A Smart Hybrid System for Parking Space Reservation in VANET

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Abstract — Nowadays, developed and developing countries using smart systems to solve their transportation problems. Parking guidance intelligent systems for finding an available parking space, are considered one of the architectural requirements in transportation. In this paper, we present a parking space reservation method based on adaptive neuro-fuzzy system(ANFIS) and multi-objective genetic algorithm. In modeling of this system, final destination, searching time and cost of parking space have been used. Also, we use the vehicle ad-hoc network (VANET) and time series, for traffic flow predict and choose the best path. The benefits of the proposed system are declining searching time, average the walking and travel time. Evaluations have been performed by the MATLAB and we can see that the proposed method makes a good sum of best cost which is useful and meaningful in a parking space reserved for drivers and facility managers.

Index Terms — VANET, Multi-Objective Genetic Algorithm, ANFIS, Reservation.

I. INTRODUCTION

Finding a parking space by drivers is one of the reasons increased traffic in major cities. Reserving an empty parking space in a crowded area, especially at peak hours is always time consuming and frustrating for drivers. Lots of strategies based on intelligent transportation technologies have been proposed to solve these problems to improve the traffic and ease congestion. Urban parking management systems can recognize and process any information about the parks in the city to allow drivers to be informed of parking information at any time. However, these systems are not able to guidance and reserve the most parking spaces for each of the drivers. In this regard, offering a new solution for centralized management of parking in the city can solve traffic problems and parking space reservation. Also, with real-time traffic information as prior knowledge, we can improve the effectiveness of path planning which is the same for parking space reservation to inform parking spaces' managers of the arrival time of their users to increase their utilization rate of parking spaces.

The contributions of our paper are as follow. (1) In this paper, we propose the traffic flow predication model to predict traffic speed. This model is based on adaptive neuro-fuzzy system(ANFIS) which collect traffic information with vehicle ad-hoc network. (2) To reserve the most suitable parking space has been done based on multi-objective genetic algorithm and the prediction model in step 1.

The rest of this article is organized as follows. Section II, an overview of related works has

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been shown. Section III, ANFIS modeling for traffic flow predication is introduced. Proposed method will be present in section IV. Simulation results are presented in Section V. finally; our conclusions are drawn in section VI.

II. RELATED WORKS

An intelligent parking space control system to make "on line" decisions whether to accept or reject a new driver's request for parking was proposed in[1]. In [2], drivers base on the budgetary constraints and the final destination taking the most parking spaces available. In this scheme, the price of parking services according to the number of available parking space and density are determined dynamically. The major disadvantage of this approach is that density and traffic conditions are not considered in reserve a parking space and is done by the driver.

A scheme that efficiently has allocated parking spaces in vehicular ad-hoc networks and avoided the competition between the vehicles was proposed in [3]. Real-time traffic information hasn't been seen in this paper. In [4], a parking space reservation method with real-time traffic information based on VANETs will be shown. A Road Side Unit (RSU) has introduced to collect traffic information which utilizes the time-prediction model. Then, a parking space reservation mechanism is proposed according to a dynamic path selection based on real-time traffic information. In [5, 6], a support vector machines (SVM) and K-NN used in predicting travel time. The authors in [7], proposed a novel cooperative technique based on Vehicle-to-Vehicle (V2V) communications and fuzzy logic to detect road traffic congestion.

III. PROPOSED SCHEME

This paper has proposed a hybrid approach using adaptive neural-fuzzy system and genetic algorithms for parking space reservation. The proposed scheme predicts traffic flow according to data collected by vehicle traffic on the VANET. All reservation requests are examined in a defined period of time by multi-objective genetic algorithm and fuzzy operators simultaneously. The desired output of the algorithm, choose the most suitable parking spaces for all drivers that have reached in the same period so that the time-consuming and the path to the final destination

and the cost of parking space for all drivers be minimized. Figure 1, have seen this scheme. In continue, the proposed approach will be explained in details.

1. Adaptive neuro-fuzzy system

This paper presents a method to collect data and predict traffic flow using neural networks. The main objective of this step is maximizing the amount of information and combine this information to obtain more accurate detailed information. $q(t)$ As the flow of traffic at the time $(t-1, t]$ (t is an integer number). By analyzing historical data traffic can be seen so that the flow of traffic always during the week (every week from Monday to Friday) changes and the weekends are the same. So, three different time series, $S_1(t)$ time series of the same daily, $S_2(t)$ time series of the same week, $S_3(t)$ hourly time series to collect time-series data will be considered.

$$S_1(t) = \{q(t-24k_1), q(t-24(k_1-1)), \ldots, q(t-24)\} \quad (1)$$

$S_1(t)$, a collection of previously recorded traffic flows at the same time at k1 days ago,

$$S_2(t) = \{q(t-7\times24\times k_2), q(t-7\times24\times(k_2-1)), \ldots, q(t-7\times24)\} \quad (2)$$

Set $S_2(t)$ includes traffic flow recorded at the same time, k_2 week before in the same day at the week. For example, to predict traffic flow on a Tuesday, need k_2 traffic flow information at the before Tuesday.

$$S_3(t) = \{q(t-k_3), q(t-k_3+1), \ldots, q(t-1)\} \quad (3)$$

$S_3(t)$ is previous set of k_3 traffic flow, before traffic flow $q(t)$.

Various models can be selected for predicting the three respective time series. Let $q_i(t)$ is the predicted value of the time series model i for $s_i(t)$, $i = 1, 2, 3$'s. In follow, a NN model is used to produce the final prediction.

$$q'DA(t) = f(q_1'(t), q_2'(t), q_3'(t)) \quad (4)$$

Where F(.) is a nonlinear function which be determined by NN trained. There are many ways to apply time series. In this paper, we used *MA* methods for time series $S_1(t)$, $S_2(t)$ and $S_3(t)$. *MA* model of rank *K* is calculated as follow.

$$y_{t+1} = \frac{y_t + y_{t-1} + y_{t-2} + \dots + y_{t-k+1}}{k} \quad (5)$$

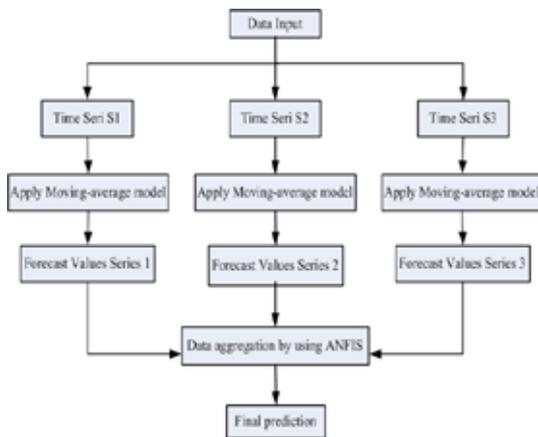Where *k* is the number of conditions defined for the *MA*. *MA* is concerned only with *K* last period known data. The flowchart in Figure 1 has be shown this step.

Figure 1: Proposed ANFIS

2. Multi-Objective Genetic Algorithm

Multi-objective genetic algorithm performs all of requested parking reservation in a defined period of time simultaneously. The desired output of the algorithm, choose the most suitable parking spaces for all applicants that have reached in the same period so that the most time-consuming and the path to the final destination and the cost of parking space for all drivers is minimized.

3. Fitness Function:

The fitness function should be able to make a good parking model for reservation. A driver will choose the lowest cost and most facilities parking for reservation. Among the facilities listed for each parking, Minimum travel time of the request to place of parking and minimum walking distance from the parking location to the destination can be considered. The fitness function of genetic algorithm has three functions. Fitness function can be stated as follows.

$$Minimize(T_m, T_a, P_t) = Minimize\left(\sum_{j=1}^{n}\left(\frac{L_m}{V_m}\right)_j, \sum_{j=1}^{n}\left(\frac{T_a}{V_a}\right)_j, \sum_{j=1}^{n} Parking\ Price\ j\right)$$

$$S.t: \quad j = 1, k, n \quad , p \in p_n$$

$$\forall p \in p_n, \sum_{j=1}^{n} Parking\ Price \leq parkingLot_p$$

$$(6)$$

Where, P_t reflects the cost of parking space, T_a is time interval needed to traverse the path from the request a reservation by the driver until the parking area. L_m Determines the distance between the request for the park to the parking place. V_m shows the average speed in each direction and is measured according to the shortest route, estimate the speed and density of the paths. T_a, will show the driver walking time from the parking place at the end of the destination.

Each gene has been shown with a parking space vehicle and amounts allocated to each gene, indicating the number of parking will be reserved for the device. Chromosome length is equal to the number of applicant cars. Figure 2 has been shown the chromosome with five lengths. To create the initial population of the chromosomes, equal weight of the empty parking lots to any of the parking spaces has been assigned. The flowchart presented in Figure 3 shows how this process is done. Flowchart of the Proposed method has been shown in figure 3.
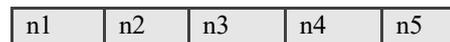
n1	n2	n3	n4	n5

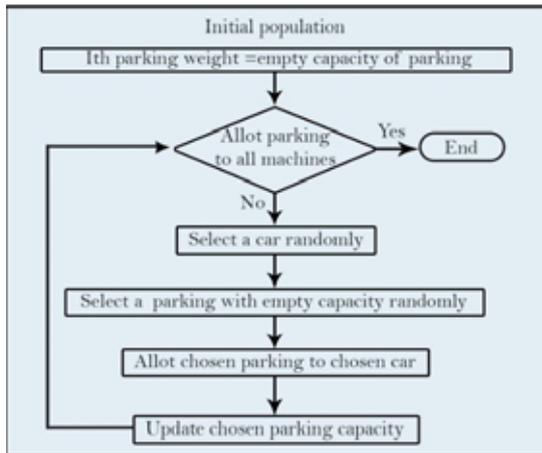**Figure 2: The chromosome Model**

Figure 3: The process of making initial population

4. Crossover

For generating the children of the two parental chromosomes, natural crossover operator is used. In this paper, to perform crossover, multi-crossover method is used. After the recombination, the number of parking spaces that will be allocated per child is checked so that the capacity does not exceed. As a further innovation in this article is combined number of points using fuzzy inference system for doing. The current generation number and variable changes in the best solution of the previous iteration is inputted into the fuzzy inference system. The output of this system is fuzzy numerical that determine the number of points in a predetermined range. The general model of the proposed fuzzy inference system for crossover operation is shown in Figure 4. Membership functions for each input and output variables of this system is shown in Figure 5.
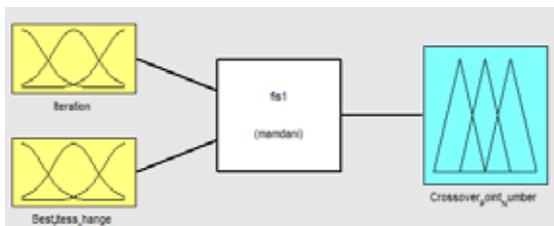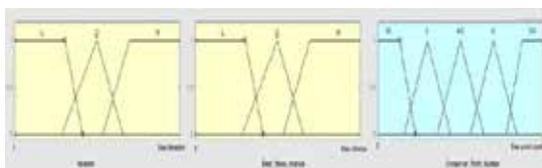

Figure 4: Crossover operation

Figure 5: Membership functions

5. Mutation

In this paper, to create random answers of the entire search space available, a random mutation operator is used. Randomly, selected a set of genes from chromosomes and changed parking numbers can be allocated also. For most operations, speed mutation or mutation operations, will not be considered fixed. This variable is calculated using a fuzzy system designed. The input fuzzy system is the current generation number and variable changes in the previous iteration of the best solution. The output is a fuzzy number that determines the number of operations mutation.

IV. SIMULATION

The speed of traffic flow contains 3000 records in 15-minute intervals from a city region that is considered for testing system. Data is collected on http://data.gov.uk/dataset. In this paper, for training the proposed ANFIS system, it has been used from 100 records of existing data in data set. In Table 1, a sample of giving training data to the proposed system has been shown. V1, V2 and V3 amounts for first time series are in order for registered data on the same day at an hour, 2 hours and 3 hours before.
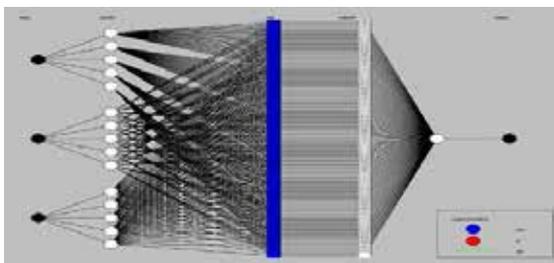
Table 1: Training data

		First time series	Second time series	Third time series
Inputs	**V1**	158	154	156
	V2	157	155	159
	V3	156	161	55
	MA	157	157.33	156.66
Output	Record of speed	158		

The speed of traffic flow column header appears in the first data column.

Second time series are in order to register data in the same hours at a one day, 2 and 3 days before. As the same way, third time series are in order to register data in the same hours (on the same day of the week) at a week, 2 and 3 weeks before. In Table 2, Training parameters of the ANFIS have been shown.

Table 2: Training parameters of the ANFIS

| The number of layers	4
The size of the input dataset	3*3000
The number of output	1
Function	gbellmf
The number of Epoch	200
The number of fuzzy rules	125

The proposed ANFIS system architecture has 4 layers that has been shown in Figure 6. In this system, back propagation learning based method is used so that grading vector is accounted in the opposite direction of output. The error is defined in the form of the difference between real output and reference vector.

Figure 6: The proposed ANFIS system architecture

The training data to ANFIS system has been shown in Figure 7. If the error rate is zero, it has been expected that the test output data put in data training.
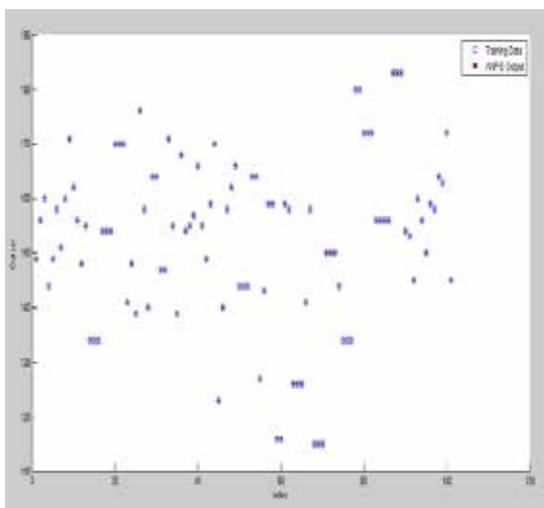
Figure7: The proposed ANFIS system testing using training data

In the next, the proposed neural fuzzy systems using training data will be evaluated. In Figure 8, the result is shown. As can be seen in this figure, in most cases, the predictions of adaptive neural-fuzzy systems that are shown in green color has been adapted to the data recorded that are shown in blue.
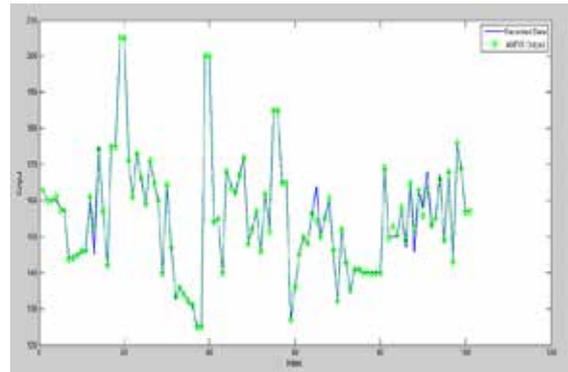
Figure8: Prediction of proposed ANFIS system testing using training data

To evaluate the effectiveness of the proposed system, we test proposed system using the information that has been predicted using ANFIS system. To check the road network system area of 2km by 2km is covered. The system includes six intersections in each of the vertical and horizontal directions. Figures 10-12 have been shown to optimize the tree objective function in different generations of the algorithm.

We can be seen in Figures 9 to 11, the mean values and the best of each of the objective functions improved simultaneously. Where, despite the overall decline, the objective function value increases, a significant reduction in the values of other functions as well. The performance of fuzzy-genetic operators has been shown in Figure 12. In Table 3. the values of variables in the proposed algorithm have been shown. The initial population is 100, the mutation rate is 0.4 and maximum fuzzy crossover is 0.8. For each of the above modes, this algorithm run 10 iterations and its mean will be shown. The result of the proposed system with fuzzy operators shows that in 71 generation, the optimal response be achieved while without using of the fuzzy operator after 95 generation can be achieved. This result indicates that the use of fuzzy

operator increases the speed of achieve optimal response and causes improved the performance of the algorithm. In the remainder of this section (Figure 13), we compare the proposed system with the blind search system and reserved system proposed in [4]. The system proposed in [4] not consider traffic information and this has led to inefficiency of the system. This figure shows that the blindly search has the worst condition in during peak hour traffic. In Figure 14, two peaks show the peak time of traffic around 12 pm and 8 pm.
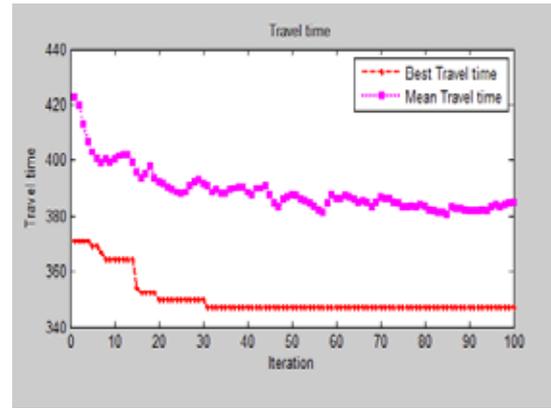
Figure 10: Average and the best value of the walking time

Table 3: The values of variables

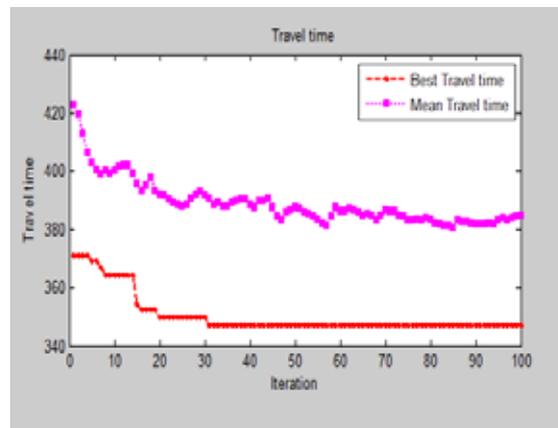| The number of initial population	100
The number of generation	100
Recombination rate in the first case	0.8
Mutation rate in the first case	0.4
Recombination rate in the second case	0.8 for fuzzy
Mutation rate in the first case	0.4 for fuzzy

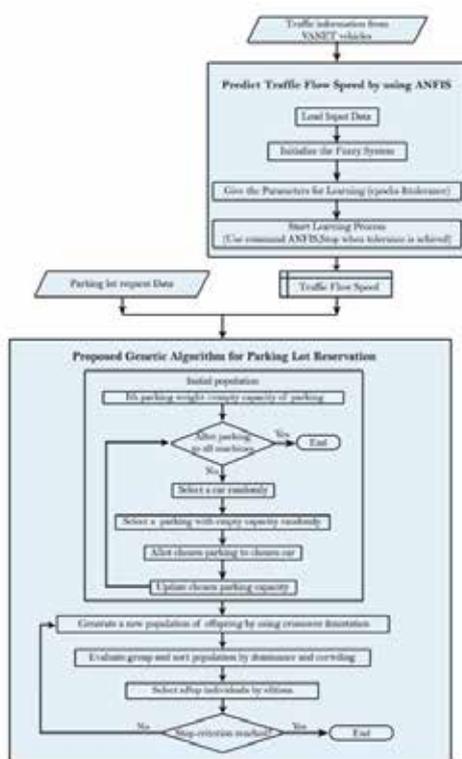**Figure 11: Average and the best value of the travel time**

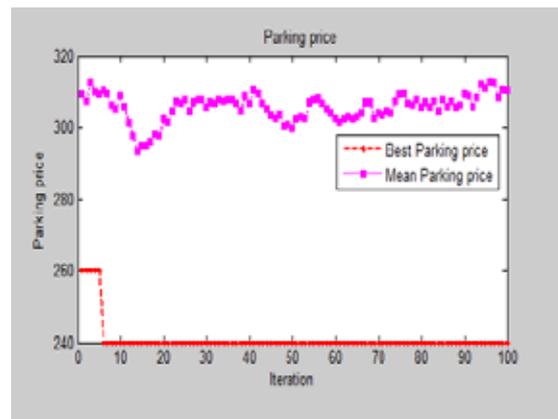**Figure 9: flowchart of the Proposed method**

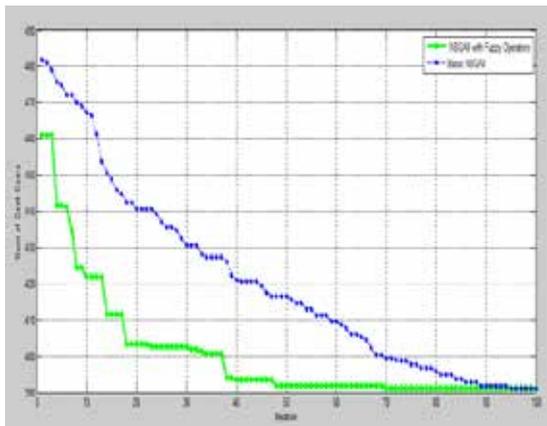**Figure 12: Average and the best value of the cost objective function**

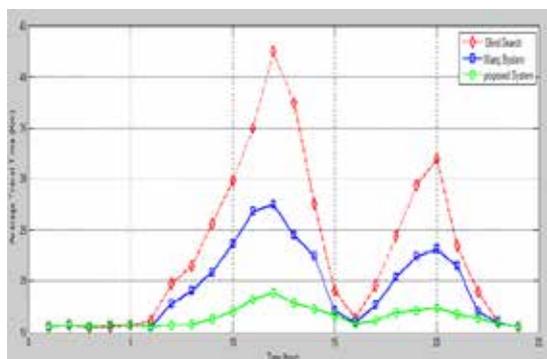**Figure 13: Compare the performance of the proposed system**

Figure 14: Searching time in proposed method

V. CONCLUSION

The main objective of this paper is to provide a parking space reservation system based on the optimal selection method. The proposed system seeks the most suitable space based on the information collected from the VANET and using an adaptive neural-fuzzy system and genetic algorithms to solve this problem. In this paper, at first, we proposed that the information collected in VANET classified form a series of hourly, daily and weekly times. After the stage, classified information will be delivered to ANFIS system. With this series of time, the proposed ANFIS system trained and will be able to quickly predict traffic flows with acceptable accuracy. The simulation results show that the performance and accuracy of the method have been significantly improved compared to previous works.

For future work, we can account the prediction of traffic speed with the use of online data and past time series. Also, by the use of this data, it's possible to predict the density and its time in each path.

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