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Travel Speed Prediction Model for Urban Arterial Road and Traffic Management

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Abstract

The recent orientation in transportation development is based on the criteria of sustainability especially in developed high-income countries and they depended in transportation development on the green engineering. Iraq is one of countries that based on the traditional orientation in transport development where other conditions assist in applying this orientation such as security issues and environmental conditions. One of the major factors contribute to more efficient and safe transportation traffic system is accessibility management. This research study the spatial and temporal variation of travel speed and developed a travel speed model using statistical SPSS software (ver.21). It can observed that the distribution of travel speed at region I and region II with different land uses for 2016,2017,2018 and 2019 years respectively. The average travel speed increased significantly at 2018 and 2019 for region I and the distribution of travel speed for region II is skewed to the right, which indicated that the maximum travel speed, and most of drivers' exhibit greater speed than its mean value. Also a negative effect on average travel speed for region I and II is observed and a reduction of 11% and 7% are obtained for region I and II. The transportation accessibility management resulted in an increase of 45% and 49% for travel speed at 2018 and 2019 years respectively. This provided that the access management increased and maintained the desired speed with reduced delays. This research demonstrated the effectiveness of travel speed model

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on two component, access points and mixed land use using linear multiple regressions model. A travel speed model with correlation coefficients R and R^2 of 0.827 and 0.685 respectively is obtained. The verification of the regression model is based on the correlation coefficient (R^2) of 0.789 between the observed travel speed and estimated travel speed as the goodness of fit of the predicted model.

Keywords: Travel Speed, Access Points, Arterial, Accessibility Management, Sustainability, Green Engineering, Multiple Regression.

1 Introduction

The major factors that can be considered to be more efficient and safe for transportation traffic system are accessibility management. The objective of this study is to capture statistical relationships between travel speed and the influential variables in terms of access management that considered as a fundamental issue to traffic operation in urban cities. It is used as a congestion indicator in urban arterials and service quality. The travel speed of major arterial with signalized intersections considered as an important role in measuring the operating performance of the traffic system. Several factors effect on travel speed such as; access point, pavement, traffic conditions, type of land use, geometric design elements and so on should be considered in the travel speed studies. In addition, the accessibility management of traffic speed enhanced safety and better operation of the road network. A statistical model was predicted for the major street in Baghdad city (Palestine-Street) for travel time and delay based on the information for the field traffic that obtained by using GPS techniques. The greatest fit is obtained as compared to the prediction models with observed field travel time data. Excess delay is obtained on link (1), (2) and (3) interims of 95% percentile travel time of about (301.9, 219.4, and 193.8 Sec). for the studied links [1]. The effect of different types of vehicle on the speed-flow relationships in signalized arterials was discussed. He concluded that a small change in speed with the high range of flow and low variation in flow but great difference in speed. In addition, the congestion region resulted in low variation of speed [2]. One of major parameters that contribute to understanding the variation of travel time and speed was travel time reliability, which aid in the transportation management system [3]. The travel speed on Japan's arterial streets was studied and contributed the low travel speed due to the absence of performance goals such as traffic and access [4]. Travel speed followed different distribution probabilities and spatial-temporal correlations for different links and different times [5].

A validation of field data of travel speed dataset by calculating the Pearson correlation coefficients using integrating numerical comparison and disciplinary analysis was applied [6]. The lateral placement of subject vehicle

was modeled using multiple linear regression and it was found that the type of vehicle and speeds effect on lateral placement of vehicle [7]. Modeling the overtaking behavior of different types under mixed traffic conditions. It was found that the number of overtaking increased with rise in ongoing direction flow and decreased with increment in opposing direction flow [8]. Different microscopic simulation model used for street stretch based on some assumptions and observation from field data [9]. A distributed fuzzy inference system for controlling traffic lights signal from multiple intersections by selecting dynamic phase and controlling signals for pedestrian crossings. At each intersection, there was a fuzzy system that can communicate with other fuzzy systems in the connecting intersection. Each fuzzy system consisted of three main modules: The green phase, red phase, and decision modules [10]. Neural networks have been used to short-term traffic estimation in the over past years. This work suggests a novel architecture of neural network. Long Short-Term Neural Network (LSTM NN) to capture non-linear traffic dynamic flow in an effective manner. The LSTM NN can overcome the issue of back-propagated error decay through memory blocks and however, shows the superior capability for time series prediction with long temporal dependency [11].

A best performance of greater speed of travel along corridors could be realized by jointly considering the link length and limit of speed in the setting of the cycle length. The difference in the average speed of travel along a hypothesized two-lane highway by changing the segment length, density of signalized intersections, cycle length, and offset settings is examined. Results displayed that average travel speed of travel decreased with increment signalized intersection density and the network layout had an important impact on the speed of travel [12]. Compound traffic control mechanisms at intersections are generally consisting of two or more traffic control devices (TCD); such as roundabout and traffic signals combined or if you like; traffic signal and one-way-flow Compound. Roundabouts work on the base of circulation and entry flows, whereas signalized intersections depend on staging or phasing for effectiveness. Safety at roundabouts is improved by limiting circulating speeds and this is realized in geometric design by entrance path curvature. Delay information for single and compound signalized intersections were analyzed and compared. The results appeared a slightly enhanced in the level of service with roundabout, more significant importantly, it was achieved a great decrease in conflicting movement and gridlock when the traffic signals were switched-off. This study summarized that at signalized intersections a composite traffic control mechanisms have significant effect on vehicular conflict, gridlock and red light running compared with single control devices [13].

2 Study Area and Data Collections

Palestine Street located in Eastern Baghdad , which is described as one of the major arterials roads in Baghdad-City. Different mixed land-uses surrounded it; educational, residential and commercial that led to high number of daily trip generation and attractions. Selected study area are shown in Figure (1). The field information were collected manually at chosen two regions of Palestine-Street; region I and II with different mix land uses respectively to reflect the impact of mixed land use effect on travel speed. The recorded data were observed at different short-term periods from 2016 to 2019 to study the temporal variation of travel speed. Traffic data were collected at field by using a manual counter. Every five minutes the traffic flow was recorded on a special form sheet. Different time periods in years; 2016, 2017, 2018 and 2019 were collected manually and recorded during the non-peak hours of the daytime (10-11 A.M.) and (4-5 P.M.) within the different days of a week (Monday, Tuesday and Wednesday) for (100) number of sample size.

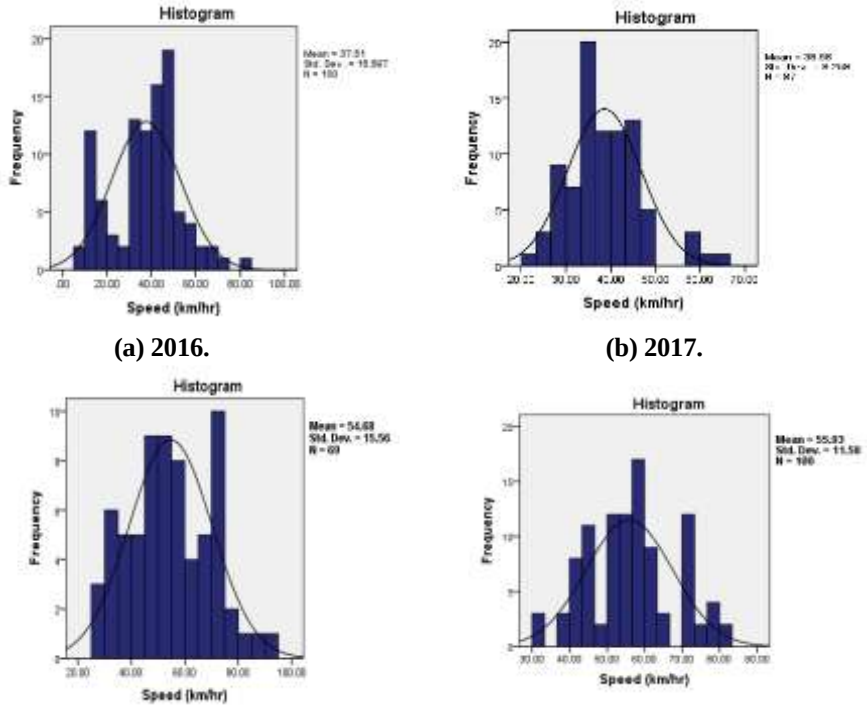
Figure 1 Selected Study Area Palestine Arterial Street.

3 Results and Discussions

3.1 Statistical Analysis of Travel Speed

In order to illustrate the spatial-temporal variation of travel speed; two different regions II and I were selected (Palestine near Al-Mustansiriyah

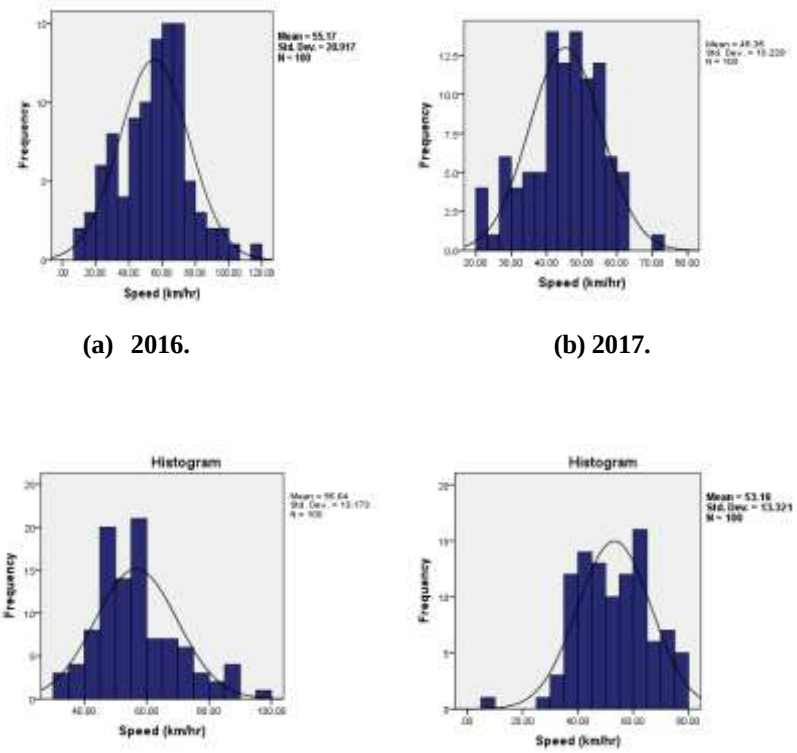
University and Zayona near Mayslone square) with different land uses respectively. The field data at different time periods in years; 2016, 2017, 2018 and 2019 were collected and statistically analyzed using the SPSS (ver.21) to capture the variation of travel speed at signalized urban arterials. Figure (2) and (3) depicted the distribution of travel speed at region I and region II for 2016, 2017, 2018 and 2019 years respectively. The average travel speed increased significantly at 2018 and 2019 for region I. Moreover, the distribution of travel speed for region II is skewed to the right that explained the maximum travel speed and most of driver's exhibit greater speed than the mean value. Figure (4) shows the variation of travel speed with different time periods from (2016) to (2018) years for regions I and II.



(a) 2016. **(b) 2017.**

(c) 2018. **(d) 2019.**

Figure 2 Frequency Distribution of Travel Speed for Region I at Different Time Periods.



(a) 2016. **(b) 2017.**

(c) 2018 **(d)2019**

Figure 3 Frequency Distribution of Travel Speed for Region II at Different Time Periods.

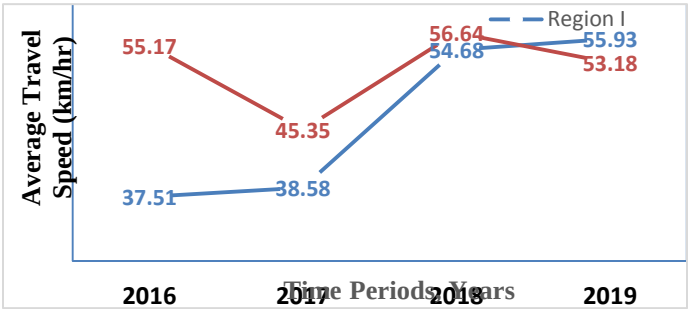


Figure 4 Average Travel Speed Variation with Time Periods.

3.2 Effect of Access Point on Travel Speed

The effect of access management points for left turn usage along different segments of urban arterials have been investigated. Figure (5) shows the adverse impact on average travel speed for region I and II respectively. A reduction of 11% and 7% are obtained for region I and II.

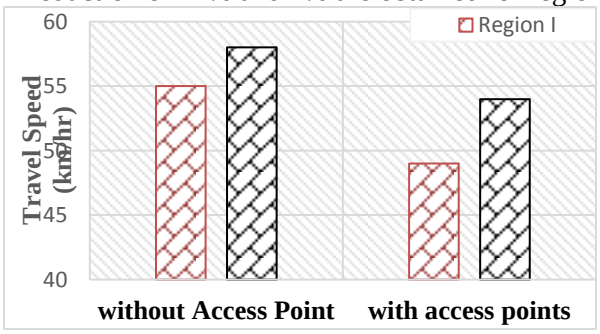


Figure 5 Effect of Access Points on Average Travel Speed.

3.2.1 Effect of Accessibility Management on Travel Speed

Palestine Street is a major urban road in Baghdad city with different land uses surrounded it that results in traffic congestion and dramatically decreased in travel speed. Al-Anbariy and Alkaissi (2017) estimated the sustainable indictors for transportation road and the congestion index RSR (78%) for Region I [14]. They concluded that the sustainability requirements to reduce congestion, air pollutions, economic should be harmonically coordinated with education peoples to change their attitude behavior aspect as a whole community live within and understanding the transportation concept so they can provide actions to minimize recourses needs and then reduced negative impacts. Figure (6) shows Region I with closed accessibility due to security management until 2018.

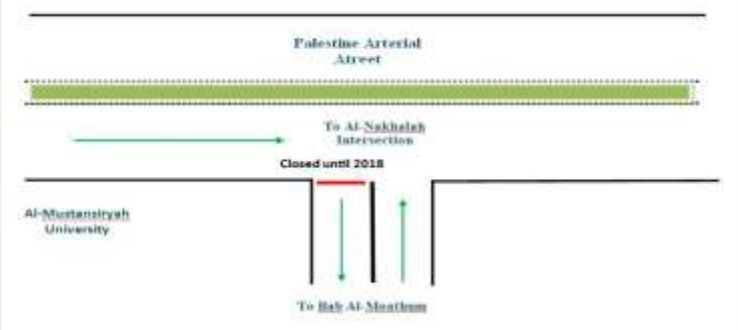


Figure 6 Effect of Accessibility Management on Average Travel Speed.

Transportation accessibility considered as one of the factors that stated for travel speed impact in this research. Figure (7) showed an increase of 45% and 49% for 2018 and 2019 years respectively. This indicated that access management increased and maintained the desires speed with reduced delays.

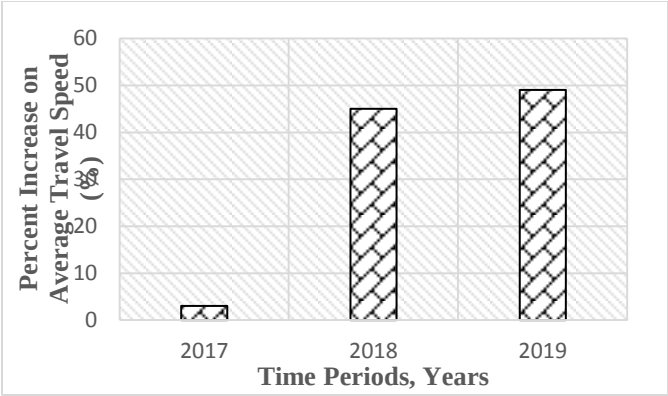


Figure 7 Average Travel Speed Variation over Time Periods in years.

4 Empirical Model of Travel Speed

The influence of land use mix and access points for left turn movements are of particular interest in the empirical model of travel speed in urban arterial streets with signalized intersections. A multiple linear regression analysis is applied for prediction of travel speed using the SPSS (software ver.21)[15]. Travel speed is modelled as a function of several independent variables: Access points and Land use with corresponding coefficients. To get a best-fit model at level of confidence (95%), the independent variables are entered in a stepwise regression method. The predicted model summary presented in Table (1) with correlation coefficient R and R^2 of the model for the Travel speed reach 0.827 and 0.685 respectively. Table (2) illustrated the details of the Regression Models for Independent variable travel Speed and dependant explanatory variables; Access points, Land use. In addition, the bivariate coefficients of correlation, which determines the relationship between each of the predictor variable (Travel Speed and the dependent variables; Access points and land use), are shown in Table (3). From the multiple regression modelling which is a set of statistical process to predict the relations between recorded field variables in this paper; Access points, Land use, a developed travel speed model is presented as shown below Eq.1:

$$\text{Speed}=50.983-9.663\ (\text{Access points})-4.453(\text{Land use}) \quad (1)$$

Where:

S: Travel Speed (km/hr.).

Access points: No. of Access points /km.

Land use: [0] for residential and [1] for commercial land use.

Table 1 The Descriptive Statistics for Dependant Variable (Travel Speed).

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.827[a]	.685	.675	4.39942	.685	73.849	2	68	.000	1.051
a. Predictors: (Constant), Land use, Access point										
b. Dependent Variable: Speed										

Table 2 Details of the Regression Models for Independent Variable Elastic Modulus and Dependant Explanatory Variables; Access points, Land use.

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Constant	50.983	1.009		50.511	.000		
	Access point	-9.663-	1.427	-.490-	-6.769-	.000	.755	1.324
	Land use	-4.453-	1.443	-.223-	-3.086-	.002	.755	1.324
a. Dependent Variable: Speed								

Table 3 The Correlation Coefficients between Travel Speed and Access points; Land use

Correlations				
		Speed	Access point	Land use
Pearson Correlation	Speed	1.000	-.379-	.019
	Access point	-.379-	1.000	-.495-
	Land use	.019	-.495-	1.000
Sig. (1-tailed)	Speed	.	.000	.392
	Access point	.000	.	.000
	Land use	.392	.000	.
N	Speed	210	210	210
	Access point	210	210	210
	Land use	210	210	210

4.1 Model Validation

A best fit is presented in Figure (8) for the observed travel speed and predicted travel speed based on field data. For creating a general model with great performance, a 75% data and 25% separating strategy have been provided and adopted extra-recorded field results for the model of travel speed for chosen Palestine arterial-street. The verification of the regression model based on the correlation coefficient (R^2) of 0.789 between the observed travel speed and estimated travel speed as the goodness of fit of the predicted model.

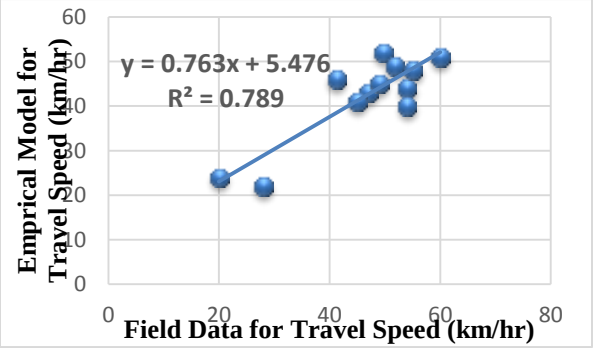


Figure 8 Predicted Travel Speed Model Versus Field Recorded Travel Speed.

5 Conclusions

This research illustrated the spatial-temporal variation of travel speed and predicted a statistical model for travel speed using statistical SPSS software (ver.21). The following concluding notes can be drawn:

- The distribution of travel speed at region I and region II with different land uses in 2016, 2017, 2018 and 2019 years respectively. The average travel speed increased significantly in 2018 and 2019 for region I and the distribution of travel speed for region II is skewed to the right, which indicated that the maximum travel speed, and most of driver's exhibit greater speed than the mean value.
- Adverse impact on average travel speed for region I and II respectively was observed and a reduction of 11% and 7% are obtained for region I and II.
- Transportation accessibility management resulted in an increase of 45% and 49% for travel speed in 2018 and 2019 years respectively. This provided that access management increased and maintained the desired speed with reduced delays.
- Travel speed is modelled as a function of several independent variables: Access points and Land use with their corresponding

coefficients: Speed=50.983-9.663(Access points)-4.453(Land use) with correlation coefficient, R and R^2 of the model for the Travel speed reach 0.827 and 0.685 respectively. The verification of the regression model based on the correlation coefficient (R^2) of 0.789 between the observed travel speed and estimated travel speed as the goodness of fit of the predicted model

6 Recommendations

The present research is captured the effect of access management and land use on travel speed. It is recommended to extend the work of this research using comprehensive field data from various regions in Baghdad city network for arterials streets.

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