Crowd Simulate in Panic Situations

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Abstract. *This paper describes a model for simulating crowds in real time. We deal with the hierarchy of the crowd, groups and individuals. We present two different ways for controlling crowd behaviors: - by defining behavior rules, to give intelligence to the agent. By providing an external control to guide crowd behaviors, this control is done by the user or by an autonomous agent called the guide. The main contribution of our approach is to combine these two ways of behaviors (autonomous, guide) in order to simulate the evacuation of a crowd in emergency situations. Many strategies of evacuation have been implemented and we will demonstrate that in most situations, the guided method decrease the average escape time in emergency situations.*

1. Introduction

Crowd and group simulations are becoming increasingly important in the entertainment industry and in emergency simulation. Such technology can be used in situations where it is dangerous for real people to perform the actions. Recent research into crowd simulation has to large extent been inspired by the flocking work of Reynolds (1987). A key element of this type of animation is the collision avoidance. There are several approaches for modeling autonomous crowds Brogan (1997), Reynolds (1999), Tu (1994). In some virtual environments, it would be useful to simulate populations in an autonomous way, thus the agents have a kind of knowledge and are able to move and interact within this environment. Musse(2001) has defined three levels of autonomy: Autonomous crowd, Guided crowd and Programmed crowd.

Panic is one of the few natural catastrophes caused by humans. Collective hysteria may be set off by other disasters like fires, earthquakes. Computer models for emergency and evacuation situations have been developed and most research into panics has been of empirical nature and carried out by social psychologists and others Helbing (2001). As a first step to addressing the problem of simulating evacuation situations that include social interaction, Murakami (2003) simulated the controlled experiments conducted by Ashida (2001). He established a simple environment with human subjects to determine the effectiveness of two evacuation methods: the "follow-direction method "and the "follow-me method ".

The goal of this paper is to present a model for studying the simulation of crowds with different types of control: autonomous, guided and we try to combine these two types of control in order to simulate the evacuation of a crowd in complex environment.

2. Our crowd model

We defined our crowd as a set of groups composed each one of individuals. In normal situation, our model distributes the crowd behaviors to the groups and then to the individuals. In panic situation, and depending on the evacuation method chosen, the concept of group is lost. The priority is done to the basic behavior of the individuals. Each Individual has a repertoire of basic behaviors. Examples of basic behaviors: collision avoidance, obstacle avoidance.

2.1. Crowd information

In order to characterize the crowd we deal with three categories of information:
Crowd obstacles: The first type of obstacles to be avoided by the crowd is defined as simple objects. The second type of obstacle is the wall.
Crowd exits: The second information needed for the crowd is the number, the size and the positions of the exits. We defined in our system two types of exits: **blocked exit** and **open exit**.
The individuals (agents): The crowd is a set of groups and each group is formed by a number of individuals. All these parameters could be modified by the user: the number of groups, the number and position of individuals in each group and the speed.

2.2. Crowd movement

The individuals of the crowd moved in free-way or free-walk-way. To simulate a realistic environment, it is necessary to implement group behaviour. High level behaviors are specified in order to characterize the crowds. These behaviors can be programmed or directly informed using guided control by the user:
Flocking: The agents from the same group walk together at the same speed towards the same goals in normal situation.
Following: The individuals of the same group follow the leader of their group.
Goal changing: in panic situation, the individuals change their initial goal to the appropriate (goal) exit.
Avoid static obstacles: We have used a very simple method of obstacles avoiding using mathematical equations to determine the future position from the current one. The collision is avoided by going around the obstacle.
Collision avoiding: collision avoiding is one of the most important and most commonly performed behaviors in all human being and animals. Once the agent perception system detects a potential collision it immediately acts to avoid it by altering the direction and the speed. Collision between agents cannot always be avoided.

3. Evacuation simulation

An evacuation simulation is a good example of social simulation. Social interaction is extremely common and strongly influences the responses seen in real world evacuations. In order to have a global view of the evacuation simulation we have decided to use three strategies of evacuation for each kind of behavior (individual or group), so we have six in total: The nearest exit, the less encumbered exit and the guided.

The less encumbered exit: The evacuees percept the visible exits and choose the exit which not crowded at this moment. He has no idea of the status of the exit where is blocked or no. So he may choose the wrong exit for many times and in this case he wasted time. The first one who finds the wrong exit, inform the others and at this moment they choose another exit and modify theirs paths.

The nearest exit: They used the same strategy of the less encumbered; only they choose the nearest exit.

The guided: The choice of the exit is done by the guide, it could be an autonomous agent that has a global view of the environment, and this guide can direct all the individuals of the scene or all the groups. He knows the status of the exits and can combine the last two strategies discussed before.

The architecture of our system is as follow: the first step is the modelisation of the environment, and then the user can activate the normal situation of the crowd. The individuals or the groups of the crowd walk in random manner using the behaviors of the crowd movement until a panic event arrived from the user. The second step occurs when a panic event arrived. In this case the user will choose one of the six evacuation strategies and calculate the evacuation time.

4. Results analysis

Our System is a prototype to simulate the evacuation of a crowd in an open environment like supermarket. It is a three dimensional software as described in figure 1. It was implemented in C++ Builder 6 with OPENGL library. Before starting the evacuation of the crowd, the system saves the environment in order to be compared for each strategy. We have to fix the different parameters: The number, size, position of the obstacle; the number, size, position and status of the exits; the number of groups and the number of individuals in each group of the crowd. Change the strategy of evacuation and then comparing the evacuation time of the crowd. All the parameters listed below affect the evacuation time but we emphasis on some of them, such as the number of individuals, the number and the status of the exits. We have run many simulations by changing different parameters and different methods, in each simulation we compute the evacuation time.

For one exit in the environment, there is no difference in evacuation time between the strategies. This model generates realistic phenomena, as arcs formation in the exit. It is similar to Helbing (2001). In the event of panic, the concept of group increases the time of evacuation. The individuals of the same group should go to the same exit.

In every method of our system the density of the crowd affects too much the time of evacuation. The blocked exit causes problems in the treatment of collision avoidance. A group of individuals is spirit of going towards a blocked exit on the other hand; a second group is spirit to return from this exit. For many exits, the majority of simulations, the guided method give better results than the others. The guide has a total sight of the environment (free exits, blocked exits, less encumbered exit or closest one). It is a combination of the two other methods.

5. Conclusions and future works

We have described in this paper a model to simulate the movement of crowds in real time. Two situations were implemented, normal and emergency situations. A novel idea of this paper is to present the possibility of simulating various levels of realism including individuals and group behaviors. For each level, we have implemented several strategies of evacuations (the less encumbered exit, the nearest exit, and the guided). For many simulations and environments, the guided method decrease the average escape time and increase the chance of survival in emergency situation. We are currently investigating the sociological behaviors of the individuals in these situations, and we are trying to improve the behaviors of collision avoiding especially when two groups are walking in opposite ways.

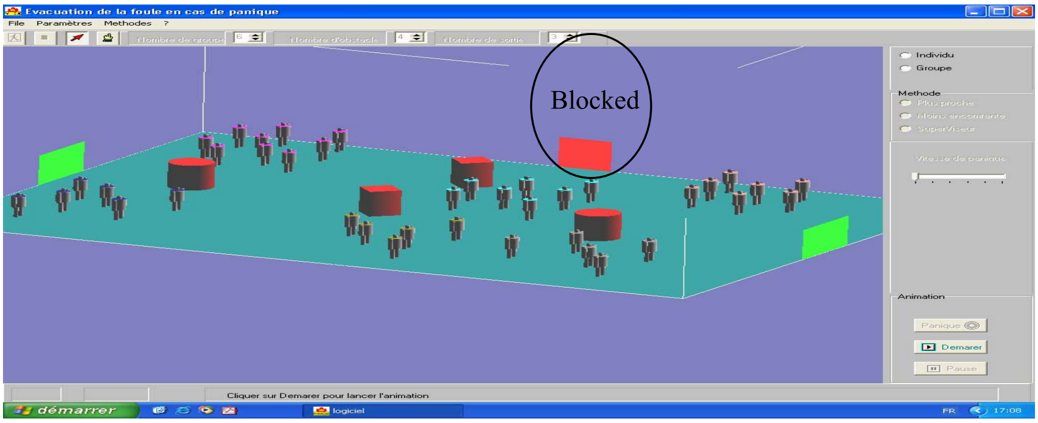

Figure 1. The two green exits are visible and open; the red exit is visible and blocked. The scene contains 5 groups and 4 obstacles.

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