BDI Agent model Based Evacuation Simulation (Demonstration)

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ABSTRACT

The analysis of building evacuation has recently increased attention as people are keen to assess the safety of occupants. We believe that human psychological conditions must be taken into consideration in order to produce accurate evacuation simulations, and human relationships are factors that influence the psychological conditions. Our BDI model based simulations generate emergent behaviors in a crowd evacuation such as a result of interactions in the crowd.

Categories and Subject Descriptors

I.2 [**ARTIFICIAL INTELLIGENCE**]: Multiagent systems

General Terms

Algorithms, Experimentation

Keywords

Emergent behavior, Social force, BDI model, RoboCup Rescue

1. INTRODUCTION

The analysis of building evacuation has recently increased attention as people are keen to assess the safety of occupants. The traditional fluid-flow model cannot handle the interpersonal interaction mechanism among evacuated people. It is difficult to simulate the joining flows of humans at staircase landings using the grid based simulation method. Agent based simulation provides a platform on which to compute individual and collective behaviors that occur in crowds.

Galea et al's study on the World Trade Center disaster presents five points that are required to simulate egress from buildings: travel speed model, information seeking task, group formation, experience and training, and choosing and locating exit routes [**?**]. They are related to each other, and are affected by people's mental condition.Kuligowski reviewed 28 egress models and stated that there is a need for a conceptual model of human behavior in time of disaster so that we can simulate actions such as route choice, crawling, and even group sharing of information[**?**].

We believe that human relationships cause behaviors such that people either form a group to evacuate together or they fall away from the group. We apply BDI model in which human relationships affect evacuation behaviors, and modify Helbing's social force model so that it involves the intentions of agents [**?**]. Our simulations reveal typical behaviors in a crowd evacuation such as interactions in the crowd. The simulation indicates that congestions caused by the interaction take a longer time to evacuate from buildings as often happen in actual situations.

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2. HUMAN EVACUATION BEHAVIOR

2.1 BDI model of evacuation behavior

Agents change their choice methods of actions according to disaster situations. When we fear for our physical safety, we think only of ourselves and will get away from a building with no thought to anything else. When we feel no anxiety, we think of other people and evacuate together. Agent belief-desire-intention (BDI) model is applied so that the selected actions interfere with the behaviors of others and cause evacuation grouping and breaking in a crowd.

2.2 Intension presentation in social force

Helbing's model of pedestrian dynamics is

$$m_i \frac{d\mathbf{v}_i}{dt} = \mathbf{f}_{ie} + \sum_{j(\neq i)} \mathbf{f}_{ij} + \sum_{W} \mathbf{f}_{iW}. \quad (1)$$

$\mathbf{f}_{ie}$ is a social force that moves the agent to its target. $\mathbf{f}_{ij}$ and $\mathbf{f}_{iW}$ are repulsion forces to avoid collision with other agents or walls, respectively.

We present the intentions of agents as target places or persons that are determined by BDI models. For example, when child agents follow their parent, the targets are their parent whose positions change during the simulation step. The motions of the agent are calculated by micro simulation which simulation step $\Delta\tau$ is finer than the simulation step Δt of the intention decision. The social force is

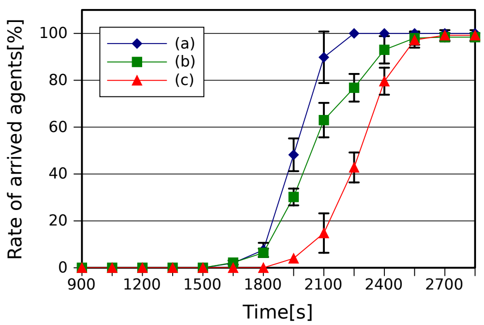
$$\mathbf{f}_{ie} = m_i \frac{v_i^0(t)\mathbf{e}_i^0(t) - \mathbf{v}_i(t)}{\tau_i}. \quad (2)$$

$\mathbf{e}_i^0$ is a unit vector to the targets and $\mathbf{v}_i(t)$ is a walking vector at t. m_i is the weight of agents i, and v_i^0 is the speed of walking. The speed is set according to the age and sex of the agent. It becomes faster when the agent feels fear and becomes zero when it arrives at its destination.

campus layout case a) case c)

white and dark ∘ show child and parent agents, respectively.

Figure 1: Snapshoot of evacuation from buildings.



Average and standard deviation of 5 simulations.

Figure 2: Rate of evacuation at refuge2.

3. DEMONSTRATION OF SIMULATIONS

3.1 RCRS based Evacuation Platform

Agent with BDI model and traffic simulator that calculates agents' positions according to eq.(1) are integrated in RoboCup Rescue Simulation (RCRS) v.1 [**?**]. We implement three types of agent that act according to their principle.

adult agents move autonomously and have no human relations with others. This type of agent can look for exits when they have no knowledge of escape routes.

parent agents are adult agents and have one child. They are anxious about their child and evacuate with them.

child agents have no data on escape routes and no ability to move autonomously. They can only recognize and follow their parent.

3.2 Evacuation scenario example

An evacuation scenario is illustrated in Fig. 1. An event is held at the campus and two hundred agents, 100 parents and 100 children participate the event. They are divided into two groups: 100 agents in both Building1 and Building2.

In case of an accident, they evacuate to a nearby refuge location. Refuge1 is near Building1 and Refuge2 is near Building2. They move to the nearest refuge location through a square in the front of Building 1 & 2 under three cases.

a) Parents and their children are in the same building, namely, 50 parent-child pairs are in each building.

b) Agents are randomly located in terms of which building parents and their children are. Some parents and their children are in different buildings, while other parent-child pairs are in the same building.

c) For all parent-child pairs, parents and their children are in different buildings.

Fig.1 presents screen shots of cases a) and c). Parent-child pairs evacuate smoothly in case a). However, in case b) and c), parents who are in different building move to their child. This movement causes congestion in the square and in the entrances of buildings. Fig.2 illustrates the rate of agents who arrive at Refuge 2. The congestion is greater in b) than in c). It takes more time to evacuate in cases with greater congestion.

4. SUMMARY

We apply BDI model in which the human relationships affect at the stages of the sense-reason-act cycle of agents, and adopt Helbing's model so that it involves the factor of agent intentions.

The intention decision model of agent and a social force based traffic simulator are implemented using RCRS. Several evacuation scenarios including one in 3.2 are examined. The results of evacuation simulations reveal the following:

1. Family-minded human behaviors result in family members evacuating together, which causes interactions in the crowd.

2. Evacuation guidance affects crowd evacuation behaviors. The movements of a small number of agents are involved in a number of agents' behaviors.

3. As real life, evacuation takes more time when congestion occurs.

These are not programmed explicitly in the code of agents. The emergent behaviors occur as a result agent behavior-decision stages implemented as part of human relationships. These results demonstrate the effectiveness of our model.

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