AN INTEGRATED TRAFFIC MICROSIMULATION MODEL OF ILLEGAL ON-STREET PARKING IN DOWNTOWN TORONTO

Ramadan, A. and M. J Roorda

Submitted for presentation at the 2017 Transportation Research Board Meeting and publication in the Transportation Research Record.

iCity: Urban Informatics for Sustainable Metropolitan Growth

A project funded by the Ministry of Research and Innovation of Ontario through the ORF-RE07 Program and by partners IBM Canada, Cellint Traffic Solutions, Waterfront Toronto, the City of Toronto and the Region of Waterloo

Report # 17-02-02-02

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

UTTRI

AN INTEGRATED TRAFFIC MICROSIMULATION MODEL OF ILLEGAL ON-STREET PARKING IN DOWNTOWN TORONTO

Ahmed Ramadan
Dept. of Civil Engineering
University of Toronto
35 St. George Street, Toronto, ON, Canada M5S 1A4
Tel: 647-862-7757; Email: ahmed.ramadan@mail.utoronto.ca

Matthew J. Roorda
Dept. of Civil Engineering
University of Toronto
35 St. George Street, Toronto, ON, Canada M5S 1A4
Tel: 416-978-5976; Fax: 416-978-6813; Email: roordam@ecf.utoronto.ca

Word count: 4552 words text + 5 tables/figures x 250 words (each) = 5802 words

Submission Date
August 1, 2016

ABSTRACT

On-street parking involves the blockage of the lane on which a vehicle parks, thus reducing its capacity. As a result, large cities such as the city of Toronto restrict on-street parking on main routes during traffic peak periods. As with any parking restriction, the compliance rate to this policy is not a 100%. This study aims to use Traffic Microsimulation to quantify the impact of illegal on-street parking during the AM peak period on the level of congestion in the city of Toronto. The study uses traffic demands and parking citation data from the year 2011 to simulate existing traffic conditions and reflect the existing level of incompliance to the on-street parking policy. Quadstone Paramics is used to incorporate the illegal parking activity into the Toronto Waterfront Network simulation model. Link delay, travel time, speed and link flow along links affected by illegal parking are the measures of effectiveness that reflect the implications of illegal parking in the study. The base case where no illegal parking is simulated is compared with simulations incorporating illegal parking to derive the difference in travel times resulting from illegal parking. It is observed thst on average link delay increases by 50% and link flow reduces by 7% upon introducing illegal on-street parking onto a link.

Keywords: Traffic Microsimulation, Parking, Illegal Parking, Parking Tickets, Downtown Parking

INTRODUCTION

The City of Toronto Central Business District (CBD) experiences the highest volumes of traffic during the A.M. and P.M. peak periods, when travel demand is at its maximum value for the day. During these peak periods, congestion resulting from high traffic volume arises, causing significant delays to passenger vehicles, commercial vehicles, streetcars and buses. In an effort to alleviate these congestion levels, the City of Toronto, like many major cities around the world, restricts on-street parking on most major streets during the peak periods in the CBD. This policy ensures that the streets' full capacity is utilized since on-street parking effectively blocks the right-most lane. A vehicle parked on-street forces the vehicles behind it to merge into the next lane, causing a bottle-neck at that location.

However, as with any parking policy, the compliance rate is not a 100%. Between the years 2008 and 2014, 2.7 million parking infractions per year on average were recorded in the City of Toronto (City of Toronto, 2015). The offenders that do not comply to the rush hour parking restrictions, either by standing, stopping or parking on prohibited streets, exacerbate the already critical traffic situation in the CBD. In addition to the delays caused by illegal parking, the conflict resulting from vehicles switching lanes and cyclists exiting the bike lanes can pose a safety concern. In an effort to try to discourage this phenomenon, a parking enforcement blitz was launched in January 2015 and again in October of that year. Extra parking enforcement officers were dispatched during morning and afternoon rush hours. Offenders were ticketed then towed. The cost of the ticket is $150 and towing costs $200, in addition to the inconvenience encountered by drivers to recover their towed vehicles. Between January and October, more than 61,000 vehicles were ticketed and more than 12,000 towed (Shum, 2015).

This paper uses traffic microsimulation to study the impact of illegal parking on congestion during the A.M. peak period in Toronto's CBD. Although simulation models for Toronto's road network exist, these models omit illegal parking and therefore do not account for their adverse effects on network travel times and delays. This research builds on an existing microsimulation model and tries to improve its accuracy and realism by incorporating illegal parking into the model.

The paper is organized as follows: After the introduction, a review of past literature discussing the impacts of illegal parking is presented, followed by an explanation of the data used to generate the microsimulation model and the methodology involved. Then, the results of the study are summarized, ending with a discussion of the results and a conclusion derived from the findings.

BACKGROUND

Illegal parking arises as a result of insufficient parking supply, whether on-street or off-street, near locations where parking is at high demand. Barter argues that there are 2 paradigms at play when deciding the parking supply level at a location (Barter, 2015).

The first is whether parking is managed on a site by site basis or as an infrastructure item that serves its surrounding area. The second paradigm is whether parking should be treated as an infrastructure item that is regulated as such or whether it should be treated as a market item where its price and supply level is determined by market dynamics.

Illegal parking can be discouraged if a mode shift can be induced, pushing drivers to a zone to shift to other modes of transportation. The lesser the number of drivers to a zone the lower the demand for parking and the lesser the chances are of illegal parking. A multinomial logit model used in a study by Simićević et al. predicted that as the price of parking in an area is increased, existing drivers are likely to give up driving to that zone (Simićević, Vukanović, & Milosavljević, 2013). Arnott & Inci (Arnott & Inci, 2006) and Shoup (Shoup, 2006) suggest that increasing the price of on-street parking specifically reduces the number of drivers cruising for on-street parking therefore reducing the probability of illegal on-street parking. Kobus et al. (Kobus, Gutiérrez-i-Puigarnau, Rietveld, & Van Ommeren, 2013) also suggests that increasing the price of on-street parking encourages drivers that are going to park for longer durations to park off-street, making legal on-street parking more readily available to drivers that are going to park for shorter durations, thus reducing illegal on-street parking incidents since illegal parking is mostly a result of vehicles that park for short durations near their destinations for pick-up, delivery or short stop activities. Arnott et al. (Arnott, Inci, & Rowse, 2015) concluded in their study that off-street parking should be provided when the demand for parking in an area, such as a CBD, is high.

The familiarity of drivers with an area, and the amount of information about the availability of parking in an area available to drivers can have a significant impact on the amount of cruising for parking as well as parking choices. Cools et al. (Cools, van der Waerden, & Janssens, 2013) discuss that the lack of drivers' mental knowledge of parking facilities has a negative impact on local roads and parking lots, such as overcrowded "famous" lots and increased cruising for parking around the destination. The frequency of driving to a location, in addition to the age and education of the driver were found to be the only significant contributors to the drivers' mental knowledge. Therefore, parties involved in parking management should be concerned with providing parking availability information to drivers that do not frequently visit the area, and are therefore unfamiliar with the available parking infrastructure. These drivers are the most probable culprits to illegal parking incidents since drivers with high familiarity of an area are more likely to plan their parking choices around parking facilities that were deemed convenient to them in previous trips. A parking guidance system (PGS) can be very useful in helping drivers plan their parking in advance and therefore avoid illegal parking resulting from lack of adequate information as drivers arrive to their destination. Moini et al. (Moini Ph D, Hill Ph D, Shabihkhani, Homami, & Rezaei, 2013) evaluated the impact of PGSs on mobility and emissions. A PGS was found to significantly improve mobility and reduce cruising for parking.

Parking search analysis can be used to study the behavior of drivers during a parking search scenario, enabling parking policy makers to improve their understanding of the parameters involved in the parking decision making process, resulting in more informed decisions when formulating new parking policies. The conventional data collection method for the analysis involves using surveys that ask drivers to self report their searching time, walking distance, etc. Self reporting can be quite inaccurate since it heavily relies on drivers' recollection of minute details that are not usually of concern to the drivers. Using GPS data, as suggested by Montini et al. (Montini et al., 2012) can serve as a more reliable alternative to conventional driver surveys.

Microsimulation involves creating a virtual model of a city's transportation infrastructure. The interaction between unique entities, such as vehicles, buses, pedestrians and cyclists is simulated microscopically by utilizing algorithms capturing car following, lane changing and gap acceptance behaviors (Quadstone Paramics, 2016). A microsimulation based assessment was conducted by Kladeftiras and Antoniou to study the impact of double parking, a form of illegal parking, on traffic conditions in the city of Athens, Greece (Kladeftiras & Antoniou, 2013). The sensitivity analysis concluded that limiting double parking by means of increasing enforcement or adding strategically placed cones to prevent double parking may result in an increase in vehicle speeds by 10-15% and a 15-20% decrease in delay and stopped time. The study also concluded that eliminating double parking completely may result in a 44% increase in vehicle speeds and a 33% decrease in delay as well as a 47% decrease in stopped time.

Another microsimulation study by Lu and Viegas explained that some drivers in Lisbon, Portugal choose to park illegally when the designated roadside parking lot is fully occupied during high demand periods (Lu & Viegas, 2007). The authors discovered that the practical scenarios to be simulated are complex, as a result of the varying parking duration as well as the varying proximity of an illegal parking incident from the upstream and downstream intersections of a link. The study concluded that the effect of illegal parking is increased with higher traffic flows and that illegal parking results in increased conflicts leading to decreased safety and higher chances of accidents.

Jia et al. used the cellular automata traffic flow model, a form of traffic microsimulation, to study the effect of bottlenecks, illegal parking being one of its types, on traffic flow (Jia, Jiang, & Wu, 2003). The simulation results revealed that the capacity of the bottleneck is slightly lower than the maximum flow rate of a single-lane road.

Parking enforcement is considered to be the main deterrent of illegal parking, as drivers are less likely to exhibit illegal parking behavior if they perceive a higher chance of getting caught by an enforcement agent. The most traditional and widely used enforcement agent is the enforcement officer. However, the high cost and limited number of these agents limit the enforcement level of that method. One of the emerging methods of enforcement is image processing from fixed surveillance cameras. Lu and Li developed an algorithm that reduces the computational complexity and overcomes low visibility scenarios in outdoor environments with the help of 1-D transformation (Lee, Ryoo, Riley, & Aggarwal, 2009). Kashid and Pardeshi develop another algorithm for detection, extraction, localization, segmentation and recognition of vehicle number plates from surveillance videos (Kashid & Pardeshi, 2014).

DATA

This chapter describes the data that is used as an input to the illegal parking simulation model.

Travel Demand Matrices

Travel demand within the simulated network is obtained from the Origin-Destination matrices from the 2011 Transportation Tomorrow Survey (TTS). The TTS is a comprehensive travel survey that is conducted every five years in the Greater Toronto and Hamilton Area (GTHA) by the data management group at the University of Toronto (Data Management Group, 2011).

Study Area

The study area is the Toronto Waterfront network. The area is bordered by Dundas Street in the North, Woodbine Avenue in the east and Parkside Drive in the west.

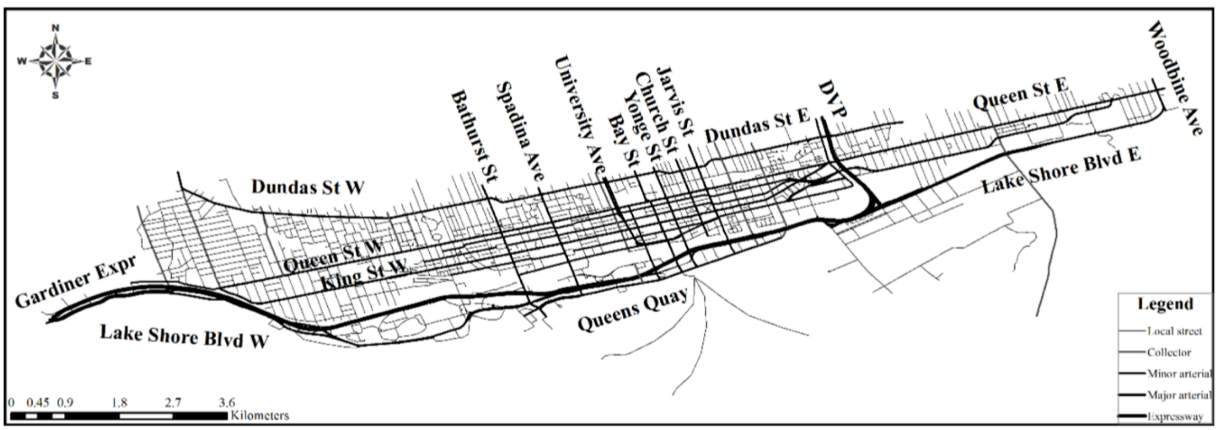

FIGURE 1 Toronto Waterfront Network (Amirjamshidi et al., 2013)

49,691 vehicles traverse the Toronto Waterfront network in the morning rush hour (8 a.m. to 9 a.m.), according to the data released in the 2011 TTS survey. The highest number of vehicles entering the network comes from the western portion of the Gardiner Expressway, which releases 5,877 vehicles into the network, followed by the southbound Don Valley Parkway, which adds 4,899 vehicles into the network. The zone bordered by Queen Street in the north, King Street in the south, Bay Street in the east, and University Avenue in the west receives the largest number of vehicles in the network during the morning rush hour, where it receives 5,253 vehicles, which is expected since this corridor is one of the densest in the downtown core.

The Waterfront Network has been chosen for this study since it the largest employment center in the Greater Toronto Area and it receives a large number of vehicle trips relative to its area in the morning rush hour. Furthermore, the limited parking supply in that network further exacerbates the problem of illegal parking.

Toronto Parking Citations Record

Parking citation data is published by the City of Toronto in its open data website (City of Toronto, 2015). The citation data is published on a yearly basis and contains a list of all the parking tickets issued in the City of Toronto for that year. Parking citations for the year 2011 are used in this research to be consistent with the 2011 travel demands obtained from the TTS. The parking citations record contains the following details about a parking citation:

- Date of infraction
- Time of infraction
- Type of infraction
- Location of infraction
- Fine amount

The total number of infractions recorded in the year 2011 was 2,805,492 infractions. Out of these infractions, 882,956 were for vehicles parked or stopped on a street at a prohibited time of day (220,763 in the waterfront area). The distribution of infractions over the different periods of the day (AM Peak, Mid-day, PM Peak, Off-peak and overnight) is shown in FIGURE 2.

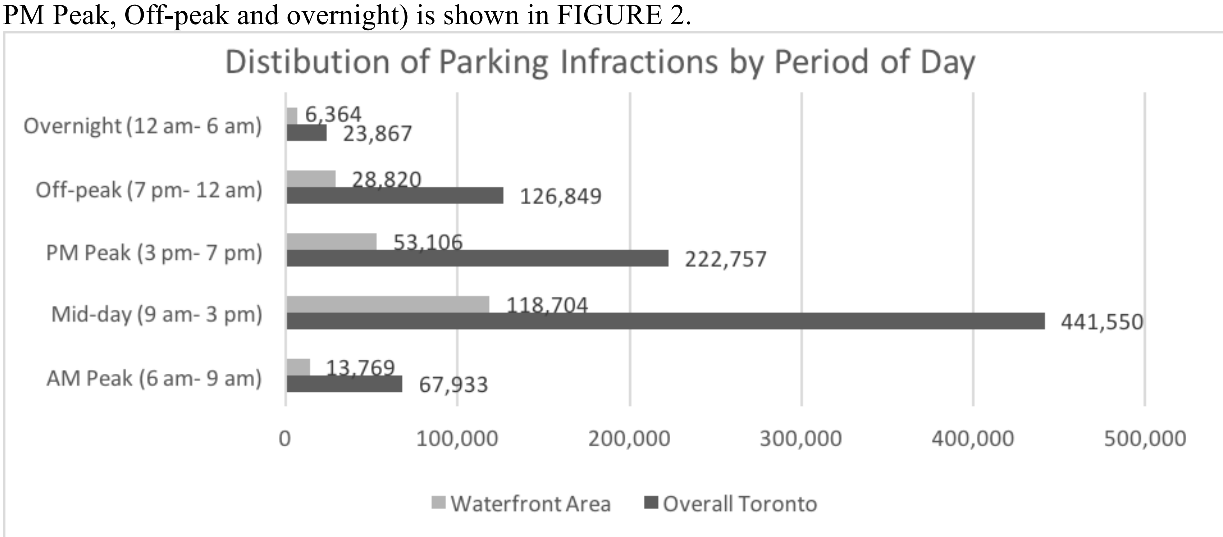

FIGURE 2 Distribution of Infractions by Period of Day

The breakdown of parking citations by type, time and location is shown in TABLE 1.

TABLE 1 Breakdown of Toronto Parking Citations, 2011

Total number of citation records for 2011	2,805,492
Number of vehicles parked or stopped during prohibited time of day on restricted highway, all times of day	882,956

Number of vehicles parked or stopped during prohibited time of day on restricted highway, between 8 a.m. and 9 a.m.	37,152
Number of vehicles parked or stopped during prohibited time of day on restricted highway, between 8 a.m. and 9 a.m., in the Toronto waterfront area	6892
Number of vehicles parked or stopped during prohibited time of day on restricted highway, between 8 a.m. and 9 a.m., in the Toronto waterfront area, after omitting one-lane links	4704

METHODOLOGY

The illegal on-street parking model setup can be divided into 3 main components: Data filtering, geocoding infraction addresses, and coding illegal on-street parking into Quadstone Paramics.

Data Filtering

The parking citations data obtained from the City of Toronto is a record of all the parking tickets issued by the city's parking enforcement officers in 2011. Parking tickets are issued for a variety of different parking offences, such as not paying for parking, exceeding the meter duration and parking on a restricted street. The parking tickets record contains citations occurring at all times of day, and at various locations throughout the City of Toronto.

However, not all parking infraction types are relevant to this research. The intended infractions are those of vehicles parked or stopped at a prohibited time of the day. Moreover, since this study evaluates the impact of illegal parking on AM rush hour traffic, only citations recorded between 8 a.m. and 9 a.m. are needed. Then, there is the location of the citations. The study area only examines citations occurring within the Toronto Waterfront area boundaries. All in all, 3 main filters are applied to the parking citations record.

1) Infraction type filter- only parking infractions involving vehicles parked or stopped on-street on roadways that prohibit such parking activity during the AM peak period are extracted.
2) Infraction time of day filter- only citations recorded between 8 a.m. and 9 a.m. are considered since the simulation lies within this hour.
3) Infraction location filter- only tickets issued within the Toronto Waterfront boundaries are considered.

In addition, links with only one lane per travel direction are omitted from the study. This is due to a limitation of the microsimulation algorithm of Quadstone Paramics, as it does not instruct vehicles to move onto the lane with the opposing direction of travel to maneuver around an obstacle ahead, which is what would drivers do in a real-life scenario. Therefore, if a parked vehicle was to be added on to a one-lane link, vehicles would queue up behind that vehicle without the ability of clearing that vehicle, creating an unrealistic traffic condition.

After applying the filters, the remaining infractions would be those of the intended type, time of day and location for the study. The next step would be to geocode the infraction addresses (see the next section). But before geocoding these addresses, several omissions and changes to the text of these addresses needs to be applied in order to align the way the addresses are recorded with the syntax of the geocoding software (ArcGIS), eliminating errors in the geocoding process. In summary, the following changes were made to the parking infractions record:

1) Add a municipality column for all entries, set municipality as Toronto
2) Delete entries with empty address field (1138 entries affected)
3) Deleting addresses beginning with 0 or special characters (520 entries affected)
4) Create a column that contains the intersection closest to the address recorded 131,499 entries affected)
5) Delete entries with no number address and no intersection data (2098 entries affected)
6) Delete spaces between street numbers (188 entries affected)
7) Set province to ON for all entries
8) Delete entries with no time of day recorded (2009 entries affected)

Geocoding Infractions Addresses

The location of infractions in the parking citations record obtained from the City of Toronto is the address of the closest building to where the vehicle was cited (eg. 1 Yonge St. Toronto, ON Canada). However, Quadstone Paramics, the microsimulation suite used in this study, requires the distance between the infraction and its closest upstream intersection as means of adding the illegally parking vehicle into the network.

In order to obtain these distances for all the infractions to be simulated, a geocoding software can be used to perform this measurement collectively. ArcGIS is used in this research. Geocoding is “the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface (Esri, 2010).” Once the addresses are geocoded, ArcGIS calculates the distance between each infraction and its upstream intersection, providing the parameter needed to code the infractions into the microsimulation model (see next section).

Coding Illegal On-street Parking into Paramics

Quadstone Paramics, the microsimulation software used in this research, requires the following pieces of data to be incorporated into the code describing the infractions to be simulated:

1. The name of the link at which the incident occurred
2. The distance of the infraction from the upstream intersection
3. Infraction type
4. Infraction duration

The names of the links as well as the distance of the infraction from its upstream location have been obtained previously in the steps described above. The infraction type instructs Paramics whether to create parking incidents at random times and locations in the simulation or whether it should create parking incidents with times and locations specified by the user. Since a dataset of defined times and locations is used, the second option is selected.

As for the duration of the illegal parking activities, an assumption has to be made. Since the parking citations record only contains the time at which the ticket was issued, there is no way of knowing when the vehicle's parking activity began and when it ended. And to the best knowledge of the authors, no studies have examined these durations through surveys. The following durations are used:

1. 10-minute duration for parked vehicles
2. 5-minute duration for stopped/standing vehicles

A separate file for each simulation day, which is includes all the infractions recorded for a given day, is created. This ensures that the effects of infractions recorded for a day are captured without being influenced by infractions recorded on other days.

Another assumption was made for the time at which a vehicle starts its illegal parking activity in the simulation network. It is assumed in this study to be the time the ticket was issued, rounded down to the nearest 10 minutes. For example, if the citations record shows that a ticket was issued at 8:46 a.m., that corresponding simulated parking activity would begin at 8:40 a.m. in the simulated network. This assumption was made for the following reasons:

1. The exact time at which the vehicle stopped at the link is unknown
2. To capture as much of the effect of the infraction as possible within the 10-minute interval reporting period, where the reporting period is how often the model reports the performance metrics of the network
3. To avoid an infraction occurring within more than 1 reporting period.

DISCUSSION OF RESULTS

The network performance metrics for the base case, where illegal parking is not simulated, and the scenario where illegal parking was added to the network, are summarized in TABLE 2 and TABLE 3. In total, 616 links that experienced illegal parking and 1778 adjacent links were simulated to capture the effect of the illegal parking activity on the surrounding links.

TABLE 2 Performance metrics of links that experience illegal parking

Scenario	Link Delay (Sec)	Travel Time (Sec)	Speed (Km/Hr)	Flow (Passenger Car Units/Hr)
Base Case	7	16.6	31.1	656
Illegal Parking Added	10.5	20.3	26.8	609
% Change	+50.3	+22.3	-13.9	-7.1

TABLE 3 Performance metrics of links that are adjacent to the links that experience illegal parking

Scenario	Link Delay (Sec)	Travel Time (Sec)	Speed (Km/Hr)	Flow (Passenger Car Units/Hr)
Base Case	9.2	18.3	25.8	523
Illegal Parking Added	14.8	20.3	22.4	353
% Change	+60	+11.3	-13.1	-32.4

It is observed that for both types, the link delay and travel time increases while the speed and flow decreases, implying a reduction in the level of service of links experiencing illegal on-street parking. The increased delay and travel time is encountered by all drivers on the link affected by illegal parking, resulting in worsening traffic conditions that propagate downstream. The reduced link speed can be attributed to the merging activity caused by the lane blockage created.

On the other hand, reduced link flow indicates a reduction in the capacity of the link experiencing an illegal on-street parking activity. Since unimpeded traffic flow across all lanes of a link is no longer possible due to lane blockage at the location of an infraction, the link operates below capacity and consequently the number of vehicles able to clear the link in a given interval reduces.

CONCLUSION AND FUTURE RESEARCH

Illegal on-street parking during peak periods considerably deteriorates an already critical traffic condition. The increase in travel time is experienced by all drivers in the area, which results in lost productivity time that is a multiple of that travel time increase. The social cost of this phenomenon cannot be ignored, and more policies and solutions need to be devised to curb its existence. This research can be expanded in the future to include more accurate parking durations that are obtained from field surveys or GPS Data. The impact of the proximity of an infraction to upstream/downstream intersections on link performance metrics and the correlation between higher travel demand on a link and the increase in travel time as a result of an illegal on-street parking incident can be studied. This simulation model can also be used to identify the most critical links that should be a priority for parking enforcement.

REFERENCES

1. Amirjamshidi, G., Mostafa, T. S., Misra, A., & Roorda, M. J. (2013). Integrated model for microsimulating vehicle emissions, pollutant dispersion and population exposure. *Transportation Research Part D: Transport and Environment*, *18*, 16–24.
2. Arnott, R., & Inci, E. (2006). An integrated model of downtown parking and traffic congestion. *Journal of Urban Economics*, *60*(3), 418–442.
3. Arnott, R., Inci, E., & Rowse, J. (2015). Downtown curbside parking capacity. *Journal of Urban Economics*, *86*, 83–97.
4. Barter, P. A. (2015). A parking policy typology for clearer thinking on parking reform. *International Journal of Urban Sciences*, *19*(2), 136–156.
5. City of Toronto. (2015). Parking Tickets. Retrieved February 4, 2016, from http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=ca20256c54ea4310VgnVCM1000003dd60f89RCRD&vgnextchannel=7807e03bb8d1e310VgnVCM10000071d60f89RCRD
6. Cools, M., van der Waerden, P., & Janssens, D. (2013). Investigation of the Determinants of Travelers' Mental Knowledge of Public Parking Facilities. Presented at the 92nd Annual Meeting of the Transportation Research Board, Transportation Research Board of the National Academies.
7. Data Management Group. (2011). *Transportation Tomorrow Survey Area Summary: 2011, 2006, 2001, 1996 & 1986 ORIGIN-DESTINATION MATRICES*. Department of Civil Engineering: University of Toronto.
8. Esri. (2010). Introducing Geocoding. Retrieved from http://desktop.arcgis.com/en/arcmap/10.3/guide-books/geocoding/what-is-geocoding.htm
9. Jia, B., Jiang, R., & Wu, Q.-S. (2003). The traffic bottleneck effects caused by the lane closing in the cellular automata model. *International Journal of Modern Physics C*, *14*(10), 1295–1303. http://doi.org/10.1142/S012918310300542X
10. Kashid, S. G., & Pardeshi, S. A. (2014). Detection and identification of illegally parked vehicles at no parking area (pp. 1025–1029). Presented at the Communications and Signal Processing (ICCSP), 2014 International Conference on, IEEE.
11. Kladeftiras, M., & Antoniou, C. (2013). Simulation-based assessment of double-parking impacts on traffic and environmental conditions. *Transportation Research Record: Journal of the Transportation Research Board*, (2390), 121–130.
12. Kobus, M. B., Gutiérrez-i-Puigarnau, E., Rietveld, P., & Van Ommeren, J. N. (2013). The on-street parking premium and car drivers' choice between street and garage parking. *Regional Science and Urban Economics*, *43*(2), 395–403.
13. Lee, J. T., Ryoo, M. S., Riley, M., & Aggarwal, J. (2009). Real-time illegal parking detection in outdoor environments using 1-D transformation. *Circuits and Systems for Video Technology, IEEE Transactions on*, *19*(7), 1014–1024.
14. Lu, B., & Viegas, J. (2007). The Analysis of the Influences of the Double Parking Vehicles to the General Traffic Flow (pp. 3121–3126). Presented at the International Conference on Transportation Engineering 2007, ASCE.
15. Moini Ph D, N., Hill Ph D, D., Shabihkhani, R., Homami, P., & Rezaei, H. (2013). Impact assessments of on-street parking guidance system on mobility and environment. Presented at the Transportation Research Board 92nd Annual Meeting.
16. Montini, L., Horni, A., Rieser-Schüssler, N., Axhausen, K. W., Axhausen, K. W., & Axhausen, K. W. (2012). *Searching for parking in GPS data*. Eidgenössische Technische Hochschule Zürich, IVT, Institute for Transport Planning and Systems.
17. Quadstone Paramics. (2016, February 17). What is Traffic Microsimulation? Retrieved from http://www.paramics-online.com/what-is-microsimulation.php
18. Shoup, D. C. (2006). Cruising for parking. *Transport Policy*, *13*(6), 479–486.
19. Simićević, J., Vukanović, S., & Milosavljević, N. (2013). The effect of parking charges and time limit to car usage and parking behaviour. *Transport Policy*, *30*, 125–131.