Periodica Polytechnica
Transportation Engineering

44(2), pp. 69-74, 2016
DOI: 10.3311/PPtr.8226

RESEARCH ARTICLE

Improving Traffic Flow Characteristics by Suppressing Shared Taxis Maneuvers

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Received 12 May 2015; accepted 10 August 2015

Abstract

The sudden maneuver of shared taxi through lanes in order to pick-up and drop-off passengers and asking their destinations -due to lack of designated stop locations- may lead to disorder in traffic flow. The main hypothesis in this research was that shared taxis sudden maneuvers and lane changings have negative effects on traffic flow characteristics and subsequently, suppressing these maneuvers will improve traffic flow characteristics. For this purpose, a study was done on a path in the city of Isfahan in Iran. First the investigated path simulated without shared taxi sudden maneuvers and then the outputs of this simulation were compared to the real measurement data. By this comparison, some differences were observed. The shared taxis maneuvers were added to simulation to see if the observed difference can be lowered. By comparing the outputs of these two simulations to the real situation parameters, the considerable negative effect of this maneuvers was recognized. After observing of the mentioned maneuvers negative effect, an innovative solution – allocating a line to shared taxis and High Occupancy Vehicles - was added to suppress shared taxi maneuvers in order to improve traffic flow characteristics. By applying this scenario on current situation delay of traffic flow and delay of shared taxis decreased from 458.48 sec. to 383.01 sec. and from 506 sec. to 450 sec. respectively. Besides, traffic flow and the number of shared taxis increased from 11986 to 12980 and 663 to 718 vehicle per hour respectively.

Keywords

Shared taxi, Lane changings and maneuvers, Traffic simulation, Allocated line

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1 Introduction

Shared taxi is a mode of public transportation used in Iran (Gholami et al., 2014). There are many examples of informal taxi sharing which are well used and are commercially viable to the operators, e.g. the Kombi shared taxis of Cape Town, South Africa; the Taxi Collectives of Havana, Cuba; the Dolmus of Istanbul, Turkey; the Taxi Train of Mauritius; Motorcycle taxis in Bangkok, Thailand and Rio de Janeiro, Brazil; the Jeepneys of Manila, Philippines; and the Sherut taxi, Israel (Enoch, 2005; Salomon and Silman, 1985). Shared taxi has a low capacity with high capacity utilization rate and works on high demand corridors, resulting in a high-frequency service (Gholami et al., 2014). There are some studies that are somehow related to shared taxis. Factor and Miller explored a special type of taxi called transit-taxi. A transit-taxi is like a bus service, but instead of buses, taxi vehicles are used. They showed that transit-taxi is a good option during off-peak and low-demand times of the day (Factor and Miller, 2006; Yang et al., 2015). Shariat Mohaymany et al. studied on the affection of taxi stops position on the functionality of urban intersections. Maneuvers of shared taxis were surveyed in order to record origin-destination of pick-up and drop-off passengers and in the vicinity of an urban intersection. In this research, they suggested to prohibit stopping in the mentioned areas and move the stop locations to a certain distance far from the vicinity of intersections (Shariat Mohaymany et al., 2010). In order to investigate the effect of these maneuvers and sudden lane changing on traffic flow, it is essential to simulate these maneuvers with intelligent traffic simulator software to enhance road safety situation (Mitsakis et al., 2015). Martinez and Viegas presented a simulation procedure to assess the market potential for the implementation of a new shared taxi service in Lisbon (Martinez and Viegas, 2011). Brake et al. provided guidelines for the implementation and development of flexible transport services (FTS) at a policy level (2007). Cervero and Golub studied the supply, demand, and performance characteristics of informal transport services (shared taxis, vans, and minibuses), and reviewed the range of informal transit experiences in third-world cities (Cervero and Golub, 2007). In many cities in Iran as in developing

countries, shared taxi sometimes has more than 25% of all urban trips (Gholami et al., 2014). Fixed route, unscheduled operation, unlimited pick-up and drop-off locations, lack of designated stop locations, and share ride are common features of shared taxi (Gholami and Shariat, 2011), therefore, shared taxis are semi-flexible way of passenger transport (Andrejszki and Török, 2014; Horváth et al., 2013). A view of designated and undesignated taxi stop location is shown in Fig. 1 and Fig. 2.

Fig. 1 A view of undesignated taxi stop location
(Source: Shadabmehr, 2011)

Fig. 2 A view of designated taxi stop location
(Source: Molon, 2009)

Lack of designated stop locations for shared taxis may induce them to have some maneuvers in order to pick up and drop off passengers in everywhere through the path (i.e. while they are cruising through the path) or even to seize passengers in competition with other shared taxis. Lane-changing not only affects traffic individually but also has the considerable impact on the global traffic flow status, especially when there is a large quantity of lane-changing behaviors (Feng et al., 2015). Lane changing's negative impact on traffic breakdowns and bottleneck discharge rate reduction at the onset of congestion (i.e., capacity drop) (Cassidy and Rudjanakanoknad, 2005), and significant roles played by lane changing in, formation and propagation of stop-and-go oscillations (Kerner and Rehborn, 1996; Mauch and Cassidy, 2002; Ahn and Cassidy, 2007), and the significant effect of lane changing on driving safety and the stability of traffic flow (Sivak et al., 2007) have been revealed in some studies. In general, the literature on lane-changing phenomenon is regarding traffic behavior of individuals or a particular situation, for example, heavily crowded conditions (Hidas, 2005), speed differentials between lanes (Lv et al., 2011; Hu et al., 2012), and reduced lanes or transport bottlenecks (Hidas, 2005; Laval and Daganzo, 2006; Meng and Weng, 2011). Shared taxi maneuvers for picking up and dropping off passengers are related to the one which is related to traffic behavior of individuals. The main hypothesis in this research was that shared taxis maneuvers and sudden lane changings have negative effects on traffic flow characteristics and subsequently, suppressing these maneuvers will improve traffic flow characteristics. The remainder of this paper is organized as follows: Section 2 describes how the methodology processed in order to find out whether these lane changings have the negative effect on flow characteristics or not. Section 3 presents an innovative solution to reduce the negative effect of the mentioned maneuvers and lane changings on flow characteristics. Section 4 presents results of applying this solution on the real current situation. Finally, Section 5 summarizes the conclusions.

2 Methodology

The first step in this research was to find out whether shared taxi maneuvers and sudden lane changings have negative effects on traffic flow characteristics or not. The steps of the entire procedure are shown in Fig. 3.

To do so the selected path (in city of Isfahan in Iran as a research area) was simulated in AIMSUN traffic modelling software WITHOUT shared taxis maneuvers (SIM. 1) based on user manual of AIMSUN (Khashaeepour, 2012) and own recording of traffic (i.e. Flow volume, Traffic lights cycles, approximate stop location of shared taxis in order to pick up and drop off passengers, duration of stopping time separated in two complete stop time and monetary stop time for asking passengers destination, The approximate shared taxis maneuver lengths) (Maghrour Zefreh, 2015).

This research is a simulation-based research by AIMSUN traffic simulator software. Hence, the whole theoretical background is based on this software.

By comparing the average travel time recorded in the real situation and obtained from SIM. 1, 24.8 % difference was observed. Moreover, 13.81% difference was observed for the average travel time of shared taxis in the two cases.

The mentioned average travel times of traffic flow and shared taxis are shown in Table 1.

By observing this difference, shared taxis maneuvers and lane changings were added to the previous simulation (SIM. 1) in the next simulation (SIM. 2). The average travel time obtained from SIM. 2 and real situation are shown in Table 2.

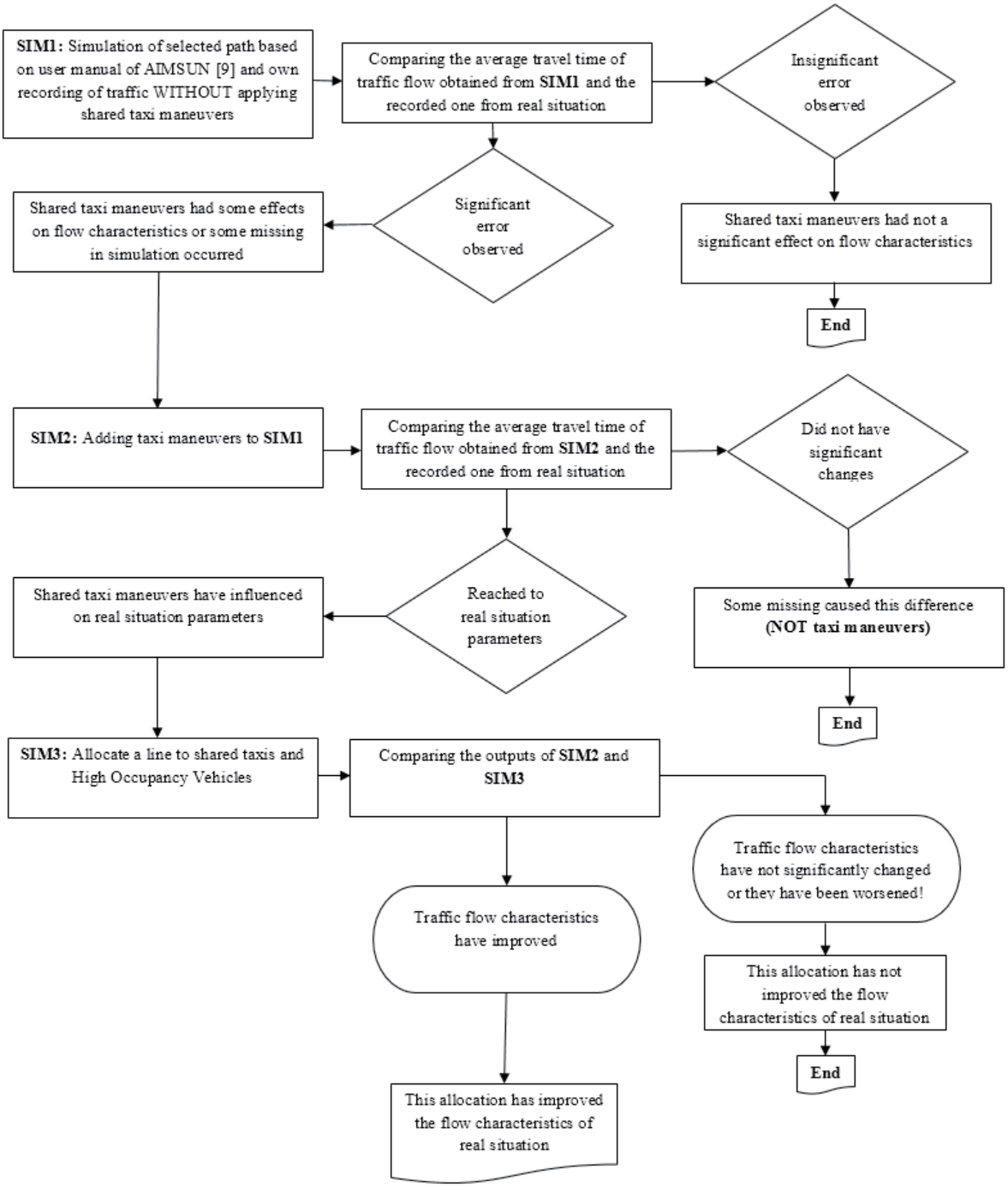

Fig. 3 The entire procedure

Table 1 Average travel time of traffic flow and shared taxis obtained in real situation and sim. 1

Azadi-Boz. Path (Both direction)	Average Travel Time of traffic flow (sec.) (Azadi-Boz.)	Average Travel Time of traffic flow (sec.) (Boz.-Azadi)	Average Travel Time of shared taxis (sec.) (Azadi-Boz.)	Average Travel Time of shared taxis (sec.) (Boz.-Azadi)
Real Situation	600	980	890	1370
SIM. 1 (Without applying shared taxi maneuvers)	461	721	769	1178

Table 2 Average travel time of traffic flow and shared taxis obtained in real situation and sim. 2

Azadi-Boz. Path (Both direction)	Average Travel Time of traffic flow (sec.) (Azadi-Boz.)	Average Travel Time of traffic flow (sec.) (Boz.-Azadi)	Average Travel Time of shared taxis (sec.) (Azadi-Boz.)	Average Travel Time of shared taxis (sec.) (Boz.-Azadi)
Real Situation	600	980	890	1370
SIM. 2 (Adding shared taxi maneuvers)	647	1057	956	1567

By taking a wide look at Table 2, it is obvious that shared taxis maneuvers and lane changings not only phenomena that caused the negative effect on traffic flow but also have the influence on the average travel time of shared taxis as well.

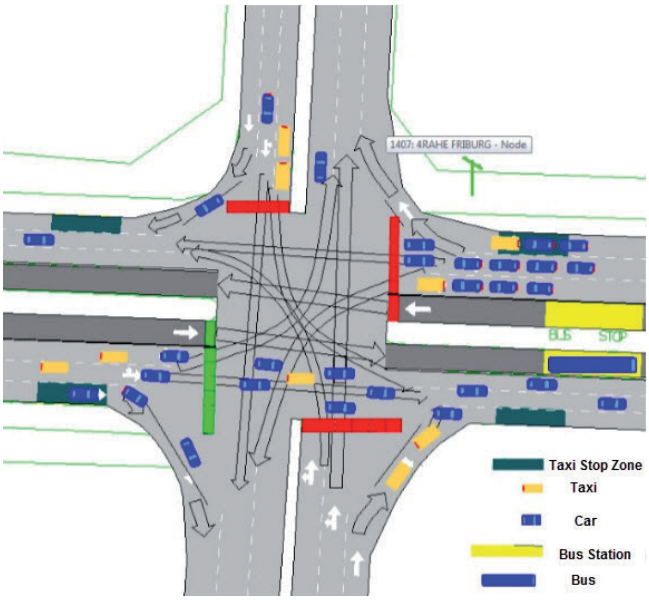

Fig. 4 A view of sample intersection of selected path in intelligent software environment

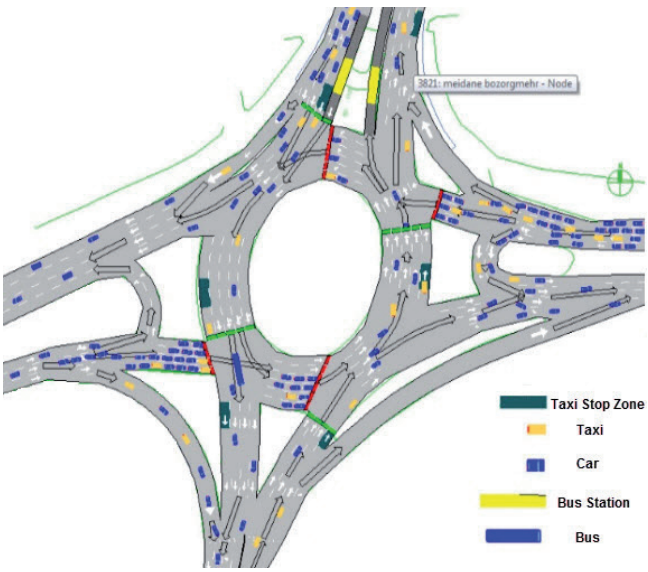

Fig. 5 A view of sample roundabout of selected path in intelligent software environment

It can be seen from Table 2 that average travel time of traffic flow has been enhanced to 647 sec. and 1057 sec. and average travel time of shared taxis has been enhanced to 956 sec. and 1567 sec. in the second simulation which are more than the real situation. This difference may occur due to the statistical approximation of maneuver length (Maghrour Zefreh, 2015). As it can be seen from results the difference is insignificant. Some simulation views of the simulated path are shown in Fig. 4 and Fig. 5.

3 Presentation of solution

After revealing and evaluating the negative effects of shared taxis maneuvers for traffic flow, the simulation is considered appropriate. Further on a scenario (SIM. 3) which was allocating a line to shared taxis and High Occupancy Vehicles was investigated. This solution is to improve traffic flow characteristics. In this scenario shared taxis forced to go through this line compulsorily and HOVs could go through this line arbitrary (e.g. in peak hours or in congested areas). A view of sample intersection of the presented solution after is shown in Fig. 6.

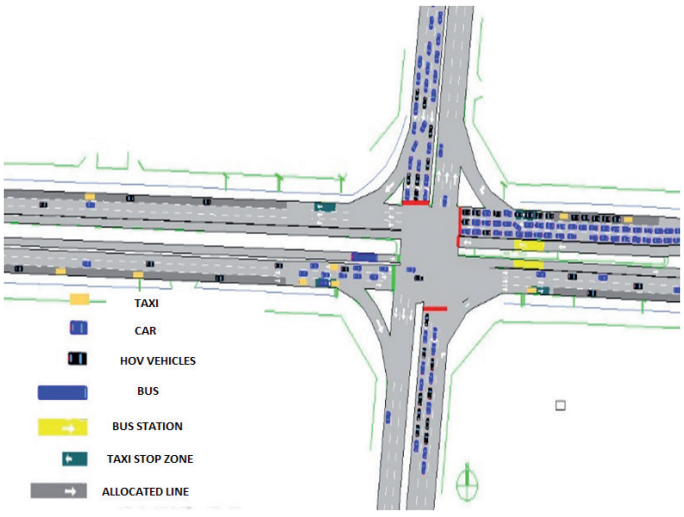

Fig. 6 View of a sample crossroad in presented solution

4 Results

The outputs bar charts of presented solution (SIM. 3) compared with the real and evaluated situation (SIM. 2) in two different flow characteristics (Delay and flow) are shown in Fig. 7 and Fig 8. and Fig. 9 and Fig. 10. As it can be seen from

Fig. 7 and Fig. 8, after applying this solution on the current situation, the average delay of both traffic flow and shared taxis have been decreased by 16.46 % and 11.06 % respectively. By separating shared taxis lane, their maneuvers have been suppressed therefore their sudden lane changing will not have any negative effect on delay of traffic flow or even their own delay. Namely, the delay parameter of both traffic flow and shared taxis have been improved by applying this solution on the real situation. By taking a look at Fig. 9 and Fig. 10 we will find out that, not just delay of both shared taxis and traffic flow have been decreased, but their flow is increased in comparing to the real situation. Altogether, the presented solution (suppressing shared taxi maneuvers) improved both delay and flow of both shared taxis and traffic flow together.

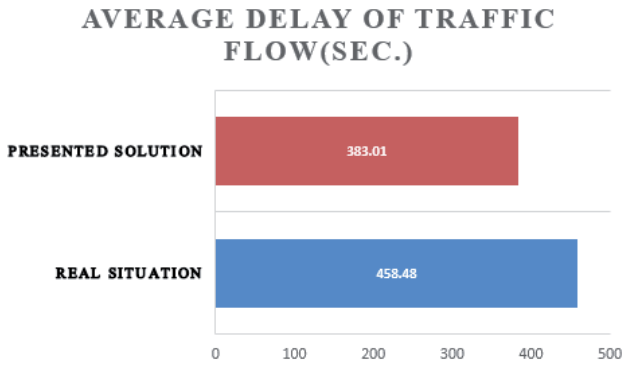

Fig. 7 Average delay of traffic flow (sec.)

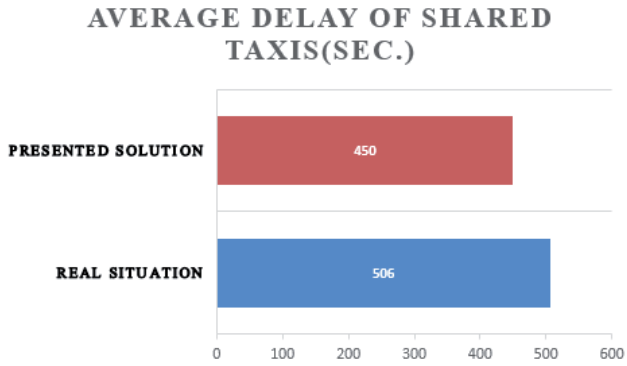

Fig. 8 Average delay of shared taxis (sec.)

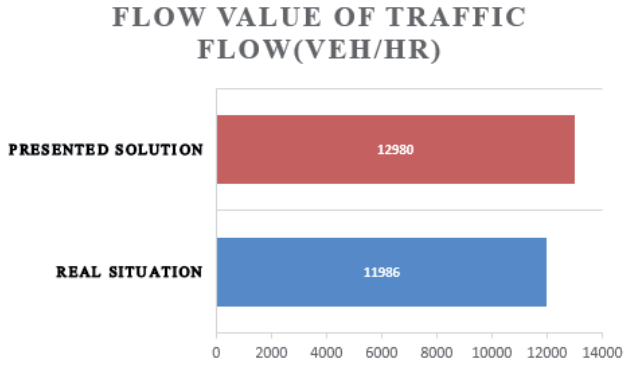

Fig. 9 Flow value of traffic flow (veh/hr)

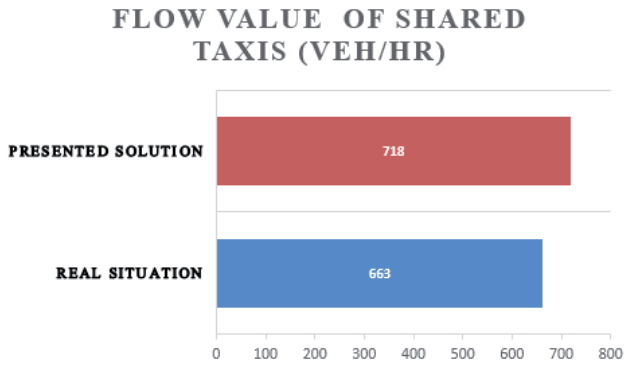

Fig. 10 Flow value of shared taxis (veh/hr)

5 Conclusions

The main purpose of this research was to find out whether the shared taxi maneuvers (due to lack of designated stop locations in order to pick up and drop off passengers) have the negative effect on flow characteristics or not and is it possible to improve flow characteristics by suppressing this kind of maneuvers or not. After simulating the investigated path with and without shared taxi maneuvers and comparing the simulated results with the real parameters recorded from the current situation, a considerable negative effect of the maneuvers have been recognized. By applying the presented solution to the current situation an improvement on both flow and delay characteristics of both shared taxis and traffic flow were observed. To wit, delay of the entire traffic flow and shared taxis decreased from 458.48 sec. to 383.01 sec. and 506 sec. to 450 sec. respectively. On the other hand, flow value of the entire traffic flow and shared taxis increased from 11986 to 12980 and 663 to 718 vehicle per hour respectively. Approximately most of HOVs (High Occupancy Vehicles) decided to choose the allocated line in the congested side of intersections or any other congested areas of the selected path based on the simulations. It should be mentioned that approximate stop zones of shared taxis were located out of this line. By this solution, people will be encouraged to carry a high number of passengers to be eligible as a High Occupancy Vehicle to be allowed to go through the allocated line in congestions. Therefore, the number of single passenger vehicles will be decreased.

References

Ahn, S., Cassidy, M. (2007) Freeway traffic oscillations and vehicle lane-change maneuvers. In: *Proceedings of the 17th International Symposium on Transportation and Traffic Theory.* Amsterdam. pp. 691-710.

Andrejszki, T., Török, Á. (2014) Pricing systems analysis of DRT systems. *Acta Technica Jaurinensis*. 7(2), pp. 123-129. DOI: 10.14513/actatechjaur.v7.n2.075

Brake, J., Mulley, C., Nelson, J. D., Wright, S. (2007) Key lessons learned from recent experience with flexible transport services. *Transport Policy*. 14(6), pp. 458-466. DOI: 10.1016/j.tranpol.2007.09.001

Cassidy, M. J., Rudjanakanoknad, J. (2005) Increasing the capacity of an isolated merge by metering its on-ramp. *Transportation Research Part B: Methodology*. 39(10), pp. 896-913. DOI: 10.1016/j.trb.2004.12.001

Cervero, R., Golub, A. (2007) Informal transport: a global perspective. *Transport Policy*. 14(6), pp. 445-457. DOI: 10.1016/j.tranpol.2007.04.011

Enoch, M. P. (2005) Demand responsive transport: Lessons to be learnt from less developed countries. *Traffic Engineering and Control*. 46, pp. 68-71.

Factor, R. J., Miller, M. A. (2006) Transit-Taxis: From Concept to Implementation of Enhanced Transit Services. In: *Transportation Research Board, 85th Annual Meeting*. Washington, D.C.

Feng, S., Li, J., Ding, N., Nie, C. (2015) Traffic paradox on a road segment based on a cellular automaton: Impact of lane-changing behavior. *Physica A: Statistical Mechanics and its Applications*. 428, pp. 90-102. DOI: 10.1016/j.physa.2015.02.043

Gholami, A., Taghizadeh, Y., Tian, Z. (2014) Classification of taxi khattee (jitney) lines based on topography and line cost indices. *Transportation Research Part A: Policy and Practice.* 59, pp. 239-249. DOI: 10.1016/j.tra.2013.12.004

Gholami, A., Shariat, A. (2011) Analogy of fixed route shared taxi (taxi khattee) and bus services under various demand density and economical conditions. *Journal of Advanced Transportation.* 46(2), pp. 177-187. DOI: 10.1002/atr.157

Hidas, P. (2005) Modelling vehicle interactions in microscopic simulation of merging and weaving. *Transportation Research Part C: Emerging Technologies.* 13(1), pp. 37-62. DOI: 10.1016/j.trc.2004.12.003

Horváth, B., Horváth, R., Gaál, B. (2013) Estimation of Passenger Demand in Urban Public Transport. *Acta Technica Jaurinensis*. 6(3), pp. 64-73.

Hu, X., Wang, W., Yang, H. (2012) Mixed traffic flow model considering illegal lane-changing behavior: Simulations in the framework of Kerner's three-phase theory. *Physica A: Statistical Mechanics and its Applications*. 391(21), pp. 5102-5111. DOI: 10.1016/j.physa.2012.06.010

Khashaeepour, M. (2012) Calibration of traffic engineering softwares based on Tehran traffic condition, 5th Volume, A review of studies in calibration of traffic simulation softwares for Tehran. Tehran: Avaye Fahim. (in Persian)

Kerner, B., Rehborn, H. (1996) Experimental features and characteristics of traffic jams. *Physical Review E*. 53(2), pp. 1297-1300. DOI: 10.1103/physreve.53.r1297

Laval, J. A., Daganzo, C. F. (2006) Lane-changing in traffic streams. *Transportation Research Part B: Methodology.* 40(3), pp. 251-264. DOI: 10.1016/j.trb.2005.04.003

Lv, W., Song, W., Fang, Z. (2011) Three-lane changing behaviour simulation using a modified optimal velocity model. *Physica A: Statistical Mechanics and its Applications*. 390(12), pp. 2303-2314. DOI: 10.1016/j.physa.2011.02.035

Maghrour Zefreh, M., Török, A., Mandoki, P., Toth, J. (2015) Maneuvers analysis of shared taxi and their effects on flow characteristics. MT-ITS Conference, Budapest, June 2-5. 2015.

Martinez, L., Viegas, J. (2011) An Agent-Based Simulation Procedure for Measuring Market Potential of Shared Taxis: An Application to the Lisbon Municipality. In: *Transportation Research Board, 90th Annual Meeting*.

Mauch, M., Cassidy, M. J. (2002) Freeway traffic oscillations: observations and predictions. In: Taylor, M. A. P. (ed.) *Proceedings of the 15th International Symposium on Transportation and Traffic Theory*. Oxford: Pergamon-Elsevier. pp. 653-674. DOI: 10.1016/b978-008043926-6/50034-8

Meng, Q., Weng, J. (2011) An improved cellular automata model for heterogeneous work zone traffic. *Transportation Research Part C: Emerging Technologies.* 19(6), pp. 1263-1275. DOI: 10.1016/j.trc.2011.02.011

Mitsakis, E., Stamos, I., Grau, J. M. S., Morfoulaki, M. (2015) Bus Drivers Risk Perception of Roadway Hazards. *Periodica Polytechnica Transportation Engineering*. 43(1), pp. 15-21. DOI: 10.3311/PPtr.7481

Molon, A. (2009) Taxi stand picture photo. Miscellaneous, Milan. [Online] Available from: http://www.molon.de/galleries/Italy/Milan/Misc/img.php?pic=11 [Accessed: 11th May 2015]

Salomon, I., Silman, L. (1985) Scheduled bus and Sherut taxi operation in Israel. *Transportation Research Part B: Methodology.* 19(3), pp. 259-264. DOI: 10.1016/0191-2615(85)90009-8

Shariat Mohaymany, A., Rasekh, A., Amiripour, M.M. (2010) Studying the affection of taxi stops position on the functionality of urban intersections. Presented *at 5th National Congress on Civil Engineering*, Ferdosi Uni., Mashad. (in Persian)

Shadabmehr, H. (2011) Development of Traffic Conflict Prediction Models for Mashhad signalized Intersections. *The 10th International conference on Traffic and Transportation Engineering*. Tehran. (in Persian)

Sivak, M., Schoettle, B., Reed, M. P., Flannagan, M. J. (2007) Body-pillar vision obstructions and lane-change crashes. *Journal of Safety Research*. 38(5), pp. 557-561. DOI: 10.1016/j.jsr.2007.06.003

Yang, M., Sun, G., Wang, W., Sun, X., Ding, J., Han, J. (2015) Evaluation of the pre-detective signal priority for bus rapid transit: coordinating the primary and secondary intersections. *Transport*. pp. 1-11. DOI: 10.3846/16484142.2015.1004556