An Agent-Based Model of Crowd Cognition

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Keywords:
crowd modeling, agent-based model, cognitive states

1. The Need for Crowd Models

Crowds are pervasive and typically begin as a heterogeneous set of individuals. However, even a relatively undifferentiated heterogeneous set of individuals will rapidly form a cohesive unit and perceive themselves as part of the larger group when faced with an external threat (Reicher, 1996; Stott & Reicher, 1998). It is important to understand the factors that drive the behavior of such crowds from a physical as well as psychological perspective. The purpose of this paper is to present a real-time agent-based approach to modeling human behavior that is based on complementary psychological and engineering principles.

While operating within a group, individual members’ behavior is typically driven by external influences, common goals, individual goals and environmental constraints. The approach by which these factors are incorporated into a model dictates the application areas for which such a model can be used. For example, focus on external influences and environmental constraints would be appropriate for evacuation disaster modeling, as crowd behaviors in such situations are largely reactive and driven by danger avoidance. On the other hand, a model used for analysis on crowd control approaches would need to incorporate common goals (i.e., protest) and individual goals (i.e., incite). Our approach is general in the sense that it incorporates all of these factors but allows independent calibration and customization of their contribution into the overall model. Our model uses a typical agent-based feedback loop where environmental influences affect an individual’s internal state, which in turn yields behaviors and actions that allow interactions with and affect the external environment. Figure 1.1 illustrates the basic structure of the model.

1.1 Model parameters

Typical crowd behavior models concentrate entirely on the physical aspect of an individual’s behavior. There has been extensive work on the development of algorithms for realistic and efficient simulation of crowd motion, path planning, and grouping. Such models have focused on the motion of crowds (Helbing & Molnar, 1995), and the ability to influence crowds (Kirkland & Maciejewski, 2003). Earlier versions of our model have attempted to incorporate some realistic, culturally-differentiable behaviors based on physical as well as credible, psychological principles (Petty, McKenzie & Gaskins, 2003; Weisel & Petty, 2004). However, little if any work has been done on simulating specific cognitive and emotional aspects of crowds.

Our model achieves this by incorporating a physical layer that builds on the social forces model (Helbing & Molnar, 1995) by adding action- and context-specific steering forces to the basic model. This extension
allows implementation of various actions such as seeking, fleeing, escaping, queuing, etc. However, the unique contribution of our work is the scientific approach used to model the cognitive aspects of an individual. For example, this model would illustrate the conjoint effects of emotion sharing, spreading attitudes (Walther, 2002) and nonverbal gestures of crowd members. An individual’s cognitive state is treated as a vector of scalar state variables, each representing a basis emotion, for example, fear, anger, surprise etc. Each emotional component in turn is influenced by two factors – (1) a self-decay, that represents the subsiding of reactive emotions over time, and (2) a stimuli-driven factor that depends on perceived stimuli. The state vector itself is quantized into a discrete value which is then used to generate new actions or maintain existing actions. Figure 1.2 illustrates this approach.

Figure 1.2. Illustration of key model parameters

There are several challenges associated with each model component. For example, the model must realistically handle multiple stimuli and their cumulative effect on each emotional component. One particular challenge is the presence of contradictory stimuli, for example fear inducing stimuli such as an explosion and fear reducing stimuli such as positive emotions on the faces of crowd members. We have developed an approach based on basic human psychology that handles the repeated and cumulative effect of similar and contradictory stimuli on each state. Another challenge is that the model must also handle action generation in a way that produces realistic and feasible behaviors. Our model addresses this issue by associating priorities and preempt-ability with each action, along with an algorithm that resolves and fuses new actions with existing actions. The working model incorporates various scenarios and has the capability to simulate typical crowd behavior assuming different cognitive states under each of these scenarios.

3. References


Author Biographies

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