Realistic pedestrian navigation in crowded environment

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Abstract

The aim of our work is to create virtual humans as intelligent entities, in order to accomplish this task, our agent must be capable to interact with the environment, interacting with objects and other agents. The virtual agent needs to act as real person, so it should be capable to extract semantic information from the geometric model of the world where he is inserted, based on his own perception, and he realizes his own decision. The movement of the individuals is representing by the combination of two approaches of movement which are, the social force model and the based-rule model. These movements are influenced by a set of socio-psychological rules to give a more realistic result.

Keywords: Intelligent Agent, virtual crowd, cognitive map, social force, based-rule model

1. Introduction

Realistic simulation of large virtual crowds has become a desirable goal in recent years for diverse applications [5, 3] in emergency evacuation [6], urban planning, personnel training, transportation research and entertainment in psychology. Existing work in this area can be broadly range from those that do not distinguish individuals such as flow and network models, to those represent each individual as being controlled by rules based on physical laws or behavioral models. The goal of the research presented in this paper is to propose a microscopic architect to automatically animate 3D animated virtual crowds with high density in a large dynamic and more complex environment. The difficulty of the problem results mostly from the enormity number of pedestrian and the complexity of controlling all the agents in the crowd, while still maintaining detailed behaviors considering the differences between individuals and treat everyone as having different behaviors and different psychological traits.

In order to navigate in a complex environment, we need to have an efficient abstract representation of the virtual environment [7]. For this reason, we use two different approaches for represent our space, which are cell graphs and portal graph. These two approaches can also be used to store some pre-computed information [3] about the environment that will speed up the navigation and also be helpful to achieve fast perception. The aim of our work is to create virtual humans as intelligent entities in these space, which includes approximate the maximum as possible the virtual agent animation to the natural human behavior. In order to accomplish this task, our agent must be capable to interact with the environment (objects and other agents) and be capable to extract semantic information from the geometric model of the world where he is inserted, based on his own perception, he realizes his own decision. The movement of the individuals is representing by the combination of two approaches of movement which are, the force social model and the rule-based model. These movements are influenced by a set of socio-psychological rules to give a more realistic result.

2. Related work

Some researchers have worked to simulate the behavior of groups of agents in a realistic way. In all existing work, there exist quite a three different approaches for modeling pedestrian streams which are Macroscopic Simulation, Microscopic, and the Mesoscopic simulations are a mixture of macroscopic and microscopic models [6]. In our work, we interest with microscopic approach that is divided into cellular automata models, behavioral force models, and rule-based models. Helbing [4] describes microscopic method for simulating pedestrian motion that solves Newton's equation for each individual and considers repulsion and tangential forces to simulate interactions between people and obstacles. One problem with Helbing's model is that of computational complexity due to the calculation of the effect that each agent (obstacle) has on all the other agents. This may limit the model's ability to simulate many agents. Braun et al [1] expand Helbing's social force model. In their model, each pedestrian is assigned a 'family' identifier and an 'altruism' level. Reynolds [8] simulated group behaviors, (more specifically, birds and fishes) where each bird or fish is an autonomous agent that navigates according to its own local perception of the dynamic environment.

3. Architecture Overview

In this context, a microscopic architecture has been proposed for handling high-density crowds of autonomous virtual agents composing of an important number of pedestrians autonomous in reconstructed large and more complex environments, demonstrating realistic human activity, moving in a natural manner in its space. In this architecture, a virtual agent can be defined as an autonomous entity in a virtual environment, he must perceive its environment through sensors or perception, it receives from the environment the list of entities that are in its field of view, so he is capable to extract semantic information from the geometric model of the world where he is inserted, and based on his own perception, he decides its decision and acts as real people. The complexity of pedestrian behavior comes from the presence of collective behavioral patterns (as clustering, lanes and queues) evolving from the interactions among a large number of individuals. These comportments are demonstrated by using a set of Sociological rules.

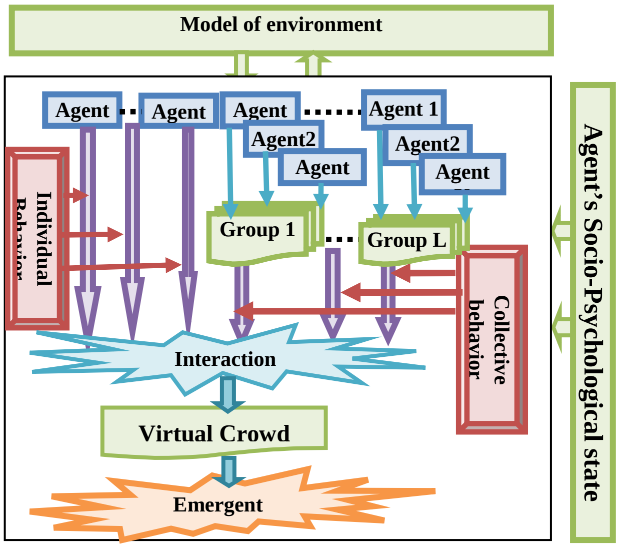


Figure 1: Our system architecture

Psychological and Sociological rules are integrated on our model for improve high-density crowd movement and realism. Since applying the same rules to all agents leads to homogeneous behavior, but agents with different psychological (impatience, panic) and sociological (level of dependence) traits triggers heterogeneous behaviors based on crowd density and personality. These parameters are specified by the user through an interface that allows us to visualize how changes in the personality of the agents are affected during a simulation.

3.1 Model of environment

Our system can handle two different approaches for represent our space, which are grid graph [2] and topological graph [9]. The combination presented here gains the best of both worlds: accuracy/consistency and efficiency. Finally these two approaches can also be used to store some pre-computed information about the environment that will speed up the navigation. The representation of the environment is shown in Figure 2.

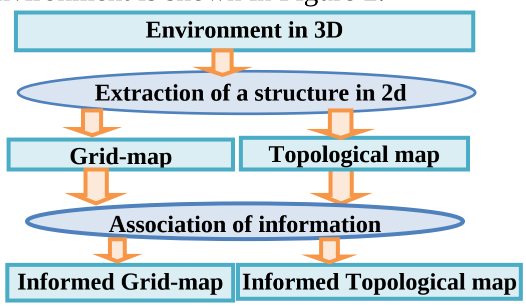


Figure 2: Model of environment

3.2 Model of agent

In this paper, the agent model follow the Sense-Decide-Act (SDA) cycle, where it can be broken up into subsystems, each one associated in turn with more specific routines. From the perception sub-module, the individual perceive the environment according to its position, personality and knowledge, and he obtains the environment information on a semicircular front region of the agent, it detects the positions, orientations and speeds of other agents, and obstacles. Moreover, the agent cans predicted future positions changes of each character and of objects in the VE.

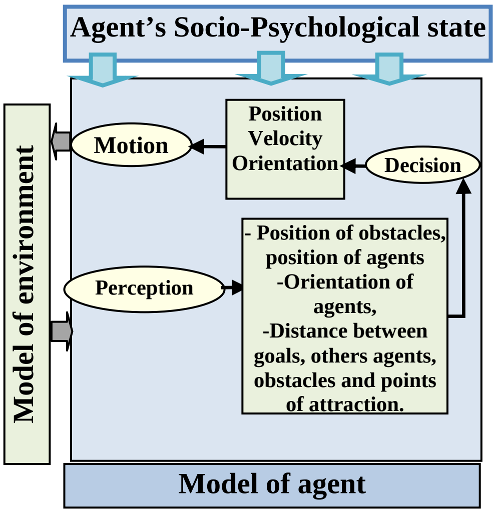


Figure 3: Model of agent

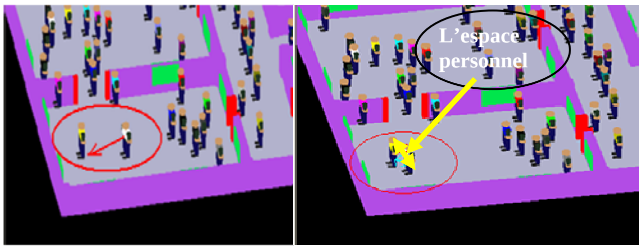
Based on information perceived, the internal state and the socio-psychological traits of the agent (current behavior, panic, role, impatience…), he decides its actions (Decision sub-model) by calculating the orientation, the velocity and next position of the agent, finally the Motion sub-model execute and realize this decision. The complexity of pedestrian behavior comes from the presence of collective behavioral patterns (as clustering, lanes and queues) evolving from the interactions among a large number of individuals. The aspect is realisez by including a set of sociological rules implements collectif comportments.

3.2.1 Motion

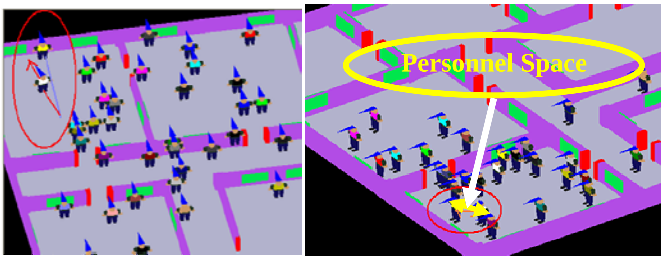
In this work, the movements of agents are inspired by the combination of two approaches which are the approach based-rules and the approach of social force. The Rule-based [8] model used three simple rules for controlling the behavior of each individual. This model gives realistically results for a crowd with low density. To mitigate the insufficiencies of the rule-based approach, we combined this approach with the approach of social force inspired of the model of Helbing [4]. It is based on physics and the socio-psychological forces in order to describe the human behavior of crowd in situations of panic, this model can simulate a crowd with high density but does not give realistic results. Therefore the module of motion of our pedestrian consists in calculating the new position and the new for each agent by using a certain forces; that show broad variety of behaviors in an individual or collective way. These forces are: Advance Force, Acceleration Force, Occupant-attractive Force, Goal-attractive Force, Occupant-Repulsive Force and Obstacle-Repulsive Force.

4. Results and Performances

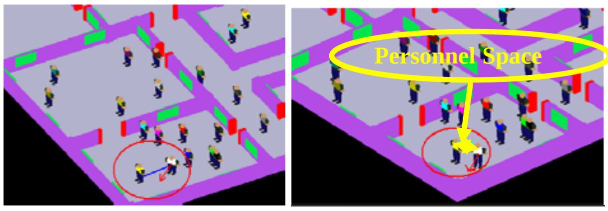
We have chosen the museum like an example of application of our system, the museum contains a set of room where each room is decorated by pictures suspended on the walls and it can contain a set of obstacles, in this environment our virtual agents, in normal situation, can move and see a predefined number of the images, but if the situation changes, i.e. an alarm announces the event of panic, all the pedestrian try to find the best way to leave the environment. The pedestrian movements are influenced by a set of psychological and sociological rules which play a role of balancing of rationality in the behavior and the decision-making that we illustrate a broad more realistic variety of behaviors. Several situations have been studied to present the influence of socio-psychological rules in the realism of the behaviors human; these situations are: The behavior of avoidance of collision and the avoidance of obstacles, Attractions Forces, the agent are guided by three attractive forces, Attraction force towards a sub-goal, attraction force towards an exit, attraction force towards agent.



The avoidance of normal collision in case, such as personal space is narrow, and the impatient agent.



The avoidance of collision, such as personal space is average, and the impatient agent, the collision is treated with a broad distance (2 meter).



The avoidance of collision, such as personal space is narrow, and the patient agent, the collision is treated with a short distance (1 meter).

Figure 5: The behavior of avoidance of collision influenced by socio-psychological state

5. Conclusion

We have proposed a microscopic model of simulation of a crowd with high density of virtual human in a dynamic environment. We have used two approaches of representation of the environment: the graph of grid and the topological graph. The originality of our work is the introduction of a number of socio-psychological rules influencing the behavior of crowd. The integration of these rules in our model and the combination of the approach based rules and the approach of social force have conducted to realistic simulations.

Our system gives acceptable results, but optimizations remain to be done such as, the addition of a cognitive layer in the human behaviors, the training in its process of navigation and the reasoning, to integrate a responsible module to produce realistic movements, like walk, run, etc.... We can also introduce the concept of group and the collective behaviors.

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