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A Combined Fuzzy Logic and Aanalytical Hierarchy Process Method for Optimal Selection and Locating of Pedestrian Crosswalks

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Abstract

One of the main challenges for transportation engineers is the consideration of pedestrian safety as the most vulnerable aspect of the transport system. In many countries around the world, a large number of accidents recorded by the police are composed of accidents involving pedestrians and vehicles, for example when pedestrians may be struck by passing vehicles when crossing the street. Careful consideration of the parameters that are involved in selecting the type and optimum location of pedestrian crosswalks results in a higher pedestrian safety coefficient and a reduced accident rate at these facilities. At the start of this study, these parameters that are important in specifying the optimum type and location of pedestrian crosswalks were determined. Then the data layers of these identified parameters were defined using the ArcGIS software. These layers can subsequently be used for determination of the optimal positioning of pedestrian crosswalks. To specify the boundary changes for each parameter, fuzzy membership functions were defined for each parameter using fuzzy logic. The Analytical Hierarchy Process method (AHP) was used in order to combine these layers of information after the fuzzy membership functions were defined. Expert Choice software was used to determine the final weight resultant of the professionals' poll that was conducted. A field study sample has been carried out to determine the optimal location of pedestrian crosswalks in the city of Tehran. The final output from the ArcGIS software shows the ideal locations and the appropriate type of pedestrian crosswalks in the field study sample. The results indicate that the use of fuzzy logic in definition of membership functions of location parameters, along with using AHP for determination of the weight of data layers built in ArcGIS, is a satisfactory combined method for specifying the location of pedestrian crosswalks.

Keywords: Pedestrian crosswalk, Safety, ArcGIS, Fuzzy logic, Analytical Hierarchy Process

1. Introduction

Pedestrian studies, with a focus on pedestrian safety, have been studied by experts and researchers in many academic fields (Lassarre et al., 2012). Pedestrians are the most Vulnerable users within a transport system, therefore considering different aspects of pedestrian safety is essential, and should be incorporated into management discussions and in the field of planning and implementation [Quistberg, 2017]. Considering and defining the important effecting parameters in the design of pedestrian facilities [Anciaes & Jones, 2016], and investigating the safety of pedestrians while crossing the streets, results in a reduction in the number of traffic accidents and thus encourages people to walk. Reliable guidelines such as MUTCD [Agenda, 2017], FHWA [Travel, 2006], HCM [Manual, 2010], ITE [Lalani, 2001] and AASHTO [AASHTO, 2001] contain detailed criteria concerning pedestrians in walkways and crosswalks. Based on standards presented in these guidelines and by considering local conditions, different countries have suggested hierarchies and methodologies to locate pedestrian crosswalks, among which are Pedestrian Crossing Treatment Warrants [Transplant Associates, 1996], Pedestrian Design Considerations [Crandall et al., 2002; Washington State Department of Transportation, 2009], Pedestrian Crosswalks [Knoblauch et al., 2001] and Pedestrian Policies and Design Guidelines [NZ Transport Agency, 2005].

A comparison among methods presented in different guidelines shows that each of the guidelines uses a set of locating parameters as a basic toolkit to determine the optimal positions for pedestrian crosswalks [Papadimitriou et al., 2016 (a)] The methods employed in these guidelines are used traditionally and are based on experience and engineering judgment [Papadimitriou et al., 2016 (b)]. By surveying the effects of these methods in countries where there is a notable benefit from the identification of pedestrian crosswalk locating parameters, it has been attempted in this study to use all of the existing parameters for locating pedestrian crosswalks. This was done by presenting a combined method in order to eliminate the defects of the present locating pedestrian crosswalk methods.

2. Determination of Pedestrian Crosswalk Parameters

Current studies have shown that different countries employ different criteria to identify appropriate locations for pedestrian's crosswalks. However, it can be seen that if the methods and parameters used are considered carefully, they are very similar, and it just the language of expression and restrictions for the parameters in different

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studies under different conditions that vary. Increasing the number of assumed parameters results in an increase in efficacy of the crosswalk locations selected, and also in simplicity of evaluation and analysis. Considering the specific ability of the ArcGIS software to create different layers of information and connect them, in this study almost all of the currently used parameters are combined in order to optimally locate the pedestrian crosswalks. These parameters are:

- Pedestrian volume
- Vehicle volume
- Stopping sight distance
- Time required to cross the street
- Vehicle speed
- Distance from the adjacent pedestrian crosswalk
- Distance from the adjacent intersection
- Number of passing vehicle lanes
- Pedestrian accidents
- Land use of the study district

2.1. Research method

Having determined the parameters that affect the optimum location of pedestrian crossings, the layers had to be defined in GIS, the first step towards this being to define the fuzzy parameter. In step two, data was collected from fieldwork, and the second layer was applied to the ArcGis software. The third step was to combine the information collected from the different layers and also the Analytical hierarchy process AHP, and use the Expert Choice software to combine it all. Step four was to define the algorithm for location allocation of pedestrians in ArcGIS for optimum location of crossings.

3. Definition of Fuzzy Membership Functions for Locating Parameters

The starting point for creating a fuzzy system is obtaining a set of fuzzy 'if-then' rules based on literature and the knowledge of experts in the field of study. The important theoretical aspect of fuzzy systems is that they provide a systematic procedure for converting a rule base to a nonlinear [Zimmermann, 2011]. In order to determine the fuzzy membership functions of criteria for locating pedestrian crosswalks, it is necessary to take into account the variation range of assumed parameters based on the minimum, maximum, and desirable value of the regarded parameter. After this, the membership function for each parameter can be determined. Functions are explained below.

3.1. Pedestrian volume Fuzzy membership function for zebra crossing

$$\begin{cases} 0 & x \le 15 \\ y = 2\times10^{-3}x^2 - 5\times10^{-2}x + 0.3 & 15 < x \le 35 \\ y = 9\times10^{-4}x^2 - 1.22\times10^{-1}x + 4.1889 & 35 < x < 65 \\ 0 & x \ge 65 \end{cases} \qquad \text{x: Pedestrian hourly volume} \qquad (1)$$

3.2.Pedestrian volume Fuzzy membership function for signalised crosswalk

$$\begin{cases} 0 & x \le 15 \\ y = 2\times10^{-3}x^2 - 5\times10^{-2}x + 0.3 & 15 < x \le 35 \\ y = 9\times10^{-4}x^2 - 1.22\times10^{-1}x + 4.1889 & 35 < x < 65 \\ 0 & x \ge 65 \end{cases} \qquad \text{x: Pedestrian hourly volume} \qquad (2)$$

3.3.Pedestrian volume Fuzzy membership function for grade separate crosswalk

$$\begin{cases} 0 & x \le 100 \\ y = -5\times10^{6}x^2 + 6.3\times10^{4}x - 0.575 & 100 < x \le 350 \\ 1 & x > 350 \end{cases} \qquad \text{x: Pedestrian hourly volume} \qquad (3)$$

3.4.Vehicle volume Fuzzy membership function for zebra crossing

$$\begin{cases} 0 & x < 2700 \\ y = -1\times10^{-8}x^2 + 3\times10^{-4}x - 0.7849 & 2700 \le x < 9000 \\ y = 2\times10^{-8}x^2 - 7\times10^{-4}x + 5.5 & 9000 \le x < 15000 \\ 0 & x \ge 15000 \end{cases} \qquad \text{x: Average Daily Traffic(ADT)} \qquad (4)$$

3.5.Vehicle volume Fuzzy membership function for signalised crosswalk

$$\begin{cases} 0 & x \le 12000 \\ y = -1\times10^{-8}x^2 + 4\times10^{-4}x - 3.7143 & 12000 < x < 22000 \\ y = 8\times10^{-9}x^2 - 6\times10^{-4}x + 9.25 & 22000 \le x < 30000 \\ 0 & x \ge 30000 \end{cases}$$ x: Average Daily Traffic (ADT) (5)

3.6.Vehicle volume Fuzzy membership function for grade separate crosswalk

$$\begin{cases} 0 & x \le 28000 \\ y = 2\times10^{-9}x^2 - 5.45\times10^{-5}x - 0.04 & 28000 < x < 40000 \\ 1 & x \ge 40000 \end{cases}$$ x: Average Daily Traffic (ADT) (6)

3.7. Waiting time Fuzzy membership function for crossing

- Fuzzy membership function for zebra crossing

$$\begin{cases} 1 & 0 \le x \le 30 \\ y = 1.1\times10^{-3}x^2 - 1.34\times10^{-1}x + 4.0275 & 30 < x \le 61 \\ 0 & x > 61 \end{cases}$$ x: Pedestrian waiting time(s) (7)

- Fuzzy membership function for signalised and grade separate crosswalk

$$\begin{cases} 0 & x \le 60 \\ y = -1.11\times10^{-4}x^2 + 3.66\times10^{-2}x - 1.8 & 60 < x < 120 \\ 1 & x \ge 120 \end{cases}$$ x: Pedestrian waiting time(s) (8)

3.8. Stopping sight distance Fuzzy membership function

$$\begin{cases} 0 & x \le 20 \\ y = -7\times10^{-5}x^2 + 2.49\times10^{-2}x - 0.4697 & 20 < x < 75 \\ 1 & x \ge 75 \end{cases}$$ x: Stopping sight distance (m) (9)

3.9.Vehicle speed Fuzzy membership function for zebra crossing

$$\begin{cases} 1 & 0 < x \le 30 \\ y = 1\times10^{-3}x^2 - 1.25\times10^{-1}x + 3.85 & 30 < x < 55 \\ 0 & x \ge 55 \end{cases}$$ x: Vehicle speed (Km/hr) (10)

3.10.Vehicle speed Fuzzy membership function for signalised crosswalk

$$\begin{cases} 1 & 0 < x \leq 64.4 \\ y = -1.43 \times 10^{-3} x^2 + 1.42 \times 10^{-1} x - 2.25 & 64.4 < x < 80 \\ 0 & x \geq 80 \end{cases}$$ Vehicle speed (Km/hr) (11)

3.11.Vehicle speed Fuzzy membership function for grade separate crosswalk

$$\begin{cases} 0 & x \leq 50 \\ y = -1.3 \times 10^{-3} x^2 + 2.075 \times 10^{-1} x - 7.054 & 50 < x \leq 72 \\ 1 & x > 72 \end{cases}$$ x: Vehicle speed (Km/hr) (12)

3.12.Geometric characteristic Fuzzy membership function for zebra crossing

$$\begin{cases} 1 & 0 < x \leq 6.9 \\ y = 4.07 \times 10^{-2} x^2 - 9.866 \times 10^{-1} x + 5.86 & 6.9 < x < 10.5 \\ 0 & x \geq 10.5 \end{cases}$$ x: Crossing the line in one direction(m) (13)

3.13. Geometric characteristic Fuzzy membership function for signalised crosswalk

$$\begin{cases} 1 & x \leq 6.9 \\ y = -8.4 \times 10^{-3} x^2 + 1.192 \times 10^{-1} x + 0.578 & 6.9 < x < 18 \\ 0 & x \geq 18 \end{cases}$$ x: Crossing the line in one direction(m) (14)

3.14. Geometric characteristic Fuzzy membership function for grade separate crosswalk

$$\begin{cases} 0 & 0 < x \leq 10.35 \\ y = -1.26 \times 10^{-2} x^2 + 4.928 \times 10^{-1} x - 3.75 & 10.35 < x < 17.25 \\ 1 & x \geq 17.25 \end{cases}$$ x: Crossing the line in one direction (m) (15)

3.15. Distance from adjacent intersection Fuzzy membership function

$$\begin{cases} 0 & x \leq 89 \\ y = 2.49 \times 10^{-4} x^2 - 1.983 \times 10^{-2} x - 0.2088 & 89 < x < 120 \\ 1 & x \geq 120 \end{cases}$$ x: Distance from adjacent intersection (m) (16)

3.16. Distance from the adjacent pedestrian cross walk Fuzzy membership function

- Zebra crossing

$$\begin{cases} 0 & x \le 89 \\ y = -8\times10^{-5}x^2 + 3.27\times10^{-2}x - 2.263 & 89 < x < 200 \\ 1 & x \ge 200 \end{cases}$$

x: Distance from adjacent Crosswalk (m) (17)

- Grade separate crosswalk

$$\begin{cases} 0 & x \le 200 \\ y = -4\times10^{-4}x^2 + 2\times10^{-1}x - 24 & 200 < x < 250 \\ 1 & x \ge 250 \end{cases}$$

x: Distance from adjacent Crosswalk (m) (18)

3.17. Pedestrian accident Fuzzy membership function

$$\begin{cases} 0 & x \le 0 \\ y = -0.0833x^2 + 0.5833x - 4\times10^{-16} & 0 < x < 3 \\ 1 & x \ge 3 \end{cases}$$

x: Number of pedestrian accident in five years (19)

4. Data Collection

Shariati Street in Tehran has been selected as the location for the case study for this research project. The aim was to determine the optimum location for a pedestrian crosswalk in this location, which is considered as a first degree arterial street [Sohrabpour wt al., 1999; Tehran Transportation Master Plan, 2007]. Shariati Street is in a linkage position in terms of providing access to different areas of the city. In addition, the existence of attractive land use along the street and its alleys results in an increase of travel demand along this route. The area between Qods Square and Pole Rumi Street, which has a length of about 1500 meters, has a relatively high travel demand during both peak hour and non peak hour due to its attractive marginal land use and also the incidence of educational, health, administrative and recreational land use along street. So this area was selected as the case study for this project. Pedestrian and vehicle volume record stations are illustrated in figure 1. Pick hour vehicle and pedestrian volume is illustrated in table 1.

Table 1
Pick hour vehicle volume

Station number	Pick hour vehicle volume
1	2265
2	2203
3	1231
4	2018
5	1576
6	903
7	2478

The waiting time needed for a pedestrian to estimate the time for crossing a street in a safe manner is required for later analysis. In order to obtain this time a test subject crosses the section of road under study five times at a normal walking pace. The average time of these crossings is considered as the waiting time of pedestrians for traversing the street [Graeme Fitton, 2006]. Table 2 illustrates the waiting time of survey stations and Crossing pedestrian volume.

Table 2
Pick hour pedestrian volume

Station number	Pick hour pedestrian volume	Waiting time (s)
1	2189	80
2	1414	10
3	798	4
4	247	5
5	232	4
6	220	4
7	418	5.5
8	95	6.75
9	144	5.75
10	129	6
11	72	4.5
12	53	4.5
13	84	4.75
14	99	4.5
15	84	3
16	110	70
17	144	78

Vehicle speed is also a very important parameter in pedestrian studies. To determine this for a particular road section, the length between two adjacent intersections is divided by the time that a vehicle takes to pass the link as part of the general traffic flow. The result of this is the calculation of the average speed of the desired link. The average speed of the pathways in the selected studied area is shown in table 3.

Table 3
Average speed of studied area

Location	Average speed (Km/hr)
Bahona to Baradarane vaezi	17
Baradarane vaezi to musivand	19
Musivand to Saba blv.	34
Saba blv. Pole Rumi	10
After pole Rumi	20

Generally in pedestrian studies and economic evaluation of projects, the accident rate is a basic parameter that is a main source of economic and social loss. For that reason, the number of pedestrian accidents was chosen as one of the fundamental parameters in determining optimal locations of pedestrian crosswalks in the studied region. Pedestrian accident data obtained from the Traffic Department of Tehran is illustrated in table 4 [Traffic Department of Tehran, 2008]. Stopping sight distance is another effecting parameter when locating pedestrian crosswalks. Stopping sight distance can be calculated from the following Equation (20) [Lamm et al., 1999].

$$S = 0.278Vt + \frac{V^2}{254(F \pm G)} \qquad (20)$$

V: vehicle speed (Km/hr)
F: Coefficient of friction on wet pavement
G: Gradient way in terms of percentage

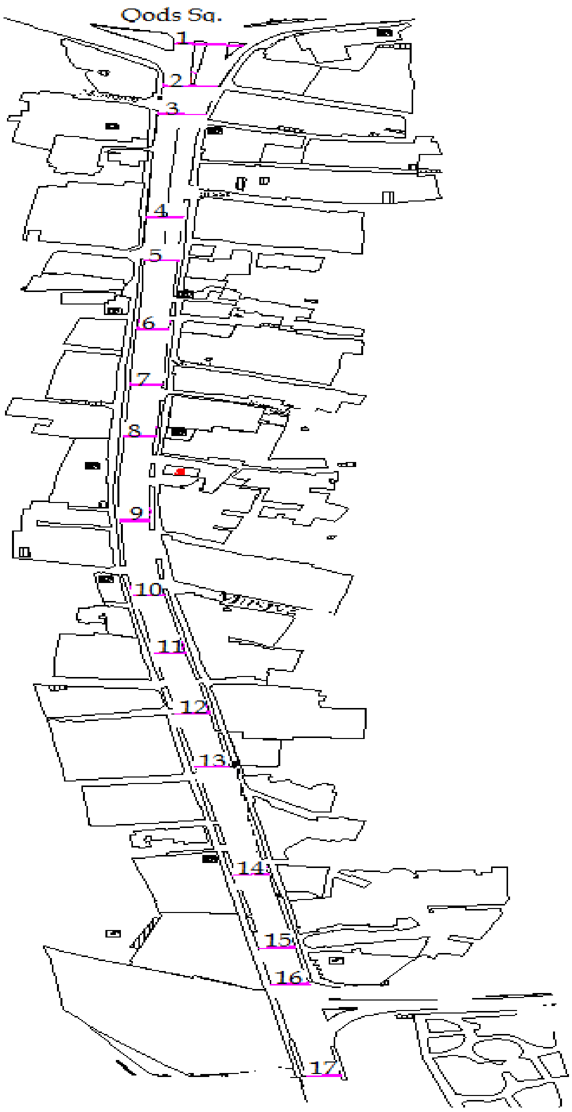

Fig 1. Pedestrian and vehicle volume record stations

Table 4.
Pedestrian accident Data of Shariati Street from 2003 to 2008

Date	region	Street name	Type of accident		
			Traumatic	**Mortality**	**Sum**
From 2004 to 2008	1	Shariati	35	1	36
		Shariati-bahonar	10	0	10
		Shariati- polerumi	1	0	1
	3	Shariati	83	0	83
		Shariati-zargandeh	1	0	1
		Shariati-purmeshkani	1	0	1
		Shariati-golnabi	4	0	4
		Shariati-hemat	2	0	2
		Shariati-pasdaram	19	0	19
Sum			156	1	157

The information relating to the road cross section and land use is collected through field studies. It should be noted that guidelines recommend that the minimum appropriate distance between two safe pedestrian crosswalks is 90 m and the minimum appropriate distance between a grade-separated walkway and an adjacent safe pedestrian crosswalk is 200m.

5. Assigning Information Layer Weights

Assignation of information layer weights in ArcGIS Software was carried out using the Hierarchy Analysis method and Expert Choice software. For this purpose, a questionnaire is completed by the transportation professionals who are familiar with pedestrian issues. Hierarchy structure for assignation information layer weights for locating pedestrian crosswalks is presented in Fig 2.

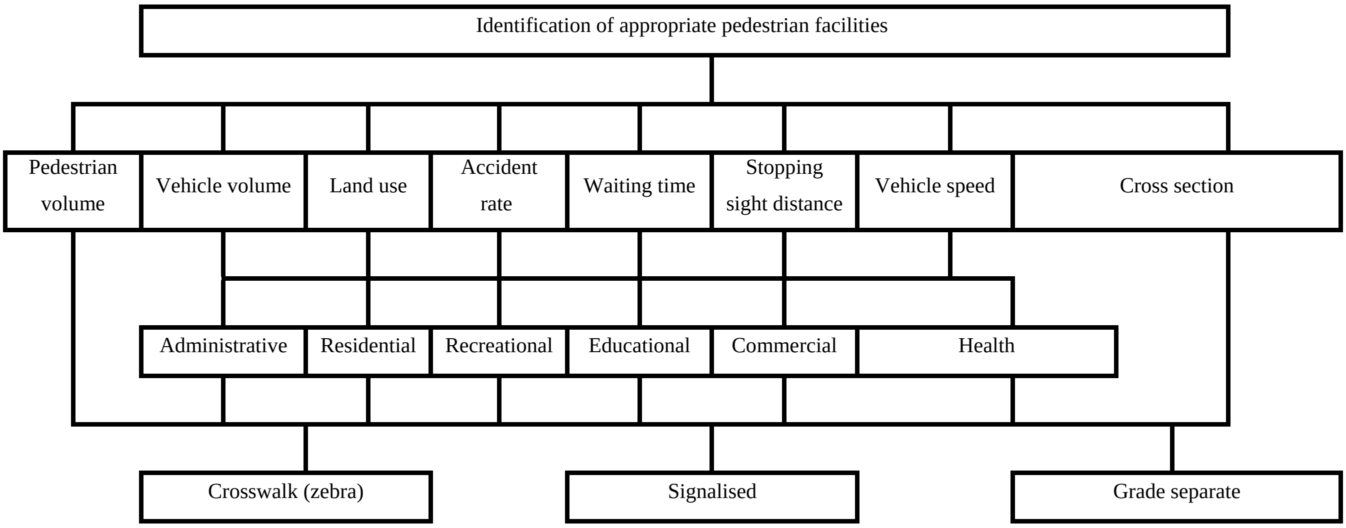

Fig. 2. Hierarchy structure for identifying appropriate pedestrian facilities

After defining the hierarchy structure, the next step is evaluation of the elements by way of the couple comparison methodology. Couple comparison is a process for comparing the significance or priority of two elements in relation to the other higher level elements. To this end, after implementation of the geometric mean operation on the results from the questionnaires detailing the professionals' opinions, and determining the couple comparison matrices of locating parameters, these resulting matrices are defined in the Expert Choice software. In Tables 5 to 18 the couple comparison matrixes obtained from the questionnaire results are shown.

Table 3
Pedestrian volume couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	0.39	0.14
Signalised	2.59	1	0.3
Grade separate	7.32	3.37	1

Table 4.
Vehicle volume couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	0.46	0.38
Signalised	2.15	1	0.72
Grade separate	2.64	1.38	1

Table 5.
Pedestrian facilities couple comparison matrix in Residential land use

	Zebra	Signalised	Grade separate
Zebra	1	1.64	1.38
Signalised	0.61	1	0.8
Grade separate	0.72	1.25	1

Table 6.
Pedestrian facilities couple comparison matrix in Educational land use

	Zebra	Signalised	Grade separate
Zebra	1	0.37	0.26
Signalised	2.43	1	0.57
Grade separate	3.86	1.77	1

Table 7.
Pedestrian facilities couple comparison matrix in Health land use

	Zebra	Signalised	Grade separate
Zebra	1	0.53	0.8
Signalised	1.87	1	1.43
Grade separate	1.25	0.7	1

Table 8.
Pedestrian facilities couple comparison matrix in Recreational land use

	Zebra	Signalised	Grade separate
Zebra	1	0.83	0.58
Signalised	1.21	1	0.81
Grade separate	1.73	1.24	1

Table 9.
Pedestrian facilities couple comparison matrix in Commercial land use

	Zebra	Signalised	Grade separate
Zebra	1	0.5	0.33
Signalised	1.99	1	0.71
Grade separate	3.07	1.4	1

Table 10.
Pedestrian facilities couple comparison matrix in Administrative land use

	Zebra	Signalised	Grade separate
Zebra	1	0.55	0.49
Signalised	1.8	1	0.92
Grade separate	2.03	1.08	1

Table 11.
Pedestrian Accident couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	0.23	0.16
Signalised	4.09	1	0.39
Grade separate	6.3	2.54	1

Table 12.
Pedestrian waiting time couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	4.56	6.54
Signalised	0.22	1	1.71
Grade separate	0.15	0.59	1

Table 13
Stopping sight distance couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	3.47	5.9
Signalised	0.29	1	2.72
Grade separate	0.17	0.37	1

Table 14
Vehicle volume couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	4.74	7
Signalised	0.21	1	2.42
Grade separate	0.14	0.41	1

Table 15
Cross section couple comparison matrix in selecting pedestrian facilities

	Zebra	Signalised	Grade separate
Zebra	1	2.92	4.36
Signalised	0.34	1	1.67
Grade separate	0.23	0.6	1

Table 16.
Land use couple comparison matrix in selecting pedestrian facilities

	Residential	Recreational	Educational	Commercial	Health	Administrative
Residential	1	1.33	0.29	0.62	0.23	0.91
Recreational	0.75	1	0.32	0.8	0.5	0.65
Educational	3.37	3.04	1	2.9	1.88	3.15
Commercial	1.61	1.25	0.34	1	0.38	1.29
Health	4.34	1.99	0.53	2.59	1	2.27
Administrative	1.09	1.54	0.31	0.77	0.44	1

In the final stage, the absolute weights of each locating parameter are obtained from the software. The incompatibility rate of the hierarchy process is less than 0.1, which indicates sound judgment in selection of the parameters that were investigated [Tui, 1980]. Table 19 displays the calculated weights of the locating parameters for construction of pedestrian crossings, traffic lights, and grade separate pedestrian crosswalks.

Table 17
Weighting of parameters for each pedestrian facility

Parameters	Weight of parameter (zebra)	Weight of parameter (Signalised)	Weight of parameter (Grade separate)
Pedestrian volume	0.027	0.106	0.260
Vehicle volume	0.051	0.174	0.178
Residential land use	0.011	0.011	0.010
Recreational land use	0.008	0.015	0.015
Educational land use	0.014	0.053	0.070
Commercial land use	0.006	0.033	0.022
Health land use	0.019	0.055	0.030
Administrative land use	0.007	0.020	0.017
Pedestrian accident	0.025	0.142	0.235
Waiting time	0.219	0.082	0.040
Stopping sight distance	0.204	0.110	0.037
Vehicle speed	0.220	0.089	0.033
Cross section	0.190	0.110	0.053

After defining the information layers of locating parameters, they are combined according to their weights presented in table 20 in the ArcGIS software in order to determine the type and location of optimal pedestrian crossings. The algorithm introduced into the software for defining the best location of pedestrian facilities works in the following way. In the first step, the software compares all of the cross sections of the studied region, and it selects the section which has the most appropriate construction for the specified type of pedestrian facilities (crossing, traffic light or grade separate crosswalk) . In the next step, the second section is selected by considering the minimum distance between pedestrian facilities, and this will be carried out for all of the locations in the studied region. The final output from the software for constructing pedestrian facilities can be seen in fig 2, where the optimised location for constructing the traffic light is near Moosivand Street and the optimised location for the construction of grade separate crosswalk is opposite Alvand Alley. It should be noted that the intersections defined as Bahonar-Shariati, Saba-Shariati and Poleroomi-Shariati are the main intersections, which means that the safe pedestrian passes must be positioned at these locations.

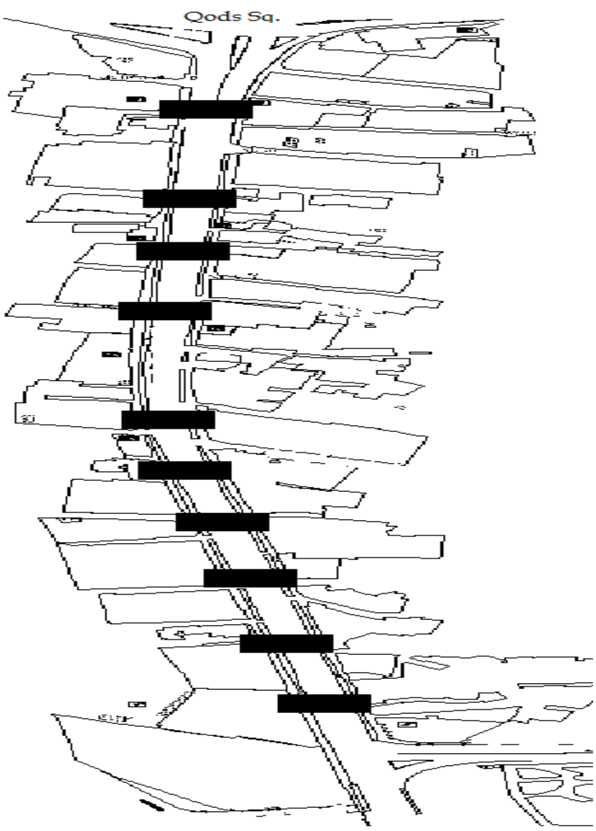

Fig. 2. Optimum location of constructing pedestrian crosswalk facilities

6.Conclusion

In this study, after selecting and defining the important locating parameters for pedestrian passes, the extent and importance of each parameter was determined through research and questionnaires, and the attributed fuzzy belonging functions were identified based on these considered limitations. The information layers derived from these parameters were combined with each other using weighs obtained from hierarchy analysis in Expert Choice 11, based on their attributed fuzzy belonging functions to create the final output. This method was applied to a case study in an area of Tehran known as Shariati Street. The results have determined the optimal type and appropriate location of the pedestrian passes in the studied region. The results of this study are summarised briefly in the following:

- An increase in the number of pedestrian accidents results in an increased probability of selecting a grade separate crosswalk as an appropriate solution.
- The speed of vehicles, the width of the sectional pass, the appropriate sight distance of vehicles and the safe time between vehicles for pedestrians to cross the street all play a significant role in selecting the pedestrian crossing.
- The number of vehicles, the rate of pedestrian accidents, the appropriate sight distance for vehicles, the width of the street and the number of pedestrians are crucial for selecting pedestrian traffic lights.
- The number of pedestrians, rate of pedestrian accidents and number of vehicles play an important role in selecting the locations of the grade separate pedestrian crosswalks.
- Comparing the suggested pedestrian passes with the current real life situation shows that applying the described method in this study provides a more organised crossing system for pedestrians, and reduces the number of pedestrian passes by combining the current facilities and omitting unnecessary crosswalks.
- The results of this research provide a comparison of the suitability of various types of pedestrian passes in a single location, and suggest a methodology to choose the optimal location for the pedestrian passes in order to reduce the number of accidents.
- By systematically determining the optimised location of pedestrian passes, construction and maintenance costs of grade separate pedestrian crosswalks can be reduced.
- Analysing the software outputs and comparing them with the current real-life situation in the region indicates that the use of fuzzy logic in defining the membership functions of the parameters and assigning weights to the information layers by hierarchy analysis is an efficient method for selecting the type and optimum location of pedestrian facilities.
- Pedestrian pass location by using the ArcGIS software is highly appropriate because of the particular capabilities of this software for managing databases and their locating properties.

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