Simulation of Urban Traffic Flow Using Personal Experience of Drivers

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***Abstract*— In recent years, with increasing population and number of private and public transport vehicles, traffic flow and its control, become a major and popular challenge. Working on control and simulation of traffic flow takes back to 20th century. In order to study and simulate traffic flow, we need to understand this issue and factors that cause congestion in the network and its problems. In recent years, researchers introduced novel methods to work with traffic flow. Those methods were intelligent models. Intelligent models inspired from nature and have some specific useful properties for controlling traffic rate. This paper introduced a new model that named Personal Experience of Driver (PED). Our method is an intelligent model for simulating traffic flow. This method models natural behavior of drivers. Results show that this model properly simulates urban traffic flow based on personal experience of drivers.**

***Keywords-component** Urban Traffic Flow, Intelligent Simulation, Personal Experience, Driver Behavior.*

I. INTRODUCTION

In recent years, with increasing population and number of private and public transport vehicles, traffic flow and its control, become a major and popular challenge [1].Population growth and consequently increasing in the number of vehicles in urban and rural places create a heavy traffic on roads and streets. When traffic rate grows, people spend a lot of time on the streets and behind traffic lights. In addition, air pollution, noise pollution and higher fuel consumption are other major effects of increasing traffic rate. To pull out from those problems, we should have a way to decrease effect of them. All of these problems point that a system which manage and control traffic, is essential to overcome problems or at least reduce their rates [2].

Work on control and simulation of traffic flow takes back to 20th century. In order to study and simulate traffic flow, we need to understand this issue and factors that cause congestion in the network and its problems [1]. This article will try to study and review the various simulation models, traffic flow analysis and how they are classified.

In those years, scientists found out traffic flow relations using mathematical and physical rules and determined solutions of them to release from this crisis. Those solutions were deterministic. Deterministic methods of control and simulation of urban traffic flow classified in three main categories: Microscopic, Mesoscopic, and macroscopic methods [1, 2].

In recent years, researchers introduced new methods to work with traffic flow. Those methods were intelligent models. Intelligent models inspired from nature and have some specific useful properties for controlling traffic rates [3-5].

Next section will describe some intelligent models. Basis of those models are on Ant Colony algorithm, Particle Swarm Intelligent algorithm, Genetic algorithm, Fuzzy and Neural Network algorithm. This paper introduced a new model that named Personal Experience of Driver (PED). This method is an intelligent model for simulating traffic flow. PED method models natural behavior of drivers and will be described in section 3. In section 4, results show that this model properly simulates urban traffic flow.

II. RELATED WORK

As noted, cities are growing and changing every day, and their populations are grown. Streets in towns and villages, and roads between them change. In order to consider such dynamism, we need some methods that built on dynamism, to be able to understand changes in the environment easily and react to them. Nature is best place to find these methods. Essence of nature and its creatures is the dynamics. In those changes, order and correctness of laws that governing them, are stable. Groups such as humans and their evolutionary genetics, birds, ants, fishes and ..., mostly applied in solving dynamic problems and solutions that obtained from them was closer to reality. Such natural categories, called Swarm Intelligence [3, 4].

In recent years because of special properties of Swarm Intelligence techniques, most researchers have used these methods to control and simulation of urban traffic flow. Intelligent methods of control and simulation of traffic flow categorized in some groups such as Genetic Algorithms, Ant Colony Optimization, PSO Algorithm, Fuzzy and Neural Networks. In this section, we talk briefly, about how these techniques used in traffic flow controlling [3-5].

A. Ant Colony Optimization Applications

The most famous intelligent optimization algorithm which simulates traffic and is applied to solve its problems is Ant Colony Optimization algorithm. In this algorithm the behavior of the drivers is simulated to choose leading paths for move. For example, in 2008, Foroughi and colleagues expressed a method that drivers select optimum route between origin and destination by using ACO algorithm. In this method, path length and traffic congestion of roads is optimal [6].

Another way that uses this algorithm is solving time-dependent routing problem. Danati introduced this method in 2007. In this problem, a time window defines that it will be fine if driver reachs after this period. Danati et.al used ACO algorithm to solve this problem. They applied multi agent approach to optimize number of paths and take shortest path. Simulation results show that, always the shortest path is choosed [7].

Prediction of traffic conditions is one of the most important issues in the world, which attract many researchers. Wei-Chiang Hong et.al in 2007, introduced a method based on ACO algorithms that combined with SVR method to predict traffic flow on roads. Simulations indicate that results of this model is more accurate compared to SARIMA model that is a prediction model based on time series [8].

Another case that uses ACO algorithm is lights controlling. This model presented by Hoar et.al in 2002. In this model, interaction between drivers (agents or ants) caused by pheromone distribution. ACO algorithm optimizes required time for the traffic lights. Each car has a specific origin and destination and behaves according to traffic conditions of environment. Results indicate that this model correctly shows the dynamism of traffic [9].

Hallam et.al in 2004 used ACO algorithm to guide driving route. They defined several agents that operate on basis of ant’s behavior and used that for simulation and testing the model. In this model, the path with low traffic, small distance, and many roads are selected [10].

B. Applications of Particle Swarm Optimization Algorithm

Another method for predicting urban traffic conditions is Wavelet network. Yafei Huang in 2008 combined this model with PSO algorithm. Each entry in the Wavelet network has weight and threshold. If this model assigns different random value to each input`s weight and threshold, then outputs will be different. PSO algorithm is used for optimization of network`s values [11].

Early detection of events is one of the necessary items to reduce accidents and increase safety of roads. Srinivasan et.al in 2003 used PSO algorithm for solving problem of auto accident detection. They used artificial neural network on basis of their work and for learning phase of neural network used PSO algorithm. Simulation results indicate that PSO algorithm acts better than Back-Propagation Method [12].

Time-dependent routing problem introduced in Ant Colony Optimization algorithm section. Zhu et.al used PSO algorithm in 2006 to solve this problem. In their method, all cars are same and goal is optimal number of cars and distance. Their own methods compared with genetic algorithms. PSO algorithm in 82 percent of times obtained optimal response however, Genetic algorithm in 32 percent of times found optimal response. PSO algorithm also seems to respond in less time than genetic algorithms [13].

C. Application of Genetic Algorithm

Genetic algorithm is used to solve problem of control and leading traffic flow at intersections with traffic lights. In 2009, Zang et.al used this algorithm. In their approach, Genetic Algorithm is applied for synchronous optimizing of light timing parameters such as duration of green light. Solution to this problem was multi-parametrical. Simulations indicate that this approach operates better compared with TRANSYT-7F optimization that puts all intersections in one group and optimize timing signal with current situation [14].

Another application of genetic algorithm is in optimizing time of light switching. In this model, each line that is connect to an intersection, according to their traffic situation (more or less vehicle) sends a message to the existing traffic signal at intersection. Genetic algorithm is used to optimize performance of lights according to reception of messages. In 2008 this model has been used by Kelly and the results show that genetic algorithms increases system performance in 27 to 42 percent of cases [15].

D. Applications of Fuzzy and Neural Network methods

Fuzzy approach is mostly applied to predict, control and direct traffic flow using traffic lights. In this section, some of these methods are mentioned.

In 2009, Daneshfar et.al presented a method of two-stage fuzzy for modeling and forecasting traffic flow. In this model, the first real data is collected by a sensor at every intersection and is sent to intelligent agent. Fuzzy classification module, classified dependent Intersections. Then intelligent agent manager receives traffic flow from intelligent agents of dependent Intersections and produces appropriate controlling signals using fuzzy system. In addition to have dependent Intersections traffic flow, their traffic patterns are also important and are recorded in manager knowledge base and affect productive signals. Simulation results show that this model acts better than other existing models [16].

The problem of Traffic lights controlling is one of major problems in control and guidance of urban traffic flow. Old lights cannot control dynamic traffic flow and we require a mechanism for applying dynamism to traffic lights. For this purpose, researchers combined fuzzy and neural network techniques.

One of these approaches presented in 1996 by Pate et.al. They used neural network and a defuzzifier system for consistent controlling of traffic lights. In their method, real data that collected from intersections, sent to a consistent neural network. Then network will recognize congestions and send fuzzy results to a defuzzifier system. Defuzzifier system according to its input produces appropriate output and set up lights to remove congestion. One of the solutions for this problem is leading flow to another path [17].

Yin et.al presented another model for predicting traffic. They combined fuzzy and neural networks in 2002. This model called FNM. In their model there are two major sections with names of GN and EN. GN categories input data according to fuzzifier system and EN uses neural network, associated input and output data. Yin and his colleague's model compared with NNM model. The results indicate that this model acts better than the NNM model and executive time is less [18].

III. PED ALGORITHMS

In this section, we describe our PED algorithm and discuss about how this algorithm simulate urban traffic flow. Urban network consists of some intersections and links (roads) between them. In our algorithm urban network is illustrated as a direct graph G= (V, E) and each intersection in network assumed as a node and roads between them supposed as edges between that nodes. We assume that G has n nodes and m edges. Each edge has a capacity that shows number of vehicles on it. In our method, each vehicle supposed as car.

In this algorithm, drivers select their path from their memory or randomly by a probability measure (PM). If PM was closer to one then a new path was selected and was added to driver memory. Else, one of routes in memory was selected to follow. We calculate PM factor by (1).

$$PM= (MP-MPP)/MP \qquad (1)$$

In above formula, MP is maximum value of path power. We propose MP=315. MPP in formula (1) describes maximum power in memory. If power of one path becomes greater than 300, it will set to 300. If number of using path increased then power of that path will raise up.

Any use of each path, will increase 30 units on its power. It means that any entrance in driver memory remains 30 day in it. Each day, power of all paths in driver memory decreased one unit. If in 30 days one path dose not use, then it removes from memory. Else, if it is used again, its power will rise up and chance of removing from memory will decreased. If one path has higher power, it illustrates that path is an appropriate route and probability of discovering new paths will be lower. In fact, PM will be closer to zero.

In our method, each trip has its purpose. Trips may be for working, learning, shopping etc. Related to purpose of trips, each of them has specify time that demonstrate in Table1. For example, time of working trips is 8 hour. At the end of that time, diver will back to his/her home or will start other trip.

In our algorithm when a road or one side of it becomes damaged, drivers use their experience, or randomly select other path or link to continue trip. Then new path is added to driver memory as described. Drivers have different experience for each type of traffic rate (low, medium and high) and use it in appropriate situations.

IV. EXPERIMENTAL RESULTS

In this paper, MATLAB software has been used as simulation tool. In this simulation, number of nodes (intersections) is set to 20. Each node connects to almost four nodes. Links between nodes may be one or two-sided. Each side of edges has own capacity and time of passing from it. This time increases or decreases when number of vehicles on it increase or decrease respectively. Maximum number of trip in one minute is 30. These trips start from some nodes and end in other nodes. For each trip, source, destination and purpose of it were specifying.

For more detail, we explain our algorithm by an example. Consider Fig.1 as a simple urban network. Value on each link shows capacity of link on that time. Fig.2 (a-f) shows several step of PED algorithm.

Results show simulation of one hour of day (8-9 am). Each link in graph has three types of color. When road has low traffic rate, color of it is set to green. For example, in Fig.2 (a) majority of links have green color and are in low traffic condition. If traffic rate of link rises up to medium, color of its will set to yellow. In “Fig.2 (b)” links between node B and node T, node Q and M and K, node M and F have medium traffic rate and color of them will set to yellow. Eventually color of link will set to red if traffic rate of that road becomes high and congestion occurs. Fig.2 (5) shows that link between node D and F has high traffic rate.

We compare our method with Car-Following Model that developed by Gipps in 1981.Car-Following model is one of the Microscopic traffic simulation models. Each of Car-Following and PED methods simulate driver`s behavior. Parameters that used in Car-Following model are velocity, acceleration, deceleration and position of driver. But in PED model, only experience of each driver is used. PED model can be categorized in Mesoscopic traffic simulation models. In our method simulation is done correctly without having any of those parameters (Car-Following parameters).

Car-Following model computes interactions of each vehicle by other vehicle around it. In this model, any acceleration, deceleration or lane changes affect other vehicles. In PED model interactions are considered generally and effect of them is just on the time of crossing pass. In PED model mentioned changes are not applied. This method can forecast traffic flow rate correctly.

I. CONCLUSION

This paper proposes an algorithm for simulation of urban traffic flow. We name this algorithm by PED (Personal Experience of Driver) algorithm. In our algorithm drivers related to their experience select path of trips. At first that they have no experiences, paths are selected from artery roads of urban network.

Traffic flow simulation models categories in two groups Deterministic and Intelligent models [1-5]. Our algorithm is in intelligent algorithms group. Deterministic models are not adaptive with dynamic changes in urban traffic conditions [1, 2]. However, one of major property of intelligent methods is dynamicity and they react with condition changes. In other words, intelligent methods are fault tolerances and take effect from environment. In addition, intelligent models use positive feedback method. Therefore, results of intelligent methods are more robust and realistic [3-5]. PED algorithm, models driver behavior in road and this is another advantage of this method. This method can forecast traffic flow rate correctly. In this method, obstacles and changes in urban network are sensible and so drivers change their path and network updates.

TABLE I. TIMES OF TRIPS RELATED TO ITS PURPOSE

Purpose	**Time (Hour)**
Working	8
Learning	5
Shopping	1-3
Meeting	1-5

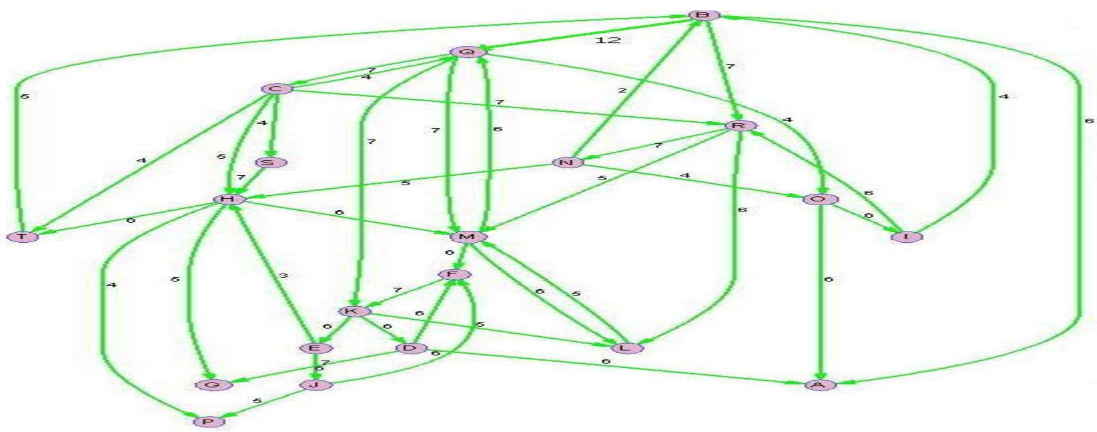
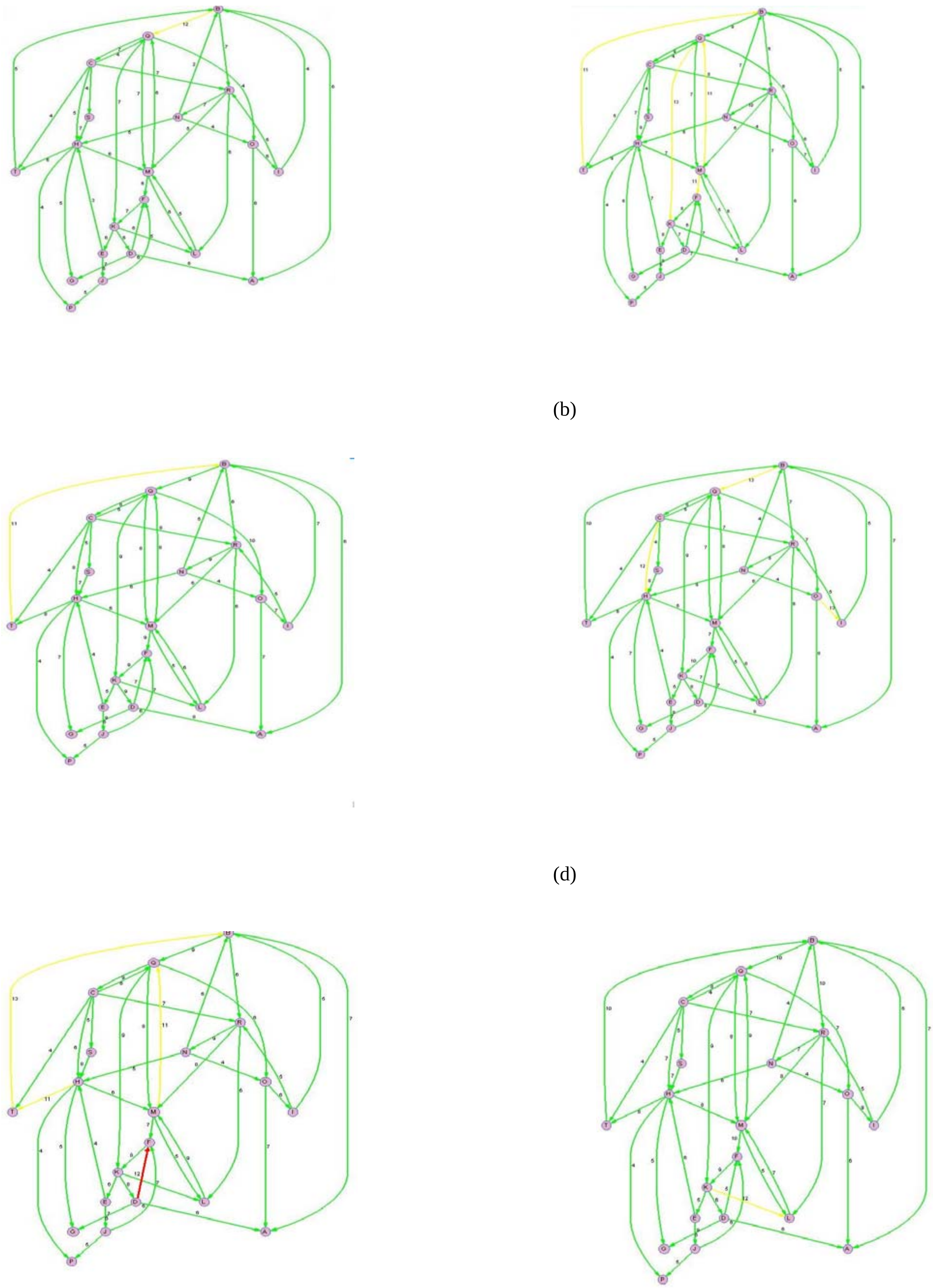


Figure 1. Sample Urban Network



(a) (b)

(c) (d)

(e) (f)

Figure 2. Some Steps of Simulation

REFERENCES

[1] S. P. Hoogendoorn, P.H.L.Bovy, "State-of-the-art of Vehicular Traffic Flow Modeling", Special Issue on Road Traffic Modeling and Control of the Journal of Systems and Control Engineering, vol. 215, pp. 283-303, 2001.

[2] M. Garavello and B. Piccoli ,"Traffic Flow on Networks Conservation Laws Models", AIMS Series on Applied Mathematics, Vol. 1, 2006.

[3] Y. Liu, K. M.Passino, "Swarm Intelligence Literature Overview", Dept. of Electrical Engineering The Ohio State University, 2000.

[4] T. White, "Routing with Swarm Intelligence", SCE Technical Report SCE-97-15.

[5] Brabazon, M. O'Neill, "Biologically Inspired Algorithms for Financial Modelling", Springer Natural Computing Series, 2005.

[6] R. Foroughi, Gh. A. Montazer, R. Sabzevari, "Design Of A New Urban Traffic Control System Using Modified Ant Colony Optimization Approach", Iranian Journal of Science & Technology, Transaction B, Engineering, vol. 32, pp. 167-173, 2008.

[7] A.V. Donati, R. Montemanni, N.Casagrande,A. E. Rizzoli, L. M. Gambardella, "Time dependent vehicle routing problem with a multi ant colony system", European Journal of Operational Research vol. 185, pp. 1174–1191, 2008.

[8] W.C. Hong1, P.F. Pai, S.L. Yang, and C.Y. Lai, "Continuous Ant Colony Optimization in a SVR Urban Traffic Forecasting Model", Springer-Verlag Berlin Heidelberg, pp. 765-773, 2007.

[9] R. Hoar, J. Penner, C. Jacob, "Evolutionary Swarm Traffic: If Ant Roads Had TrafJic Lights". IEEE, pp. 1910-1916, 2002.

[10] N. Hallam, M. Hartley, P. Blanchfield, G. Kendall, "Optimisation In a Road Traffic System Using Collaborative Search", IEEE International Conference on Systems, Man and Cybernetics, pp. 2008-2012, 2004.

[11] Y, Huang, "Short-term Traffic Flow Forecasting Based on Wavelet Network Model Combined with PSO", IEEE, Computer Society, International Conference on Intelligent Computation Technology and Automation, 2008.

[12] D. Srinivasan, W. H. Loo, R. L. Cheu, "Traffic Incident Detection Using Particle Swarm Optimization", IEEE, pp. 144-151, 2003.

[13] Q. Zhu, L. Qian, Y. Li, S. Zhu, "An Improved Particle Swarm Optimization Algorithm for Vehicle Routing Problem with Time Windows", IEEE Congress on Evolutionary Computation, pp. 1386-1390, 2006.

[14] L. Zang, L. Jia, X, Meng, "An Optimization Control Algorithm of Traffic Signals for Urban Arterials", IITA International Conference on Control, Automation and Systems Engineering, pp. 338-342, 2009.

[15] M. Kelly, "Decentralised Urban Traffic Control using Genetic Algorithm and Cellular Automata", IEEE Congress on Evolutionary Computation, pp. 945-950, 2008.

[16] F. Daneshfar, J. RavanJamJah, F. Mansoori, H. Bevrani, B. Z. Azami, "Adaptive Fuzzy Urban Traffic Flow Control Using a Cooperative Multi-Agent System based on Two Stage Fuzzy Clustering", IEEE, 2009.

[17] M. I. Pate, N. Ranganathan, "An Intelligent System Architecture for Urban Traffic Control Applications", IEEE, 1996.

[18] H. Yin, S.C. Wong, J. Xu, C.K. Wong, "Urban traffic flow prediction using a fuzzy-neural approach". Transportation Research Part C, vol 10. , 2002.