

Modeling Pedestrian Flow in Urban Pedestrian Facilities Using Meta-Heuristic Algorithms (Case Study: Rasht City)

Seyed Ebrahim Abdolmanafi¹

Termeh Vedadi² Seyed Amir Saadatjoo³

Saeed Fatemi⁴ Seyed Ali Ziaee⁵

1. Introduction

The role of transportation in various economic, social, and political dimensions of today's societies is clear. The transportation is one of the main pillars of sustainable development in human societies. Among the transportation modes, walking is considered as one of the most common modes. Walking is one of the most important aspects of human presence in urban spaces, which causes the vitality and dynamism of these spaces and also increases their social role. The pedestrian flow modeling can be the background for designing the optimal facilities to make a city pedestrian. The pedestrian behavior is influenced by the variables such as speed, density, and flow rate, which under the influence of age, gender, weight, individual or group of pedestrians, and even the type of cover can lead to different behaviors. Therefore, before designing pedestrian facilities, pedestrian traffic parameters such as speed, density, flow rate, movement, capacity of the definite zone and also pedestrian behavioral parameters such as type of coverage, age, weight, gender, etc. should be examined.

Previous studies have shown that these studies classify into three categories: macro, intermediate and micro. All the researchers have evaluated the pedestrians flow under the influence of specific parameters. Therefore, in this study, along with examining the pedestrians behavior and collecting the related parameters such as speed, density, and flow rate, pedestrian flow will be modeled at intersections and pedestrian facilities. The developed model can be used to predict the pedestrians behavior more accurately than other models.

2. Data and Methodology

The required data were collected in the present study in Rasht. In order to collect pedestrians' data to model their flow, the most important and crowded pedestrian facilities in the city were selected and the facilities were filmed. These facilities were selected from more than 50 places in Rasht. Then, by specifying a fixed section per unit length (meters) in the recorded images and also the duration of each crossing in this specific section, the walking speed of each pedestrian was extracted. In order to conduct the

survey, due to the peak of pedestrian crossings in the selected places, the peak time of 17 to 20 in the early spring was selected. The time chosen for the survey was due to the clear weather, the saturation of the pedestrian flow, and the peak time of the pedestrian flow. Finally, 10,210 pedestrian data were prepared for use as modeling data.

One of the methods used for modeling in this study is regression model. In this model, the aim is to obtain a mathematical correlation between one or more independent variables and a dependent variable in order to predict the dependent variable using the independent variables. In regression equation, there is one independent variable and one dependent variable, which in the multivariate regression equation, the number of independent variables is more than one. In this study, by drawing a distribution diagram and fitting the curve in Excel and SPSS software and using regression method, the required equations were extracted.

Moreover, the meta-heuristic algorithms as an approximate optimization algorithm that have solutions for exit from local optimal solutions, were used.

To develop these models, first based on the people number crossing the definite length of the sidewalks and pedestrian malls per minute obtained from the recorded images, the flow rate (v) was determined at survey in the pedestrian facility. After that, using a stopwatch, the people walking time was determined for all pedestrians. Then, by dividing the distance traveled of the people by their walking time, the people speed (S) was obtained. Finally, using the relation ($v=S \times D$), the density (D) for each minute were calculated. Three methods of linear and nonlinear regression and genetic algorithm were used to model the obtained relationships.

Different methods of modeling the flow of pedestrians on sidewalks and pedestrian malls in Rasht are shown in accordance with Table 1. As can be seen from these results, the accuracy of the genetic method is higher than the regression method. Therefore, the metaheuristic algorithms have a higher accuracy for modeling pedestrian behavior.

Table 1. Comparison of the models results

Type of facility	Type of model	R ²
Sidewalk	regression methods	0.9103
	genetic algorithm	0.9451
Pedestrian mall	regression methods	0.9082
	genetic algorithm	0.9062

¹ Corresponding Author: Assistant Professor, Department of Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran. **Email:** abdolmanafi@srbiau.ac.ir.

² Master Graduate, Department of Civil Engineering, Islamic Azad University, Tehran North Branch, Tehran, Iran.

³ Ph.D. Candidate, Department of Civil Engineering, Iran University of Science and Technology, Tehran, Iran.

⁴ Ph.D. Candidate, Department of Civil Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran.

⁵ Assistant Professor, Department of Civil Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran.

3. Results and Conclusion

The examination of the pedestrians behavioral characteristics in pedestrian facilities showed:

- The highest values of the 15th percentile in both normal and rainy weather conditions belong to men in all pedestrian facilities. However, women especially women with hijab walk at a lower speed in all conditions, and also they have the lowest values of the 15th percentile.
- The speed of pedestrians on the sidewalks and when crossing the width of the passages is equal to each other and have very low values compared to crossing the intersections. Moreover, the lowest speed among all pedestrian facilities in both normal and rainy weather conditions belongs to the sidewalk. Perhaps the reason for this is the special design of sidewalks with pedestrian priority, as well as the placement of sidewalks in tourist, recreational or shopping areas.
- With 95% confidence level in middle-aged and older age groups, the difference in speed between women with hijab and other women is statistically significant and hijab has an effect on people speed. In other words, women with hijab compared to other women, men and platoon movements have the lowest speed values. Therefore, it is not possible to predict which people will cross the definite area over a period of time with what type of cover; Therefore, it is better to be considered the type of cover for designing woman walking facilities.
- Among the various models obtained using linear and nonlinear regression methods, for all pedestrian facilities, the flow-density rate model has the highest prediction accuracy;
- The accuracy of the developed models for different facilities including sidewalks, and pedestrian malls, intersections without signals and with signals using the genetic algorithm is equal 0.9451, 0.9062, 0.9822 and 0.9938, respectively.
- Genetic algorithm for all types of pedestrian facilities is more accurate than regression model for predicting pedestrian flow; Therefore, this method can be introduced as the best methods of modeling to predict pedestrian behavior.