Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 2 (2014) 430 – 435

Transportation Research Procedia

www.elsevier.com/locate/procedia

The Conference on Pedestrian and Evacuation Dynamics 2014 (PED2014)

Do groups matter? An agent-based modeling approach to pedestrian egress

Andrew Collins[a]* , Terra Elzie[a], Erika Frydenlund[a], R. Michael Robinson[a]

[a] *Virginia Modeling, Analysis and Simulation Center, Old Dominion University, Suffolk, 23435, USA*

Abstract

Festivals in city parks attended by individuals and families are a universal feature of urban life. These venues often have the common attributes of vendors and other obstacles that restrict pedestrian movement through certain areas, as well as fixed number of exits. In this study, the authors build an agent-based model (ABM) that incorporates group cohesion forces into this type of pedestrian egress scenario. The scenario considered was an evacuation of 500 people through a single exit. This allowed an investigation into the use of two different simulated pedestrian's heading updating rules.

Peer-review under responsibility of Department of Transport & Planning Faculty of Civil Engineering and Geosciences Delft University of Technology

Keywords: pedestrian crowds; evacuation modeling; social groups; social forces; agent-based modeling and simulation

1. Introduction

Festivals in city parks attended by individuals and families are a universal feature of urban life. These venues often have the common attributes of vendors and other obstacles that restrict pedestrian movement through certain areas, as well as fixed number of exits. When determining the layout of a venue, it is important to consider the safety and effectiveness of pedestrian egress. Thus, there is a demand for using simulation to evaluate the different venue designs. There are different approaches to achieve this, from macro-simulation (Henderson (1974), Helbing (1992), Treuille et al. (2006), Bauer et al. (2007)) to meso-simulations (Hanisch et al. (2003)) to micro-simulation (Okazaki (1979), Helbing et al. (2000), Klüpfel et al. (2001)).

* Corresponding author. Tel.: +1-757-638-4437.
E-mail address: ajcollin@odu.edu

Peer-review under responsibility of Department of Transport & Planning Faculty of Civil Engineering and Geosciences Delft University of Technology
doi:10.1016/j.trpro.2014.09.051

In the early days of pedestrian micro-simulation, the flow of the individuals did not look natural to an observer; the movements were very jumpy and did not appear to replicate the expected flows of pedestrians that are observed in crowds. To overcome this jumpiness, modelers introduced coherent and smoothing functions. The two most famous of these are Reynold's Boids model (Reynolds (1987)) and the Social Forces of Helbing and Molnar (1995). Both of these approaches average out the potential influences on a simulated individual's heading and produce an aesthetically pleasing visualization of the flow of pedestrian movement. One reason for the improved results is that all of the simulated pedestrians tend to have the same directional goals; that is, they are homogeneous. What if the simulated pedestrians were heterogeneous and had different heading objectives like maintaining cohesion within their own individual groups as well?

In this study, the authors use Repast Simphony to build an agent-based model (ABM) that incorporates group cohesion forces into this type of pedestrian egress scenario. The pedestrian agents have two goals: (1) exit the venue and (2) maintain a level of cohesion within their group. The study compares two approaches to updating agent headings while incorporating these two goals. The first approach uses the weighted averaging approach of social forces (Helbing and Molnar (1995)). The second approach considers a discrete stochastic selection approach between the two goals, which is updated at each time-step. The results from this approach were quite surprising. The paper also considers the impact of the level of group cohesion.

Several other researchers have looked at the effects of group dynamics on simulated pedestrian egress (Vizzari et al. (2013), Wijermans et al. (2013), Pluchino et al. (2014)). However, other studies used a weighted average heading approach to dealing with multiple individual pedestrian objectives. We believe that this is the first paper that takes a step-back from the currently accepted approach of weighted averaging headings to consider ways to overcome its limitations. The approach to group dynamics, outlined in this paper, is a simple one for this simple purpose; for a more detailed approach to pedestrian group dynamics, please see Elzie et al. (2014).

The next section discusses the scenario and the model design. This is followed by a discussion on the simulation results. Finally, conclusions are given.

2. Model

The simulation is based on a simple scenario of a large group of people trying to exit an area. The exit is on the other side of a wall which has a single gap in it for the pedestrians to traverse; this gap also has a single pillar in front of it to disturb flow. The scenario is designed to represent a generalizable pedestrian evacuation where individuals leave a non-descript venue through one exit (Fig. 1). The simplicity of the scenario allows for experimentation of heading update algorithms which can later be applied to more specific venues. The evacuees, 500 in this example, must pass through a narrow passage, shown as a gap in the black wall, to reach the red square-shaped exit on the right. There is also a black square pillar placed immediately before the gap. Each group is uniquely colored with the leader outlined in black. Given the sheer number of groups (67 in this example) the coloring between different groups might look very similar. The left-hand side of the diagram shows several groups heading toward the exit led by their leaders. The size of the groups varies from one to fifteen.

On initialization, the simulation splits the pedestrians into groups of size one to fifteen. A leader is selected for the group and, initially, the agents are placed near the leader (on the left-hand side of Fig. 1). If a leader leaves the simulation for any reason, a new leader is randomly selected. At every time-step each individual will move a fixed distance, about half a meter, in the direction of their current heading. The heading is determined by a mechanism within the simulation that has several parts, namely:

- If the pedestrian is within a fixed distance of the leader, then she heads towards the exit.
- If the pedestrian is more than a fixed distance of the leader, then a heading is selected depending on the simulation setup.