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A Survey Paper on Intelligent Traffic Lights

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Abstract - *As the steady increase in number of vehicles on the road has amplified the prominence of managing traffic flow efficiently to optimize utilization of existing road capacity and many other problems such as high fuel consumption, high rate of carbon dioxide emission and most commonly traffic congestion which further leads to delay in travel time. So, there is a need of Intelligent control of traffic signal timing sequence. To this, Artificial Intelligence can play major role in solving the traffic congestion problem by using various techniques. In this paper, we have studied and presented a brief review on few of these techniques, which focuses on solving traffic congestion problem and prioritizing emergency vehicle towards their destination. The main objective of this paper is to find and study related works and algorithms to actuate the traffic lights in real-time scenarios with AI. Also, we studied and figured out some drawbacks for each technique and mentioned in this paper.*

Key Words: Fuzzy Expert Systems, Reinforcement Learning, Computer Vision, RFID.

1.INTRODUCTION

Traffic control is a topic of conversation with increasing number of vehicles on the road, it has become more prominent to control traffic signals, in-order to maintain a sustainable flow of traffic. Due to this, it is essential to optimize the critical issues like High fuel consumption, insufficient capacity of the road, environment concerns (CO_2 emission), transportation costs, addition in travel time and increase propensity to break traffic laws. Traffic jams are not only the root cause for delays and stress to the drivers, but also creates an obstruction for the emergency vehicles to reach their desired destination in time. Traffic congestion during the peak hours in four metropolitan cities in India – Mumbai, Delhi, Kolkata, and Bengaluru nearly cost the economy ₹ 1.47 Lakh Crore annually, according to survey conducted by Boston Consulting Group in 2018 [1]. Improving traffic conditions could improve economy, increase city efficiency, and ease people's daily life.

Nowadays, the most common traffic control systems used In India are physical controlling, pre-set traffic signals, and electronic sensors control system. Physical controlling, as the name suggests it requires manpower to control traffic throughput. The traffic police are allotted to respective signal intersections to maintain a smooth traffic flow. By manual operation of switching traffic signals in each phase. This type of control system has a big drawback, as it requires a lot of manpower to regulate the traffic flow. Another system, pre-set traffic signals, operate on a fixed time cycle, by automatically switching traffic lights to a different phase based on pre-set timer value. The drawback for this, it does not adapt to the real-time traffic conditions on the road and works in fixed time.

Electronic sensors control system, some loop detectors or proximity sensors are embedded on the intersections. These sensors provide the data of the traffic and based on that data; the traffic lights are actuated. The data obtained by sensors are less reliable as the sensors may detect any other object instead of a vehicle. Thus, the accuracy becomes low in case of sensors being used and it is expensive to implement and has a high maintenance cost. These types of conventional traffic control systems are not designed to worked with the real-time traffic conditions and cannot give a real-time adaptive traffic result. However, the rules of these conventional traffic control systems are pre-defined and cannot be adjusted dynamically with the respect to real-time traffic conditions.

To dynamically adjust the traffic signals according to real-time traffic conditions, people started using Artificial Intelligence. AI appears to be much reliable when it comes to solving traffic congestion problems. Many AI approaches such as, Fuzzy expert System, Intelligent Agents, Reinforcement Learning, Computer Vision, can be implemented to tackle the traffic congestion problem.

The structure of this paper is as follows: section 2 reviews related work using artificial intelligence techniques, section 3 studies the technologies of electronic sensors, which gives the data of real-time traffic conditions. the conclusion to this paper is presented in section 4.

2. ITL USING AI TECHNIQUES

In this section, we will go through different research studies on Intelligent Traffic Lights scheduling which uses the following artificial intelligence techniques.

2.1 Fuzzy Expert Systems.

Fuzzy expert system is an expert system that uses fuzzy logic over Boolean logic. Many efforts have been done relaying in Fuzzy Expert System because it approximates how humans think. Furthermore, it is easy to implement. It provides considerable improvements in the efficiency of traffic intersections management. Most of ITL (Intelligent Traffic Lights) systems that implement Fuzzy Logic are used for the management of the road traffic flow at road intersections.

According to authors **Stephen Chiu et al**. [2] They have presented a distributed approach to traffic signal control, where the signal timing parameters at a given intersection are adjusted as functions of the local traffic condition and for the signal timing parameters at adjacent intersections. So, the signal timing parameters evolve changing using only local information to enhance traffic flow. This shared approach provides for a fault-tolerant, highly responsive traffic management system. Three parameters: Cycle Time, Phase Split and Offset are adjusted by fuzzy rules, based only on local Information of traffic condition.

According to authors **Madhavi et al.** [3] They have proposed two methods, Fuzzy Logic and Morphological Edge Detection to tackle traffic congestion problem and have a result-based comparison of both to control the traffic lights. Firstly, In Morphological Edge Detection, using the cameras the density of traffic is detected by matching, the edges of the reference image (i.e., empty road without traffic) with the real-time image with traffic on the road and based on the percentage matching, the traffic lights are controlled. Another technique, Fuzzy Logic has been used to count the number of vehicles on the road using electronic sensors and in processing, the fuzzy rule base is generated and based on this rule base traffic lights are actuated. Comparison shown between Morphological Edge Detection and fuzzy Logic that It does not perform well at night while fuzzy logic provides accurate results at night as well. It is less costly to implement morphological edge detection system than fuzzy expert system.

2.2 Reinforcement Learning.

Reinforcement Learning idea comes from nature. It was commonly used when human's trained animals and when we are learning things ourselves. The core idea was punishment and encouragement. This is very simple rule; good actions will be encouraged, and bad actions will be punished. The founders of AI had once proposed that we build the artificial brains based on reinforcement learning. This notion was believed and reinforced by a machine learning method named Reinforcement Learning.

According to authors **Yujie Dal et al**. [4] They have designed a Neural Network (NN) based signal controller to actuate the traffic lights in an urban traffic road network. Neutral network takes real-time traffic conditions data as input and generates several traffic time plan parameters as output. Most of the time, NNs has given detailed results in traffic Signal Congestion problem but designing and training of the NNs are complex and experience needed. To this, they adopted a simple three layered NNs to implement traffic signal controller for a road intersection and proposed a simple training method based on the reinforcement learning idea. The idea of reinforcement learning is that what actions to be taken that may lead to a better reward. So, the reinforcement learning method was used to train the Neutral Networks to obtain a better map between traffic conditions and actions. The traffic signal controller method they used was the NN controller with input of traffic condition generated a control action at each time step. Then action of last time step is reinforced according to observed reward from traffic condition. Furthermore, they used a microscopic software named TSIS (Traffic Software Integrated Systems) to verify effectiveness and adaptability of this method and conducted several scenarios of simulation in the TSIS. It was used to compare pre-fixed timer and actuated algorithm.

According to authors **K.J Prabuchandran et al**. [5] They have presented traffic signal control problem of obtaining an optimal order of phase sequence as Markov decision problem. Because they said, it becomes more complex problem, when simultaneously all the junctions are considered in the road network. Preferably, making the TSC problem hard to solve. To this, they proposed a decentralized multi-agent reinforcement learning (MARL) algorithm for solving traffic signal congestion problem by considering each intersection as separate agent (controller). Each agent observes only its own part of the state space. Furthermore, to decide the order of phase sequence for its own intersections, each agent obtains a feedback cost signal from its adjacent intersection. This facilitates coordination between agents. This is done by using Q–Learning algorithm for each agent(controller) with exploration mechanism based on either upper confidence bound and E-greedy based method. The cost function of an agent in the Q-Learning algorithm used the information traffic congestion level of its lanes and its adjacent intersections lanes to enable co-ordination. They also used VISSIM traffic simulator for performance comparison of their algorithm and other algorithms including the conventionally pre-set timer controller algorithm.

2.3 Computer Vision.

This paper proposes a novel image segmentation method to detect lanes and number of vehicles on the road. As we know image segmentation is a process of dividing images in multiple smaller segments (sets of pixels) and identifying objects present within these segments. The segment size is fixed set of pixels and vehicle identification cannot be directly applied due to

varying sizes of vehicles. Therefore, windshields and rooftops are considered for the edge detection as it is visible and can be distinguished. Automating the traffic lights with intelligent system is the goal as well as priority towards the Emergency Vehicles must be taken into consideration which is not covered in this paper.[6] Detection of emergency vehicles using image processing may require additional resources (multiple data sources) for better prediction and provide more accurate results. The detection of vehicles is not accurate and depends on many factors directly or indirectly which include the image quality, camera position, road width and vehicle congestion on the road. These factors affect the edge detection process of the image which is the source for the vehicle detection. Other factors which may cause a difficulty in the process are different climatic conditions in different regions across the globe. Weather conditions such as rainy, fog, smog and snowfall will directly affect the entire process of vehicle detection and cause a major problem. As observed from the experimental results (table 1) of this paper. [7] we can notice that there is a significant change in the vehicle identification accuracy at different time slots of a particular day due to the change in light condition throughout. Tail gating is a very common practice in many countries including India, implementing such a system will affect the vehicle identification accuracy and it may not be able to majorly contribute towards the goal of reducing the traffic congestion. The system is responsible to control traffic routes for a particular road intersection, and this will result into affecting the traffic flow at adjacent road intersection and this can be resolved by having a communication model between adjacent road intersection.

3. ITL USING ELECTRONIC SENSORS

The central point in the following paper is to provide a green corridor for the ambulance (emergency vehicles) to reduce any delay caused by traffic congestion, therefore minimizing the travel time which would save lives at critical time using RFID technology and android application.[8] Green Corridor system can be defined as all the red signals which will be coming in the path of the ambulance (emergency vehicles) becomes green primarily it creates a green path for the ambulance (emergency vehicles). As the paper presents a fine proposal on solving the issue of delay in travel time for ambulance (emergency vehicles) due to traffic congestion but considering the proportion of emergency vehicles to other public service and personal means of transport the paper focuses only on prioritizing the traffic flow for ambulances and not for all vehicles in general. The identification of ambulance is done by using RFID technology and an android application to trigger the ambulance mode. As we are aware of three existing types of RFID sensors based on their range which are as follows show in table 1.

Table -1: RFID Frequency Bandwidth and Range. [9]

RFID Frequency Bandwidth and Range			
Name	**Bandwidth**	**Range**	**Data Speed**
Low Frequency RFID	120 - 150kHz	up to 10cm	low
High Frequency RFID	13.56 MHz	10 cm – 1 m	Low to moderate
Ultra-high frequency RFID	433MHz	1 – 100m	moderate

The use of Ultra-High frequency RFID sensors has some serious healthcare issues as it is studied that the frequency range on which it operates may cause dementia and other thermal damage in brain tissues due to the burning of glucose. Apart from this the proposed system makes use of the android application to detect the accurate location of the ambulance and to avoid unnecessary changes in the traffic signals by cross verification, the application is also used to trigger the ambulance in an emergency state or not as ambulances can also be used in non-emergency situations. This requires human involvement which also brings in the chances of errors or misuse of this feature if not monitored accordingly.

4. CONCLUSION

In this paper, we have studied and presented a brief evaluation on the existing Traffic Lights and Intelligent Traffic Light algorithms. There are various technologies developed for Intelligent Traffic Light system with different hardware approach that may improve traffic scenarios in the urban cities. To sustain the flow of traffic by monitoring and controlling the traffic lights in real-time traffic conditions on the road. The various techniques discussed in this paper were fuzzy expert system, reinforcement learning and computer vision. Fuzzy expert system is feasible to implement in single intersection, reinforcement learning, may be used for improving the whole traffic network of the urban cities by decentralizing the controller and allocating a separate intelligent controller for each intersection which enables a communication between the adjacent intersection controllers. Computer vision is to detect the density of the vehicles on the road by image acquisition and image segmentation. It will provide better results in good weather conditions, low – medium traffic congestion and sufficient lights. The data provided to process these techniques can be taken from various electronic devices such as camera, RFID, infra-red sensors, Zigbee and more.

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