Towards a computational model of social comparison: Some implications for the cognitive architecture

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Natalie Fridman *, Gal A. Kaminka

The MAVERICK Group, Computer Science Department, Bar Ilan University, Israel

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Abstract

We investigate a general cognitive model of group behaviors, based on Festinger's social comparison theory (SCT), a prominent social psychology theory. We describe two possible implementations of SCT process at an architectural level, on the basis of the Soar cognitive architecture. The first, which seems to follow directly from Festinger's social comparison theory, treats the SCT process as an uncertainty-resolution method. The second, takes a different approach, in which an SCT process is constantly active, in parallel to any problem solving activity. We present the implementation of these approaches in the Soar cognitive architecture and argue that one is more suitable for modeling crowd behaviors. In previous work, we have shown that SCT covers a variety of pedestrian movement phenomena. In this paper we present the use of the SCT model in generation of imitational behavior in loosely-coupled groups. Based on experiments with human subjects, we show that SCT generates behavior in-tune with human crowd behavior.
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1. Introduction

Models of crowd behavior facilitate analysis and prediction of the behavior of groups of people, who are in close geographical or mentally similar states, and are affected by each other's presence and actions. Existing models of crowd behavior, in a variety of fields, leave many open challenges. In social sciences and psychology, models often offer only qualitative description, and do not easily permit algorithmic replication. In computer science, models are often simplistic, and typically not tied to specific cognitive science theories or data. Moreover, existing computer science models often focus only on a specific phenomenon (e.g. flocking, pedestrian movement), and thus must be switched depending on the goals of the simulation.

In our previous work (Fridman & Kaminka, 2007), we presented a model of crowd behavior, based on social comparison theory (SCT) (Festinger, 1954), a popular social psychology theory that has been continuously evolving since the 1950s. The key idea in this theory is that humans, lacking objective means to evaluate their state, compare themselves to others that are similar. We believe that social comparison is a general cognitive process underlying the social behavior of each individual in crowd. However, it was described as a stand-alone algorithm, with no discussion of how it should be integrated into the action–selection processes of the agent. Moreover, the model was evaluated almost entirely in the domain of synthetic pedestrian movement, without comparison to human crowd behavior.

In this paper we describe the implementation and adaptation of the SCT model in the Soar cognitive architecture, and provide a detailed description of its use in modeling imitational behavior. We describe two implementations of SCT process at an architectural level. The first, which seems to follow directly from Festinger's social comparison theory, treats the SCT process as an uncertainty-resolution method, i.e., as a weak (read: general) problem-solving method, which is *social*. The second takes a different

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* Corresponding author.
  E-mail addresses: fridman@cs.biu.ac.il (N. Fridman), galk@cs.biu.ac.il (G.A. Kaminka).

approach, in which an SCT process is constantly active, in parallel to any problem-solving activity. We argue that the latter approach, in which comparison is a continuous process, is more suitable for modeling crowd behaviors.

In addition, we evaluate the use of SCT in generation of imitational behavior in studies with human subjects. We show that SCT generates behavior in-tune with human crowd behavior: The subjects ranked SCT to be a middle-ground between completely individual behavior, and perfect synchronized ("soldier-like") behavior. Independently, human subjects gave similar rankings to short clips showing human crowds.

2. Background and motivation

Social psychology literature provides several views on the emergence of crowds and the mechanisms underlying crowd behaviors (Allport, 1924; Le Bon, 1968; Reicher, 2001; Tajfel & Turner, 1986). These views can inspire computational models, but are unfortunately too abstract to be used algorithmically. In contrast, computational crowd models tend to be simplistic, and focus on specific crowd behaviors (e.g., flocking). A common theme in all of them is the generation of behavior from the aggregation of many local rules of interaction, e.g. (Reynolds, 1987; Yamashita & Umemura, 2003).

2.1. Social psychology

A phenomenon observed within crowds, and discovered early in crowd behavior research, is that people in the crowd act similar to one another, often acting in a coordinated fashion as if governed by a single mind (Allport, 1924; Berk, 1974; Le Bon, 1968; Reicher, 2001; Tajfel & Turner, 1986). However, this coordination is achieved with little or no verbal communication.

There are several psychological theories that explain this coordinated behavior. For example, Le Bon (1968) noted that individuals seem to lose their individuality (in terms of personality and thought) when becoming part of a crowd. Contagion Theory carried this further, emphasizing a view of the crowd as a "Collective Mind" that transforms an individual into becoming identical with the others in the crowd. Thus, according to Contagion Theory, the crowd as a collective causes an individual to behave in a manner similar to others (Le Bon, 1968).

Convergence theory (Allport, 1924) states that crowd behavior is a product of the behavior of like-minded individuals. According to Allport (1924), individuals become a part of the crowd behavior when they have a "common stimulus" with people inside the crowd. Allport's explanation of crowd homogeneous behavior is that similar people act in similar ways; otherwise they would not be a part of the same group. However, individual behavior affected by the behavior of his surrounding, thus, according to Allport, "the individual in the crowd behaves just as he would behave alone, only more so."

Additional explanations of coordinated crowd behaviors (Reicher, 2001; Tajfel & Turner, 1986) suggest that this coordination emerges because people in the crowd share a common social identity. Unlike Allport's individualistic behavior of people in crowds, Social Identity theory combines together the societal aspects with individual aspects.

Berk explains crowd behavior using decision theory (Berk, 1974). According to Berk each individual tries to maximize her reward and minimize her cost and the crowd behaviors is no exception for this. Berk's explanation of coordinated behavior of crowds is that according to a mini-max strategy, the greater the number of participants that engage in specific action, the less will be an individual cost for engaging in this action. Thus, each individual selects the action of the majority.

Different theories provides different explanations on what derives the individual behavior as being part of the crowd. However, all agree that individual behavior is affected by behavior of others when he or she is part of the crowd which displays coordinated crowd behavior.

2.2. Computational models

Work on modeling crowd behavior has also been carried out in other branches of science, in particular for modeling and simulation. However, only a few models have been validated against human data (Daamen & Hoogendoorn, 2003; Helbing, 2001; Kretz, 2007).

Reynolds (1987) simulated bird flocking using simple, individual-local rules, which interacted to create coherent collective movement. There are only three rules: avoid collision with neighbors, match velocity with neighbors and stay close to the center of gravity of all neighbors. Each simulated bird is treated as a particle, attracted and repelled by others.

Blue and Adler (2000) used Cellular Automata (CA) in order to simulate collective behaviors, in particular pedestrian movement. The focus is again on local interactions: Each simulated pedestrian is controlled by an automaton, which decides on its next action or behavior, based on its local neighborhoods. Blue and Adler showed that this simple rule results in the formation of lanes in movement, similarly to those formed in human pedestrian movement (Wolff, 1973).

Helbing (2001), Helbing and Molnar (1997), Helbing, Molnar, Farkas, and Bolay (2001) also focused on simulating pedestrian movement. Each entity moves according to forces of attraction and repulsion. Pedestrians react both to obstacles and to other pedestrians. They observed phenomena of self-organization in collective motion which can be caused by interaction among pedestrians similarly to the human pedestrian movement (Wolff, 1973). By self-organization, it means that there are some behavioral phenomena which were not planned: for example, creation of lane formation in pedestrian movement.

Kretz (2007) proposes the Floor field-and-Agent based Simulation Tool model (FAST) which is a discrete–space