Empirical Investigation on Pedestrian Dynamics in Presence of Groups: a Real World Case Study

(Extended Abstract)

Stefania Bandini, Luca Crociani, Andrea Gorrini, Giuseppe Vizzari
Complex Systems and Artificial Intelligence (CSAI) research center
University of Milano-Bicocca
Viale Sarca 336/14, 20126, Milano
{bandini, crociani, gorrini, vizzari}@disco.unimib.it

ABSTRACT

The paper reports the results of an empirical investigation on pedestrian dynamics in presence of groups. We consider a real world scenario in which an analysis of the impact of groups on the overall observed system dynamics was performed through manual counting and tracking. The simulation results are compared to empirical data and they show that the adopted model is able to produce quantitatively plausible results in situations characterised by the presence of groups of pedestrians.

Categories and Subject Descriptors

I.6 [**Simulation and Modeling**]: Applications

General Terms

Experimentation

Keywords

pedestrian and crowd modeling, interdisciplinary approaches

1. INTRODUCTION

The simulation of pedestrians and crowds is a consolidated and successful application of research results in the more general area of computer simulation of complex systems. One of the aspects of crowds of pedestrians that has only been recently considered is represented by the implications of the presence of groups. This paper represents a step in this direction, since it reports the results of a field observation and analysis of pedestrian and group behaviour then it introduces results of the application of a model for pedestrian simulation encompassing an adaptive model for the preservation of group cohesion [4] that is applied in a virtual counterpart of the observed scenario.

2. FIELD DATA ABOUT GROUPS

We report here some results of an observation performed on 24^{th} of November 2012 from about 2:50 pm to 4:10 pm, that analysed the bidirectional pedestrian flows within the Vittorio Emanuele II gallery, a popular commercial-touristic walkway situated in the Milan city centre (Italy). We will not report here details on the observation and analyses carried out (that can be found in [1]), we just report some relevant results from analysed samples that regard group influence on overall pedestrian behaviour in the scenario.

First of all, considering the *flow composition*, 16% of the pedestrians arrived alone, while the 84% arrived in groups: 44% of groups were couples, 17% triples and 23% larger groups (composed of four or five members). Large structured groups, such as touristic committees, were analysed considering sub-groups. We also measured the length of the *average walking path* of pedestrians: singles (M=13.96 m, ±1.11) present a longer trajectory than couples (M=13.39 m, ± 0.38), triples (M=13.34 m, ± 0.27) and groups of four members (M=13.16 m, ± 0.46). On the other hand, the *average walking speed* of singles (M=1.22 m/s, ± 1.16) is higher than that of couples (M=0.92 m/s, ± 0.18), triples (M=0.73 m/s, ± 0.10) and groups of four members (M=0.65 m/s, ± 0.04). Singles have frequent changes of direction in order to maintain their velocity, avoiding perceived obstacles (i.e. other pedestrians and groups), *trading travel distance for speed*. On the contrary, groups have a more stable overall behaviour, adjusting their spatial arrangement and speed to face the contextual conditions of irregular flow: this is probably due to (i) the difficulty in coordinating an overall change of direction and (ii) the tendency to preserve the possibility of maintaining cohesion and communication among members. Finally, we measured the average proxemics dispersion in terms of distance of each member from centroid of the group (as discussed in [2]); the growth of group size implies a growing dispersion since couples (M=0.35 m, ± 0.14) are more compact than triples (M=0.53 m, ± 0.17), which in turn are less dispersed than groups of four members (M=0.67 m, ± 0.12).

3. SIMULATION RESULTS

The scenario analysed in the previous section has been also simulated adopting the model model described in [4]. For sake of space we omit details of the model, reporting only some characterising elements of the model and a few relevant details of its configuration for this simulation.

The adopted model essentially extends a floor-field Cellular Automata approach granting agents the possibility to adaptively modulate the significance of different behavioural

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LoS	Size	Av. Dispersion	Observed
A	2	0.336 (± 0.157)	
	3	0.479 (± 0.153)	
	4	0.575 (± 0.146)	
B	2	0.351 (± 0.174)	0.35 (± 0.14)
	3	0.505 (± 0.194)	0.53 (± 0.17)
	4	0.609 (± 0.210)	0.67 (± 0.12)

Table 1: Average groups dispersion achieved by the simulations (standard deviation inside parentheses).

LoS	Size	Av. Speed	Observed
A	1	1.19	
	2	1.115	
	3	1.119	
	4	1.11	
B	1	1.172	1.22
	2	1.107	0.92
	3	1.105	0.73
	4	1.099	0.65

Table 2: Average speeds of groups.

LoS	Size	Av. Distance	Observed
A	1	13.767 (± 0.57)	
	2	13.922 (± 0.621)	
	3	13.980 (± 0.624)	
	4	14.052 (± 0.653)	
B	1	13.857 (± 0.577)	13.96 (± 1.11)
	2	13.99 (± 0.628)	13.39 (± 0.38)
	3	14.049 (± 0.654)	13.34 (± 0.27)
	4	14.087 (± 0.653)	13.16 (± 0.46)

Table 3: Average travelled distance of groups.

components, and in particular goal orientation, to preserve the cohesion of the group they belong to.

The environment in which simulations were performed is a discrete representation of the part of Vittorio Emanuele Gallery consisting in a large corridor with size 12.8 m × 13.6 m. Pedestrians were configured to perform a kind of trajectory resembling the observed one and their generation respected the frequency of arrival observed in the videos, corresponding to Level of Service (LOS) B but also lower density conditions, LOS A. The agent population comprises 15.8 % of individuals, while the remaining part is divided in groups of 2 (52%), 3 (20%) and 4 (28%) members, consistently with the observed composition of pedestrian population. In order to overcome biases caused by the simulation initialisation, for both density configurations, a set of 5 relatively short simulations (5 minutes of simulated time, for a total of 25 minutes of simulated time for both LOS conditions) has been run with different random seeds.

The first measured data represents an indicator of the average dispersion of the different types of group during the simulation. The results, shown in Table 3 show that the cohesion mechanism is quite effective: the dispersion of groups in the two settings (LoS A and B) is similar and the increase of density have led to a very light increase of the average and standard deviation. The most important consideration, however, is the fact that these data are consistent with the empirically observed values (which refer to the B LOS conditions).

Table 3 shows instead the average speed characterising the movement of the different types of pedestrians (individuals or members of a certain type of group), calculated using the length of the actual trajectory and the time needed to move from the start area to any cell of the destination area of the corridor. In this case the model has only been able to reproduce results similar to the empirically observed data only for individuals and it only showed a slight decrease in the velocity of group members. On the other hand, it must be noted that all the agents have been configured with the same desired speed of 1.3 m/s, that is based on empirically observed velocity for pedestrians traveling for business purpose [3]. The same observation reports that pedestrians moving for leisure generally have a lower average walking speed. Therefore, our conjecture is that the much lower walking speed of groups might be due not only to the fact that members try to preserve the possibility to establish verbal and non-verbal communication, but also to a change in the reason and motivation for moving in the environment.

Finally, Table 3 analyses average travel distances covered by pedestrians in the simulations. This measure is obviously strictly related to the previous one, being actually used in the computation of the walking speed. As a consequence, even if simulated trajectories are very close to the measured ones also in this case the model was not able to differentiate paths covered by individuals and group ones (in some cases the traveled distance of individuals was actually lower, unlike in the observed data). In addition to the above considerations on motivations of the movement, that can also have an influence in the frequency of direction changes, we want to emphasise that a discrete model has intrinsic limits in the faithful reproduction of trajectories (that are inherently jagged and not as smooth as the real ones), so it could be difficult improving this kind of result adopting a discrete model.

4. REFERENCES

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