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An Information Extraction Approach with Vehicle and Pedestrian Activity Monitoring for Traffic Management in Smart City

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Abstract: Traffic congestion is one of the main concerns of big cities for traffic management. Among different dimensions that make a city smart, one of the very important is transportation. This paper offers an efficient information extraction approach from vehicle and pedestrian activity monitoring for traffic management in the smart city. The proposed approach is related to vehicle and pedestrian activity recognition and traffic optimization in order to manage traffic in smart. The traffic management system includes implementation of Particle Swarm Optimization algorithm and Fuzzy Logic Controller in the solution of the traffic signal timing optimization. Moreover, activity recognition is performed to detect traffic lights that are in wrong place, missing and unnecessary. It has been interested not only in activity recognition of vehicles but also in activity recognition of pedestrians in this work. The implementation of this method does not entail complex equipment and feasibility of this proposed method is quite high.

Keywords: Activity Recognition, Fuzzy Logic Controller, Intelligent Transport, Particle Swarm Optimization, Traffic Management, Traffic Optimization.

INTRODUCTION

Nearly half of the world's population is living in cities and it is waited for raising more in the near future. As the number of people increases, the number of vehicles also increases. This situation causes traffic to be a major problem in cities. Since the growing population deteriorates traffic congestion. Traffic network is an inseparable part of the civil infrastructure in many major metropolitan cities. Traffic jam happens a hot topic not only developing countries but also modern countries. Traffic congestion leads to vehicle latencies, several problems, and concerns such as air population, safety, and energy consumption [1]. Traffic congestion not only affects the physiological state of the road user but also affects economic and environmental problems. [2]. In terms of physiological problems, the traffic congestion performs drivers and pedestrians paying a lot of attention. This means that the pedestrians and drivers are experiencing stress along the way. In terms of economic issues, traffic congestion increases fuel consumption, and this refers to transportation costs. In terms of environmental issues, the traffic block boosts the vehicle waste gas pollution. [2]. Therefore, all countries need an efficient transport system. A method that can be used to reduce the congestion problems, is to optimize the parameters of the intersection.

Many studies in the literature related to the topic mentioned. Shen and Kong recommended a road traffic flow using intelligent control method with bus priority [3]. K. L. Hong and A. H. F. Chow proposed a dynamic intersection optimization method in order to optimize traffic congestion [4]. Z. Zhang et al. [5] recommended a new model that combines the Cell Transduction Model with the Macroscopic Basic Diagram. G. E. Cantarella et al. [6] proposed a model that Genetic Algorithm (GA) is enforced to resolve the design of signal setting at one intersection. In [7] paper, S. M. Odeh et al. presented sectional Fuzzy Logic Controller and GA Algorithm to a traffic signal system. The block diagram of this algorithm [7] is presented in Fig. 1.

S. A. Zargari et al. [8] offered a method that Genetic Programming (GP) and GA algorithms are utilized to optimize signal timing in sequential signalized intersections. In [9] paper, a novel method of Particle Swarm Optimization (PSO) Algorithm with Global Best Gradient Descent is recommended. C. Y. Cui and H. H. Lee [10] recommended a new method that Bayesian Network model and Cellular Automaton are used to model the traffic congestion and then a standard PSO algorithm is enforced to optimize the traffic signal. C. Dobre [11] proposed a method that provides a model to establish wireless communication between traffic lights and vehicles, to activate vehicles to notify their drivers the minimum necessary speed to prevent stopping.

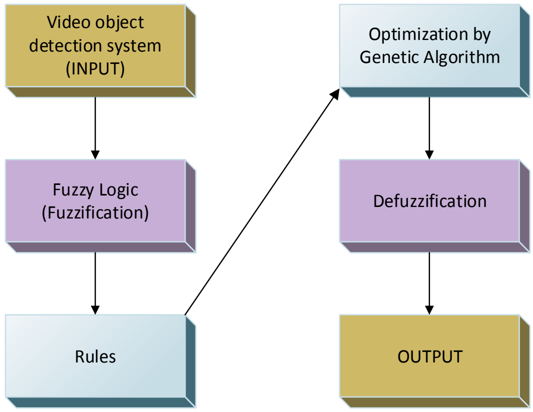

Figure 1. The block diagram of algorithm in [7]

In this work, we suggested a novel method where are used Particle Swarm Optimization (PSO) algorithm and Fuzzy Logic Controller to optimize the traffic control signal in the road-intersection traffic system. The PSO algorithm is utilized to optimize the membership functions of the Fuzzy Logic Controller and the rules of the Fuzzy Logic Controller. It has been performed an efficient information extraction approach from vehicle and pedestrian activity monitoring for traffic management in the smart city. The particle swarm optimization (PSO) algorithm is utilized to optimize driver' s waiting time on a red light at junction and number of vehicles waiting at a red light at the junction. Moreover, activity recognition is performed to detect traffic lights that are in the wrong place, missing and unnecessary. It has been interested not only in activity recognition of vehicles but also in activity recognition of pedestrians in this work.

TRAFFIC MANAGEMENT IN SMART CITY

Traffic management systems comprise a set of components that contain traffic monitoring platforms and the collection and processing of real-time traffic data [20]. Traffic lights at any intersection are actually synchronized [12]. That's why, regional traffic signals in the direction of a particular traffic can be integrated into a single traffic signal, which regulates the flow of all vehicles oncoming the same intersections in different directions at the same time. This integration can degrade the number of control variables and speed up the solution process in the traffic flow optimization problem [22-25]. It is presumed that each integrated traffic signal is referred to as a traffic signal and carries out traffic flow arrangements in N-S and E-W directions.

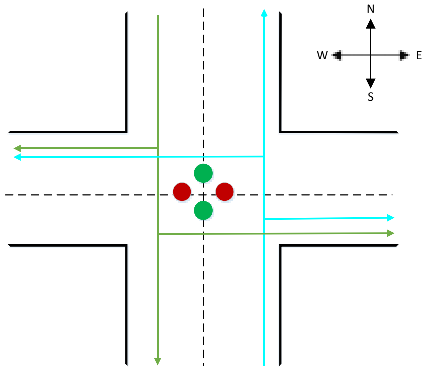

Figure 2. Green in N-S direction

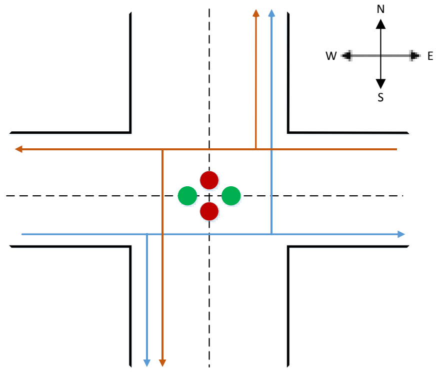

Figure 3. Green in E-W direction

Fig. 2 and Fig. 3 depict two different signal phases that regulate traffic on a junction. Arrows represent the permitted traffic direction. By being controlled traffic flow at the junction, a number of vehicles waiting can be mitigated. Thanks to traffic management system, time loss in traffic will be reduced, traffic lights will be optimized, and pedestrians and drivers will be ensured to be safer in traffic.

THE PROPOSED APPROACH

In this work, it is aimed to reduce vehicle waiting time on a red light at the intersection, to extract information from vehicle and pedestrian activity recognition, and to determine traffic lights that are in erroneous place. The first of all is to decrease drivers waiting time.

Modelling of traffic intersection has been performed in order to make this goal. It consists of 4 streets, each of which has two directions. Each direction is also a two-lane road. All cars in any street are able to turn around in any direction. It is assumed that the intersection is clear when the simulation begins (i.e. no queue at the beginning). It is also assumed that the number of vehicles at the road connection point is known and that sensor type detectors are located at the intersection point. Maximum and minimum green time are selected 45 seconds and 0 seconds. The arrival and departure speed is 0 seconds, the human reaction time is 0 seconds.

A. The Optimization of Green Light Time

Time is an important value in the traffic control system. In the non-adaptive traffic control system, the streets have fixed green times which equal to 45 seconds. Moreover, this system does not include sensors and the green light alternates to the other streets. Whereas in intelligent traffic control system, number of vehicles and waiting time are taken into account and the green time can be calculated by depending on these values. The sensor calculates a number of cars in each street in a given time. The number of vehicles is referred to S_t^i, in which *i* symbolizes the street number in the time t. Total number of all vehicles in the junction, S_{total}, is computed by sum of 4 the streets as shown in Eq. 1.

$$S_{total} = S_t^1 + S_t^2 + S_t^3 + S_t^4$$

Where the S_{total} is the queue length and f_i is flow rate of traffic. The optimum green time is calculated by using Fuzzy Logic Controller (FLC) whose inputs are these two parameters. The structure of FLC contains two-inputs (S_{total}, f_i) and one-output (T_{greeen}). The main block diagram of the FLC is given in Fig. 4.

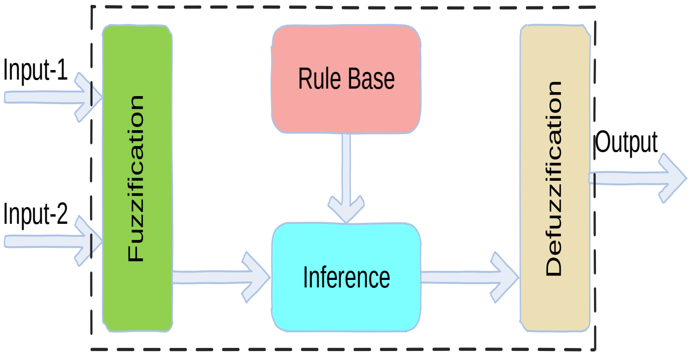

Figure 4. Block diagram of the FLC

The centroid method has been adopted for defuzzification [13-15]. Fig. 5, Fig. 6, and Fig. 7 depict the membership functions of the two-inputs and one-output variables. The membership functions are given in Fig. 5 are *S*, *M*, *L*, and *VL*, which are respectively '*Small*', '*Middle*', '*Long*', and '*Very Long*'. The membership functions are given in Fig. 6 are *SS*, *Mid*, and *F*, which are respectively '*Slow Speed*', '*Middle*', and '*Fast*'. The membership functions presented in Fig. 7 are *Short*, *Enough*, and *Long*.

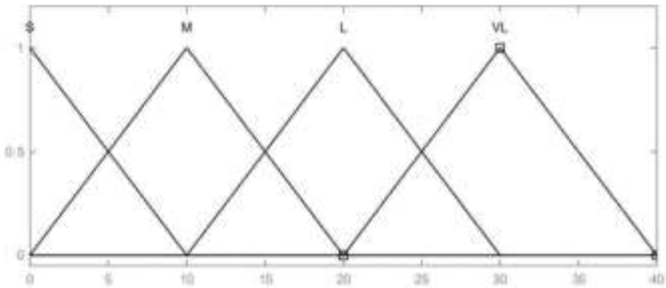

Figure 5. Queue length

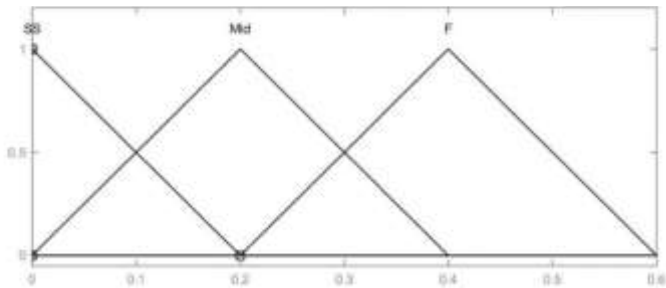

Figure 6. Flow rate of traffic

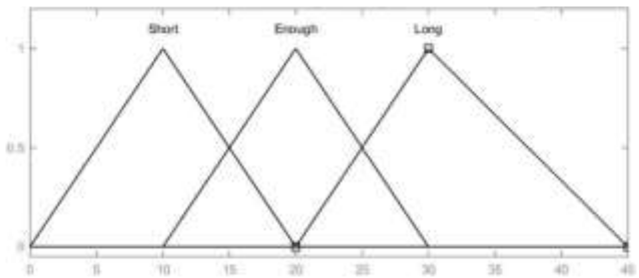

Figure 7. Green time in traffic

The PSO algorithm is utilized to detect the optimal input and output membership functions and optimal rules in FLC. The aim of the PSO algorithm is to minimize average delay (*AD)* of vehicles in traffic flows. The other aim of the PSO algorithm is to maximize the number of vehicles (*NoV*) separated from the intersection. The PSO algorithm is used to maximize the fitness function that is defined as *FF = NoV – AD*. Fig. 8 depicts a block diagram of FLC with PSO algorithm.

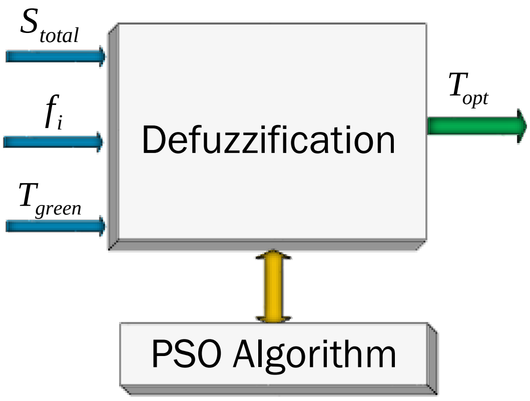

Figure 8. Block diagram of the FLC with the PSO algorithm

Steps of the PSO algorithm are respectively population creation, evaluation of each particle, comparing of particle's current position, determination of the best particle, updating of the particle's velocities by an equation, moving particles to their new positions by an equation, and applying these steps until stopping criteria are satisfied [16-18]. Let's examine this algorithm in more detail. The first step of the PSO algorithm is to start populations with random locations and velocities of particles. The second step of the PSO algorithm is to evaluate fitness value of each particle [21]. And The next step of the PSO algorithm is to compare the evaluation of the objective function of each particle with the existing particles p_{best}. The next step of the PSO algorithm is to compare fitness evaluation with the populations all previous best g_{best}. The next step of the PSO algorithm is to update the velocity and position of the particle according to the Eq. 2 and Eq. 3. And finally these steps are repeated until stopping criteria is met.

$$V_{id} = (w * V_{id} + c_1 rand()(P_{id} - X_{id}) + c_2 rand()(P_{id} - X_{id})) \qquad □□□$$

$$X_{id} = (X_{id} + V_{id}) \qquad □□□$$

In the Eq. 2, V_{id} is the velocity of i th particle, X_{id} is the velocity of the population, P_{id} represents the best previous position of *ith* particle, w depicts the inactivity weight, c_1 and c_2 refer to positive constants, $rand()$ means random numbers in range [0, 1].

B. Activity Monitoring of Vehicle and Pedestrian

The activity of pedestrians and vehicles in traffic is very important and shapes the traffic flow. In the many works, the activity of vehicles has been paid attention. However, in this study, both of which are considered. Problems such as waiting times and queue lengths at intersections are solved by monitoring the vehicles in the traffic flow. It is desirable to reduce the mistakes made in traffic based on the activities of vehicles and pedestrians. Missing or faulty traffic signs have been identified because of mistakes made by many vehicles and pedestrians.

In this study, traffic flows at the intersection are monitored with different angled cameras. After the number of vehicles for each street in the intersection is determined, it has been examined whether these vehicles make mistakes. Errors that are commonly made by pedestrians from different angled cameras have also been observed. The following block diagram has been used to detection pedestrians and vehicles in traffic.

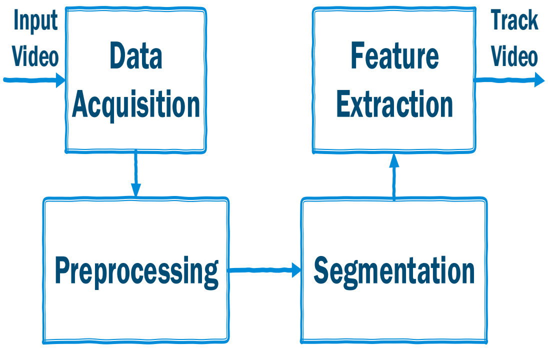

Figure 9. Block diagram of detection pedestrians and vehicles in traffic

Object detector includes several steps. These steps are point detectors, segmentation, background subtraction, and like. The point detectors are used to obtain interesting points in images. SIFT detector is utilized for that process. The background subtraction can be accomplished by creating a representation of the scene called the background model and then finding deviations from the model for each incoming frame [26, 27]. The pixel forming the modified regions is marked for further processing. Mean shift clustering is used to segmentation. Object detection can be done by learning different object views automatically from a number of examples through the supervised learning mechanism [19]. The flowchart of the vehicle and pedestrian tracking algorithm is given in Fig. 10.

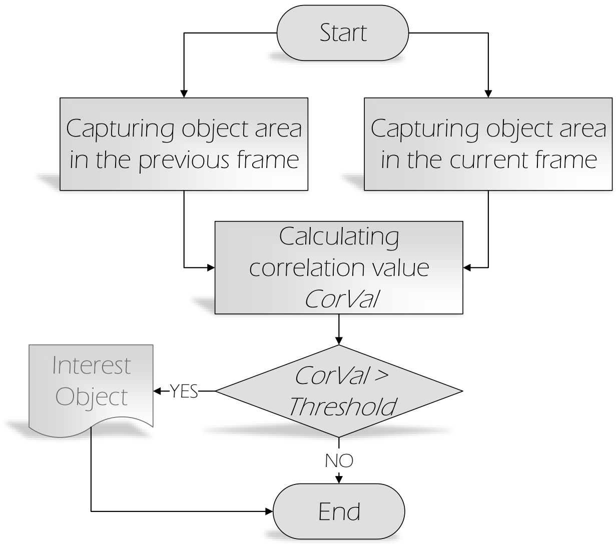

Figure 10: The flowchart of object tracking

CASE STUDY AND APPLICATION

The green time optimization and objects monitoring in traffic have been performed in this study. When the queue length and the flow rate are taken into account, the distribution of green light duration in traffic is shown in the graph below. In this application, the duration of the green light is assumed between 0 and 45 seconds. The surface viewer of the FLC whose membership functions and rules are determined is shown in Fig. 11.

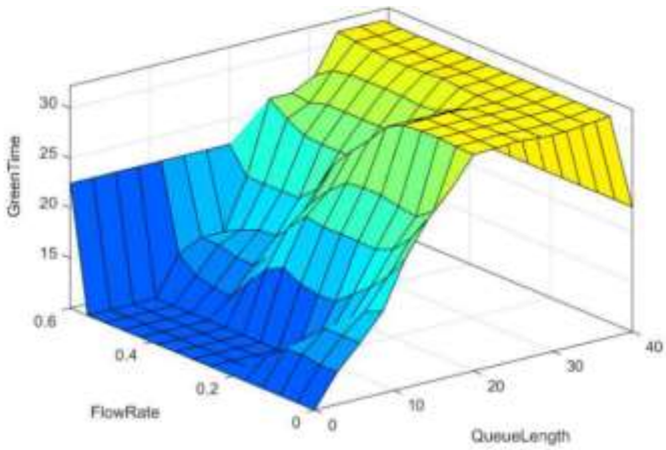

Figure 10. Surface viewer of the FLC

As seen in Fig. 11, the green time has increased as the queue length increase and the flow rate decrease. Whereas the green time has reduced as long as the queue length decrease and the flow rate increase. By considering of the queue length and flow rate parameters, the green time has been specified. Table 1 shows the vehicles number and the wait time in the intersection when it executing the adaptive method and the PSO method with the FLC.

TABLE I. ADAPTIVE AND PSO METHOD RESULTS

Adaptive traffic		PSO traffic	
Vehicle number	**Wait time**	**Vehicle number**	**Wait time**
5	0	5	1
7	1	8	2
8	2	8	3
13	4	13	5
24	6	22	3
35	9	33	7
48	12	44	10
60	18	55	16

Efficiency in traffic flow is supplied by monitoring vehicles and pedestrians. The behavior of vehicles or pedestrians in traffic gives a clue that is about how to fix the mistakes in traffic.

CONCLUSIONS

Traffic management in smart cities is an important work issue. One of the problems in smart cities is traffic congestion. Traffic lights timing optimization is done to solve the traffic congestion. In addition, vehicles and pedestrians have been observed to make traffic flow more efficient. The PSO algorithm and the FLC have been used to the traffic management system in the solution of traffic signal timing optimization. The aim of the PSO algorithm is to minimize average delay of vehicles in traffic flows. The other aim of the PSO algorithm is to maximize the number of vehicles separated from the intersection. The flow of traffic has been accelerated by reducing the number of vehicles that accumulate at intersections and waiting times. The queue length and traffic flow rate were taken into consideration by using FLC in traffic light optimization. Thus a dynamic system has been achieved for traffic green light. Monitoring the traffic flow with different angled cameras made it easier to detect faulty or missing traffic signs. As well as the monitoring of pedestrians in traffic helped to identify the common errors that pedestrians made in traffic. Necessary traffic signs have been determined to prevent these mistakes. So that measures are taken to ensure the safety of the pedestrians in traffic. The implementation of this proposed work does not require complicated hardware and feasibility of this proposed method is quite high.

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