Studying the effect of traffic elements by GIS

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Abstract
Today, there are a number of techniques like simulations which are used to study how various elements affect the speed of cars in urban streets. Gathering the data required to feed such techniques is a costly and time consuming process. In this paper a new method, so called "The adjustment" is presented which uses only the total travel times and volumes in streets to estimate the effect of all traffic elements on a car's speed. This technique considers a buffer around any given traffic element and estimates the value of the elements such that the total travel times and volumes are fulfilled.
The technique proposed was tested in many Tehran streets using available traffic data. The elements used were bus stops, pedestrian paths, and decelerators. The results suggested that the presented method requires much less data, though giving similar accuracy compared with the traditional techniques. In addition, this method can be used to anticipate the speed using GIS taking into account the parameters studied.

1-introduction
Inspection of traffic due to its landuse is so important. It can help specialists to detect or predict traffic problems base on event position, strength rate and its time delay. This measurement can create proper inputs for weather quality models, which need travel speed and distance (Kutz, 2004).
Knowledge of these elements is the first step to evaluate the effective elements on traffic. Effective elements on traffic can be group as human, route characteristics, Vehicle characteristics, traffic managements and control tools (Hosseini, 2006). In this paper, Tehran (the capital of Iran) has selected as case study and the following elements has detected on it. By detecting the following elements, it is also necessary to estimate its effect.
Using traffic manual and exploitation of researchers are the most common way in order to estimate the effect of the following elements on traffic. Therefore, estimation the effects of some elements with commercial methods are difficult and wide range of traffic data may be need. Preparations of these data are so expensive and time consuming, so involving them are not possible. For some elements, there is no method to evaluate their effects; therefore, a method that can evaluate these two types of elements, is necessary.
After estimating the effects of each element, in order to evaluate different effective elements on traffic, it is necessary to have an instrument, to help researchers. Today geographic information system (GIS) has known as a system with many capabilities to analysis spatial and attributes data that can be use as many several forms in traffic transports.
According to published papers base on evaluating traffic by GIS, results show that GIS can be use as a suitable instrument with low price and capability of numerous

analysis. the researches shows that by using GIS and Demand modeling , the necessity of gathering large number of vehicles in traffic evaluation is reduced, therefore the Volume of vehicles by using simulated models could be predicted (sheikh mohammadzadeh, 2004; Harvey et al, 1999).

Therefore, the aim of this paper is to propose a method that can estimate the effects of the elements with minimum needed data. This method must be design in a way that can be use in speed prediction by using GIS in urban streets.

To obtain the main aim of this research, first it is necessary to detect all the effective elements in traffic and then divide the effective problems by possibility or impossibility landuse in the commercial methods. After that in order to evaluate the elements effect, in cases that, we can involve commercial methods, use them and for others develop a new method.

2- Detecting the effective elements on traffic

By considering that the effective elements on traffic are different in each city, firstly, Tehran has selected as case study by having many different effective elements on traffic. In order to evaluate the effective parameters in Tehran, we had some methods that can use them and for others we did not have any. To know all the effective elements in Tehran, as shown in table (1), we listed the entire elements.

Figure 1: Effective elements on traffic: elements that their effect with commercial methods and adjustment are evaluated (black on gray background), and the effects which are omitted or not existed (white on black background) and elements that had factors (black on white background)

Line width	Route slope	Number of lines	Elements which can be use by existent models
Unsignalized intersections	Base saturation flow rate for each line	Signalized intersections	
arcs	(Area type(in or out of the central limitation		
Rout type (autobahn, highway, (, arterial	(Land use(commercial or residential		
Vehicle type(truck, bus , private bus, regular bus, minibus, private car, taxi, (motorcycle, bicycle			
parking	(Decelerators (yellow color , zebra lines		Elements which can not be use with existent models
Bus station	Route quality (tarmac, dirt (road	Zebra line	
(Climate (temperature, vision, humidity, snow, rain, freeze, storm			
(Accidental events (contingencies, vehicle failure, social group (rally			
Day time	Technology (ITS, notification systems to drivers		
(Driver behavior and its characteristics (spiritual, physical			
(Vehicle characteristic (model, age, engine size, power, quality			

After all elements have determined, it is necessary to estimate effects of each parameters on traffic, so in next section we focus on it in detail.

3. Determining the effective elements on traffic

In this paper effects such as unsignalized intersections, arcs and other types of routs apart arterials from group one of table(1) and effects of weather, accidental events, technology, daytime and parking from group two (table 1),due to huge number of data, didn't estimate. However, to omit their effects on other elements, by doing several tests, try to omit their effects. Thus for other existent elements in first group, we used the commercial methods and for other existent elements from second group we develop a new method called "adjustment".

3.1 Using existent methods to estimate effects of elements

Commercial methods in estimating the effective elements on traffic contain using American manual adjustment coefficients and using result of transportation specialist. For elements that it is not possible to use American manual adjustments coefficient, such as slope, number of motion lines, width of streets and type of areas, use these coefficients. Also for vehicle type and street type, we use other traffic specialists (Table 2).

Table 2: Estimation of effective elements on traffic by using commercial methods: in this table all rows with gray backgrounds related to estimation effects by using specialists and the other rows related to American manual

Indexes	Effective elements and evaluation effective functions
f_w	W: line width between 3.6 to 17 meter : adjustment coefficient for line width $f_w = 1 + \frac{(w - 3.6)}{9}$
f_a	Commercial regions or regions in central limitations=0.9 Residential regions or regions out of central limitations=1
f_g	G: Slope percentage between 6-10 $f_g = 1 - \frac{G\%}{200}$
s_0	Base saturation flow rate for each line= 1900
w_i $(i = v, b, ta, bi, hv)$	=5(w_b)Bus Truck, regular bus and minibus (w_{hv})= 2.5 Taxi (w_{ta})=2 Private car (w_v)=1 Motorcycle and bicycle (w_{bi})=0.5
t_0	Free travel time for first order arterials: 60 km/h Free travel time for second order arterials: 55 km/h

For signalized intersections because of their complicated characteristic and multiplicity of effective elements on traffic, Hipcap2000 software have used. This software computes all the effective elements by using existent adjustment coefficient in American manual (HCM[1], 2000). For other elements, that could not be use from commercial methods has generated a new way call "Adjustment". in nest section we will discuss it in detail.

3.2 Generating a method for those elements that can not use with commercial methods

Existent of any effective elements on traffic in line increases the travel time. A maximum effect of this element is in its surrounding areas. In this paper, by this principle a new method "adjustment" has generated. In this method to estimate

[1] Highway Capacity Manual

effective elements on traffic such as bus stop, zebra line, yellow decelerator, decelerator with zebra line and other unpredictable elements like vehicle character and driver behavior a model has created. So presented methods in city Tehran has examined.
To create this model, first a cost-flow function as base function has selected, after that considered a coefficient for effects of each element on this function and in each elements limitation in street, a separate model has computed. At last, by collecting all these models for each area of streets, travel time model has generated. In next part, we discuss on it.

3.2.1 Choosing a function as cost-flow base function

The function that use in adjustment computations is BPR[1] function. BPR function is one of the famous cost-flow functions (1), and can be use to predict vehicles speed in travel request models.

$$S = \frac{S_0}{\left[1 + a\left(\frac{v}{c}\right)^b\right]} \qquad (1)$$

Here, S is mean speed, S_0 (km/h) free flow speed, $\frac{v}{c}$ (km/h) volume to capacity ratio, a=0.15 and b=4. This function has created in 1965 in American manual (HCM) and can be written as follow (Dowling, 2006):

$$t = t_0\left[1 + a\left(\frac{v}{c}\right)^b\right] \qquad (2)$$

In this case, BPR function has used to compute travel time. t_0, Travel time in 1 kilometer of street and t is real travel time. In addition, the above formula (2) has used as basic function. After choosing basic function, in order to define each effective element, need to add coefficient to this function.

3.2.2 Defining coefficients for effective elements on traffic

For effective elements on traffic must use coefficients. These coefficients indicate the effects of each element on travel time and represented by $(1 + x_i^2)$ .the aim of choosing this structure for coefficients are as follows:

- To prevent values to become minus in adjustment process. So the coefficients choose positive.
- To prevent the reducer effects on values 0 and 1 these coefficients choose in a way that always is greater than one.

Beside the coefficient of effective elements, each element has a limitation effect. So in order to estimate the effect of each element in the following limitation we need other coefficient. In nest part, we will discuss on it.

3.2.3 Generating model for each limitation of street due to elements

[1] Bureau of Public Roads

The BPR function (previous section), have designed for a distance equal to 1 kilometer. This function to become useful for shorter distances must multiple to the coefficient that indicates the studying areas. By noticing that each effective element on traffic, effects on speed in the street, for each element due to its limited area, constitute a separate model. Also in each street, there is always a limitation which no effective elements on speed existent there. In addition, for that limit a separate model were constituted. In table (3) different models for different limitation are shown.

Table 3: Travel time models

Travel time model in effective elements on terrific limitations	Elements	Travel time model in effective elements on traffic limitations	Elements
$t_{ps} = t_0 \times \left(1 + 0.15 \times (1 + x_{ps}^2) \times \left(\frac{v}{c}\right)^4\right) \times n_{ps} \times L_{ps}$	Zebra line decelerator	$t_s = t_0 \times \left(1 + 0.15 \times (1 + x_s^2) \times \left(\frac{v}{c}\right)^4\right) \times n_s \times L_s$	Bus station
$t_{ys} = t_0 \times \left(1 + 0.15 \times (1 + x_{ys}^2) \times \left(\frac{v}{c}\right)^4\right) \times n_{ys} \times L_{ys}$	Yellow decelerator	$t_p = t_0 \times \left(1 + 0.15 \times (1 + x_p^2) \times \left(\frac{v}{c}\right)^4\right) \times n_p \times L_p$	Zebra line
$t_{free} = t_0 \times \left(1 + 0.15 \times \left(\frac{v}{c}\right)^4\right) \times \left(L - \left(n_s \times L_s + n_p \times L_p + n_{ps} \times L_{ps} + n_{ys} \times L_{ys}\right)\right)$			No element

As shown above, for each limit of street, we have one model, but travel time data from sampling is for the entire street. For solving this, in next step, we obtain on general model from others.

3.2.4: General model of street

After generate the following models for each sections of street, to obtain one general model, all the models group together, the reasons are as follows:

- existents of volume data and travel time data for the entire street
- inaccessibility of these data in each part of the street

So general model for travel time can be as follows (3):

$$t_{total} = t_s + t_p + t_{ps} + t_{ys} + t_{free} \qquad (3)$$

By substitute table 3 equations in equation (3), simplifying it and adding effective elements on terrific by using existent methods (table 2), model (4) has produced.

$$t_{total} = t_0 \times (L + 0.15 \times (\frac{\sum (w_v v_v + w_b v_b + w_{ta} v_{ta} + w_{bi} v_{bi} + w_{hv} v_{hv})}{s_0 \times N \times f_w \times f_{\text{Unpredict}} \times f_a \times f_g})^4$$
$$\times (L - (L_s \times n_s + L_p \times n_p + L_{ps} \times n_{ps} + L_{ys} \times n_{ys} -$$
$$(L_s \times n_s \times (1 + x_s{}^2) + L_p \times n_p \times (1 + x_p{}^2) + L_{ps} \times n_{ps} \times (1 + x_{ps}{}^2) + L_{ys} \times n_{ys} \times (1 + x_{ys}{}^2))))) \qquad (4)$$

By this model, we can compute all coefficients related to effective elements on speed such as decelerators, zebra lines and bus stops by introducing limited effects for each element and using volume and capacity data for Entire Street by adjustment. Thus, this method has executed in Tehran. In nest section, we will discuss on it.

3.2.5 Adjustment

To do adjustment, in first step all the necessary data have collected and prepared. After that, all the unknown parameters of model computed and to evaluate the model, accuracy and precision tests used.

A. data collection and preparing

Volume and travel time data of 71 parts of several streets gathered from transportation and Traffic Company of Tehran. The collected data used by plaque registration method (shahi, 2004). After that all the elements were detect on that.

In order to compute unknown coefficient where in that use around streets (commercial or non-commercial), street area type (central areas or outside areas), and street types (first order arterial or second order arterial) were considered, all data (volume and time related to travel speed of top morning) to omit time effects on data, were grouped. Grouping street base on street type have done by traffic specialists due to free speed of streets. For grouping data on their landuse and street type, the most landuse of streets and areas, which the street is located on it, attended.

To choose reliable data, two tests done, accuracy test and base saturation flow rate test (dowling, 2006). At last, after the following tests, data related to volume and time of top morning travel of 18 first order non-central raterial streets, 5 first order central arterial streets, 6-second order commercial arterial and 15 residential second order arterial streets used.

After grouping data and above test, therefore, all time and accidental events on speed omitted, and choosing coefficient base on their area type, street type and landuse type were possible.

B. computing unknown parameters

To use adjustment base on its rules, parametric models were used (vanicek, 1986). To compute coefficient, by programming with Matlab software, the entire coefficient were calculated. However, the main problem here is how to compute the coefficients for unpredictable $f_{\text{Unpredict}}$ elements. In order to compute it from minimum possible value (1/1000) to one we assigned a number to it, and in each time, the adjustment take place. After that the number, which has the minimum RMSE, then selected as unpredictable coefficient. The computed values are as follows: for first order, non-central Arterial Street is 0.379, for central first order Arterial Street 0.391, for second order commercial arterial 0.488 and for residential 0.278.

For other four parameters related to speed from adjustment, for each area the effect of these coefficients in each element were changes and the value that had given from model 4 is x_i in $1+x_i^2$, to represent these coefficient as similar models in HCM2000, other coefficients as adjustment coefficients were selected. In addition, their values computed by model (5).

$$f_i = \left(\frac{1}{1+x_i^2}\right)^{0.25} \qquad i = s, p, ps, ys \qquad (5)$$

As mentioned before, we can represent the capacity model as follows:

$$c = s_0 \times N \times f_w \times f_{\text{Unpredict}} \times f_a \times f_g \times f_s \times f_p \times f_{ps} \times f_{ys} \quad (6)$$

In this model f_s, f_p, f_{ps}, f_{ys} are the adjustment coefficients of yellow decelerator, zebra line decelerator, zebra line and bus stop. These four coefficients computed from model (5) in adjustment. After that for the adjusted coefficient, several diagrams have drawn. To draw these diagrams, the effective limits of the element selected between 5 to 100 meters. For each part, the adjustment done and the coefficient values from model 5 were computed. After that, diagrams base on their effective limitation and the adjusted values were drawn. In figure (1) the effective coefficients from the above commutations are shown.

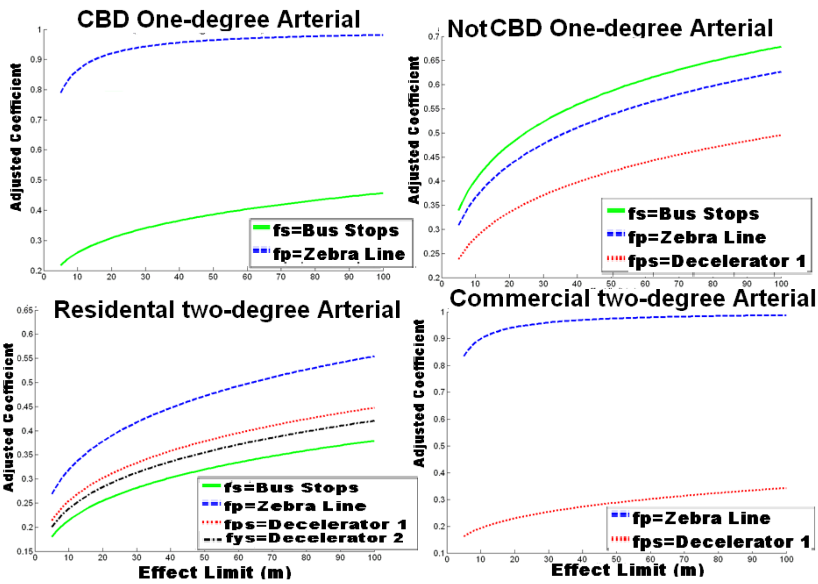

Figure 1: Effective coefficients on speed due to effective regions: (above) first order arterial (central and non-central areas), (below) second order arterial (commercial and residential).

As shown, in first order central arterial streets, there were no decelerators between data, the maximum effect was for bus stop and minimum effect was for zebra line. However, for first non-central Arterial Street, there was no sign of yellow decelerator and the maximum effects was for zebra line decelerator and the minimum effect was for bus stop. The main reason is traffic limitation areas and using bus instead of private vehicles.

For second order Commercial Street, the maximum effects was for bus station and minimum effect was for zebra line. In addition, for second order residential streets there were no bus station and yellow decelerator and the maximum effects was for zebra line decelerator and the minimum effects was zebra line. By noticing to above diagrams, as seen the effect of zebra line in second order arterial streets are minimum.

Beside the following gleanings in adjustment, in order to evaluate the effects of zebra line, against t adjustment coefficient in American manual, there is no need to have the pedestrian's numbers. In addition, to estimate the effects of bus station, against adjustment coefficient in this manual, there is no need to know the number of bus station either. Therefore, the adjustment method omits all the problems, which were much costs and time consuming in collecting these data. In addition, this method can evaluate the effects of decelerators that it could not be done in American manual.

C. Evaluating the used method

In order to evaluate the accuracy of adjustment, this method has compared with standard and real BPR model. Criterion for this evaluation is RMSE. Capacity in BPR model consists of these parts: number of lines and base saturation flow rate, slope adjustment, width and type of area. In table (4), standard deviations of each method have shown. The result shows that the adjustment method is 3 times better than BPR model.

Table 4: standard deviation values for adjustment method and BPR standard for 4 group of streets

Second order residential arterial	Second order commercial arterial	First order central arterial street	First order non-central arterial street	methods
22.79	**22.84**	**16.35**	**9.11**	**BPR**
11.24	**5.38**	**5.82**	**3.70**	**adjustment**

To test the precision of adjustment, data of three streets that have not used in computation, were involved. Standard deviations of the adjustment for these streets are 7.85 seconds. However, the standard deviation of BPR model computed 14.84 seconds. Moreover, the accuracy of this method computed to be 0.11 compare to BPR model 0.29.

8. Conclusions

As mentioned in introduction of, the main aim of this research was presenting a method by specific capabilities in order to evaluate the effective elements on traffic. These capabilities can assume as lower cost and time than commercial methods and all the facilities need in speed prediction by GIS.

therefore we developed a new method. As have seen, we did not use data related to pedestrian's volume and number of buses in each station to estimate zebra-line adjustment coefficients and bus stops. Therefore, we save much costs and time. Besides the above parameters, accuracy of this method must notice and the results of this method are 0.11, which in contrast by BPR model (0.29), is so much better. By using this method, we can reach the better accuracy because we did not mention different days, and different climate condition for entire head counts. Besides the high accuracy of this method, it is possible to obtain another unpredictable coefficient. This coefficient for several streets in Tehran was calculated 0.4. This result shows that the cultural driving and quality of vehicles respect to traffic in Tehran is 40% of America. Besides these result we gain two other useful things, firstly number the bus stop in central part of the city is more to those are in non-central parts. This result is for traffic limitation in central parts and existent more buses in those areas. Secondly, low effects of zebra line due to oversight of drivers and tehranian pedestrians to zebra .line

By all the advantages of the mentioned method, results of this method can be use in speed prediction in urban streets by GIS and due to effective elements on speed.
Because this method evaluate speed due to effective limited of areas.

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