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MODELLING PEDESTRIANS & CYCLISTS INTERACTION WITH TRAFFIC FLOW IN URBAN AREAS

إستنباط نماذج رياضية لتأثير المشاه والدراجات على إنسياب حركة المرور فى المناطق الحضرية

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الملخص العربى للبحث:

نتيجة لما تعانيه دول العالم الثالث من عدم إنسياب وإضطراب فى الحركة المرورية خصوصا داخل المدن ، أصبح من الواجب ضرورة إستغلال المتاح من الإمكانات فى تنظيم حركة النقل والمرور على أفضل ما يمكن ، وقد إهتم هذا البحث بدراسة مدى تأثير حركة المشاه والدراجات المشاركة للمركبات فى نفس بحر الطريق على إنسياب الحركة المرورية ، حيث لوحظ وجود قصور فى الأبحاث التى تدرس مدى تأثير حركة وإنسياب المركبات باحجام حركة المشاه والدراجات المشاركة لها فى نفس المسار ، لذا إتجه هذا البحث لوضع نماذج رياضية توضح مدى تأثير تداخل حركة المشاه والدراجات على سرعة وإنسياب حركة المركبات ، وقد تمت الدراسة على محورين رئيسيين من محاور وسط مدينة أسيوط لهم نفس المواصفات تقريبا حيث المرور فى إتجاه واحد وهما محور شارع ٢٦ يوليو وهو محور ذات كثافة حركة مشاه ودراجات عالية من (١٢٠٠ إلى ٢٠٠٠) شخص فى الساعة ، وكذلك محور شارع يسرى راغب وهو محور عليه حركة مشاه ودراجات متوسطة (من ٥٠٠ إلى ٦٠٠) شخص فى الساعة، وقد تم إستنباط أنه فى حالة حركة مشاه ودراجات متوسطة الحجم فإن مكافئ المشاه و الدراجة يمثل حوالى ٠,٣ و ٠,٥ وحدة سيارة ركوب مكافئة على الترتيب ، أما فى حالة حجم دراجات ومشاه عالى كما هو الحال فى شارع ٢٦ يوليو فإن مكافئ المشاه او الدراجات تمثل حوالى ٠,٥ وحدة سيارة ركوب مكافئة ،. هذا بالإضافة أنه تم إستنباط نماذج رياضية تمثل التداخل بين حجم المشاه وحجم الدراجات وحجم السيارات (بالوحدة المكافئة) على سرعة سريان حركة المرور والتى تمكن مخطط المرور من إمكانية عمل بدائل ودراسة الجدوى من الناحية البيئية و الناحية الإقتصادية لتنظيم حركة المرور داخل المدن..

Abstract :-

Little work has been done on pedestrians and cyclists as a viable form of transport in urban areas to assess their characteristics and their interaction with traffic. Software designed for motor vehicles and are not appropriate for modelling pedestrians and cyclists sharing the traffic the road space in busy shopping areas within the (C.B.D) of towns. There are distinct incompatibilities between traffic charactaeristics and pedestrians & cyclists behaviour. In this paper an attempt has been made to assess the interaction of both pedestrians and cyclists with traffic flow through a study in urban area (Assiut City C.B.D). Recommended values for pedestrians and bycicles equivelency factors are given for planning applications to enable the best utilization of transport facilities.

KeyWords : **Pedestrians , Cyclists , Central Business District (C.B.D) , Traffic space – speed, stepwise regression , Conversion factors.**

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4.2-b Conversion Factors Analysis

Excel 2000 computer programme has been used to establish the best conversion factors of Pedestrians & Bicycles. Correlation factors between traffic volumes expressed in (pce's) and Pedestrians & Bicycles with various conversion factors relation vehicle space-speed,.

The purpose of these computer runs is to reach a sutable relationship between space_mean_speed and traffic variables and attributes parameters with high correlation coef. This has been established using Linear, Logarithmic, and Power Regression Techniques, Table (4 - b) gives Excel program outputs.

Analysis shows that the best correlation coefficient is represented by linear and quadratic functions when the equivalent factor for pedestrians and bicycles ranges between (0.5 –0.3).

The best correlation formula abtained expressed in the following two relations, the first is linear, while the second is quedratic

$U_s = 46.015 - 0.1141q$.....(5)

$r = 0.96$ $R^2 = 0.926$

$U_s = 29.691 + 0.1304q - 0.0009q^2$ .....(6)

$r = 0.98$ $R^2 = 0.963$

5 – Summary and Conclutions

In developing countries where resources are limited, the tendency has been to a dopt policies and measures that enables the best utilization of available transport facilities in most efficient way to relief traffic congestion.

The objective of this paper is to assess the interaction between pedestrians and cyclists and traffic vehicles sharing the same road space with traffic vehicles and to what extent they would affect the traffic flow and add to the traffic congestion proplems.

A selected study of Assiut city (C.B.D), two selected traffic links with various pedestrians and cyclists volumes sharing with the traffic vehicles the same road space has been adopted.

Data collected were processed and standard regression programmes were used for exploring traffic / space relationships for each study link using conventional conversion vehicle equivelleney factors for traffic and different conversion equivalancy factors for pedestrians and bicycles

Major conclusions with respect to data collection procedures and outputs are:

1- Quedratic formulation is better than linear formulations for space-speed and volume of vehicles.relationships

2- Traffic space – speed (km/hr) has a poor correlation with traffic volume as (p.c.e's) $R^2 < 0.30$ when excluded pedestrians and bicycles volumes from analysis.

3- Traffic space – speed (km/hr) has a good correlation with traffic volume as (p.c.e's) $R^2 > 0.90$ for pedestrians and bicycles as they were included in the traffic volume with equivalency factors ranging from 0.3 to 0.5 (p.c.e's).

4- Recommended values for pedestrians and bicycles equivelency factors would be 0.5 and 0.3 (p.c.e's) for low or medium mix

5- Recommended values for both pedestrians and bicycles equivalency factors would be 0.5 (p.c.e's) for high mix with traffic .

6- Side walks for pedestrians or bicycles need seriously to be looked after in the traffic management plans.

1 – Introduction

In the past decade, significant efforts have been directed towards the improvement of accessibility and revitalization of the Central Business District (C.B.D) in many large metropolotian areas. The ingenious concepts have emerged to achieve economic goals as well as to satisfy the demand for C.B.D accessibility in many urban transportation developments. Despite these successful developments, the most vital element of urban transportation i.e., pedestrians and cyclists movement,has been treated incomprehensively in many transportation studies.[1]

Walking, and cycling are re-emerging as a viable form of transport in urban areas. Walking and cycling are a healthy and economic modes of transport. They have no effect on the environment such as air pollution, noise impact, and for some trips can even be quicker than using motorised modes of transport for short distance trips [2]. Road space is shared between different classes of users with vehicles having priority on the roads. Pedestrians waiting to cross the road have to a dopt their openion, either to take any gap in vehicle flow or to walk to the nearest formal crossing facility.

Pedestrians are more vulnerable in any accident situation since there are alternative methods of crossing the road at random points. Observations [3 ,and 4] of bedestrian behaviour suggest the following:

- The pedestrians may wait at the kerbside for a siutable gap in vehicle flow, then cross directly to the otherside
- The pedestrians may walk along the pavement which scanning vehicle flow and cross directly as siutable gap appears.
- The pedestrians may cross between stationary vehicles as traffic come to a halt
- Not surprisingly walking problems and the number of pedestrians accidents are closly liked [5].

Computer software and models are frequently used to predict motor traffic and the effect of any changes in the transport system. These models are tools of the transport planners. Little attention was paid to the pedestrians and cyclists as a traffic modes in the modelling of transport system process, since the idea is that they have been assumed to have little important on the general traffic flow and therefore to be ignored in the modelling process.

There are however, several factors which justify the inclusion of pedestrians and cyclists in the modelling process[6]. They are:

a – Accuracy current modiling software caters for motor traffic, but ignoring pedestrians and cyclists as transport modes. The more aspect of reality that they have to be included, the more likely to reflect reliable the situation on the ground.

b – Pedestrians and cyclists share the same road space especially in busy shoping areas with traffic flow. Little work has been done on their characteristics [7,8,9 and 10]

c – Completeness : To ensure that cyclists and pedestrians, their needs are included when alternative proposals are being considered by planners.

There are a number of reasons explaining why pedestrians and cyclists have not been included in the modelling software currently used they include:

i- incompatibility with modelling software designed for motor – vehicles.

ii- Lack of information on other traffic characteristics

iii- Limitations of modelling software of other traffic

In this paper an attempt has been made to assess the interaction of pedestrians and cyclists with traffic flow in urban areas in order to cover some aspects of the above

mentioned points in such a manner for planning application to enable the best utilization of transport facilities.

2 - Study Area

Assiut city the capital of Assuit Governorate was chosen as a medium size city for data collection. Assuit central Buissiness District (C.B.D) was selected as busy shopping center.

The corriders selected are unique in that they have a variety of pedestrians and cyclists volumes, heavy, medium and little sharing the traffic road space.

The main traffic corriders selected for this resesrch in the (C.B.D) are:

1 – 26 th of July link : as a mix of high volume of traffic , pedestrians and bicycles, sharing the same road space 1200 - 2000 pedestrians and bicycles/hour

2 – Youssri-Raghib street as a mix of high traffic volume and medium volumes of pedestrians and bicycles sharing the same road space 500 - 600 pedestrians and bicycles/hour. Table (1) gives selected links physical and operational characteristics [11]

3-Surveying and Data Collection

Extensive surveys to collect information related to traffic flow variables and factors affecting these variables were carried out at the same time during morning peack period, on a five minutes interval bases. Data collected include:

1.a - Traffic volumes by vehicle type

1.b - Pedestrians and bicycles sharing the same road space with traffic

2 - Traffic space-speed , using floating car for travel times on selected links

Convertion factors used to convert different vehicle type to passenger car equivalency (p.c.e^{s}) are as given in table (2)

Table (1) : Selected links physical and operational characterists

.No	Link name	Length (m.)	Paved width	No of lanes	No of usable lane	parking	N^{o} of junction	Traffic direction
1	26 th of July	75	8.5	2	2	No parking	-	One-way
2	Youssri-Raghib	199	11.25	3	2	parking	-	One-way

Table (2): Vehicle Equivalent Factors; (P.C.E.'^{s}).[12]

Code	1	2	3	4	5	6	7	8	9
Vehicle Type	Private Car	Taxi	Micro Bus	Private Bus	(P.T) Bus	Semi-truck	Truck	Motor cycle	Bicycle
Equiv. Factor (p.c.e^{s})	1	1	1.30	1.30	2	1.5	2.5	Variable factors	

4 - Modeling Traffic Flow- Variables and Affected Factors (Pedestrians and Bicycles)

Two types of regression analysis have been used to find the effect of the values of Pedestrians and Bicycles on the space- speed of traffic [13].

Firstly, a stepwise regression technique was used to distinguish and include variables into the model. Analysis has been done using the application of (Matlab 6.1) [14] The regression models were made as a Linear, Logarithmic and Power quadratic relationship.

Secondly, Excel 2000 computer program was also used on each link to present data collected and processing. The purpose of this technique is to find the apropriate vehicle equivalency factor for pedestrians and bicycles, also to reach good relationship between space_speed and traffic variables and attributes parameters with high correlation coeficient.

4.1 Traffic Volume / Space - Speed Relationships for 26 th July Link

This link has a unique characteristics of traffic flow including high volumes of traffic, pedestrians, and bicycles.

To find the effect of the equivelant values of Pedestrians and Bicycles on the traffic space-speed; a stepwise regression technique was used. to incude into the model each variable.

4.1- a Stepwise Regression Technique

The computer enters variables in single steps from best to worst provided that they meet prestablished static criteria. Computer program was carried out to include traffic parameters attributes such as, vehicle, pedestrians and bicycles. Several computer runs include traffic volume (p.c.e[5]) unit plus the volume of pedestrians and bicycles were carried out.

In the following stepwise regression analysis; the best coefficients of correlations (r), and coefficient of determination (R^2), moreover, Linear, logarithmic, and power regression, have been considered.

Table (3-a) shows that the three parameters (vehicle , pebestrian , and bicycle) have significance effect on space-speed values of the vehicles. Linear regression give the higher coefficients of correlations, where r=0.84 , and R^2 = 0.71. The relationship is developed and represented by the relation shown below:

$$U_s = 29.64 - 0.0934B - 0.0678P - 0.0249V. \quad (1)$$

Where:-

U_s = Space - speed in km/hr.
B = number of bicycles / (5 minutes).
P = number of pedestrians / (5 minutes).
V = number of vehicles in pce"s/(5 minutes)..

Table (3.a): Stepwise regression analysis for 26 th July Link

Math. formulated	Step	Parameters added	r	R^2
Linear	1	U_s= 50.6272 - 7.2166P- 0.0338V	0.70	0.5
	2	U_s= 28.8099 - 0.1303B - 0.0414V	0.47	0.22
	3	U_s=29.64 - 0.0934 B - 0.0678 P -.0249V	0.84	0.71
Logarithmic	1	U_s= 28.1736 - 0.1049logP- 0.0398logV	0.70	0.49
	2	U_s= 46.0849 - 6.318logB -0.0356logV	0.43	0.19
	3	U_s=49.55-4.1737logP-0.0675logB-2.413logV	0.81	0.65
Power	1	$U_s = 25.4016 - P^{4.319} + V^{0.0839}$	0.39	0.15
	2	$U_s = 27.4956 - B^{0.551} - V^{0.0823}$	0.39	0.15
	3	$U_s = 30.6412 - P^{0.3413} - B^{0.0818} - V^{0.2345}$	0.80	0.41

Table (3.b) Excel regression programe space-speed &. traffic volume q in (P.C.E^S) for 26 th July Street.

Math. formulated	Equivelent factor for Pedestrians	Equivelent factor for Bicycles	Equations	R^2
linear	0.0	0.0	U_s = -0.0967q + 26.538	0.330
	0.3	0.3	U_s = -0.1007q + 30.607	0.644
	0.3	0.4	U_s = -0.0972q + 30.728	0.668
	0.3	0.5	U_s = -0.0947q + 30.923	0.695
	0.4	0.3	U_s = -0.096q + 30.641	0.666
	0.4	0.4	U_s = -0.0939q + 30.887	0.695
	0.4	0.5	U_s = -0.0907q + 30.95	0.720
	0.5	0.3	U_s = -0.0922q + 30.739	0.689
	0.5	0.4	U_s = -0.0902q + 30.96	0.716
	0.5	0.5	U_s = -0.0879q + 31.115	0.738
Quadratic	0.0	0.0	U_s =51.173- 0.6417q + 0.0029q^2	0.429
	0.3	0.3	U_s = 44.966- 0.3355q +0.0009q^2	0.679
	0.3	0.4	U_s = 43.501 - 0.2977q +0.0008q^2	0.702
	0.3	0.5	U_s = 42.03 – 0.2631q +0.0006q^2	0.722
	0.4	0.3	U_s = 43.168 -0.2896q + 0.0007q^2	0.700
	0.4	0.4	U_s = 41.846 - 0.2577q +0.0006q^2	0.722
	0.4	0.5	U_s = 39.458 - 0.2145q+0.0004q^2	0.738
	0.5	0.3	U_s =41.758 – 0.2543q +0.0006q^2	0.718
	0.5	0.4	U_s = 40.563 - 0.2271q +0.0005q^2	0.738
	0.5	0.5	U_s = 39.354 –0.2018q + 0.0004q^2	0.756

4.1-b Conversion Factors Analyasis

Excel 2000 computer programme has been used to establish the best conversion factors of Pedestrians & Bicycles. Correlation between traffic volumes expressed in (pce's) and Pedestrians & Bicycles with various conversion factors with vehicle space-speed, several mathematical formulations were invistigated through different runs. Computer runs were carried out to include traffic parameters attributes such as , pedestrians and bicycles using different conversion factors for equivalency as (p. c. e"s) values of (0.3 to 0.5) were tested against traffic space mean-speed (km/hr). The regression models were made as a linear, and quadratic relationship. Table (3-b) gives Excel program outputs.

Analysis show that the best correlation coefficient is represented by linear and quadratic functions when the equivlent factor for both pedestrians and bicycles is about 0.5.

The best correlation formula abtained expressed in the following two relations, the first is a linear, while the second is a quedratic.

$$U_s = 31.115 - 0.0879q \quad \text{.....(2)}$$

$r = 0.86$ $R^2 = 0.739$

$$U_s = 39.354 - 0.2018q + 0.0004q^2 \quad \text{.....(3)}$$

$r = 0.87$ $R^2 = 0.756$

Where:

U_s = Space - speed in km/hr.
q = total number of traffic in pce"s.

4.2 Traffic Volume / Space-Speed Relationships for Yossry-Raghib Link.

This link has high traffic volumes with medium values of pedestrians and bicycles. To find the effect of the values of Pedestrians and Bicycles on the space- speed of traffic, firstly a stepwise regression technique was used Secondly, the analysis has been done using Excel 2000 computer programme

4.2-a Stepwise Regression Technique

The stepwise regression analysis has been established to find the model that discriminate effect of each parameters (vehicle, pebestrian, and bicycle) on the value of coefficients of correlations (r), and square coefficient of determination (R^2). Linear, logarithmic, and power regression relations, has been considered.

Table (4-a) shows that the three parameters (vehicles , pedestrians, and bicycles) have significance effect on space-speed values. Linear regression gives the higher coefficients of correlations, where r=0.95, and R^2 = 0.904. The relationship is developed and represented as follows.

$$U_s = 46.9504 - 0.1139B - 0.1061P - 0.1139V \quad \text{.....(4)}$$

$r = 0.95$ $R^2 = 0.91$

Table (4.a): Stepwise regression analysis for Yossry-Raghib Link

Math. formulated	Step	Parameters added	r	R^2
Linear	1	$U_s = 46.8395 - 0.1121P - 0.1141V$	0.94	0.89
	2	$U_s = 43.7973 + 0.0288B - 0.1163V$	0.91	0.83
	3	$U_s = 46.9504 - 0.0061B - 0.1139P - 0.1139V$	0.95	0.91
Logarithmic	1	$U_s = 45.6929 - 0.3466\log P - 0.1138\log V$	0.93	0.86
	2	$U_s = 42.1875 + 0.2474\log B - 0.1162\log V$	0.91	0.83
	3	$U_s = 95.6329 + 0.0368\log B - 0.1239\log P - 3.1086\log V$	0.93	0.87
Power	1	$U_s = 51.3661 - P^{2.3867} + V^{0.1121}$	0.88	0.77
	2	$U_s = 42.2875 - B^{0.2474} - V^{0.1162}$	0.91	0.83
	3	$U_s = 46.7491 - P^{0.1171} + B^{0.2478} - V^{0.2244}$	0.10	0.01

Table (4.b) Excel regression programe for space-speed &. traffic volume q in (P.C.E^S) for Yossry-Raghib Link

Math. formulated	Equivelent factor for Pedestrians	Equivelent factor for Bicycles	Equations	R^2
linear	0.0	0.0	$U_s = -0.1151q + 44.127$	0.902
	0.3	0.3	$U_s = -0.1139q + 45.414$	0.915
	0.3	0.4	$U_s = -0.1131q + 45.488$	0.912
	0.3	0.5	$U_s = -0.1122q + 45.547$	0.907
	0.4	0.3	$U_s = -0.114q + 45.722$	0.921
	0.4	0.4	$U_s = -0.1132q + 45.798$	0.918
	0.4	0.5	$U_s = -0.1124q + 45.859$	0.914
	0.5	0.3	$U_s = -0.1141q + 46.015$	0.926
	0.5	0.4	$U_s = -0.1136q + 46.028$	0.924
	0.5	0.5	$U_s = -0.1125q + 46.158$	0.919
Quadratic	0.0	0.0	$U_s = 28.501 + 0.1574q - 0.0011q^2$	0.952
	0.3	0.3	$U_s = 28.703 + 0.1471q - 0.001q^2$	0.958
	0.3	0.4	$U_s = 28.628 + 0.1469q - 0.001q^2$	0.954
	0.3	0.5	$U_s = 28.685 + 0.1445q - 0.0009q^2$	0.949
	0.4	0.3	$U_s = 29.184 + 0.1388q - 0.0009q^2$	0.961
	0.4	0.4	$U_s = 29.093 + 0.1389q - 0.0009q^2$	0.957
	0.4	0.5	$U_s = 29.131 + 0.137q - 0.0009q^2$	0.953
	0.5	0.3	$U_s = 29.691 + 0.1304q - 0.0009q^2$	0.963
	0.5	0.4	$U_s = 29.289 + 0.1359q - 0.0009q^2$	0.961
	0.5	0.5	$U_s = 29.607 + 0.1293q - 0.0008q^2$	0.955

4.2-b Conversion Factors Analyasis

Excel 2000 computer programme has been used to establish the best conversion factors of Pedestrians & Bicycles. Correlation factors between traffic volumes expressed in (pce's) and Pedestrians & Bicycles with various conversion factors relation vehicle space-speed,.

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3- Traffic space – speed (km/hr) has a good correlation with traffic volume as (p.c.e's) $R^2 > 0.90$ for pedestrians and bicycles as they were included in the traffic volume with equivalency factors ranging from 0.3 to 0.5 (p.c.e's).

4- Recommended values for pedestrians and bicycles equivelency factors would be 0.5 and 0.3 (p.c.e's) for low or medium mix

5- Recommended values for both pedestrians and bicycles equivalency factors would be 0.5 (p.c.e's) for high mix with traffic .

6- Side walks for pedestrians or bicycles need seriously to be looked after in the traffic management plans.

6. References:

[1] - Behnam J. and Patel B.G., "Pedestrians volume estimation" Transpotation engineering journal of ASCE, VOL.103 No.TE4, PP. 507-520 , July 1977

[2]- Snelson A., Lawson S. D. and Marris B., " Cycling motorists-haw to encourage them" Traffic Engineering Control , Vol 34, No 11, PP.555-559 , November 1993

[3] – Hunt J., and Williams S.,. " Delay to pedestrians crossing the road at a random point" Traffic Engineering Control , Vol 23, No 4, PP.216-221 , April 1982

[4] - Olzewski P. and Cher-Sin Tan " Walking lessons: Pedestrians travel in Singapore" Traffic Engineering Control , Vol 40, No 10, PP.480-483 , October 1999

[5] - Hass-Klau C, Douglas J. and Nold L., " Pedestrians routes in centeral Edinburgh" Traffic Engineering Control , Vol 34, No 5, PP.252-256 , May 1993

[6] - Shaples R., " Modelling cyclists in SATURN" Traffic Engineering Control , Vol 34, No10, PP.472-475 , October 1993

[7] - Daly P.N., McGrath F. and Annesley T. J., " Pedestrians speed/flow relationships for underground station" Traffic Engineering Control , Vol 32, No 2, PP.75-78, February 1991

[8] - Williams M.C. and Layfield R. E., " Pedal-cyclists at dual-carriageway slip-roads" Traffic Engineering Control , Vol 28, No 11, PP.597-600 , Novembe 1987

[9] - layfield R. E. and Gmaycock, " Pedal-cyclists at roundabouts" Traffic Engineering Control , Vol 27, No 6, PP 343-346 , June 1986

[10]- Powell M. " Modelling the behaviour of motorcycles at traffic signals" Traffic Engineering Control , Vol 38, No 10, PP.521-528, October 1997

[11] – Owais A. M., "Investigating The Factors Affecting Traffic Flow Variables in Urban Areas A Case Study: (Assiut City Road Network) A Thesis for A Master of Science. Fac. Of Eng., Assiut Univ., November 2002.

[12]–Speed / flow relationships Transportation & Road Researsh Laboratory (TRRL) Report 279 (1992).

[13] – Tawhed W. Development of Traffic Flow Stream Relationships for Rural Road in Egypt. M Sc. Helwaan University, 1997

[14] – MATLAB-Computer Program, Version 6.10.450, Release 12.1, The Math works Inc. May, 2001.