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An Approach towards Density Estimation of Vehicle Classes in Simulated Traffic Network

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Abstract*— Recent year has witnessed exponentially growing vehicles in the available traffic infrastructure, which are geographically constrained. Managing traveling entities in the traffic network with same physical parameters is major challenge to research community. Verification process of the algorithmic solutions proposed against this issue on real-time system is very complex because of its dynamic nature. So, different traffic simulation tools exist to evaluate performances on the basis of some elementary attributes such as density measurement over a period of time, or average waiting time. But one important statistics related to vehicle classes in the network is not considered in any tool. In this presented work, simulation run is analyzed for density distribution of classification of traveling entities in the form of graphical plot. This output could be useful for controlling and guiding vehicles by better strategic planning.

***Keywords*— traffic management, vehicle classification, traffic simulator, Intelligent transport system**

I. INTRODUCTION

Modern life style and daily needs of the increasing population are increasing the vehicle count at an alarming rate in every country worldwide. In India, this fact can be verified by the statistics of annual production and sales for different categories of vehicles [1]. On the contrary, the existing traffic infrastructure has its physical limitation for expansion to accommodate this exponential growth of moving entities. So transportation of vehicles within required time limit has been a serious issue over the years and there are continuous efforts by the research community to handle this problem using a dedicated domain termed as ITS (Intelligent Transport System).

It applies modern communication and information technology like GPS, RFID, GSM and many more, into existing traffic networks, vehicles and users to manage traffic network in best possible way. Several other applications also get benefited from contributions of ITS such as vehicle routing, controlling traffic signal, automatic number plate recognition, incident notification, parking guidance etc.

Any algorithmic ideas proposed for improving the throughput of traffic system needs to be validated against the problem definition to confirm its success or failure. But the dynamic nature and randomness of running system complicate the testing process. Instead, the experiments are carried out on software platforms which simulate different parameters of traffic system artificially. Various vehicular traffic simulators with different features and characteristics are available for traffic modeling[2].

Its very important for these traffic simulators to provide analytics for certain parameters of traffic scenarios to get the feasibility aspect of proposed algorithm. Generally simulation run are associated with statistical output of trips of moving entities like journey time, cumulative density, speed etc but one important parameter related to different categories of vehicles is ignored. for these statistical output is related to different categories of vehicles in the traffic scenario. This categorization can be done on the basis of its priorities, length, speed and others.

Here, one idea is proposed to represent the density of each vehicle class available in a traffic scenario. This aspect can play an important role in even distribution of density over the traffic network and to utilize the traffic network efficiently.

II. PREVIOUS WORK

There have been several works proposed for different purposes of vehicular traffic networks till date. This section briefs about the technologies used and motivation behind those ideas.

A. Estimation of traffic parameters

Randomness in traffic scenario requires estimating values of important attributes for better planning of traffic system under consideration, such as vehicles speed, their waiting time, traffic density over a stretch of road or identifying a certain type of vehicles. Speed of vehicle can be measured using image sensors [3], video frames [4] or GPS enabled smartphones [5].

Various ways are available to measure traffic congestion on road such as RFID and GSM equipped probe vehicle [6] [7], analyzing signal patterns in cellular core network of that area [8] or processing optical images of road network [9]. Other applications of ITS are identification of specific vehicles [10], controlling traffic lights [11], automatic traffic monitoring [12][13], incident notification [14][15] and number plate recognition [16].

B. Traffic Simulator

Considering the complexity of measuring traffic related parameters, real scenarios are simulated through computer model and they generate various statistics to have additional information. The possibilities of investigating the output depends on the open accessibility of simulation softwares. For example, simulation package Aimsun [17], SimTraffic [18], CORSIM [19] do not include statistical output in their demo version but, SUMO (Simulation of Urban Mobility) has gain popularity for its various advantages over the existing products [20-22]. It generates output data files related to Network state dump, vehicle related information, and many other analytics along with running a given traffic scenario [23].

None of the simulation environment provides statistical output for density estimates for different classes of traveling entities. The issue is addressed in this presented work and opens scope for newer ideas to distribute the total density over the network evenly.

III. PROPOSED METHODOLOGY

A traffic network S consists of {*nodes, edges, vehicles*} having generic structure as given in fig[1]. This system provide output files for analyzing the behavior of its elementary attributes. Contribution of this paper is to find the density $\delta_{vehicle_i}$ such that $\delta_S = \sum_{i=1}^{n} \delta_{vehicle_i}$, where n is the number of classes of moving entities. Here, classification is based on *priority* of vehicles in the system S.

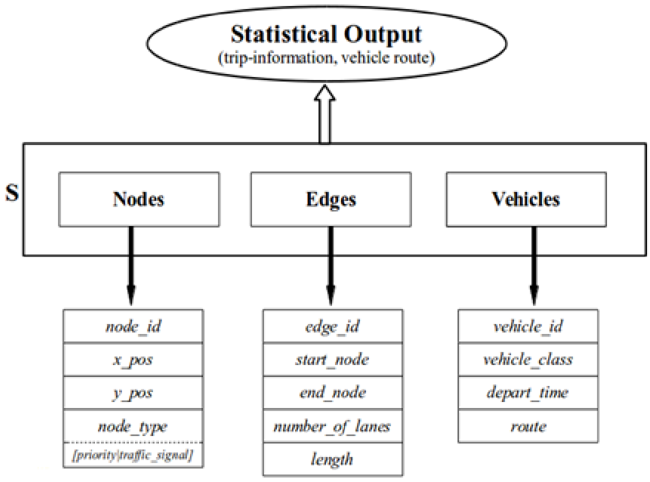

Fig. 1 Generic structure for elements of traffic network

A. Algorithm

Let Y be a matrix which stores the statistical information for $vehicle_k$ moving from *node m* to *n* such that $Y_i = (node_m, node_n)_{vehicle_k}$. The rows and column of this matrix can be represented by Y_r and Y_c respectively. Information contained in $\forall Y_i \in Y$ gives more insight about vehicles except *(id, departTime, route, type)* in the form of *(arrivalTime, waitingTime, travelTime)*. If the total number of elements in Y_c is p, then the dimension of matrix will be $n \times p$, where n is the number of moving entities in the traffic network S. Algorithm for mapping function $f_{density}$ is given below:

Input to $f_{density}$ is $Y_{cj} = (departTime)_{vehicle_k}$, where $1 \leq k \leq n$

- $mem_{sh}[q] \leftarrow Y_{rj} \in Y$, where $departTime_{(q+1)} > departTime_q > departTime_{(q-1)}$ for $1 \leq q \leq n$
- $M'_t \leftarrow mem_{sh}$
- $\forall M'_{tri} \in M'_{tr}$, such that $1 \leq i \leq n$
    - $l \leftarrow M'_{tri}$
    - $type_l = y$, where $1 \leq y \leq g$, and g = number of classes of moving entities
    - $N[y] = N[y] + 1$
- Output of $f_{density}$ is graphical plot of densities δ of different classes g of vehicles.

If $\delta_c < \delta_t$, then $N[y]$ is detained in traffic flow in the order of $y < y + 1$ satisfying following condition:

$$1 \leq y < g \;\&\&\; y \neq g$$

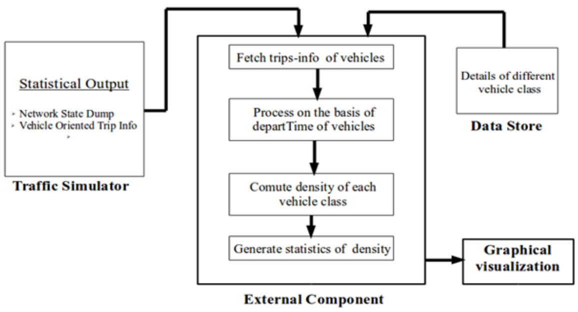

Fig. 2 Block diagram of proposed method

B. Set up of Traffic Scenario

Important input files are:

- *Node* files (named as example.nod.xml as per convention)
- *Link* files (provides connectivity between two nodes. Conventionally named as example.edg.xml).
- *Link Property* file (optional file defined as example.type.xml)
- *Lane Connection* files (Also known as traffic movement file and named as example.con.xml)
- *Network* file (netconvert imports digital road networks from different sources)
- *Traffic Demand* file (contains route information and named with extension .rou.xml)

The output *Y* can be generated either using the CLI (Command Line Interface) or GUI (Graphical User Interface) of the simulator for better visualization to further get processed using fdensity.

TABLE I CLASSES OF MOVING ENTITIES

Priority	Length	MaxSpee	Color	Probability
1	5	70.0	red	0.3
2	15	50.0	white	0.2
3	5	40.0	yellow	0.45
4	10	30.0	yellow	0.05

There are four classes of vehicles defined for a traffic scenario [Table 1]. One instance of simulated traffic environment is shown in figure 3, where different classes of vehicles can be identified. The behavior of the simulation run is observed for 1000 time step without (default) and with the proposed idea. Comparative analysis for waiting of both cases are shown in figure 4 and figure 5.

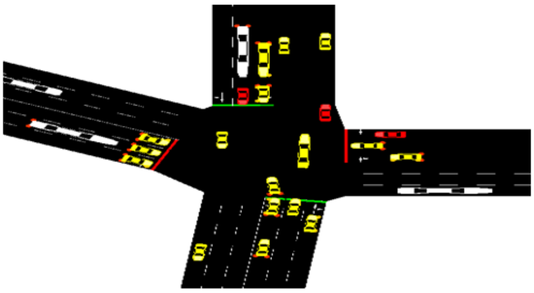

Fig. 3 Simulation Run Instance

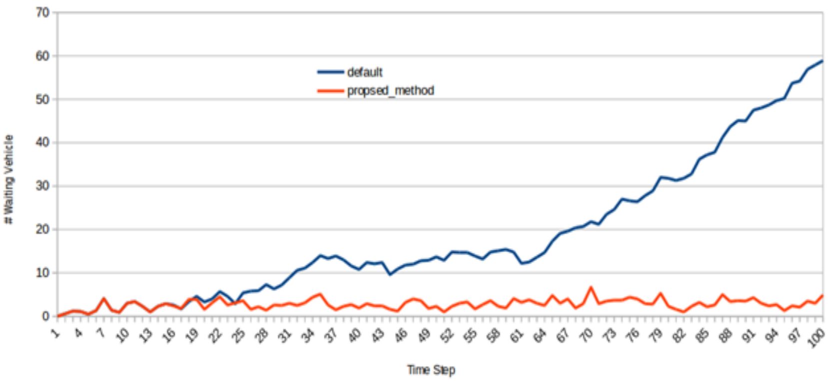

Fig. 4 Statistics of number of vehicles waiting

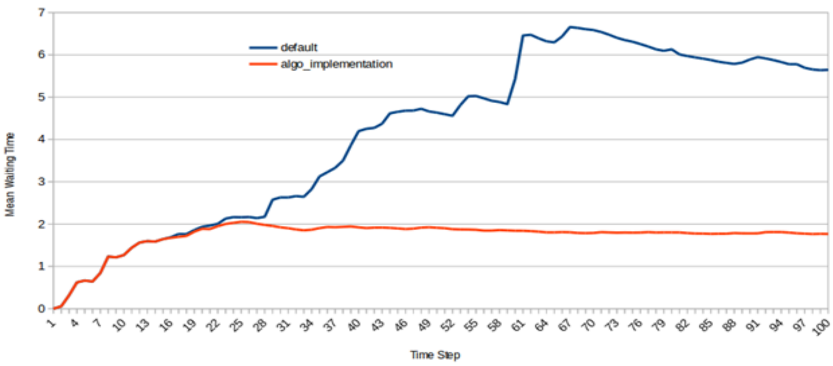

Fig. 5 Average waiting time of vehicles

IV. Conclusions

The proposed work has addressed the issue of not considering an important attribute of trips related info in a traffic scenario for statistical output, which is density of different categories of vehicle. Though outputs based on other attributes gives many useful information about the traffic scenario but the importance of vehicle type can not be ignored as it can be a major factor to distribute the overall density through the network evenly.

Waiting time in terms of number of vehicles or through the trips to destination incur additional cost which should be reduced for enhanced system throughput. This waiting time depends directly on traffic density of the system. When threshold density of a traffic system is reached then altering the default traffic flow can reduce the waiting time for the considered system. In this presented work, classes of moving entities in the system are managed to improve the system performance by reducing the cost in the form of waiting time. The statistical plots [figure 4 and 5] show a comparative analysis of a simulated environment against measures of waiting vehicles and mean waiting time. The datasets are processed with averaging methods for smoothing the values of required attributes fetched from smulation run.

References

[1] http://www.siamindia.com/statistics.aspx?mpgid=8\&pgidtrail=9
[2] G. Kotusevski and K. A. Hawick, "A review of traffic simulation software." (2009)
[3] M. Litzenberger, A. N. Belbachir, N. Donath, G. Gritsch, H. Garn, B. Kohn, Ch Posch, and S. Schraml, "Estimation of vehicle speed based on asynchronous data from a silicon retina optical sensor." Intelligent Transportation Systems Conference, 2006. ITSC'06. IEEE, 2006.
[4] L. Grammatikopoulos, G. Karras, and E. Petsa, "Automatic estimation of vehicle speed from uncalibrated video sequences." Proceedings of the Int. Symposium on Modern Technologies, Education and Professional Practice in Geodesy and Related Fields. 2005.
[5] C. J. Herrera, D. B. Work, R. Herring, X. J. Ban, Q. Jacobson, and A. M. Bayen, "Evaluation of traffic data obtained via GPS-enabled mobile phones: The Mobile Century field experiment." Transportation Research Part C: Emerging Technologies 18.4 (2010): 568-583.
[6] K. Mandal, A. Sen, A. Chakraborty, S. Roy, S. Batabyal, and S. Bandyopadhyay, "Road traffic congestion monitoring and measurement using active RFID and GSM technology." Intelligent Transportation Systems (ITSC), 2011 14th International IEEE Conference on. IEEE, 2011.
[7] M. S. S. Roy, S. Bandopadhyay, and S. Pal, "Real time traffic congestion detection and management using active rfid and gsm technology." ITSC, Kyoto, Japan (2010).
[8] D. Valerio, T. Witek, F. Ricciato, R. Pilz, and W. Wiedermann, "Road traffic estimation from cellular network monitoring: a hands-on investigation." Personal, Indoor and Mobile Radio Communications, 2009 IEEE 20th International Symposium on. IEEE, 2009.
[9] G. Palubinskas, F. Kurz, and P. Reinartz, "Detection of traffic congestion in optical remote sensing imagery." Geoscience and Remote Sensing Symposium, 2008. IGARSS 2008. IEEE International. Vol. 2. IEEE, 2008.
[10] R. Sundar, S. Hebbar, and V. Golla, "Implementing Intelligent Traffic Control System for Congestion Control, Ambulance Clearance, and Stolen Vehicle Detection." Sensors Journal, IEEE 15.2 (2015): 1109-1113.
[11] K. Al-Khateeb and J. Johari, "Intelligent dynamic traffic light sequence using RFID." Computer and Communication Engineering, 2008. ICCCE 2008. International Conference on. IEEE, 2008.
[12] J. Zhou, D. Gao, and D. Zhang, "Moving vehicle detection for automatic traffic monitoring." Vehicular Technology, IEEE Transactions on 56.1 (2007): 51-59.
[13] P. Handel, J. Ohlsson, M. Ohlsson, I. Skog, and E. Nygren, "Smartphone-based measurement systems for road vehicle traffic monitoring and usage-based insurance." Systems Journal, IEEE 8.4 (2014): 1238-1248.
[14] M. Abuelela, S. Olariu, and M. C. Weigle, "Notice: An architecture for the notification of traffic incidents." Vehicular technology conference, 2008. VTC Spring 2008. IEEE. IEEE, 2008.
[15] MRS. Devi, MVT Kesavan, and MV. Gayathri, "Traffic Accident Classification and Automatic Notification Using GPS." International Journal 13 (2015).
[16] NA. Prasath, G. Sivakumar, and N. Kumaresan. "Vehicle Speed Measurement and Number Plate Detection using Real Time Embedded System." Network and Complex Systems 5.3 (2015): 21-29.
[17] http://www.aimsun.com/wp/?page_id=21
[18] http://cubist.cs.washington.edu/projects/09sp/cse403/traffic/index.html
[19] http://mctrans.ce.ufl.edu/featured/tsis/version5/corsim.htm
[20] D. Krajzewicz, G. Hertkorn, C. Rössel, and P. Wagner, "Sumo (simulation of urban mobility)." Proc. of the 4th middle east symposium on simulation and modelling. 2002.
[21] M. Behrisch, L. Bieker, J. Erdmann, and D. Krajzewicz, "SUMO–Simulation of Urban MObility." The Third International Conference on Advances in System Simulation (SIMUL 2011), Barcelona, Spain. 2011.
[22] D. Krajzewicz, J. Erdmann, M. Behrisch, and L. Bieker, "Recent development and applications of SUMO–simulation of urban mobility." International Journal On Advances in Systems and Measurements 5.3\&4 (2012).
[23] http://sumo.dlr.de/daily/userdoc/Tools/Visualization.html

