An Agent-Based Model for Pedestrian and Group Dynamics: Experimental and Real-World Scenarios

(Extended Abstract)

Giuseppe Vizzari, Lorenza Manenti*
Complex Systems and Artificial Intelligence (CSAI) research center
University of Milano-Bicocca
Viale Sarca 336/14, 20126, Milano
{vizzari, manenti}@disco.unimib.it

ABSTRACT

The paper presents a modeling and simulation effort aimed at studying the implications of the presence of groups of pedestrians in different situations (e.g. changing density, configurations of the environment) in experimental and real world scenarios.

Categories and Subject Descriptors

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

General Terms

Experimentation

Keywords

pedestrian and crowd modeling, interdisciplinary approaches

1. INTRODUCTION

The agent–based approach to the simulation of complex systems is a relatively recent but extremely successful application area of concepts, abstractions, models defined in the area of autonomous agents and multi–agent systems (MAS). Crowds of pedestrians represent a typical example of complex system: the overall behavior of the system can only be defined in terms of the actions of the individuals that compose it, and the decisions of the individuals are influenced by the previous actions of other pedestrians sharing the same space. Despite the substantial amount of research efforts this area is still quite lively and we are far from a complete understanding of the complex phenomena related to crowds of pedestrians in the environment: one of the least studied and understood aspects of crowds of pedestrians is represented by the implications of the presence of groups [1]. In particular, little work has been done on the modeling and simulation of relatively large groups within a crowd of pedestrians [3].

This work presents the results of an agent–based model of pedestrians considering groups as a first–class abstraction influencing the behaviour of its members and, in turn, of the whole system. The model was tested in a schematic situation, also analyzed by means of experiments, to characterize the implications of groups in the overall pedestrian dynamics and in a real world scenario in which pedestrians were organized in large groups for sake of crowd management.

2. MODEL AND SIMULATION RESULTS

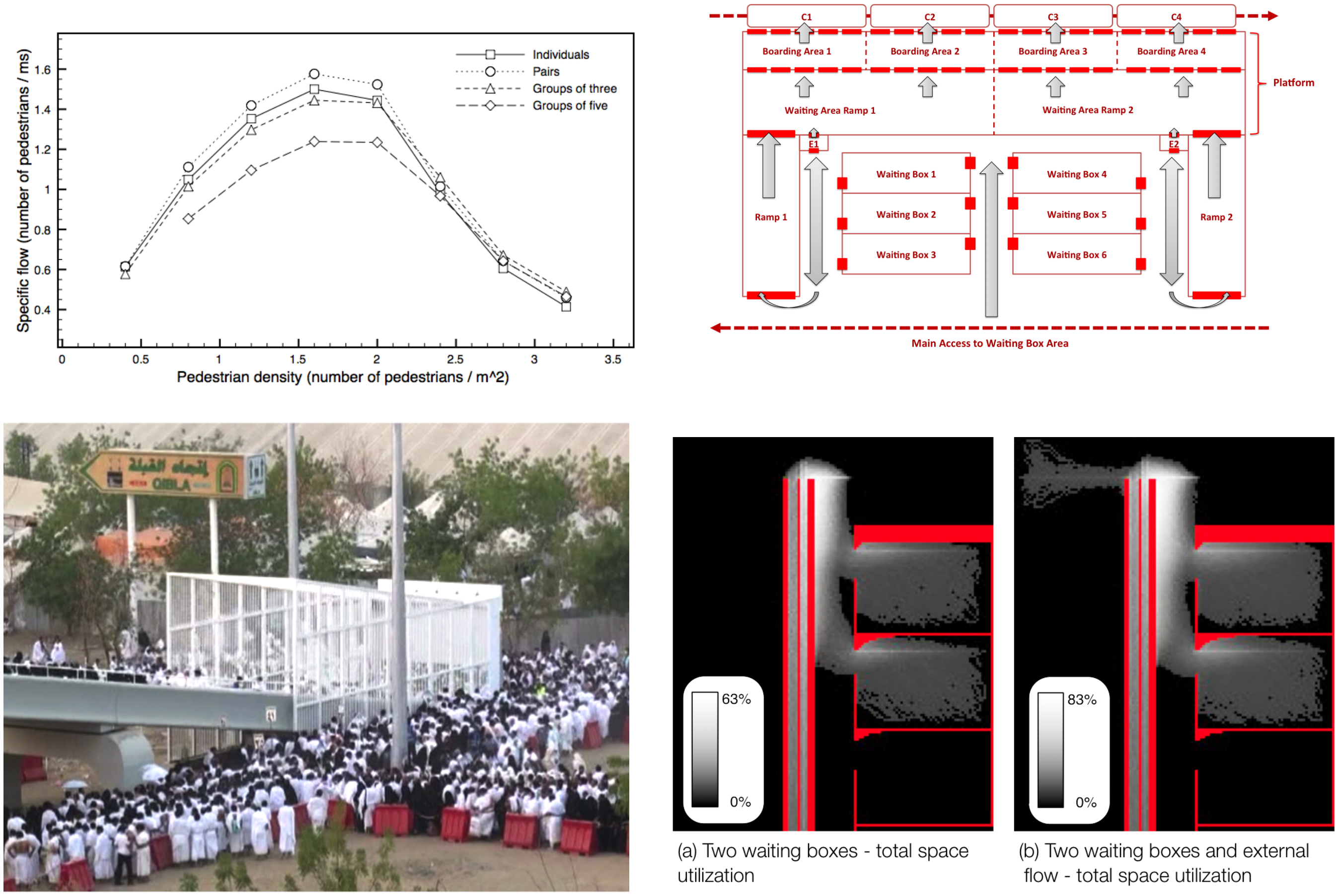
The adopted approach is discrete both in space and in time; the environment in which the simulation takes place is a lattice of cells, each representing a portion of the simulated environment and comprising information about its current state, both in terms of physical occupation and in terms of additional information. To support pedestrian navigation in the environment, the lattice is provided with a static floor field [4] which specifies the shortest path to destinations and targets. Pedestrians have a limited form of autonomy: they can choose were to move according to their perception of the environment and their goal. The choice of the actual movement destination is based on the elaboration of an utility value, called *likability*, representing the desirability of moving into a given position: the presence of members of the group a pedestrian belongs to in a nearby cell is considered positively, unlike the presence of other pedestrians. A complete description of the model can be found in [2].

A set of simulations in an experimental and in a real world situation aimed at evaluating the impact of the presence of groups has been investigated. The figures shown in Figure 1 report an overview on simulation results. The top left part shows a fundamental diagram representing data obtained through several simulations in a simple scenario (a corridor in which pedestrians flow in opposite directions). The results are in tune with the experimental data coming from observations and available in the literature; an original result is the fact that groups of different size have a different ability to flow smoothly in different density situations.

The model was also employed in a real world scenario: a station of the Mashaer line, a newly constructed rail line in the area of Makkah to reduce the congestion caused by the presence of other collective means of pilgrim transportation (i.e. buses) during the Hajj. The simulations were focused on the Arafat I station, in particular in the process lead-

*Crystals Project, Centre of Research Excellence in Hajj and Omrah (HajjCORE), Umm Al-Qura University, Makkah, Saudi Arabia.

Appears in: *Proceedings of the 11th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2012)*, Conitzer, Winikoff, Padgham, and van der Hoek (eds.), 4-8 June 2012, Valencia, Spain.



(a) Two waiting boxes - total space utilization

(b) Two waiting boxes and external flow - total space utilization

Figure 1: Images and diagrams related to simulation results.

ing pilgrims from outside the station area to the platforms. The flow is organized adopting waiting-boxes: groups of 250 pilgrims wait in special areas for an authorization by the station agents to move towards the ramps or elevators. The top right part of Figure 1 is a schematic representation of an area of the station with the permitted pedestrian flows; the bottom left photo shows a situation in which the waiting-box principle, preventing the possibility of two flows simultaneously converging to a ramp, was not respected, causing a higher than average congestion around the ramp. Different simulation scenarios were realized to understand the capability of the model to reflect the increase in the waiting times and the space utilization when the waiting box principle was not respected. The bottom right diagrams report the space utilization, i.e., the relative frequency of the cell occupation on the whole simulation time. The second scenario, in which the waiting box principle is not respected, is characterized by a noticeably worse performance not only from the perspective of the size of the area characterized by a medium-high space utilization, but also from the perspective of the highest value of space utilization (83% respect to 63% of the regular scenario). This confirms that increasing the number of pilgrims that are simultaneously allowed to move towards the ramp highly increases the number of cases in which their movement is blocked because of overcrowding. According to these results, the management of the movement of group of pilgrims from the tents area to the ramps should try to avoid exceptions to the waiting box principle as much as possible.

Acknowledgments

This work is a result of the Crystal Project, funded by the Centre of Research Excellence in Hajj and Omrah (Hajj-CORE), Umm Al-Qura University, Makkah, Saudi Arabia, `http://www.csai.disco.unimib.it/CSAI/CRYSTALS/`.

3. REFERENCES

[1] Understanding crowd behaviours: Supporting evidence. `http://www.cabinetoffice.gov.uk/news/understanding-crowd-behaviours`, 2009.

[2] S. Bandini, F. Rubagotti, G. Vizzari, and K. Shimura. An agent model of pedestrian and group dynamics: Experiments on group cohesion. IN *AI*IA*, volume 6934 of *LNCS*, pages 104–116. Springer, 2011.

[3] M. Moussaïd, N. Perozo, S. Garnier, D. Helbing, and G. Theraulaz. The walking behaviour of pedestrian social groups and its impact on crowd dynamics. *PLoS ONE*, 5(4):e10047, 04 2010.

[4] A. Schadschneider, A. Kirchner, and K. Nishinari. CA approach to collective phenomena in pedestrian dynamics. In *ACRI 2002*, volume 2493 of *LNCS*, pages 239–248. Springer, 2002.