

Development of Evacuation Simulation Framework for High-Performance Computing

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Abstract

This research aims to develop an evacuation simulation framework using a multi-agent system that is applicable to high-performance computing. This framework enables us to compare a number of evacuation behavior models on the same system. In this study, we compared the social force model and the RVO model. The evacuation time of the RVO model is shorter than that of the social force model since the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit. Moreover, we visualized the evacuation situation on a high-definition immersive projection display in order to give the user a disaster evacuation experience.

Introduction

In the field of disaster prevention planning, evacuation simulations have been carried out on a multi-agent system that has pedestrians as agents. For the study of human behavior, a number of models have been studied. The social force model, which is one of the human behavior models, was used to simulate escape panic; this model determined a relation between social psychology and physical force. In the field of computer graphics, research was carried out for a crowd simulation model. For example, the reciprocal velocity obstacle (RVO) model was used for simulating evacuation from a building. The visualization of such an evacuation situation in a VR environment is effective in providing awareness training.

This research aims to (1) develop an evacuation simulation framework by using a multi-agent system and (2) implement the social force model and RVO model for the same purpose. Moreover, we visualized an evacuation situation on a high-definition immersive projection display in order to give the user an evacuation experience.

Method

Evacuation Behavior Model

Using evacuation simulation framework, we implemented two human behavior models, namely, the social force model and the RVO model. The social force model solves the motion equation of an agent, which is represented by a moving disc. An agent that has mass and a constant radius is subjected to a force exerted by other agents and obstacles and exit position. On the other hand, the RVO model is an expanded model of velocity obstacles for crowd simulation. Velocity obstacles are used in the velocity selection algorithm for collision avoidance between moving objects in the field of robotics. The agents evacuate from the building, updating the walking velocity calculated using one of the evacuation models.

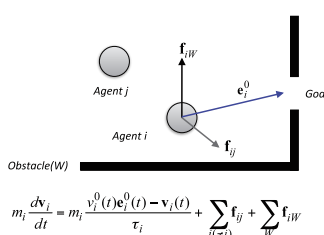


Fig.1 Social Force Model

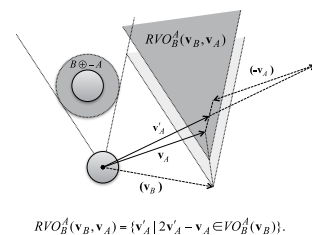


Fig.2 RVO Model

Results and Discussion

Evacuation Time

We simulated evacuation from an office building, as shown in Figure 3. Figure 4 shows the results of the evacuation time. Each graph represents the evacuation and floor evacuation times for three rooms (one meeting room, two office rooms). We observed a difference between the social force model and RVO model; the room evacuation and floor evacuation times of the RVO model were shorter than those of the social force model. This is because the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit. A characteristic of the graphs shown in Figure 4 is that in both models, the first evacuee escaped after several seconds. After that, a certain number of evacuees escaped per unit time because the exit to the staircase was the bottleneck.

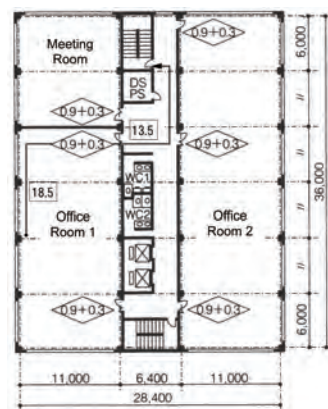


Fig.3 Office Plan



Fig.5 Simulation Image

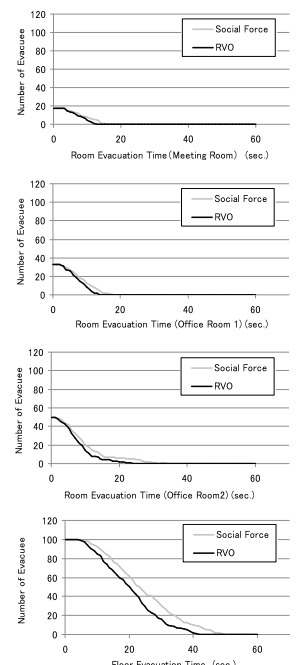


Fig.4 Evacuation Time

Visualization

We visualized the evacuation simulation on a high-definition immersive projection display (CAVE), which contains a cluster of high-performance graphics PCs and high-definition projectors in order to give the user an evacuation experience.



Fig.6 Visualization on CAVE

Conclusion

We developed an evacuation simulation framework, which implements the social force model and the RVO model. The evacuation times of the RVO model are shorter than those of the social force model because the RVO model exhibits an optimized collision-avoidance behavior that affects the flow of the exit.