signing [4, 14]. i.e. This simulation showed that lane control had some influence that lane control had some influence on congestion.

Hence the remainder of this paper is organized as follows; Section 2 introduces the literature review for the dynamic and automatic traffic light control expert system. Inside this section, Section 2.1 describes the description fuzzy expert system. Section 2.2 describes about artificial neural network. And Section 2.3 discusses about intelligence Decision-making system for Urban Traffic-Control (IDUTC). In Section 3, proposed model and Methodology is explained to improve road traffic problems. Sections 4 define an algorithm which works with our proposed model to avoid traffic problem.
II. LITERATURE REVIEW

For literature review, various types of systems are existing to solve traffic congestion/jamming problems:

1. Artificial Neural Network (ANN)
2. Fuzzy Expert System
3. An Intelligence Decision-making system for Urban Traffic-Control (IDUTC).

2.1 Artificial Neural Network Approach

An artificial neural network(ANN) is a computational simulation of a biological neural network. ANN approach modelled the adaptive traffic light problem. The researchers “Ranganathan and Patel” created an ANN model which includes predicting the traffic parameters for the next time frame and computing the cycle time adjustment values. i.e This model consist of nine inputs (i.e. one of each present and past traffic parameters; one hidden layers with 70 hidden nodes and three output nodes). Hence the ANN model shows in Figure 1.

Figure 1: ANN Traffic Model [2]

As working of ANN, the input given to the ANN models; in which list of data collected by the sensors which are placed around the traffic lights. In this model, sensors give the traffic light information which is related to the present and past traffic parameters. This model after getting this input/information; used the hidden layer to decide which nodes suite the current traffic situation. In that, each hidden nodes is given a membership function (i.e. between 0 & 1). Now after comparing the nodes and matching it with the current situation with the help of membership functions, the most suitable results or alternatives are selected as the output. That results used by the traffic lights to set the timing for the green and red lights to avoid traffic congestion problem. The output/result of the ANN model will be in the form of membership functions ranging from 0 to 1.

2.2 Fuzzy Expert System

Fuzzy expert system (FES)is a most common system used in major areas to solve various problems;also used to control the traffic lights in most cities. Generally the fuzzy expert system [1] composed of seven elements i.e. a radio frequency identification reader (RFID), a personal digital assistance (PDA),a database, a wireless network, an active RFID tag, a knowledge base and a backend server. The Figure 2 gives a brief knowledge about the connections of the different elements of the FES system.

Figure 2: Framework for Dynamic and Automatic Traffic Light Control Expert Systems [1].

As working of FES system, RFID reader detects a RF-ACTIVE code at 1024 MHz from the active tag pasted on the car. The active tag has a battery which is inbuilt inside it, so that it can periodically and actively transmit messages stored in the tag [10]. As well as the data is received, the reader will save all information in the PDA. And when the PDA accumulates the required amount of data, it uses its wireless card and connects to the backend server and stores them in to the database in the server. Now the server uses the data stored in the database to calculate maximum flow, inter-arrival time and average car speed.
When all possible congestion roads and car speed’s data are collected, then these data used as the input parameters of the traffic light control simulation model for this server.

After getting the simulation results, the system is able to automatically give different alternatives/solutions in terms of varieties of traffic situations i.e. the green light or red light duration is being set via a traffic light control interface for improving the traffic congestion problems [7, 8]. Here all the rules and reasoning are used in the IF-THEN format. The system is using the forward chaining approach (FCA), which is a data driven approach starting from a basic idea and then tries to find some conclusions.

2.3 Intelligent Decision making system for Urban Traffic Control (IDUTC)

IDUTC is a real time intelligent decision making system that computes decisions within a dynamically and automatically changing application environment to solve traffic congestion problem. The architecture of the IDUTC is shown in figure 3 as:

The ANN model collects all of the data received from the systems and process/analyze it through the use of hidden layers and gives the desired result/output. Now the output of ANN model is assigned fuzzy labels; indicates the degree to which each crisp value is a member of a domain [2, 3]. Then the FES fires the rules based on these fuzzy values.

The Defuzzification unit (in IDUTC model) convert the computed decisions into crisp values that are used to control the environment through the controllers installed at the traffic lights. After running the simulation on the traffic lights, past data are being collected along with the present data using sensors. This cycle goes on repeating and tries to change the traffic light timings condition on a regular interval of time. Hence IDUTC model working shows that this system is self-adjusting to manage traffic lights according to the situation to avoid traffic jam on roads.

Figure 3: IDUTC Architecture [3]
Generally apart from above discussed papers as literature to solve traffic congestion; many researchers also have done many researches to increase capacity and remove bottlenecks. Grau and Barcelo (1992) and Messmer et al. (1994) discussed about the minimum of queue lengths in different intersections. Stoilova et al. (1998) built a simulation model to measure the best of traffic lights to achieve low noise levels with optimal environmental pollution and traffic management. Schaefer, Upchurch et al. (1998) developed a simulation model for evaluating freeway lane control signing. The simulation results show that lane control has little influence on congestion. However, the region between heavy and medium traffic flow is sensitive to lane control.

Chen and Yang (2000) and Chen and Yang (2003) have developed an algorithm to find a minimum total time path to simulate the operations of traffic light control in a city. Wen and Hsu (2005) designed a route navigation system with a new revised shortest-path routing algorithm and made a comparison of performance evaluation. Meanwhile, to aid traffic management systems, Dougherty et al. (1997) adopted a Time Delay Neural Network (TDNN) to classify individual traveling vehicles based on their speed-independent acoustic signature [1, 6].

Besides above researches; many researches on “How to avoid traffic congestion by using the shortest-path algorithm have been published” by Chabini (1997, 1998), Hoyer and Jumar (1994), Ikeda, Hsu et al. (1994), Ikeda and Imai (1994) and Maniccam (2006) [1, 5, 7 & 9].

Moreover, the widespread use of information technology (IT) provides an opportunity to enhance the techniques of expert systems (ES) i.e., which help managers to deal with fast changing environment at a human expert level with high-quality performance [10]. Expert systems have a variety of applications in many areas. Additionally, researchers also have attempted to develop effective intelligent (agent) systems to assist managers to making (generating) valuable decisions about “how to solve various problems”. Eriksson (1996) utilized two-tier architecture and a client–server model to build a straightforward expert system which was coded in HTML and embedded Java Applet to communicate with a knowledge server in the back end. Some user-interface operations such as mouse dragging, display, and field checking were put into the front-end machine that can provide rapid response.

Findle, Surender et al. (1997) [3, 9] developed a general and flexible on-line method to determine whether the phasing as intersection in given traffic flow scenarios needs a protected left-turnor not. In their study, a simulation model was constructed to reproduce the effect of permitted left-turns at an intersection. As for comparison purposes, their new approach has been proven to produce better intersection performance than the 50,000 rule over a significant range of traffic flows.

Wangermann and Stengel (1998) proposed an intelligent aircraft/airspace system (expert system) that provides better system performance, redundancy, and safety by using the overlapping capabilities of agents. Flexible and Powerful multiple agents with the function of principled negotiations are communicated each other. The system gives airlines and aircrafts greater freedom to optimize their operations than their have now.

Fay (2000) developed a railway dispatching system which has a knowledge base system using fuzzy rules of the IF–THEN type. This system adopts fuzzy reasoning to obtain train traffic control decisions. Using this system systematically, making use of the knowledge of train dispatching, traffic quality is improved and operation costs are reduced. Like Chen and Yang (2000) and Chen and Yang (2003), Wen and Yang (2006) developed a dynamic and automatic traffic light control system to solve the road congestion problem [4]. They simulated a specific road i.e. “the Chung San North road in Taipei, Taiwan” to discuss whether a road simulation model can solve a congestion problem or not.

Finally above discussions show that using an expert system (ES) combined with a traffic light control simulation model is a good idea to solve congestion problems.

Last but not least, apart from above discussion, other three different algorithms have been implemented to solve traffic congestion. Therefore our study focuses on traffic signal improvements to improve traffic congestion problem. The system designed as that other methods can be easily added.

1. One of the algorithms uses optical flow ideas, e.g. Fonseca et al. (1999) to extract the features in both images [11].
2. The second method uses the gray level information content of the images and their local wavelet transform modulus maxima to extract a set of control points, Fonseca et al. (1997).
3. The last one uses centers of gravity of the closed boundaries and other strong edges as control points, Li et al. (1995).
Major Problems encountered in Conventional Automatic road traffic congestion control system:

1. If a single camera is used as a vision sensor for acquiring the image of traffic then it is difficult to detect the space between two vehicles means projection of camera would be crucial factor for measuring the traffic density.
2. If the position of vehicle does not come in alignment of infrared rays then IR sensor would not give response [12].
3. If the vehicle is under faulty condition in the range of IR rays then the response given by IR sensor would not be accurate.

III. PROPOSED MODEL AND METHODOLOGY

A novel methodology described in this proposed system for design and analysis of the intelligent traffic lights control system by using Image Mosaicking Techniques. Image Mosaicking is a method of assembling multiple overlapping images of the same scene into a larger image [2, 14]. The output of the image mosaic will be the union of two input images. Here Image-mosaicking algorithms are used for obtaining a mosaicked image. This algorithms is used by Structured System Analysis and Designing the traffic light control system (Figure 5). Generally image mosaicking includes five steps i.e. Image registration, computing homography, feature extraction; warping and blending (refer figure-4). In which, Image registration is an important operation in remote sensing applications that basically involves the identification of many control points in the images. Generally Image Mosaicking based methodology used as the main paradigm in our proposed model/in design methodology to apply in developing the systems for traffic congestion control.

Figure 4: Image Mosaicking Model

Generally this proposed model lead to the analysis and preliminary design to carry out and using first step of the Image Mosaic Based Design Methodology as shown in figure 5.

Therefore, the physical and logical design phases of the “Structured System Analysis and Design” were replaced by the two steps of the Image Mosaicking-based methodology to complete the crossing of the two methodologies. A hybrid methodology was necessary to implement; to examine the existing systems; i.e. classify the intersections as “Y” and “+” junction with the view of determining the major causes of traffic deadlock on road junction [4]; also the need to design the traffic control system using fuzzy rules artificial neural network and simulation to implement an intelligent traffic control system that will eliminate traffic jam and traffic deadlock problem.
In proposed model (refer figure 6), Automatic control point extraction needs only one parameter to specify registration quality. Rather than use of sensor (single or multiple) or single camera i.e. multiple cameras has been used. And using image registration/mosaicking technique; data from various cameras are collected and integrated (mosaicking) for matching the two images (reference image and text image) whose result manipulates the timing of red signals and green signals (refer section 4). Hence here decision making algorithm (refer section 4) decides the timing of Red/Green Signal according to the inter-arrival and inter-departure time measured of vehicles available on the road. In proposed model, Image registration is an important operation in remote sensing applications that basically involves the identification of many control points in the images. Image matching is also possible with image registration technique or some another methods like correlation between two images (by pixels).
Hence figure 7 shows Aerial video sequence mosaic to implement in our model to avoid congestion problem in traffic.

IV. ALGORITHM

As discussed above, nowadays traffic jamming is a severe major problem in modern cities. So to solve this traffic congestion problem, we have proposed a model for a dynamic and automatic traffic light control expert system using image registration technique, which is composed of seven sub-models coded in Arena to help analyze the traffic congestion problem. This proposed model adopts/work on inter-arrival time and inter-departure time to simulate the arrival and leaving number of vehicles on roads. Hence the algorithm for controlling all the traffic lights is as follows:

```csharp
for(;;)
{
    if (3.0 < Interarrival_time) 
    
    then Red_light_duration = 65 and Green_light_duration = 95;
    
endif;
    
    if (1.7 < Interarrival_time < 5.3.0) 
    
    then Red_light_duration = 65 and Green_light_duration = 110;
    
endif;
    
    if (0.5 < Interarrival_time < 5.1.7) 
    
    then Red_light_duration = 65 and Green_light_duration = 125 
    and Interdeparture_time = 0.6;
    
endif;
    
    if (Interarrival_time = “Exception”) 
    
    then Red_light_duration = “Manual” and Green_light_duration = “Manual”;
    
endif;
    
    exit(0);
}
```

Hence this section defines an algorithm to solve the problem of traffic jamming using inter-arrival and inter-departure time. Now next section will conclude this paper in short.

V. CONCLUSION

As on date, Traffic problems are increasing due to increasing number of vehicles day by day around the world while resources available with the current infrastructure are limited. So to overcome traffic congestion problem, this paper has presented an operational system/scheme/model for automatic control of road traffic using image registration/mosaicking techniques. In which, various useful features (refer figure 4 & 5) were included in the automatic control system (in the image mosaic and registration processes) to help users/drivers to avoid traffic jam. This proposed model provides good and satisfactory results to drivers. So for an implementation, use this approach/model in crowded/modern cities; economic zones to get satisfactory and reliable results.

Hence this section concludes this paper in short. Now next section will discuss various future works in short.

VI. FUTURE WORK

Although this paper presents and analyses the IDUTC and some other existing automated control method to remove traffic congestion problem. Now for future work several improvements can be done:

1. Improve IDUTC functions further.
2. Extend the simulation model to use two-way roads or allow vehicles turning left or right to let the model more close to the reality.
3. Collect traffic flow and average car speed by using RFID technology i.e. the method of dynamically finding a best route/a second optimal route for road navigation systems will be also a major research issue in future[13].
4. And also including the geo-referencing module; improving the registration algorithms, radiometric normalization and mosaic features to provide the reliable results will be also a major research issue in future.

REFERENCES


