ACMICS: An Agent Communication Model for Interacting Crowd Simulation

JAAMAS Track

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ABSTRACT

We present and evaluate a novel approach to simulate communication between the agents. Our approach distinguishes low- and high-level communication tasks. This separation makes it easy to extend and use it in new scenarios. We highlight the benefits of our approach using different simulation scenarios consisting of hundreds of agents. We also model evacuation behavior in unknown environments and highlight the benefits of our approach particularly in simulating such behavior.

KEYWORDS

Crowd simulation; communication model; agent communication

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1 INTRODUCTION

Crowd heterogeneity and emergent agent behaviors are important aspects in automating the simulation of behaviorally plausible crowds [1, 7]. Our work [2] was motivated by the fact that communication is inherent in real-world crowds. The behavior of a real-world crowd can be influenced by the information shared between the individuals. However, communication between human-like agents has not received much attention in the crowd simulation literature. We address the problem of modeling deliberate inter-agent communication as part of interactive crowd simulation.

Main results: We present ACMICS, a novel approach to simulate communication between agents in a crowd simulation system, and we evaluate its impact on simulated crowd behaviors. ACMICS makes use of a message structure simplified from a specification well-known in multi-agent systems community called Foundation for Intelligent Physical Agents (FIPA) Agent Communication Language (ACL) Message Structure Specification [8]. ACMICS is capable of handling message sending/receiving between the agents of a crowd in a human-like manner. Our approach makes no assumptions about local or global navigation schemes and can be easily combined with them. Some of the novel components of our work include: (1) A high-level planning algorithm to simulate the evacuation behavior in unknown environments where the agents do not have a priori knowledge about their environment. (2) A novel approach to facilitate inter-agent communication in a crowd simulation system that

- is designed as a separate module in the architecture,
- requires some form of perception capability,
- separates message/scenario dependent (high-level) tasks from those that are independent (low-level), and
- can be easily extended and used in arbitrary scenarios and/or can support different forms of communication.

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2 AGENT AI AND COMMUNICATION MODEL

We model an agent with three components: *perception*, *communication* (ACMICS), and *navigation*. Our main contribution is in modeling the communication between the agents. We combine our approach with known methods on perception and navigation. Perception consists of *hearing* and *sight* subcomponents. These subcomponents continuously keep track of important objects such as other agents, doors, or signs that are in hearing and/or sight range. Navigation makes use of well-known existing methods: (i) a precomputed navigation mesh [9] to calculate static obstacle avoiding paths and (ii) Reciprocal Velocity Obstacles (RVO) [10] for avoiding dynamic obstacles (i.e., other agents). This two-layer navigation capability is controlled by a third and higher planning layer.

We simplify the communication process by making a distinction between low- (Audiovisual – AV) and high-level (Field of Experience – FoE) tasks. AV tasks are independent of the message type. For example, signaling from a distance to catch attention. FoE tasks depend on the message type. An example is responding to a direction request.

3 MULTI-AGENT SIMULATION AND VALIDATION

We highlight the application of ACMICS using four scenarios (cf. Figure 1). The first two scenarios are simpler. The passageway scenario was used to collect flux data, which is compared to similar existing data [6]. We ran the simulation twice, first the communication was disabled, and then it was enabled. It was important to note that enabling communication did not affect the flux significantly.

The third scenario is an evacuation scenario using a realistic environment. The high-level planning here includes an algorithm we developed to model the evacuation behavior of agents without a priori knowledge about the environment (Figure 2). A boolean agent attribute represents whether or not an agent knows the environment. A realistic and complex 3D school building model is

(a) Bidirectional flow (b) Passageway (c) Evacuation (d) Chat

Figure 1: Screenshots from simulation scenarios.

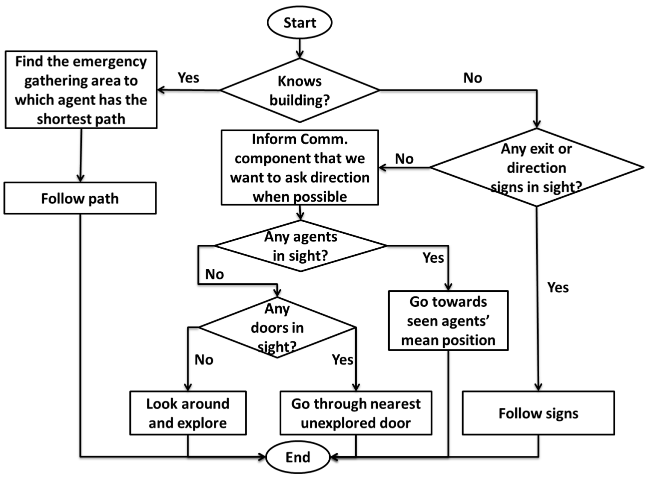

Figure 2: Our high-level planning algorithm used in the evacuation scenario.

used as the building to be evacuated. We ran simulations with six different settings (cf. [2] for details and results). The results from various settings were overall consistent with the expectations.

Chat scenario is used to compare simulated trajectories with real pedestrian trajectories. We used a video from crowd video data collected by the Movement Research Lab at Seoul National University [3]. Movement trajectories of the individuals were extracted from the video. We generated an environment model that is similar to the environment observed in the video. Agents were placed at positions corresponding to the initial positions in the video. Simulations were run both with and without communication capability. Agent movement trajectories from the simulations were extracted by recording agents' positions every second.

Vfractal estimation [5] is used to compare these real and simulated trajectories. We applied the same vfractal calculations to (1) the real trajectories, (2) the simulated trajectories without communication, and (3) the simulated trajectories where communication is enabled. In the results, we observe that the values for (3) are closer to the values for (1) than the values for (2) are to the values for (1). The direct interpretation of this observation is that when communication is enabled, straightness/crookedness of simulated agent movement trajectories better match that of real trajectories.

It is possible to pinpoint plausible autonomous behaviors when watching the simulation outputs (cf. the accompanying video of [2]). First, observed behavioral variety is improved as agents not only walk around but also autonomously engage in conversation. Even though our model only considers communication between two agents at a time, multiple instances of such communications occasionally happen at the same time, which can sometimes look like autonomous formation of standing-and-talking groups. This is consistent with the recent understanding that people in a crowd mostly move as a group rather than as individuals [4]. The measurements from the evacuation simulation show that the change in behavior is consistent with expectations about the effects on evacuation times and trajectories. The vfractal results in the last scenario show that when communication is enabled, the straightness/crookedness of the simulated trajectories are more in line with the real trajectories.

4 CONCLUSION AND FUTURE WORK

Plausible autonomous behavior is a major aim in crowd simulation research and communication takes place and affects behavior in real-world crowds. We present a model for deliberate inter-agent information exchange in virtual crowds and investigate its effects on virtual crowd behavior. Our communication model, ACMICS, combined with the perception and navigation components, was employed in four example scenarios. Using ACMICS in a new scenario only requires defining scenario-specific message types and high-level behavior related to sending and receiving specific messages. As a secondary contribution, a planning algorithm was developed to model the evacuation behavior for an agent that does not have a priori knowledge about the environment.

The cost of simulating communication is a minor addition to the overall cost of multi-agent simulation. Further, most of this cost originates from the model of perception used, which can be improved. There is also room for improvement through space partitioning and/or level-of-detail techniques. It would be possible to better judge the realism of video outputs by performing user studies or quantitatively by developing similarity metrics for comparing crowd behavior. A more efficient perception model, an intermediate level of communication tasks regarding management of dialogs, combining the communication model with more sophisticated agent AI and applying it in new scenarios are other possibilities for future extensions, some of which we plan to investigate.

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