Simulation of Pedestrian Behaviour in Urban Spaces. A Case Study of "Sidi Gaber" Public Space, Alexandria, Egypt

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1 ABSTRACT

Many people think that human behaviour in open spaces is 'chaotic' or at least very irregular. This differs from pedestrians' behaviour in complex situations to normal situations, where people apply an optimized behavioural strategy through these urban spaces. This means that urban design cannot be limited only to physical forms, but also includes people activities that play the important role in urban spaces. Hence, it supposed to be designed to meet pedestrians' needs and support their activities, while, pedestrians are trying to achieve their goals and get their destinations through those spaces. But unfortunately, there is a miss-match between their needs and spaces design in many urban spaces, which reflects on their behavior and leads them to act randomly in a very irregular way. This research discusses the idea of finding out the link between pedestrians' behavior and the design of urban spaces utilizing a computer simulation model for pedestrian movement in urban spaces, through an application in one of Alexandria's open spaces "Sidi-Gaber" railway station. This computer simulation technique would help architects, and urban designers to find, understand, and evaluate the negative and positive impacts of their designs on pedestrian's behavior through cities urban spaces before the implementation stage.

2 INTRODUCTION

Good urban design is not only about how places look, but actually it is the art of making places for people and about creating great places and spaces that work for the whole community and spell success. In this regard, the meaning of urban spaces cannot be limited only to the built environment which includes buildings, streets, plazas, trees and platforms, but also extends to people activities that play the important role in urban design (Cowan, R.et al 2006; Ellison, 2004).

Urban spaces can serve as a key design element in the urban design process in order to enhance life quality in urban areas. This leads to the need of open spaces that meet the expectation of the potential users. In order to properly design for pedestrian friendly open spaces, this research attempts to understand and analyze pedestrian movement pattern in an actual case study in order to formulate guidelines for a better people oriented activity planning.

Generally, many of our cities have the same problem of misuse of urban spaces or mismatch to user needs and that mainly, happen when a large number of pedestrians are outdoor using the same space figure (1).

Fig. 1: The relationship between urban spaces and pedestrian needs.

Spaces are supposed to be designed to meet pedestrians' needs and support their activities, while, pedestrians are trying to achieve their goals and get to their destinations through these urban spaces. In several cases, there might be a misuse in these spaces, reflected by the pedestrian behaviour and leads them to act randomly in a very irregular way. Figure (2) depicts pedestrians attempting to cross the street skipping the platforms' barriers.

Fig. 2: One of the observed behaviors in "Sidi Gaber" public space where pedestrians trying to cross the main street skipping the platforms' barriers

From many site observations people may cross the street from critical locations although there are pedestrian signs, zebra crossing lines, pedestrian tunnels or bridges. And in some cases it can be observed that pedestrians are not using walkways and street furniture in its’ right way, although of the good appearance materials. This could be for several reasons such as the existing of obstacles on their way, or possibly as a result of the bad arrangement of street furniture and traffic signs, related to narrow platforms. Through studying those behaviours, this research pinpoints the importance of analyzing pedestrian movement in conjunction with urban space design.

This research explores the link between urban space design and pedestrian needs, using a manual observation technique, in order to assess existing situation and future design proposals for pedestrian movement in one of Alexandria open spaces. The selected urban space is located in front of "Sidi-Gaber" railway station, and is characterised by a heavy and blended vehicles and pedestrian movements (Figure 3).

The research adopts a partially automated technique. A manual part consists of direct observations, photographs and videos that are used to analyze the existing situation and highlights the pedestrian movements' behaviour. While, an automated part uses a pedestrian simulator software that generates several alternative scenarios based on possible urban interventions that could change the pedestrian behaviour or movement patterns.

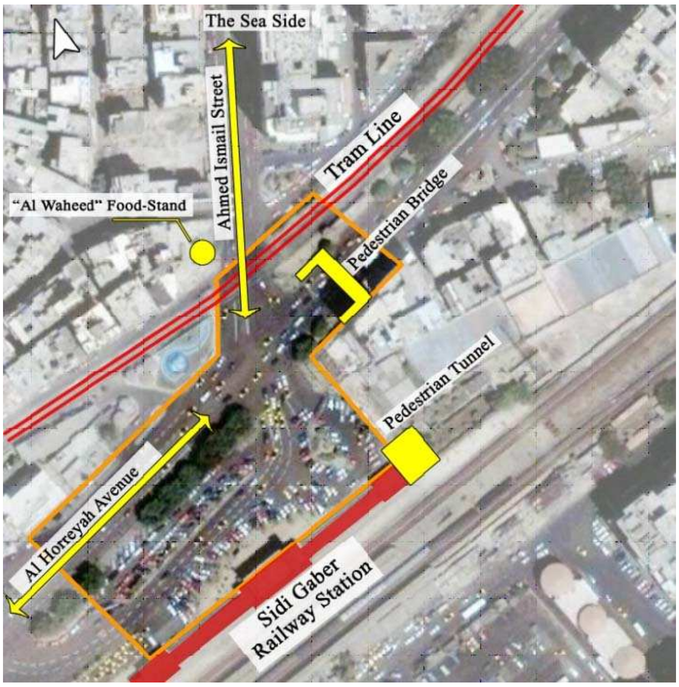

Fig. 3: The case study location, "Sidi Gaber", and the main focal points.

3 SIDI GABER OPEN SPACE

"Sidi-Gaber" open space is considered as an undefined transitional public space with loss of enclosure (figure 4a). It has several paths and nodes and contains multi focal points that play a crucial role in the city traffic and transportation functions. The main urban elements of the space are as follows (figures 4 a,b):

- "Sidi-Gaber" railway station in the south: works as a node in the space and is considered as a landmark in Alexandria city, while the railway lines could be considered as a strong edge.
- A pedestrian tunnel beside the station works as a path and is one of the pedestrians' destinations.
- The tram line in the north, works as an edge, and in the same time as a pedestrians' destination, while the tram station could be considered as a node.
- "Al-Horreyah Avenue" is an edge as a main vehicle street and in the same time works as a pedestrian path between its sidewalks.
- The sidewalks of this avenue have wide platforms for pedestrians' movement with long block barriers.
- Pedestrian bridge that links both sides of "Al-Horreyah Avenue" with escalators.
- "Ahmed Ismail Street" which is located almost perpendicular on "Al-Horreyah Avenue" and works as a path with some nodes such as "Al-Waheed" food-stand and other facilities for other shopping activities.

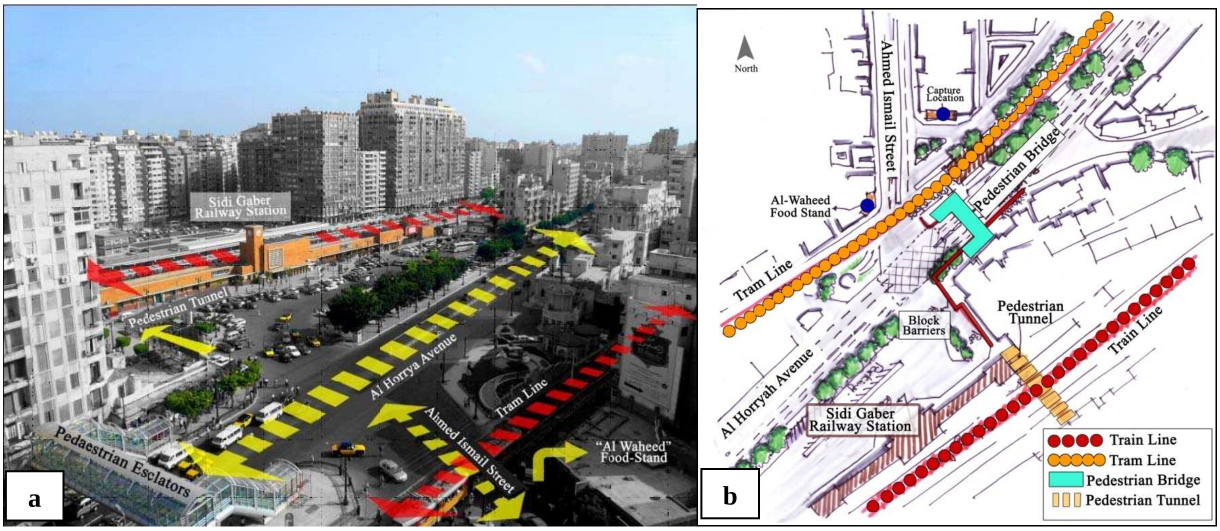

Fig. 4: (a) The study area and its main focal points, (b) Recording the selected study area and its' main surrounding elements

4 MODELING ELEMENTS

There are several modelling elements that have been applied on pedestrian movement studies on the microscopic level using time-lapse films, photographs and direct observations. These types of data gathering give a good empirical knowledge about the different behaviours of individuals in several types of environments and situations (Steiner, et al. 2007; Bierlaire, 2003; Teknomo, K. 2002). Based on this knowledge, the most important modelling elements are:

4.1 Agents

Pedestrians are translated for the modelling process into agents that are based on some elementary form of intelligence for each agent. The model belongs to the microscopic model category, where pedestrians (agents) are all pedestrians that will be traced during the simulation and act in their environment by making a sequence of decisions without considering age and gender. Simple behavioural rules are implemented (turning directions, obstacle avoidance) in order to reproduce more complex collective phenomena.

The simulation is iterating in loops over all agents where each agent is able to calculate its optimal walking path for any position and destination as long as there is such a path (Steiner, et al. 2007). To determine the next step (speed and direction), the simulation will first calculate the different forces influencing the agent:

- The forces leading the pedestrian toward its destination.
- The pedestrian force which ensures that the agents try to keep a certain distance from other pedestrians.
- The object force which ensures that pedestrians try to keep a certain distance from obstacles.

For the agents’ next step, several checks are needed to ensure that this step can actually be done as a position (figure 5):

- The position is within the field boundaries.
- No obstacles or walls are blocking the new step.
- No walls or obstacles are within the pedestrians' radius.
- No other pedestrians are standing within a range of twice the pedestrians' radius (Bierlaire, 2003).

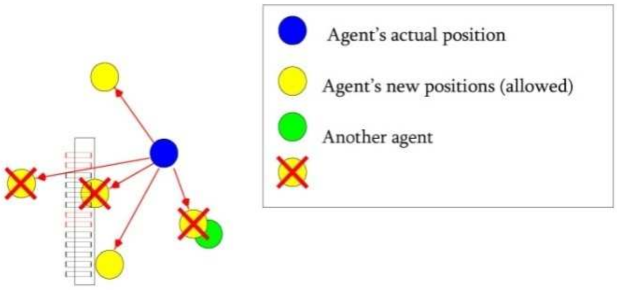

Fig. 5: Different forces influencing the agent through our simulation process.

4.2 Behaviour

From the field observations on the selected space there are a number of pedestrian paths that have been noticed as pedestrian movement destinations (figure 6). Within these paths, pedestrians need to cross “Al Horreyah Avenue” in order to arrive to their targets.

In addition, pedestrians usually cross the street from extremely critical areas that are in conflict with vehicles traffic. In order to eliminate such behaviour, the local authority constructed a pedestrian bridge and escalators that transfers the pedestrian crossing to an upper level. However, from observations, it was noticed that the pedestrians who choose to use the bridge are lower in number compared to the others who are still crossing the street from unexpected and unpredictable points.

It was noticed that both sides of "Al Horreyah Avenue” at the bridge location contain sidewalk barriers. These barriers are long and blocked, to control pedestrians and force them to use platforms. But actually, as observed, the barriers on the other side also prevent pedestrian on street from joining others on platforms, figure (7).

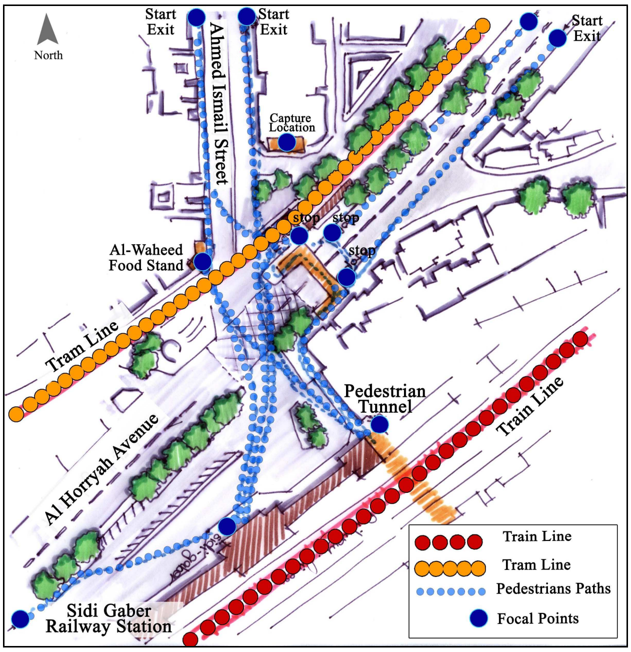

Fig. 6: Recording the main pedestrian movement patterns in the study area using manual observation.

Fig. 7: Al Horreyah Avenues' sidewalks that have long block barriers which prevent pedestrians from joining the same platform

4.3 Real Situation

The real situation has been tracked in different days (25/5/2008- 16/7/2008- 28/7/2008- 12/1/2009- 4/4/09) and recorded at different time intervals (10:00am, 11am, 12:00pm, 2:00pm, 3:00pm, 4:00pm) in order to manually analyze current pedestrian movement:

4.3.1 Before using the Pedestrian Bridge (28-7-08, 2:00 pm):

From video analysis it has been observed that there are two main pedestrian flows in the space, figure (8):

- The first flow generates from "Ahmed Ismail" street and the Tram Station in the north (which will be a Start point, presented with the blue circulation in figure 8, a), leading to the Pedestrian Tunnel and "Sidi-Gaber" railway station in the other side (as Exit points, presented with the red circulation in figure 8, a).
- The second flow was from the station and the pedestrian tunnel that is located beside the railway station (presented with blue circulation in figure 8, b) to the other side of “Al-Horreyah Avenue" (presented with the red circulation in figure 8, b).

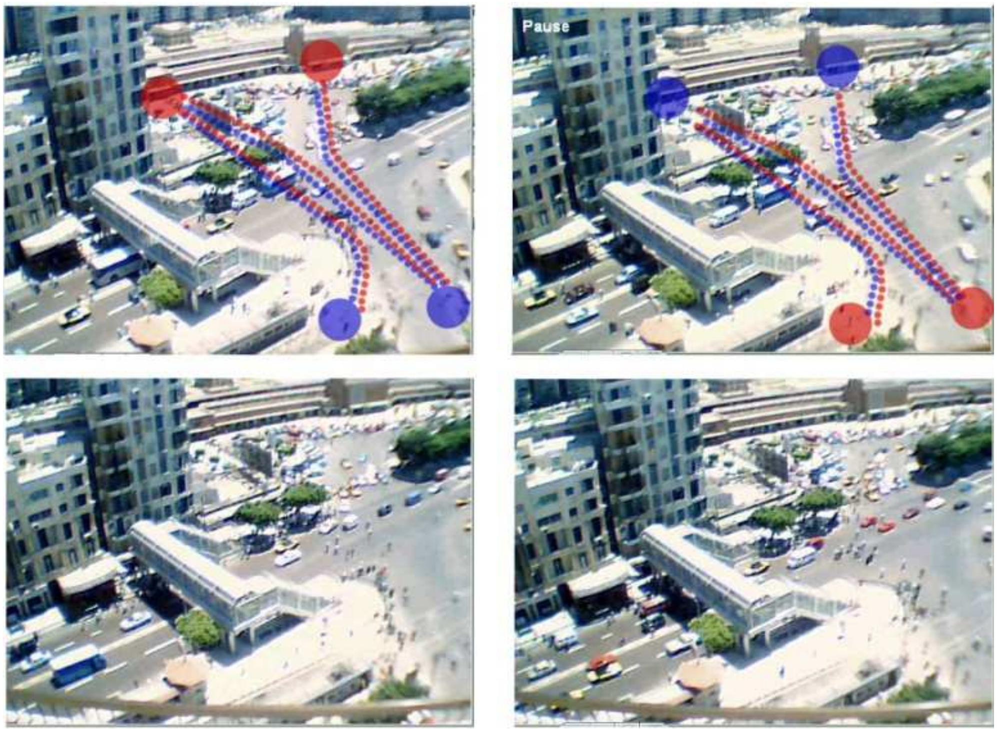

Fig. 8: The first observed flow before using the pedestrian bridge shows the main two pedestrians' flows (a,b), while (c,d) shows sample of these flows

4.3.2 After implementing the Pedestrian Bridge, (12-1-09, 11:00 am):

It is the same main two previous pedestrian directions. On one hand, pedestrians are trying to reach the pedestrian tunnel and railway station side. On the other hand, pedestrians are trying to reach the north side of the street in the ground level as figure (9), although there is a pedestrian bridge working to transfer pedestrian through the upper level.

Fig. 9: Different shots showing the new situation after using the pedestrian bridge which reflects the existing situation.

4.4 Simulation

The Microscopic Pedestrian Simulation Model (MPSM) is a computer simulation model of pedestrian movement where every pedestrian in the model is treated as an individual (Teknomo, K., 2002). This simulation is based on a two main pedestrian movement models: first, the social force model which assumes that the motivation of pedestrians to move consists of perception of the surrounding environment and the personal aims (Steiner, et al., 2007). Second, the agent based model that focuses on the behaviour of individuals and builds the image of the entire system based on the mutual interactions of the individuals. Both models have been selected for simulating pedestrian dynamics for a large number of behaviour (Kikuchi, et al., 2002).

Depending on studies of the pedestrian simulation tools, 'SimWalk 3.1.x' software, which is based on a simplified version of the Social Force Model, with the Agent Based Model, has been used to build several scenarios for existing and proposal designs in order to find the best suited one for the selected open space.

In SimWalk software every pedestrian is simulated as an autonomous agent who has been generated from a 'start point', follows a certain direction according to his goal and constrained by other agents or buildings. Pedestrian crowds can very realistically be simulated with such model which describes the different influences affecting individual pedestrian motion by a few simple force terms.

- The first force leads the agent towards its destination by using the potential field.
- A second force regulates the interactions between agents, ensuring that agents do not walk into other pedestrians and try to keep a certain distance from each other.
- The third force guarantees that agents do not walk into walls and that they try to keep a certain distance from walls.

Agents in the simulation are trying to reach their destinations through the shortest path and using any facility if it is in their way (SimWalk, 2009).

4.5 Simulation Process

The simulation process starts with determining points, according to the 'SimWalk' vocabularies, that have been applied through manual observations. These points have been analyzed and recognized depending on pedestrians' paths that have been observed as shown in figure (10).

The simulation translates these points into several architectural display objects that affect pedestrian scenarios as follows:

- "Start Points": When pedestrians are generated automatically by the program, all pedestrians are generated at the same time before the simulation through several Start Points. These start points were located according to the manual observations from the site without overlapping each other.
- "Exit Points": Where each pedestrian has origin and destination place. This origin and destination of the pedestrian are always within the pedestrian trap, when a pedestrian is generated by manual operation. These points have some parameters that should be completed within adding them such as capacity, frequency and opening time.
- "Waiting Areas": Generally, can be used as waypoints to assign a certain path to a pedestrian or a pedestrian group, for a certain direction; or as waiting areas with a certain delay time.
- "Delay Areas": Where pedestrian speed is reduced but no change of levels takes place, with some parameters as the delay percentage: utilization time, speed reduction or speed limit.

The delay area has been used in our application as a street crossing area on the ground level as it is most logically for delaying pedestrians speed because of both the traffic congestion and the lack of controlling pedestrian crossing.

- "Escalators": Are included between different levels 'ground and upper level' according to its' existing location. Pedestrians travel on escalators with a fixed speed as in reality (SimWalk, 2009).

There are some parameters that must be added with the escalators such as capacity, frequency, delay time and choosing the level which could be upper or lower level as shown in figure (11).

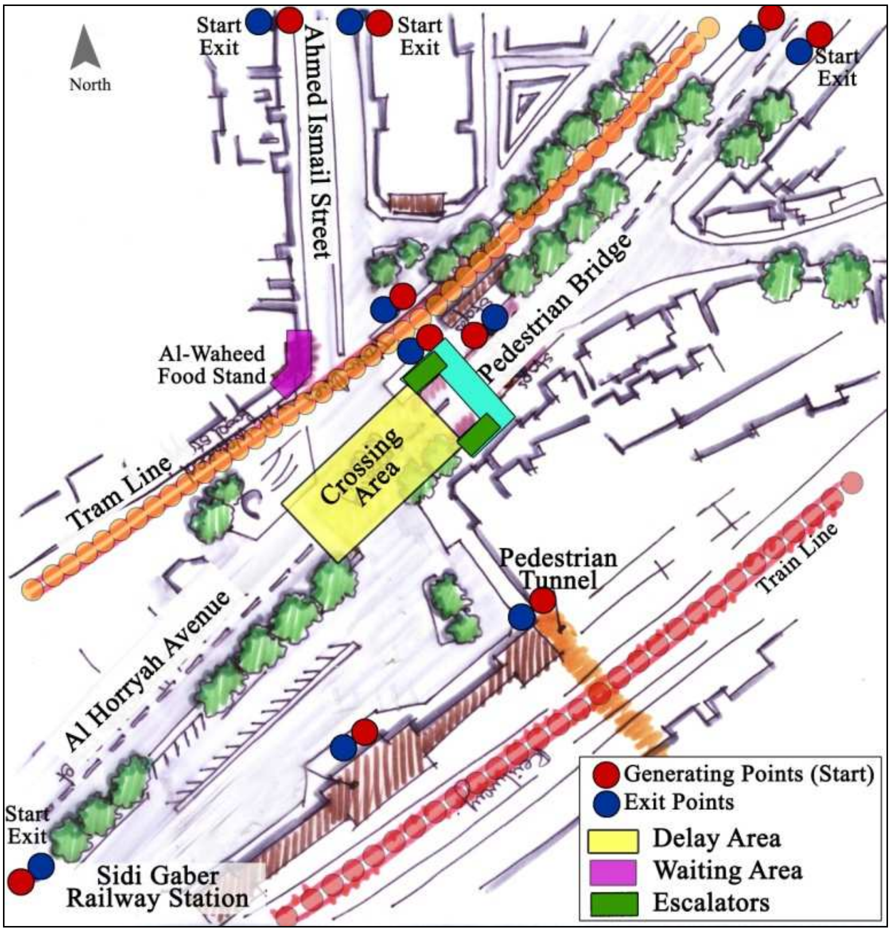

Fig. 10: A manual analysis of the main points which affect pedestrian behavior and flow through the selected area.

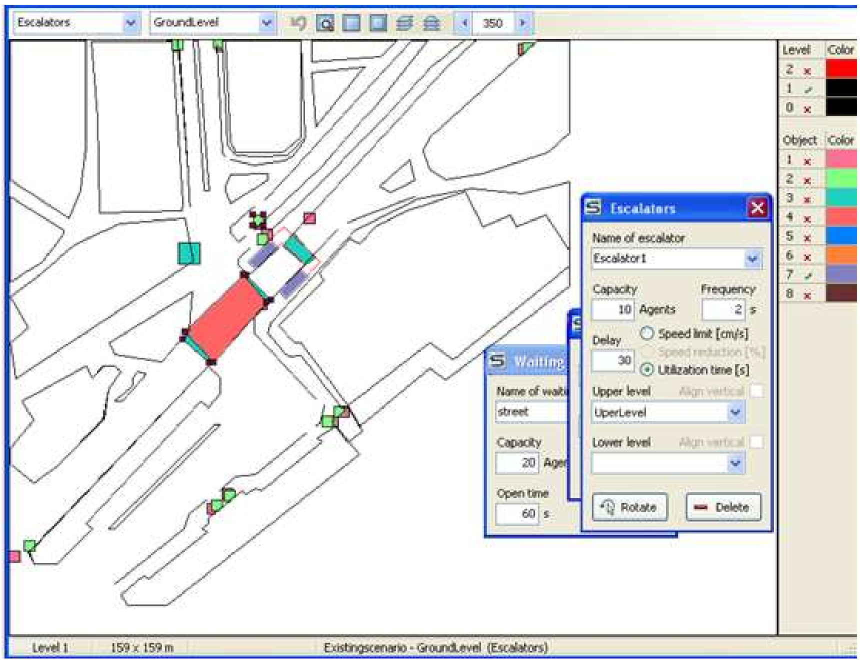

Fig. 11: The simulator display that shows the several focal points and parameters on the "Simwalk" software.

The program allows creating, editing or changing pedestrian or pedestrian group parameters and gives the ability to build the scenario by building the path from each start point to each exit point through "Agent Builder" beside if there are Waiting areas, Delay areas, Stairs, Escalators, Elevators and add that to a schedule that is free to be updated any time and saved. Here, the whole scenario is built through assigning each First point; Start point with start time range; Next point; Waiting area with waiting time and number of agents; Last point; Exit point with agents walking speed, as shown in figure (12).

The simulation output could then be used as an input to the video builder which allows creating customized video files of the simulation in (.swm) format. The video displays the simulation frames taken during the simulation run with the video capture functionality. Simwalk videos can be viewed with Simview stand-alone application. And as an output data the simulation could be displayed in several types: Agents as figure (13 a), Trails as figure (13 b), Densities or Loads.

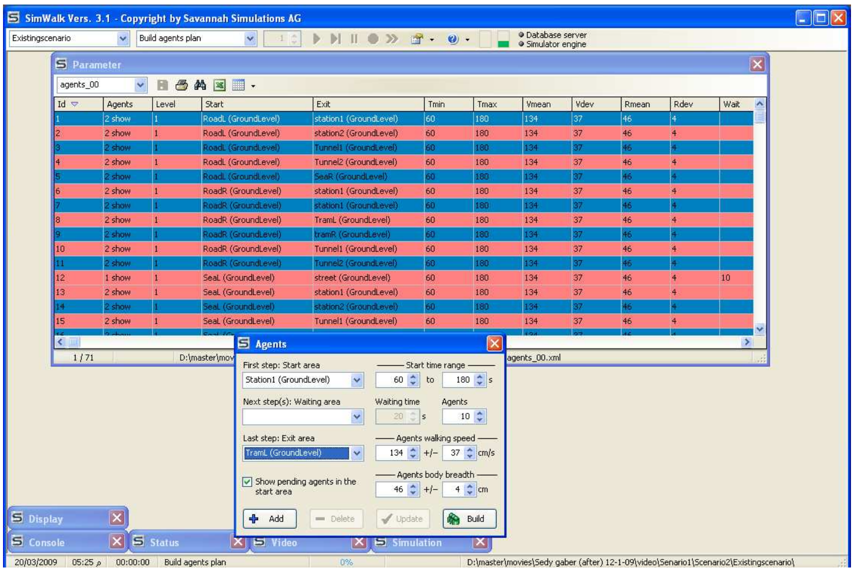

Fig. 12: The simulator display showing the Agent Builder through "Simwalk" software.

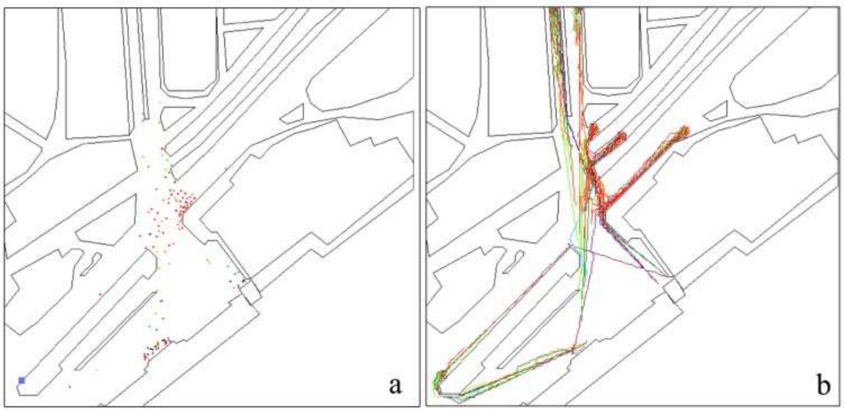

Fig. 13: (a) shows the simulations' display as Agents, (b) shows the simulations' display as Trails

4.6 The Simulation Behaviour

Through the simulation for the existing situation, it has been observed that the pedestrian choice was not in favour of using the bridge and escalators to cross the heavy vehicles traffic. One reason for that preference could be the misalignment of the bridge with the actual pedestrian path and movement, although it has been tried to attract agents to change their level through waiting area located on the upper level and has been put in their path with the agents' builder through the simulation process.

In an attempt to justify this behaviour, it has been tried to change the bridge location virtually through the Simwalk software to a new location that is better aligned with the agents' flow with some changes in the block barriers to give some entrances allowing pedestrians to join others on platforms (figure 14 a). The simulation process demonstrated an improvement in the use of the bridge in its new proposed location (figure 14 b,c,d,e).

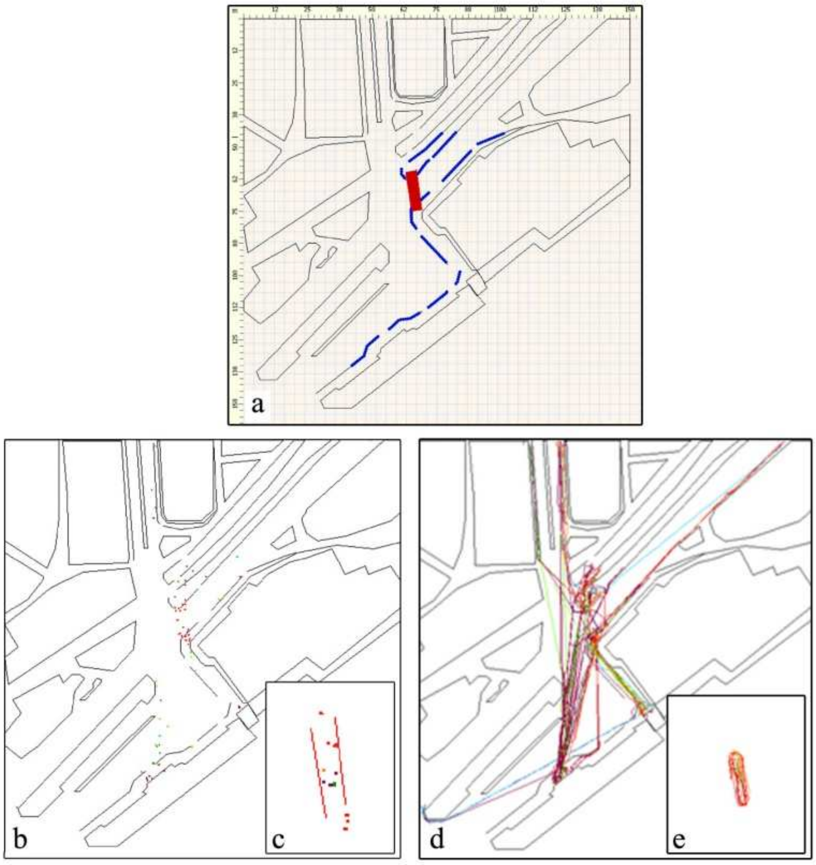

Fig. 14: (a) Shows the bridges’ virsual new location on the top view through Simwalk Draw software as a proposed design. (b,c) image shows agents scenario with the proposed bridge location that gives more chances to join the upper level using the pedestrian bridge. (d,e) image shows the resuls presented in trails

5 CONCLUSION

The study of pedestrian behaviour could be considered as one of the most important elements affecting decisions in urban design. Computer simulation models for pedestrian movement could be used as a supporting tool in the urban design process to guide architects and urban designers to find, understand, and evaluate the negative and positive impacts of their designs on pedestrian's behaviour. This tool could be more useful at the decision making phase so as to have the optimal and best design proposals before the implementation stage. Otherwise, the approuch using such a program is missing for the 3D geometrical aspects for more realistic movement simulation.

Through computer simulation several scenarios could be generated to present a broader view on the most suitable alternative that optimize pedestrian movement in conjunction with other traffic modes, while considering pedestrian needs and satisfaction.

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