ME 233
Final Project Report

Automatic Traffic Light Control System

Professor Tien-I Liu

Presented By

Pramod Krishnani

Dongun Sul

Chima Anyanwu

California State University, Sacramento

TABLE OF CONTENT

Introduction

Traffic congestion is a severe problem in many modern cities around the world. Traffic congestion has been causing many critical problems and challenges in the major and most populated cities. To travel to different places within the city is becoming more difficult for the travelers in traffic. Due to these congestion problems, people lose time, miss opportunities, and get frustrated. Traffic congestion directly impacts the companies. Due to traffic congestions there is a loss in productivity from workers, trade opportunities are lost, delivery gets delayed, and thereby the costs goes on increasing. To solve these congestion problems, we have to build new facilities and infrastructure but at the same time make it smart. The only disadvantage of making new roads on facilities is that it makes the surroundings more congested. So for that reason we need to change the system rather than making new infrastructure twice. 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, route guidance systems, traffic signal improvements, and incident management, congestion can be improved greatly from the statistical analysis of US department of transportation in 2007, it has been found that half of the congestion caused is due to the recurring congestion. Due to recurring congestion, the roads have been used repeatedly when they were not supposed to be used twice. These congestion problems are recurring congestion problems are caused due to poor guidance of travelers. The other half of the congestions are due to the non-recurring congestions which are due to traffic incidents, work zones, weather on special events. Non-recurring events dramatically reduce available capacity and reliability of the entire transportation system.

The researches done on these goals would be started by stating about the simulation model created by Schaefer, Upcburch and Asbur (1998) which evaluated the freeway lane control signing. The simulation showed that lane control had some influence that lane control had some influence on congestion. Chen and Yang (2000) have created an algorithm to find a minimum total time path to simulate the operations of traffic light control in a city. After them, many researchers worked on these problems and ultimately Wen and Yang (2006) developed a dynamic and automatic traffic light control system for solving the road congestion problem.

Types of System

The different types of system used for solving traffic congestion problems are:

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

Fuzzy Expert System

- ***Working***

Fuzzy expert system was used to control the traffic light in most cities. It was the most common system used in major areas. The fuzzy expert system composed of seven elements i.e. a radio frequency identification reader (RFID), an active RFID tag, a personal digital assistance (PDA), a wireless network, a database, a knowledge base and a backend server. The following figure gives a brief knowledge about the connections of the different elements of the system.

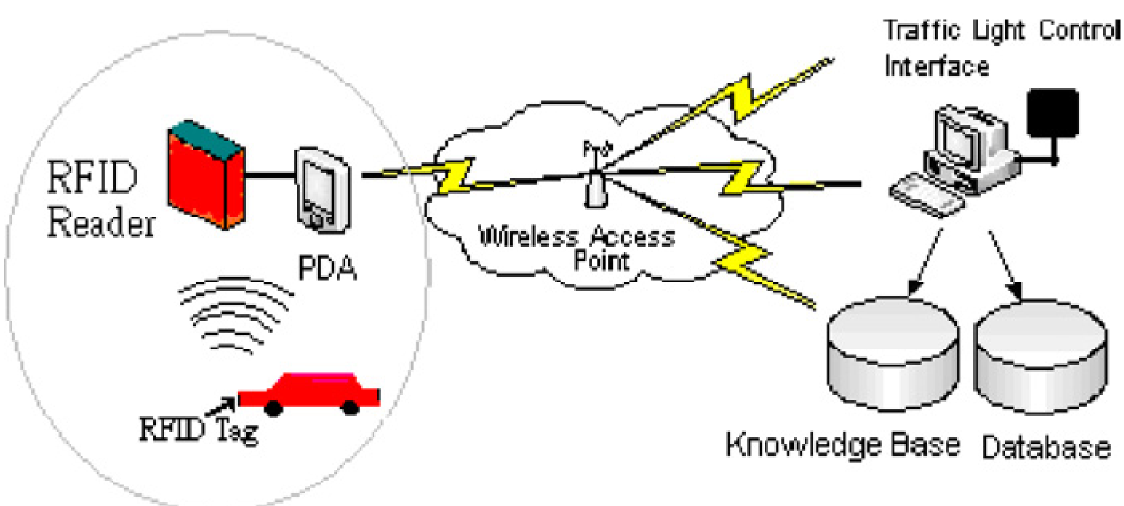

Figure 1. A framework for dynamic and automatic traffic light control expert systems.

In this system, the 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. As soon as the data is received, the reader will save all information in the PDA. When the PDA accumulates the required amount of data, it will use its wireless card and connect to the backend server and store them in to the database in the server. Now the server uses the data stored in the database to calculate maximum flow, interarrival time and average car speed. When all possible congestion roads and car speed are collected, then these data would be used as the input parameters of the traffic light control simulation model in the server. After getting the simulation results, the system is able to automatically give different alternatives in terms of varieties of traffic situations and then the red light or green light duration is being set via a traffic light control interface for improving the traffic congestion problems. All the rules and reasoning are used in the IF-THEN format. The system is using the forward chaining approach, which is a data driven approach, starting from a basic idea and then tries to draw conclusions.

The simulation model running in this system give three optimal alternatives; the best, second and third best traffic light duration. The system uses these alternatives as well as the collected data to choose the best and the most suitable solution for that particular traffic congestion situation.

- ***Description of the simulation model***

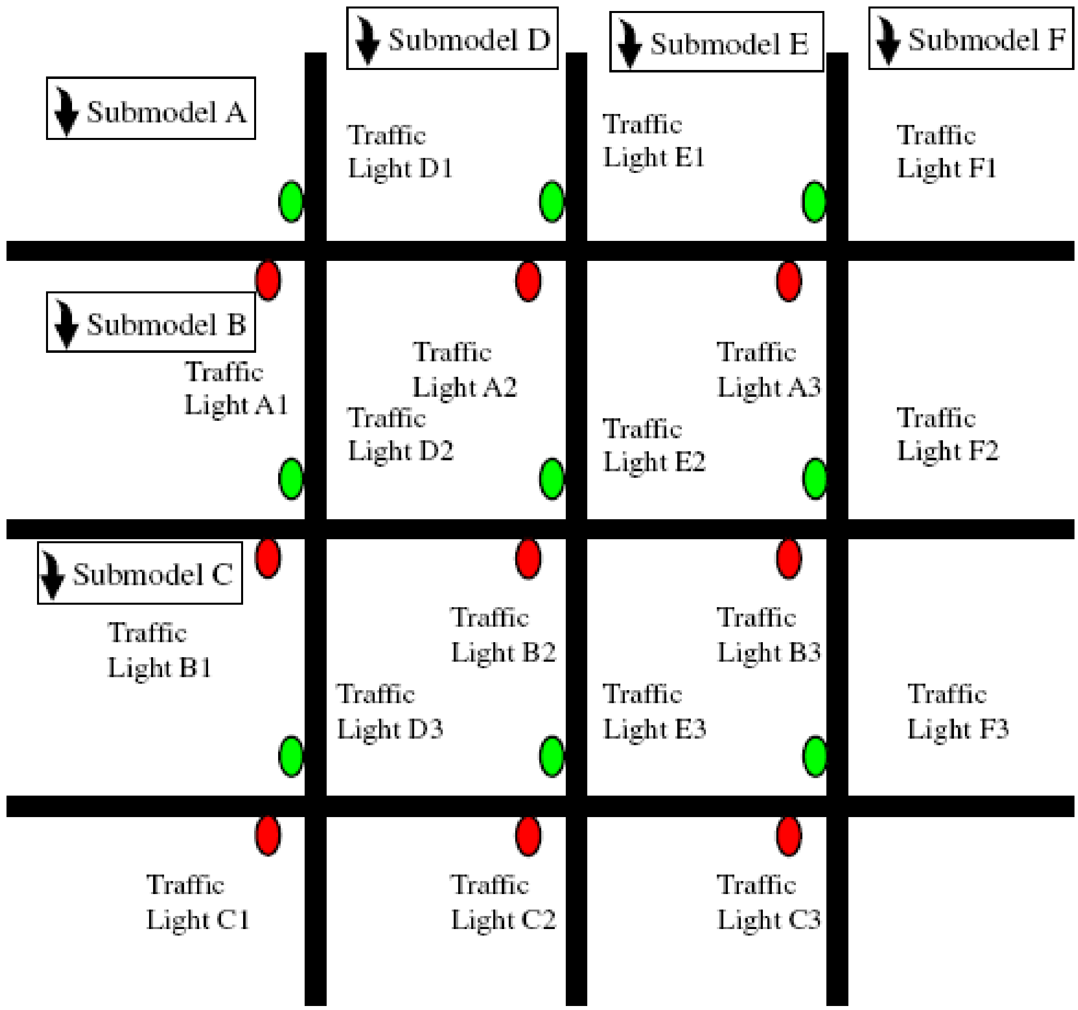

Figure 2. A traffic control simulation

From the above figure, we can say that there are 6 road traffic control simulation models. The sub models A, B & C are similar and sub models D, E & F are similar. Now we will explain the model A which has the logic diagram shown below.

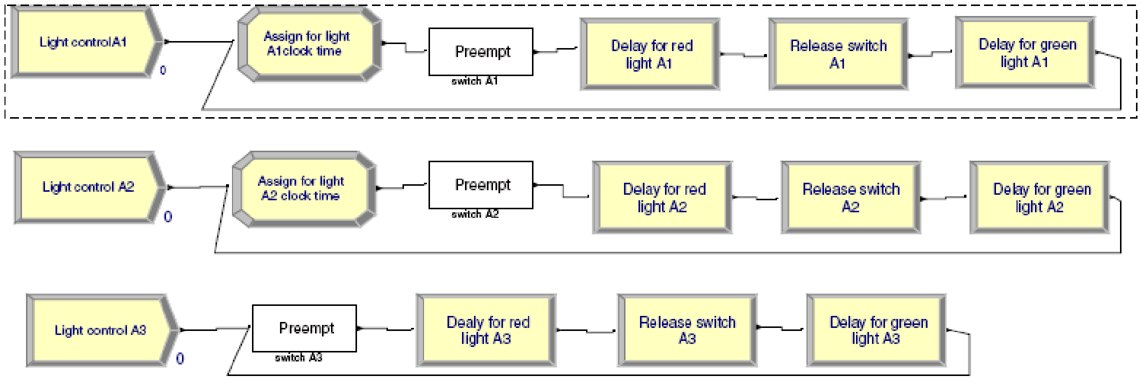

Figure 3. The simulation flow diagram for Traffic Light A1

The upper dash area in the above figure controls traffic signal at the first intersection on road A. When all the data required is collected and the simulation is being run, then the simulation gives results in the form of different alternatives. These results are the input for the light control A1.Light control A1 generates an entity to control the traffic light signal. The element named as 'Assign for light A1 clock time' gets the current simulation time. Prempt seizes the resource switch A1 as first priority to get the resource. Delay for red light A1 sets the duration for red light. Release switch A1 releases the resource switch A1 for allowing the cars to seize the resource. Finally the delay for green light A1 sets the duration for green light. Like the process of light control A1, the processes of light control A2 and Light control A3 are the same.

Artificial Neural Network Approach

The adaptive traffic light problem was modeled using the ANN approach. The researchers Patel and Ranganathan created an ANN model which included predicting the traffic parameters for the next time frame and computing the cycle-time adjustment values. This model consisted of nine inputs (one of each past and present traffic parameters one hidden layers with 70 hidden nodes and three output nodes. The ANN model, if drawn a sketch, would like the figure shown below.

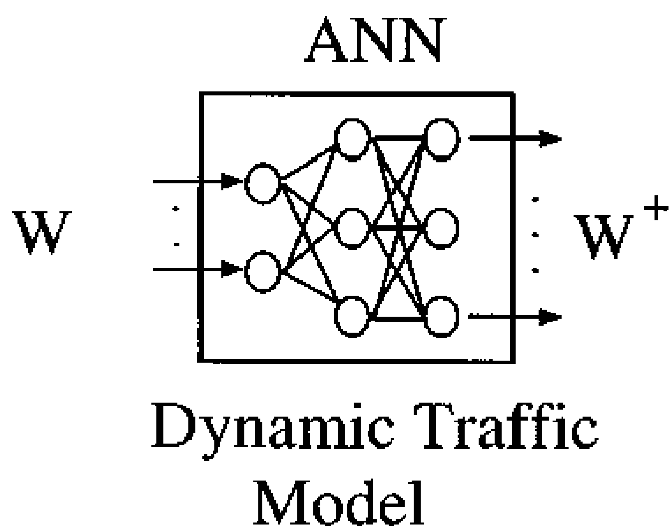

Figure 4. ANN traffic Model

The input given to the ANN models are the list of data collected by the sensors which are placed around the traffic lights. The sensors give the traffic light ANN model all the data which are related to the past and present traffic parameters. The model after getting the input used the hidden layer to decide which nodes suites the current traffic situation. Each hidden nodes is given a membership function (i.e. between 0 and 1). After comparing the nodes an d matching it with the current situation with the help of membership function, the most suitable results or alternatives are selected as the output are then used by the traffic lights to set the timing for the red and green lights. The output of the ANN model will be in the form of membership functions ranging from 0 to 1.

IDUTC

IDUTC is a real time intelligent decision making system that computes decisions within a dynamically changing application environment. The architecture of the IDUTC is shown in figure below.

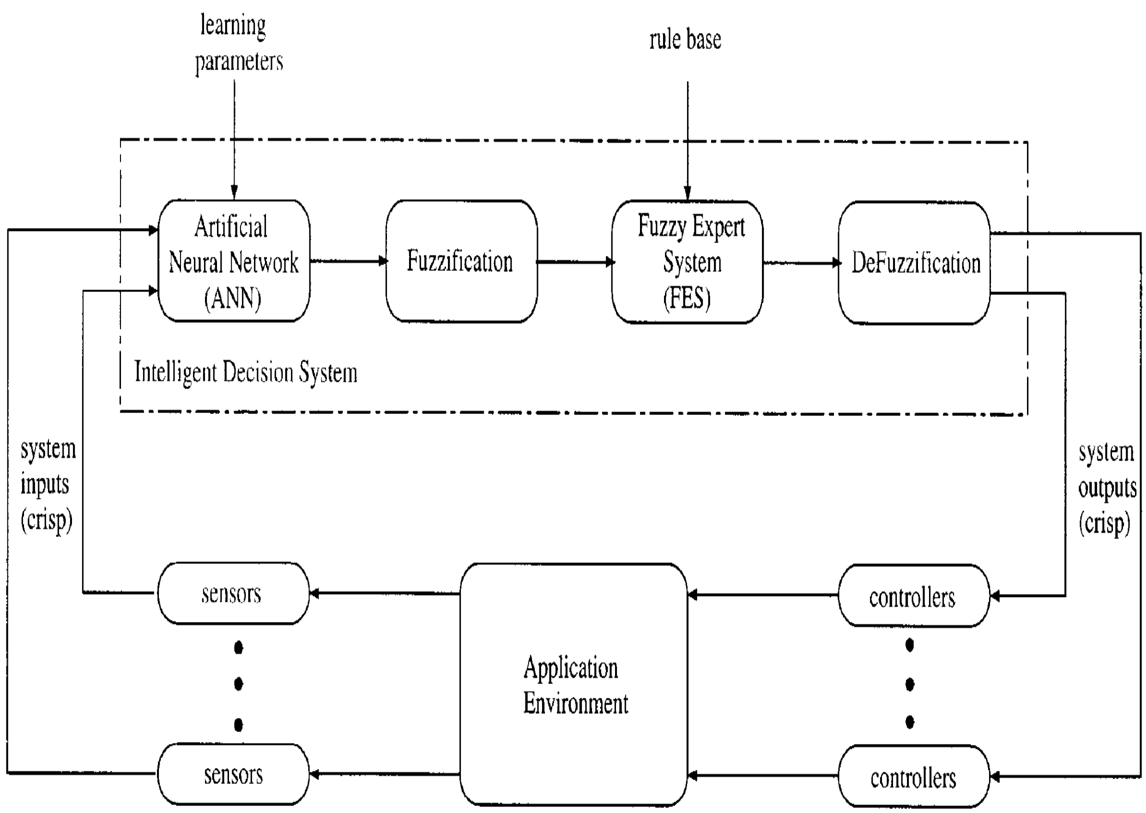

Figure 5. IDUTC architecture

The IDUTC model consists of seven elements. The names of the element are as follows.

- Artificial Neural Network (ANN).
- Fuzzification element
- Fuzzy expert systems (FES)
- Defuzzification Element.
- Application environment.
- Controllers.
- Sensors

The IDUTC is a self adjusting traffic light control system. The sensors of the system are placed at the road to sense the different parameters of the traffic conditions. The sensors are the actual input of the IDUTC model. Sensors collect the past data of the traffic conditions, which is all known as the application environments shown in the figure above. After the surrounding environmental conditions, the sensors send crisp data inputs to the artificial neural network. The ANN model collects all the data from the systems and process it through the hidden layers and gives the desired output. Now the output of ANN model are assigned fuzzy labels indicates the degree to which each crisp value is a member of a domain. Then the fuzzy expert system fires the rules based on these fuzzy values. The defuzzification unit converts 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 light, past data are being collected along with the present data by the sensors. The cycle goes on repeating and tries to change the traffic light timings condition. This shows that the system is self-adjusting according to the situation.

Conclusion

After closely reading the two technical papers listed in the reference, we could conclude that the IDUTC system provided decisions that relieve intersection congestion better than the ANN approach and was comparable to the FES approach. From the table of the simulation results, we could say that the IDUTC system imposed a lower average vehicle wait time than the other two approaches. The ANN approach required more neural network nodes than the ANN in IDUTC, which led to slower training and a higher implementation cost. The FES system lead to correct decisions but didn't reduce time for waiting as compared to IDUTC. The IDUTC uses the current and past values or data to compute decisions, but the FES uses only current traffic flows. After comparing the three different systems we could conclude that the IDUTC system is the best system for controlling the traffic light in the best and smart way.

System	Correct decision rate	Average Wait times (minutes)	Number of Nodes	Number of Rules
IDUTC	95%	2.186	55	40
ANN approach	73%	2.958	83	-
FES approach	95%	2.975	-	40

Table 1. COMPARATIVE PERFORMANCE SUMMARY

References

- *A dynamic and automatic traffic light control expert system for solving the road congestion problem by W. Wen*
- *IDUTC: An Intelligent Decision-Making System for Urban Traffic-Control Applications by M. Patel and N. Ranganathan*
- *Fuzzy System Handbook by Cox [From Library]*
- *www.sciencedirect.com*
- *www.IEEE.org*