A Framework for Modeling Social Groups in Agent-Based Pedestrian Crowd Simulations

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ABSTRACT

Grouping is a common phenomenon in pedestrian crowds and social groups can have significant impacts on crowd behavior. Despite its importance, how to model social groups in pedestrian crowd simulations is still an open and challenging issue. This paper presents a framework for modeling social groups in agent-based pedestrian crowd simulations. The developed framework integrates agent behavior modeling, group modeling, and social context modeling in a layered architecture, where each layer focuses on modeling a specific aspect of pedestrian crowds. A model of dynamic grouping behavior is developed to demonstrate the utility of the developed framework, and experimental results are presented.

Keywords: Dynamic Grouping, Framework for Group Modeling, Grouping Behavior, Pedestrian Crowd Simulations, Social Groups

1. INTRODUCTION

Grouping is a common phenomenon in pedestrian crowds. According to the work of (Adrian, 1997; Loscos, Marchal, & Meyer, 2003), pedestrian crowds contain both grouped and isolated individuals. In the settings of a city, less than a half of the pedestrians walk alone (Loscos et al., 2003). For example, in a shopping mall, family members stay beside each other and maintain the group in a clustered way during the activity (Qiu & Hu, 2009). Grouped pedestrians can be found in emergency situations as well. According to social proof theory, when an individual lacks objective evaluation in the emergency (e.g., evacuate from a building in fire), the individual tends to follow the actions of others as a guide on how he/she might act. One example of social proof is the herding behavior – when under highly emergent situations, an individual tends to follow others almost blindly (Pan, Han, Dauber, & Law, 2007). This is an example where people form social groups dynamically and follow the “leaders” spontaneously.

Social groups play important roles in affecting crowd behaviors. Social groups affect the flow of pedestrian crowds as well as the evacuation efficiency in emergency situations. As discussed in Santos and Aguirre (2004), a leader-follower group may be more smooth...
and efficient than a clustered group if the group has a large number of members. In this case, a clustered group can result in slow movement, especially in a constrained area. The work of Yang, Zhao, Li, and Fang (2005) simulates the kin behavior in emergent evacuations and shows that the number of sub-groups and the members in each sub-group influence the evacuation efficiency significantly. The work of Klupfel, Meyer-Konig, and Schreckenberg (2004) studies the effect of group size on the walking speed through controlled experiments and concludes that the walking speed decreases as group size increases.

Social group has been an active research topic in sociology and psychology where a group is generally defined as a set of collected persons who share common goals and norms (McDougall, 1920). Although social groups are extensively studied in socio-psychology, how to model social groups is still an open issue (Klupfel, et al., 2004) and group modeling is not incorporated into most pedestrian crowd models. Group modeling is a challenging task because of the non-linear interactions in pedestrian crowds and the dissimilarity nature of pedestrians. Many factors need to be considered, such as individual characteristics, group size, relationships among groups, and influences among group members (Braun, Musse, de Oliveira, & Bodmann, 2003; Santos & Aguirre, 2004). Existing work for simulating social groups mainly focuses on the perspective of reproducing some group-level behaviors based on specific social or psychological theories, such as social comparison theory (Festinger, 1954; Fridman & Kaminka, 2007) or five-factor personality model (Durupinar, Allbeck, Pelechano, & Badler, 2008; Ghasem-Aghaee & Oren, 2007; Jaganathan, Clarke, Koshti, Kaup, & Oleson, 2007). Even though these existing works study some aspects of grouping, they do not provide a unified framework to explicitly model the intra-relationship of group members and inter-connections between groups for exploring the effect of different social or psychological factors on the grouping behavior.

This deficiency motivates us to develop a framework for modeling social groups in pedestrian crowd simulations. Because of the complicated and non-linear nature of social interactions, agent-based simulation is widely adopted in pedestrian crowd systems where each pedestrian is treated as an autonomous entity, which can behave independently according to predefined action rules. Agent-based pedestrian crowd simulations can simulate many intriguing collective behaviors, such as the herding behavior mentioned above, emerging from the interactions between individuals. Our framework adopts the agent-based simulation and incorporates the grouping behavior into the model of pedestrian agents (see Section 3 for details). This paper extends our previous work (Qiu & Hu, 2009) that focuses on modeling the intra-group structure and the inter-group relationships in pedestrian crowds. Built on the previous work, this paper presents a unified and well-defined framework that integrates agent behavior modeling, group modeling, and social context modeling for modeling social groups in pedestrian crowd simulations. A model of dynamic grouping behavior is developed to demonstrate the applicability of the developed framework.

The remainder of this paper is organized as follows. Section 2 presents the related work of crowd behavior models and group modeling in pedestrian crowd simulations. Section 3 describes our framework for modeling social groups in agent-based pedestrian crowd simulations. One important component of the framework, the group model, is described in Section 4. Section 5 presents an application of the developed framework to simulate the dynamic grouping behavior where groups are dynamically changed during the simulation. Section 6 concludes this paper and proposes some future research directions.

2. RELATED WORK

Pedestrian crowd simulations are used to study crowd behaviors in situations where experi-
Scatter Search and Path Relinking: A Tutorial on the Linear Arrangement Problem
Rafael Martí, Juan-José Pantrigo, Abraham Duarte, Vicente Campos and Fred Glover (2013). *Recent Algorithms and Applications in Swarm Intelligence Research* (pp. 1-21).
www.igi-global.com/chapter/scatter-search-path-relinking/70638?camid=4v1a

The Meaningfulness of Statistical Significance Tests in the Analysis of Simulation Results
www.igi-global.com/article/the-meaningfulness-of-statistical-significance-tests-in-the-analysis-of-simulation-results/193956?camid=4v1a