A Brief review to the intelligent controllers which used to control traffic flow

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Abstract: Nowadays, with the social progress and economic development, the transport is playing a pivotal role in cities. The main problem is the traffic jams due to vehicle congestion phenomena at intersection. To solve this problem an intelligent traffic control system that continuously sensing and monitoring traffic conditions and adjusting the timing of traffic lights according to the actual traffic load must be implemented. At present, a variety of traffic control has been designed using electrical technologies. Traffic load is highly dependent on parameters such as day-time, season weather and unpredictable situations such as accidents, special events or construction activities, these parameters will cause delay on the traffic flow. The traffic system in Libya is still controlled by old fashion (i.e. equally time interval signal control) and no intelligent system used to monitor and control the traffic flow. The scope of this paper is to review the main intelligent controllers which used in smart traffic systems.

Keywords: Traffic, Intelligent control, Programmable logic, Neural network, Fuzzy logic

1. Introduction

In recent years due to traffic jams considerable interest has been shown in the application of the modern control theory to the problems of traffic flow system. Traffic signals are the most convenient method of controlling traffic in a busy road. But, that these signals in most cases will fail to control the traffic effectively when a particular lane has got more traffic than the other lanes. This situation makes that particular lane more crowded than the other lanes. To reduce the traffic jams a different scenarios have been implemented [1] such as If the traffic signals can allot different lanes to different vehicles based on their weight, like buses, trucks etc. in one lane, cars in one lane and like this the traffic congestion can be solved by diverging the traffic accordingly.

In this method, the traffic density must be measured by counting the number of vehicles in each lane and their weight, then park in automated parking or diverge them accordingly if there an alternative road. Also, it is difficult for a traffic police to monitor the whole scenario and made the proper decision. This scenario is effective on highways. In recent years an artificial intelligent (AI) traffic controllers is used effectively to control the traffic flow. The traffic AI controllers have the ability to adapt to the real time data from detectors to perform optimum signal timing plan for intersections in a network which lead a reducing to traffic congestions, [2]. In this techniques a traffic light group is defined as a set of traffic lights which are controlled by the same controller, which acts as a master or coordinator. The AI controller operates under an intelligent system that allows for controlling the lights status depending on time, traffic conditions, etc. The scope of this contribution is to view and present the AI controller used the control the traffic system flow that can continuously sensing and monitoring traffic conditions and adjusting the timing of traffic lights.

2. Modern management controller system structure

The modern management control scheme for traffic control management system is present on Fig 1. Traffic information is obtained from various traffic information units. The traffic information units have intelligent controllers. The intelligent controllers are used to determine appropriate action based on the congestion parameters and the warning information.
A Brief review to the intelligent controllers which used to control traffic flow

Fig. 1. Traffic modern management system scheme

Traffic modern management systems [3] are called Intelligent Transportation Systems (ITS), and utilize telecommunication technologies, computer science methods and transportation management methods (schemes). In such systems the following elements are taken into consideration:

- Existing road infrastructure,
- Prediction of changes in traffic intensity for the monitored area,
- Prediction of changes in traffic due to changes in traffic organization caused by for example: special events, road accidents and other unusual incidents disturbing traffic flow,
- Number of roads junctions,
- Day time, season period (Weather conditions)
- Level of traffic security,
- Vehicles queues lengths at road junctions,
- Distribution of time losses (e.g. standard deviation),
- Distribution of vehicle queues lengths,
- Human behaviors.

Recently, very often, traffic management algorithms employ artificial intelligence methods such as Programmable logic controller (PLC) [4,5], Neural networks [3, 6], Fuzzy logic [7,8].

Traffic flow depends on the following parameters:

- Time losses on each road junction,
- Number of vehicles halts,

The aims of intelligent traffic control are:

- Adjust the length of time of the traffic lights Achieve traffic intersection management.
- Accelerate the traffic flow.
• Maximize traffic capacity of the intersection.
• Interrupt heavy traffic at intervals to permit other vehicles or pedestrians to cross

3. The Intelligent traffic control System Components.

Any control system consists from three important parts. The first part is hardware system (traffic lights), the second part is the controller and the third part is the detectors (sensors) "monitor system". Fig(2) presents the general layout of traffic control system.

![Fig (2) General layout of control system](image)

3.1 The traffic system (traffic signals).

3.2 Traffic system controller can be:
1. Programmable logic controller (PLC), or
2. Fuzzy logic controller (FLC). Or
3. Neural network Controller (NNC) or
4. Combination from them (e.g., Neuro-Fuzzy)

In the following section a brief description to the most used controller will be presented.

3.2.1 Programmable logic controller (PLC)

What is the PLC?

A PLC is a microprocessor device that was invented to replace the necessary sequential relay circuits for machine control. The old relay system was complicated and inflexible due to their major rewiring or complete replacement was necessary every time when the production requirements changed and control sequences had to be modified. The PLC works by looking at its programmed inputs and depending upon their state, tuning on/off its outputs. The process can be summarized in the following diagram

![Fig (3) Structure of Traffic control system with PLCController](image)

PLC has advantages of high reliability, strong anti-jamming capability, simple programming, strong adaptability, and low cost. PLC, as parts of the intelligent traffic light system, can operate properly in harsh electromagnetic interference environment. Thus, the PLC internal counters can count the vehicle obtained by the vehicle detection signal [5].

In most control system the analysis and control of system behavior depending on its mathematical model. Accuracy in Traffic Flow Forecasting is very important in the Intelligent Transportation Systems (ITS). Traffic system on urban roads is very complex as the traffic flow changes on urban roads are uncertain. In Urban Road Traffic System, traffic flow changes in uncertainty, as traffic flow...
A Brief review to the intelligent controllers which used to control traffic flow

depends on the relevance of the adjacent road traffic, thus these systems are non-linear. This makes it difficult to find high precision characterization using mathematical model of traffic flow characterization. Therefore, non-mathematical model is used for the prediction of the traffic flow on urban roads, as it will provide more precision in the results than the mathematical models.

Neural network and Fuzzy methods come under non-mathematical models category of algorithms and are supposed to be efficient for solving the complex non-linear prediction of large-scale systems. Also these methods introduce some flaws such as convergence is slow and the solution obtained is usually local optimal solution. In the following these methods will briefly review in connected with their applications in traffic flow control.

3.2.2 Neural network
- What is the Neural Network?
The simplest definition of a neural network is, "...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs.

The most commonly used neural network feature is the ability of prediction of various road traffic parameters, such as: throughput, intensity and length of vehicle queues.

- The basics of Neural networks

Neural networks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which contain an 'activation function'. Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' where the answer is output as shown in the graphic below.

![Fig (4) illustrate the Neural network structure](image)

Most ANNs contain some form of 'learning rule' which modifies the weights of the connections according to the input patterns that it is presented with. In a sense, ANNs learn by example as do their biological counterparts: a child learns to recognize color from examples of colors. Although there are many different kinds of learning rules used by neural networks. One of these rules is called the delta rule. The delta rule is often utilized by the most common class of ANNs called 'backpropagational neural networks' (BPNNs). Backpropagation is an abbreviation for the backwards propagation of error.

![Fig (5) presents the NNA process using delta rule](image)

In literature the traffic flow control methods using Neural network are:
1. BP Neural Network.
2. Simulated Annealing Genetic BP NN.
3. RBF NN Optimized by PSO.

Back Propagation Neural Network (BPNN) is the most widely used model. BPNN is multilayer feedback network and it follows supervised learning method. The study process of BPNN consists of two parts: one is signal positive propagation and other
one is error negative propagation, these two processes run endlessly and the synaptic weights are modified continuously, until output error is reduced [7].

In conclusion using different NN structure can optimize and improve the efficiency of the non mathematical models, these systems are of great help for the traffic flow control. Back Propagation Neural Network is widely used for short term Traffic Flow Forecasting. BPNN is inefficient to predict more complex cross roads, Simulated Annealing Algorithm can be used to overcome the disadvantages of Genetic BP NN algorithm. Simulated Annealing model optimizes the synaptic weights and thresholds of BP NN and thus is more steady, feasible and effective method for Traffic Flow Prediction. RBF neural network can also be used for the prediction of traffic flow.

3.2.3 Fuzzy logic controller.

Fuzzy logic is used to determine optimum traffic light phase split based on the traffic information from the traffic information units. The optimum traffic light phase split is determined for each of the intelligent controllers. Over the past years, Fuzzy logic has been widely used to develop an adaptive traffic signal controller, as it allows qualitative modeling of complex systems. Fuzzy logic technology has the capability of mimicking human intelligence for controlling traffic lights. The rules and membership functions of the fuzzy logic controller can be selected and changed and their outputs can be compared in terms of several different representations [8].

Fuzzy logic technology allows the implementation of real-life rules similar to the way humans would think. The beauty of fuzzy logic is that it allows fuzzy terms and conditions such as “heavy”, “less”, and “longer” to be quantized and understood by the computer. Fuzzy control is a control method based on fuzzy logic. Fuzzy logic can be described simply as “computing with words rather than numbers” or “control with sentences rather than equations”. A fuzzy controller can include empirical rules, and that is especially useful in operator controlled plants. The collection of rules is called a rulebase. The rules are in IF-THEN format, and formally the if-side is called the condition and the then-side is called the conclusion. The system is able to execute the rules and compute a control signal depending on the measured inputs error and change in error. The general layout of Fuzzy logic system is represented in fig (6).

Fig (6) general Fuzzy logic structure.

The definition of FLC system parameters can be found in different textbook.

In designing FLC for the traffic monitoring & controlling, following five steps are to be followed:

Step 1: Identify and declare the inputs and outputs.
Step 2: Identify the function of control logic an membrane.
Step 3: Construct the Fuzzy rules.

4. Monitor system

The monitor system for traffic flow consists from one the following units:

1. Photoclectric sensor
2. Imaging technique
3. Loop detector technique
4. Wireless Sensors
5. Ground sensors like video image processing, microwave radar, laser radar, passive infrared, ultrasonic, and passive acoustic array.

However, these systems have a high equipment cost and their accuracy dependson environment conditions.
5. Conclusions

In this paper an overview of the Intelligent controller used to control traffic flow is presented. This work can open the door for researchers whose are interesting for traffic system monitoring and control using modern technologies. Implement the these methods would increase the efficiency and reliability of traffic system and open new vision for traffic road monitoring and design.

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