The Architecture of Dynamic Hybrid Fuzzy Logic Control of Traffic Light Network with Accident Detection / Action System

Abdulrahman Alkandari  
Computer Science Department  
International Islamic University Malaysia  
Malaysia  
aam_alkandary@yahoo.com

Imad Fakhri Al-Shaikhli  
Computer Science Department  
International Islamic University Malaysia  
Malaysia  
imadf@iium.edu.my

Abstract— With the number of vehicle increasing, urban traffic congestion became more serious. This paper focused on the architecture layer of the proposed dynamic hybrid fuzzy logic control system, which divided into three main parts: The proposed algorithm (Dynamic Webster with dynamic Cycle Time), Accident Detection System using fuzzy logic theory and Action System depending on Detection System. It covered in depth the hierarchical architecture of the system. The Architecture layer discussed the layout of the system in consideration namely the hardware and infrastructure for the system. The paper mainly focused on explaining the infrastructure of the system and how the components interact with each other. The paper ended with a proposed flow traffic controller phase flow.

Index Term— Intelligent traffic control system, Traffic light system Architecture, Fuzzy Logic with Accident Detection.

1. INTRODUCTION

Traffic congestion has become a serious problem in the world. This is mainly due to the rapid increase in the number and the use of vehicles. Many traffic control systems have been developed and installed to alleviate the problem with limited success. Traffic demands are still high and increasing [1].

The proposed hybrid system accomplishes an intelligent dynamic traffic light system for optimally controlling the traffic flow and accident detection in cities by its contributions in the proposed two-layer framework namely the architecture layer and the application layer. This paper focused on the architecture layer of this system.

The infrastructure layer discussed the points related to the physical components of the system architecture, the hardware and the software used. It also covered the communications channel used and the sensors in the system.

The Architecture of any ATCS consists of adequate hardware, software, communications, and system integration. Researches has proved in the developing nations the rate of increase in vehicular traffic areas is more than that of increase in population thus putting a lot of constraint on the transport infrastructure [2]. Thus, physical layout of any ATCS needs to develop to fit with the Traffic demands.

This paper will discuss the physical layer layout thoroughly with the hardware and software component. Then it will explained the communication and the detectors. In addition, the proposed traffic signal controller phase flow will be discussed.

2. BACKGROUND

Wiering, Veenen, Vreeken, and Koopman are mainly interested in the optimization of traffic flow by simulating and optimizing traffic control algorithms in an interesting research in Utrecht University, Netherlands. They described a model-based, multi-agent reinforcement learning algorithm for controlling traffic lights. They presented an adaptive optimization algorithm based on reinforcement learning. They explained how different approaches to modelling traffic flow could be used to explain phenomena specific to traffic and showed the practical use of some models. They explained the reinforcement learning and showed its use as an optimization algorithm for various control problems. Furthermore they demonstrates “Co-learning” as a special feature of car-based reinforcement learning algorithm that allows drivers to choose the shortest route with lowest expected waiting time [3].

The main focus of Roozemond’s research is to discuss how to apply autonomous intelligent agents in Urban Traffic Control. He proposed a system based on agent technology that autonomously can respond and adapt to changing environments. Roozemond explained aspects should be taken into account, for a specific ITSA (Intelligent Traffic Signalling Agent), implemented to serve as an urban traffic control agent. It showed that control systems based on agent technology could adapt and respond to changing conditions in real-time and in the meantime making better use of the infrastructure [4].

In Malaysia, Artificial Intelligence Center and Jalan Semarak in this paper have developed a software to simulate the situation of an isolated traffic junction based on fuzzy logic technology. This paper discussed the design and implementation of an intelligent traffic lights control system using fuzzy logic technology, which has the capability of mimicking human intelligence for controlling traffic lights.
Furthermore, it gave a great comparison between the performance of the fuzzy traffic lights controller and the conventional fixed-time controller. It explained that the fuzzy logic traffic lights controller performed better than the fixed-time controller due to its flexibility [5].

3. PHYSICAL LAYER LAYOUT

The proposed System consists of hardware and the software and the algorithm for the intelligent traffic control system. The system is based on a tree structure in which the controllers are placed on the branches. The branches divide the system into multiple subsystems thus mean the infrastructure is Hierarchical layout not central or distributable; thus forming the borders for information exchange. Only the adjacent controllers within the branch communicate with each other to facilitate the traffic flow.

Figure 1 shows the illustrative physical layout of the of the proposed tree structure. As seen in the figure, there are two branches namely A and B. The two branches do not communicate with each other the communication is only with their respective management server. In a case of an intersection, as shown in the diagram, the two different traffic flows are treated independent of each other.

Figure 2 shows a detailed architecture of the system detailing the components of the system. The controllers in the Branch A are controlled by Management Server: A and controllers in Branch B are controlled by Management Server B. As illustrated in the figure the communication is limited to the adjacent controller. A1 can talk to A2 and A2 with A3.
Also as A2 has two neighbors it can talk to both A1 and A3. The exchange of information is showed with colored regions in the figure. The detectors proposed are the inductive loop detectors as they are inexpensive and easy to install. The communication is based on layer 3 switches which connect the controllers and the branch and the central servers.

3.1. Hardware Component

i. Management Computer.
ii. Standard Windows PC or a Server.
iii. Router.
iv. Switch or a Hub.
v. Loop Detectors.
vi. Traffic light (with counter).

3.1.1. Detectors

They are used to identify the presence of a vehicle, so that the controller knows how to adjust the amount of green time to provide. There is a range of types of detectors available in the market. The most common is the loop detector, it comprises of a thin wire which runs under the surface of the road. As vehicle is above that loop, signal is conveyed to the controller. As these signals are collected across the loops, the algorithm computes the changes in timings and does the adjustments accordingly.

As shown in the figure 3 above Loop detectors are installed in the road surface. They are therefore highly durable and at the same time invisible for drivers.

Components:

3.2. Software

The proposed DWDC algorithm for the management Server. The functionality of each of the component is as follows:

i. Central management Server.
   a) Primary purpose is to collect and analyses the statistical data.
   b) Used to detect accidents and take the necessary action.
   c) It can also be used to manually control any of the traffic controllers.
ii. Branch Management Server.
   a) Control the operation of the traffic light by giving optimal green time.
   b) Traffic flow Data collection.

3.3. Communication

The communication is based on layer 3 switches based on the layer 3 placed in the communication layer. The switch will be divided into VLANs dependent on the number of branches in the system.

For example Branch A with all its controllers and Branch server are part of the VLAN A; and similarly VLAN B will consist of Branch B server and its controller. The VLANs ensure the communication is restricted in the branches level. In order the Central management computer gets all the data from different branches IP routing will be enabled for information exchange.

3.4. Detection

There are namely two types of detectors. The location of the upstream and downstream detectors is depicted in the figure 6 that is used for fuzzy logic incident detection / action system.

i. Upstream Detector: These are placed to capture the flow of the incoming traffic, while approaching the intersection.

ii. Downstream Detecto: These are placed to capture the flow of the outgoing traffic, while exiting the intersection.

3.5. Proposed Traffic Signal Controller Phase Flow

The proposed system recommends a timer to be used during the yellow phase to facilitate the traffic flow.

i. Green to Red.

In this the countdown begins when the traffic light is green and is about to become red; as shown in figure 7. This will primarily help the safety on the road as the drivers will be informed on how soon the phase is going to change so that they can safely slow down and not rush to the intersection.

ii. Red to Green.

In this the countdown begins when the traffic light is Red and is about to become Green; as shown in figure 8. This will minimize the waste time helping more vehicle to pass the intersection in the same allocated green time.

![RED TO GREEN](image)

Figure 8 red to green

4. Conclusion

This paper showed how the physical layout could help to make the proposed system more efficient. It explained in details the physical aspects of the proposed system including the hardware proposed, the software, the communication network and the detection mechanism. It focused on explaining the infrastructure of the system and how the components communicate with each other through network. This paper also introduced the counter, which is displayed on the traffic light to facilitate the traffic flow. Furthermore it introduced some concepts that are important to the physical system like phase flow.

REFERENCES


