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OPTIMIZATION OF TRAFFIC SIGNALS FOR INTELLIGENT TRAFFIC LIGHT MANAGEMENT SYSTEM

Abstract

The National Highway (N.H) 44 is one of the longest and widest highways in India, where it starts from Srinagar & terminates in Kanyakumari; the highway passes from UT and various states like Punjab, Haryana to Tamil Nadu. Road accidents occur every day, every minute due to heavy traffic congestion. Traffic signals at N.H 44 follow the fixed time signal technique, which have fixed time of red, yellow and green signal on different lanes in a sequential order. Also, no privilege is given to emergency vehicle like fire brigade; ambulance; police vans etc., waiting time will be high. Traffic light controllers are very useful for handling traffic at intersections. But fixed timer controllers are having limitations like even if no vehicle is existing, still green signal remain active on empty path. To automate the task of traffic light controllers, various artificial intelligence-based techniques has been used by different authors like fuzzy logic, genetic algorithms, neural network, reinforcement learning etc. These techniques provide variable timing signals based upon traffic condition. In this paper, a comparative analysis of various green signal optimization techniques has been discussed.

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I. INTRODUCTION

A road is the route between two places that allow us to travel by any medium from one place to another. The study is based on the National Highway (N.H.) 44 where traffic signal follows fixed time signalling technique, which consists of red, yellow & green signal on different lane in a sequential order. There will be no privilege given to the emergency vehicle like fire service, ambulance, police vans etc resulting into high waiting time [1]. The focus of traffic chocking problem is to understate the delays in roads effectively using existing traffic signal without constructing new roads [2]. Delays occur in the intersection where existing traffic system is slow as compared to the vehicle density. On an average a vehicle needs 2.50 seconds to enter the intersection. Lost time is also an important parameter for optimizing the traffic controller. Existing traffic light system encourages Manual Time Management (MTM) where the traffic warden keeps an eye on the traffic. This traffic light system is considered as SPSTLS (Static Phase Scheduling Traffic Light System). The disadvantage of this system is "low ability" because it uses a traditional traffic signal system which is fixed duration scheduling [2] [3]. The dilemma present in the traditional traffic signal system is solved through ITCS (Intelligent Traffic Control System) which can consistently mapped time according to traffic density. Due to the fixed time phase duration population will occur and it is proved by a survey about 9% of CO_2 emission is more from the vehicle. In order to upgrade the ability of traffic, pollution & flow rate will remain in consistent state, a dynamic phase duration movement is evolved where vehicle can't wait for their turn to move from the intersection. This movement is known as Dynamic Phase Scheduling Traffic Light System (DPSTLS) [3]. DPSTLS perform like MTM & ATLS, where real time traffic moments are required for better traffic. In Previous studies, optimization of traffic signal through fuzzy logic [1]-[9], neural network & deep learning [21]-[22], swarm intelligence [19]-[20], In that study they optimize one way road, two way road, four way road & T-road.

In this paper, optimization of green signal through various soft computing techniques are discussed to achieve better target space, reduce the average waiting time, reduce the CO_2 emission and give priority to the emergency vehicle, so that they can move without any delay.

II. DIFFERENT TECHNIQUES FOR GREEN SIGNAL OPTIMIZATION

1. **Fuzzy logic:** Fuzzy logic is a soft computing technique which deals with noise and imprecise data efficiently. In the fuzzy logic, input is provided using linguistic variables like low, medium, heavy etc. Output is computed by evaluating the fuzzy rules. Lot of research has been done using fuzzy logic to optimize the green signal.

2. **Reinforcement learning:** RL (Reinforcement Learning) is an discipline of ML (Machine Learning) where it can maximize the possibility of cumulative reward where agents can act according to the environment. The environment is in the form of Markov Decision Process where rewards will be allotted based on the optimized results through the chosen parameter. Deep reinforcement learning is a combination of DL (Deep Learning) & reinforcement learning where it can maximize the cumulative reward through the process of deep learning.

- **Swarm intelligence:** SI (Swarm Intelligence) deals with natural & artificial systems composed of numerous individuals, that coordinates using self- organization & decentralization method. It aims on the group of behaviours that results from the confined interaction of the individuals with each other with the similar habitat. Human artifacts also fall into the domain of swarm intelligence. Some common example of swarm intelligence is ant colony, artificial bee colony optimization etc.

- **Neural network:** Neural network is a computer program which is inspired from the human brain to solve the complex problem solving & machine learning objectives. The primary goal is to detect the human's brain pattern recognition skill. Neural network works on distributed feature of the network where machine can learn from the training of the machine. Training of the machine is important than the explicitly written code for the machine.

III. LITERATURE SURVEY

Various authors have given different approaches to optimize the green signal considering the different parameters. Summary of the literature survey is given in Table 1.

Table 1: Literature Survey Based on Fuzzy Logic

S.No	Author Name	Year	Parameters Used	Outcome
1	Musa Balta &İbrahim Özçelik [8].	2020	Direction of phase, Traffic Accidents, Priority Vehicle Transaction, Activity, Density.	In this paper, comparison of central computing and fog computing in VANET & Traditional ITS Architecture for ordinary & dynamic scenarios is given. The rate of packet losses in traditional traffic signal system ranges from 4%-5% when the traffic density tends to be normal, in case of intense traffic the rate ranges from 11%-12%. When the proposed results compared with the traditional system it improves from 28%-45%.
2	S. Mohanaselvi, and B. Shanpriya [2].	2019	Arriving vehicle, Queuing Length & Fog.	In this, 27 fuzzy rules were designed for the three parameters. The membership function for arriving vehicle & queuing length where low stands for 0-10, medium stands for 7-25 & high stands for 20-50. The member ship function for fog where low = 1000-1500 m, medium stands for 400-1200 m, high stands for 50-500 m. The

				green duration is based on the three inputs & the membership functions.
3	Maheen Firdous, FasihUd Din Iqbal, Nouman Ghafoor, Nauman Khalid Qureshi, Noman Naseer [7].	2019	Average Queue Count, Average Waiting Time, Tailback Count.	The author compared queue count (QC), waiting time (WT) & tailback count (TC) with SPSTLS & fuzzy logic control DPSTLS. In each parameter, the improvements are 81.68%, 87.04% & 18.05%.
4	Gurpreet Kaur, Usha Mittal and Kamalpreet Kaur [1].	2019	Flow Rate, Density, current lane, Priority Vehicle, Next Lane.	The author compared the results with the fixed time controller with the proposed fuzzy logic controller with DPSTLS. Author gave emergency vehicle as a priority on a single lane & proposed for multiple emergency vehicles at the similar time on individual lanes.
5	Kajal Chatterjee, Arkajyoti De, Felix T.S. Chan [4].	2018	Direction, Shadow T2 (ST2), Interval T2 (IT2), Average waiting Time.	In this comparison of ST2 & IT2 with the directions is provided.
6	NursyafiqahIkmal hisam& Noraini Noordin [5].	2018	Traffic Arrival, queue length, green time obtained in seconds.	In this, trapezoidal and triangular membership function (MF) was used 25 rules were designed. To calculate the output, centroid and AND operator is used.
7	Anurag Singh Tomar, Mridula Singh, Girish Sharma, K.V. Arya [6].	2018	Weather Conditions, Time, Day of week, Road Location.	Depending on the parameters, the fuzzy controller chooses the path of the route. The MF is different for different parameters and author uses AND operators to satisfy each condition.
8	GulnurTolebi, Nurlan S. Dairbekov, Daniyar Kurmankhojayev, RavilMussabayev [10].	2018	Queue Length, Delay, Directions, No. of Neurons, learning rate, No. of layers, Activation function on hidden & output layers.	In this, "SUMO" is used. The reward is given to the system depending on action performed. The reward is categorized depending on the parameters.
9	Mohammad Aslani, Stefan Seipel, Mohammad SaadiMesgari, Marco Wiering [11].	2018	Traffic signal controller, Average delay time, Average stop numbers, Average travel time.	RLTSC (RL embedded traffic signal controllers) technique is used and comparison is donewith fixed timer system. Proposed method has 15% improvement.

10	YizheWang, Xiaoguang Yang, Yangdong Liu, and Hailun Liang [12].	2018	Total delay time, no.of vehicles leaving the road network, totaltime of travel, total no.of stops.	Traffic optimization through RL (Reinforcement Learning) is not applicable in all the traffic domains. RL (Reinforcement Learning) is suitable for single intersection, arteries with a low traffic flow condition. In case of high traffic flow & multiple intersections RL (Reinforcement Learning) results are better than the current optimization method.
11	Rusheng Zhang, Akihiro Ishikawa, Wenli Wang, Benjamin Striner, and Ozan Tonguz [13].	2019	Agent action, Reward, State Representation.	RL (Reinforcement Learning) is focuses not only in optimization, it also focuses only in navigation with the DoT (Department of Transportation), People ca save 30% of their time.
12	Xiaoyuan Liang, Xusheng Du, Guiling Wang, Zhu Han [16].	2018	Vehicle count, flow rate, delay.	The author uses RL(Reinforcement Learning) & CNN(Convolutional Neural Network) in a structure to optimize the results. This result is structured in a form that every reward in RL in decided through CNN.
13	Hua Wei, Chacha Chen, Kan Wu, Guanjie Zheng, Zhengyao Yu, Vikash Gayah, Zhenhui Li [17].	2019	No. of vehicle, phase, Distribution of vehicle.	The author chooses homogenous &heterogeneous intersections where the conditions of the intersection is different. The proposed methodology RL with deep learning is compared with green wave & fixed time.
14	Song Wang, Xu Xie, Kedi Huang, Junjie Zeng and Zimin Cai [18].	2019	Vehicle delay, No. of stops, queue length, vehicle speed.	Reinforcement Learning results arecontrastwith the traditional signal system. Actuated control for different parameters is 21.2% & 10.1 % is the average vehicle delay, 29.7% & 16.4% is the queue length, 15.5% & 6.9% isthe average vehicle speed.
15	Deepak Rewadkar&Dharmpal Doye [19].	2016	Road segment, Intersection junction, Vehicle on the road portion, speed of the vehicle, vehicle occupying the distance, average	In this, fractional glow worm algorithm is observed from source to destination, evaluated the fitness function of the observed path &using FGWSO search optimal path from source to destination is obtained.

			distance between the vehicle & the road segment.	
16	Aleksandar Jovanovic, Miloš Nikolic, DušanTeodorovic [20].	2017	Cycle length, Density of traffic lane, flow rate, speed.	In this, 9 intersections are chosen for flowrate of the road network and bee colony optimization is used for signal optimization.
17	Hossein Hashemi & Khaled Abdelghany [21].	2018	Travel duration, average waiting time, delay.	In this, Convolution Neural Network (CNN) & training with shallow learning model is used.
18	Julian Nubert, Nicholas Giai Truong, Abel Lim3, Herbert Ilhan Tanujaya, Leah Lim3, Mai Anh Vu [22].	2018	Real Time, Fail Safeness, Superior Rules, Work under different conditions.	The author choses Convolution Neural Network (CNN) for analysis of traffic density. For training & validation purpose, they had 4582 images. “Aimsum” is a software which is used in a large scale. The accuracy for basic CNN is 71.35 & transfer learning is 66.38.

IV. COMPARISON OF DIFFERENT TECHNIQUES

Table 2: Comparison of different techniques

Technology	Parameters	Result Analysis
Fuzzy Logic	Direction of phase, priority vehicle, Accidents, Density, Activity, Fog, Arriving vehicle, queuing length, Tailback count, Current Lane, Next lane, Flow rate, ST2, IT2, Weather, Day, Phase extension	The results vary depending on the different types of parameters used by the different author. The range of result will be 28% -87.04%. It provides better results as compared to fixed timer system.
Deep Reinforcement Learning	Vehicle count, Flow rate, Delay, No. of stops.	In this, RL is accomplished with the neural network & deep learning where training is performed on a large dataset. The optimization depends on the input parameters.
Swarm Intelligence	Cycle length, flowrate, speed, Vehicle density, vehicle distance.	Swarm Intelligence follows the self-organizing & decentralize methods where each traffic pattern will be different according to time & space. It also renovates its location according to the traffic density. The location of each swarm will back to its original position

		when the traffic space will be empty
Deep learning & Neural Network	Travel duration, Average waiting time, Delay, Fail safeness.	Neural network is a clone of human brain which can solve problem solving like a human brain & deep learning is incorporate with NN (Neural Network) to solve the problem more efficiently. NN ca give efficient result when training of the machine is more & it is possible with deep learning where training is based on every scenario of the traffic signal system.

V. CONCLUSION

Traffic congestion is the primary problem for the traffic warden on the roads & intersections. Traditional traffic system could not prioritise the congested roads where traffic density is more & flow rate will be slow as compared to the vehicle density. The mean waiting time of the vehicle on the road junction& the intersection is increasing day by day. To solve this problem & make an optimized flow of road network through various parameters & optimization techniques. This paper studies all the optimization techniques like fuzzy logic, reinforcement learning, deep learning, deep reinforcement learning & many more. The level of accuracy & optimized results will be improved in every research. From the optimization of different techniques, the signal timing will be improved & decrease the traffic congestion on the road & the intersection.

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