Psychological distance of pedestrian at the bus terminal area

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Abstract. Walking is a part of transportation modes that is effective for pedestrian in either short or long trips. All people are classified as pedestrian because people do walk every day and the higher number of people walking will lead to crowd conditions and that is the reason of the importance to study about the behaviour of pedestrian specifically the psychological distance in both indoor and outdoor. Nowadays, the number of studies of crowd dynamics among pedestrian have increased due to the concern about the safety issues primarily related to the emergency cases such as fire, earthquake, festival and etc. An observation of pedestrian was conducted at one of the main bus terminals in Kuala Lumpur with the main objective to obtain pedestrian psychological distance and it took place for 45 minutes by using a camcorder that was set up by using a tripod on the upper floor from the area of observation at the main lobby and the trapped area was approximately 100 m^2. The analysis was focused on obtaining the gap between pedestrian based on two different categories, which are; (a) Pedestrian with relationship, and (b) Pedestrian without relationship. In total, 1,766 data were obtained during the analysis in which 561 data were obtained for 'Pedestrian with relationship' and 1,205 data were obtained for "Pedestrian without relationship". Based on the obtained results, "Pedestrian without relationship" had shown a slightly higher average value of psychological distance between them compare to "Pedestrian with relationship" with the results of 1.6360m and 1.5909m respectively. In gender case, "Pedestrian without relationship" had higher mean of psychological distance in all three categories as well. Therefore, it can be concluded that pedestrian without relationship tend to have longer distance when walking in crowds.

1 Introduction

Walking is one of the effective modes of transportation for either short or long trips and that are depending on the pedestrian preferences. Every single person can be classified as pedestrian because people do walk every single day and due to that particular reason, more

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people tend to walk rather than using vehicles that will cost a lot of consumptions of gas, time and as well as the money. Pedestrianization plays an important part in the sustainable urbanization that can be advantageous in reducing air pollution that caused by fuel consumption, sound pollution that caused by vehicles on the street and also death that can be triggered by many factors like car crash. In fact, the increasing number of pedestrian will lead to crowds and that is the logic of the importance to study about this issue both indoor (e.g.: shopping mall, bus terminal complex, and airport) and outdoor (e.g.: recreation park and pedestrian sidewalks).

The studies of human crowds and pedestrian behaviour since three decades ago had attracted more attentions from many researchers and it is now one of the important researches field not only in engineering but also in other fields such as computer science, mathematics, physics, psychology, urban planning, architecture and humanities [1, 3, 7, 10, 13, 14]. Pedestrian traffic flow simulation models were invented due to the needs of predicting the pedestrian movement behaviour in various kinds of environment in order to help decision makers to identify any hazardous situations and therefore may increase the safety level of pedestrian from accidents by implementing the evaluation and analysis of data that will be obtained during the experiments. Furthermore, the number of studies of crowd dynamics among pedestrian nowadays have increased due to the concern about the safety issues primarily related to the emergency cases such as fire, earthquake, festival and etc. [4]. These issues had attracted many researchers to implement their experiments for learning the causes and impacts of the importance of safety management issues of crowds and also in strengthening the need to have more refined models of pedestrian dynamics. It is necessary to understand the local interaction laws underlying collective crowd dynamics in order to develop reliable prediction models for the design of urban infrastructures, traffic management, and crowds' safety during mass events or evacuation processes. Therefore, a deep understanding of pedestrians' behaviour is vital in order to predict their motion in a complex collective characteristics emerged. Although crowds represent a group of people, it is important to study about the pedestrian behaviour individually. However, current models of crowd dynamics specifically for validating the efficiency of individual-level are in dire need. It is significant to study about the psychological distance of pedestrian and for that specific reason, the author had decided to conduct an experiment stochastically at a bus terminal area due to the high number of pedestrian that can be easily observed by making a video recording and also to understand more about the psychological distance between pedestrian at that location.

2 Methods and data analysis

An observation of pedestrian was conducted at one of the main bus terminals in Kuala Lumpur and it took place for 45 minutes by using a camcorder. The camera was set using a tripod on the upper floor from the site of the observation where the trapped area in the video recording was approximately 100 m^2 and the recorded video was converted into image sequences using DVD VideoSoft software. Hence, data analysis was performed by using a software named Human Behaviour Simulator (HBS) that was plugged into Autodesk Maya and all of the image sequences were imported into the latter software to track the gap or also can be explained as psychological radius and psychological distance between pedestrians in the video. Figure 1 shows an example of how the gap between two walking female pedestrian was obtained in data analysis stage and the process of obtaining gap between pedestrians in the video was just the same.
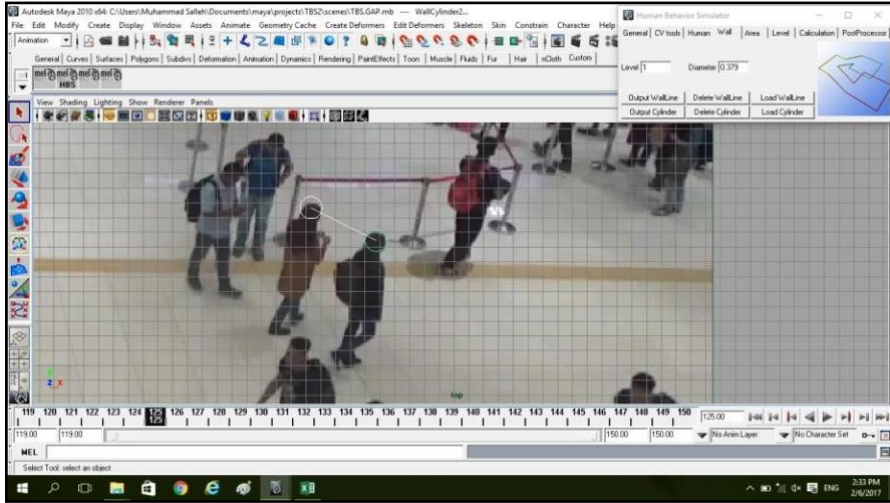
Fig. 1. An example of the step of pointing out the coordinate between two female pedestrian.

After pointing out the coordinates between the two pedestrians, the coordinates of x-axis and y-axis were generated in notepad format as shown in Figure 2 in which the first column represents x-axis (x1 and x2) while the second column represents y-axis (y1 and y2). Thus, the mathematical operation for calculating the length between two coordinates was applied to find the gap between two pedestrians.

Fig. 2. Sample of the generated coordinates between two pedestrians using HBS software.

The data analysis was concentrated on obtaining the gap between pedestrian based on two different categories which are; (a) Pedestrian with relationship, and (b) Pedestrian without relationship and there are three criteria under each category; (i) Man to woman, (ii) Man to man, and (iii) Woman to woman. Wallace et al., (2016) [15] had quoted that Hall et al., (1968) invented the term proxemics when studying the role of interpersonal distances in human interactions, and defined zones of interaction ranging from intimate (less than 0.5m), to personal (0.5m to 1.2m), social (1.2m to 3.6m), and public (3.6m to 8m). Hence, based on these criteria, the range of psychological distance of pedestrian and also the gender classifications were designed as shown in Table 1 in which the gap between

pedestrian were divided into six groups. After categorizing all of the obtained gaps, a statistical analysis was done by using T-test in SPSS software.

Table 1. Data classification based on range group and age categories.

Gender	Range (m)
Man to woman	Category 1: < 0.5999
Man to man	Category 2: 0.6000 - 1.0999
Woman to woman	Category 3: 1.1000 - 1.5999
	Category 4: 1.6000 - 2.0999
	Category 5: 2.1000 - 2.5999
	Category 6: > 2.6000

3 Results and discussions

In total, 1,766 data were obtained during the analysis in which 561 data were obtained for 'pedestrian with relationship' and 1,205 data were obtained for 'pedestrian without relationship'. The results are presented by category as aforementioned in Table 2 until Table 5 where total distance in all tables is referred to the sum of psychological distance obtained accumulatively from the number of data by each category.

Table 2. Psychological distance between pedestrian with relationship based on gender.

Category	Total distance (m)	Number of data	Standard deviation (m)	Psychological distance (m)		
				Lower	Upper	Mean
Man to Woman	26.883	216	0.4943	0.8378	0.9704	0.9041
Man to Man	23.192	121	0.5200	1.0028	1.1900	1.0964
Woman to Woman	36.538	224	0.3401	0.7854	0.8750	0.8302

Table 3. Psychological distance between pedestrian without relationship based on gender.

Category	Total distance (m)	Number of data	Standard deviation (m)	Psychological distance (m)		
				Lower	Upper	Mean
Man to Woman	43.528	508	0.6825	1.2586	1.3776	1.3181
Man to Man	47.458	458	0.6164	1.3103	1.4235	1.3669
Woman to Woman	32.318	239	0.5246	1.0299	1.1636	1.0967

Table 2 shows the results of psychological distance between pedestrian based on gender differences under 'Pedestrian with relationship' category. The most differences observed were among 'Man to Woman' with 216 number of data but the highest average value of distance was obtained by 'Man to Man' category with the mean of 1.0964m gap length while the lowest was obtained from 'Woman to Woman' category with only 0.8302m gap length and 'Man to Woman' category comes in the middle of the two categories with 0.9041m gap length. On the contrary, 'Pedestrian without relationship' category shows higher number of data based on the three classifications as shown in Table 3 where 'Man to Man' still has the highest mean of distance with 1.3669m gap length while the lowest is still among 'Woman to Woman' category with only 1.0967m gap length. Similar to Table 2, 'Man to Woman' shows the average of 1.3181m gap length as the second highest.

Logically, man is known as an aggressive type of people and they walk fast compare to woman and this leads to the higher value of distance between them. However, most women walk slower and they smaller in size compare to men in Malaysia also in other countries and as the results, the distance exists between them are not long compare to distance between men. Hence, Table 4 and Table 5 represent the results of distance between pedestrian based on range due to the consideration of the maximum and the minimum length of distance that were obtained during the analysis.

Table 4. Psychological distance between pedestrian with relationship based on range.

Range (m)	Total distance (m)	Number of data	Standard deviation (m)	Psychological distance (m)		
				Lower	Upper	Mean
Category 1 < 0.5999	61.116	137	0.0882	0.4455	0.4753	0.4604
Category 2 0.6000 - 1.0999	96.426	272	0.1393	0.7978	0.8310	0.8144
Category 3 1.1000 - 1.5999	98.575	103	0.1325	1.2611	1.3129	1.2870
Category 4 1.6000 - 2.0999	71.418	36	0.1492	1.7258	1.8268	1.7763
Category 5 2.1000 - 2.5999	40.875	8	0.1570	2.1370	2.3995	2.2683
Category 6 > 2.6000	26.634	5	0.2467	2.6326	3.2454	2.9390
Mean average of psychological distance between pedestrian (m)						**1.5909**

Table 5. Psychological distance between pedestrian without relationship based on range.

Range (m)	Total distance (m)	Number of data	Standard deviation (m)	Psychological distance (m)		
				Lower	Upper	Mean
Category 1 < 0.5999	57.057	126	0.0927	0.4547	0.4874	0.4711
Category 2 0.6000 - 1.0999	124.416	438	0.1438	0.8415	0.8685	0.8550
Category 3 1.1000 - 1.5999	158.219	296	0.1457	1.3230	1.3564	1.3397
Category 4 1.6000 - 2.0999	171.302	210	0.1544	1.8040	1.8461	1.8251
Category 5 2.1000 - 2.5999	148.129	90	0.1486	2.2894	2.3516	2.3205
Category 6 > 2.6000	47.331	45	0.4258	2.8765	3.1324	3.0044
Mean average of psychological distance between pedestrian (m)						**1.6360**

In Table 4, the most obtained average of psychological distance occurred among pedestrian was in the range of Category 2 with the number of 272 data and it is the same as shown in Table 5 with 438 number of data and the measurement of psychological distance between these two tables in Category 2 are only slightly different with 0.8144m and 0.8550m psychological distance respectively. This has proven that most pedestrian will keep their distance in the aforementioned range. Based on Malaysian ecological system, the body height of the people is not as tall as the people in other countries that are mostly tall such as in the United States, Japan or in the United Kingdom and due to that particular reason, range of gap in Category 2 should be reasonable for Malaysian people among

normal body size. Range of more than 2.600 m shows the least data obtained during the analysis for both cases of pedestrian with and without relationship with only 5 and 45 number of data respectively. In this case, some people prefer or tend to keep their distance in a wider range due to their larger body size that requires them to have more spaces for their movement. Also, some people have prejudice attitude and this keeps them even further from the people that they find strange in term of physical appearance. But this does not classify a pedestrian has negative thoughts towards others but it is for the sake of safety issue due to many crime cases happened nowadays such as pickpocketing or even worse kidnapping. Another difference that can be seen is Table 5 shows that the top three range of distance among strangers are starting from Category 2 until category 4. On the other way around, Table 4 shows that the top three range among people that know each other are in Category 1, Category 2 and Category 3. Based on logic, it is reasonable for strangers to have wider range of distance between them compare to pedestrian that have relationships and both Table 4 and 5 show strong evidence of the situation.

Psychological distance between pedestrian is an important thing to be investigated in order to have better understanding about pedestrian walking behaviour. This field of studies may contribute to the improvement of current pedestrian simulation model where these results can be applied for making a simulation of pedestrian movement such as evacuation process during emergency cases (e.g. fire, earthquake and storm). Also, these results of pedestrian psychological distance can be useful in determining the optimum design of the building area so that a better evacuation planning can be arranged effectively and for an example, the standard width of a pathway based on [2] is 2.25m and in making a simulation of an evacuation process, this width and the results in this research studies can be applied in order to understand of how many people can be possibly evacuated in certain cases. Moreover, future researchers can also apply the results in this research in improving the individual-level simulation model that are varied in every country due to the difference in some aspects such as lifestyle as reviewed by [5], people that live in Tokyo, Japan with a very busy lifestyle walk faster with the speed of 1.56 m/s than Malaysian with the walking speed of 1.16 m/s as obtained by [9] and the obtained Japanese speed of walking may contribute to the difference of psychological distance between pedestrian in that country compare to Malaysian as studied in this research. Furthermore, the difference of body size in term of height may also contribute to the difference of pedestrian distance where taller people with longer legs usually walk even faster.

4 Conclusions

A bus terminal is an easy area for obtaining the video of walking people for the purpose of studying the behaviour of pedestrian. As successfully obtained in this research, there were 1,766 data of psychological distance among the free walking people that was observed for 45 minutes on a normal weekday. From the analysis, the pedestrian were categorized based on pedestrian with and without relationship, also based on range categories that the author found reasonable in order to have better understanding about the criteria that may contribute to various psychological distance among pedestrian. Based on the obtained results, higher measurements of psychological distance were obtained from pedestrian without relationship in line of both gender and gap range. Pedestrian without relationship tend to keep their average distance for about 1.6360m in length while pedestrian with relationship had their average distance among each other for about 1.5909m and the results between these two categories were only 2.70% different. In gender cases, the highest length of average psychological distance for both cases was 'Man to Man' category where pedestrian without relationship had shown higher value of distance than pedestrian that has relationship in which the results were 1.3669m and 1.0964m respectively. Same goes to

both 'Man to Woman' and 'Woman to Woman' categories, pedestrian without relationship had greater psychological distance than pedestrian with relationship with the difference of 31.41% and 24.30% respectively. In future, the author would like to propose more research studies on psychological distance among pedestrian in different places because the results may vary due to different functions of buildings or zones. So for that reason, a simulation model of evacuation process that can predict the behaviour of pedestrian for both individual-level and group cases can be developed and suitable for various case of studies.

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