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A method of emotion contagion for crowd evacuation

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HIGHLIGHTS

- An emotion contagion method for crowd evacuation is proposed.
- A P-SIS emotional contagion model is constructed.
- The P-SIS model is coupled with the social force model.
- A photo-realistic rendering method is used to exhibit crowd evacuation results.

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ABSTRACT

The current evacuation model does not consider the impact of emotion and personality on crowd evacuation. Thus, there is large difference between evacuation results and the real-life behavior of the crowd. In order to generate more realistic crowd evacuation results, we present a method of emotion contagion for crowd evacuation. First, we combine OCEAN (Openness, Extroversion, Agreeableness, Neuroticism, Conscientiousness) model and SIS (Susceptible Infected Susceptible) model to construct the P-SIS (Personalized SIS) emotional contagion model. The P-SIS model shows the diversity of individuals in crowd effectively. Second, we couple the P-SIS model with the social force model to simulate emotional contagion on crowd evacuation. Finally, the photo-realistic rendering method is employed to obtain the animation of crowd evacuation. Experimental results show that our method can simulate crowd evacuation realistically and has guiding significance for crowd evacuation in the emergency circumstances.

1. Introduction

Recently, emergencies in public spaces have occurred frequently which results in a considerable loss to life and property. Modeling and simulating crowd behaviors has been an active research topic in recent years. The crowd evacuation is affected by natural factors such as emotion. Conducting evacuation drill cannot realistically reflect the situations in emergency circumstances because people will not feel confused and panic during this process. Using computer simulation technology for simulating the crowd evacuation can not only reduce the costing, but also improve efficiency and accuracy. Therefore, adopting computer technology to simulate the crowd evacuation is of great significance.

Emotion is a kind of psychological activity produced by individuals along with cognition and consciousness, which not only affects individual's behavior, but also can affect the behaviors of other individuals through emotion contagion. Personality is a unique psychological tendency and individuals with different personalities have different possibility to be infected by emotions of other individuals. Therefore, simulating the crowd evacuation under the influence of emotion which

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considers the personality of individuals is a very challenging issue. Although the SIS model [1] is classical and simple, it does not consider the influence of personality on emotional contagion.

To address the above problems, we present a novel crowd evacuation method based on emotion and personality. P-SIS emotion contagion model and social force model are two critical parts of this method. The personalized P-SIS model combines OCEAN model [2] and SIS model [1] to simulate the emotion contagion during crowd evacuation. The desired velocity of individual is modified so as to describe their movement under the influence of emotion. The experimental results show that this method can simulate the realistic crowd behavior under emotional contagion in the crowd evacuation.

Related work

1.1. Emotional contagion models

Researchers in VU University [3] proposed the ASCRIBE (Agent-based Social Contagion Regarding Intention Beliefs and Emotions) model. This model is a prototypical example of the heat dissipation phenomena studied in thermodynamics. Unfortunately, the ASCRIBE model is complex and does not consider the influence of personality. Bordas [4] presented an interactive installation to explore social emotional contagion. The model is used to simulate the propagation of emotions through artificial characters in an artificial environment. But the model ignores value analysis of emotional contagion. Margaux [5] put forward a model of emotional contagion based on individual personality and relationship in crisis situations, but the model just numerically describes emotional contagion, and does not perform in crowd simulation. Gratch [6] proposed the EMA model and defined a framework between individual emotion and social relationship. However, the model only supports small-scale movement. Dodds [7] presented the emotional contagion model based on epidemiology and divide people into two types: Susceptible Infected Recover (SIR) and Susceptible Infected Recover Susceptible (SIRS). These models have many emotional states which are inconvenient for calculation. Actually, in emergency situations, we only need to consider two emotional states: infected and susceptible. Therefore, we adopt SIS [1] model to describe the emotion contagion in crowd. We improve the model to consider the personality of individuals. This paper combines OCEAN model with SIS model and constructs the P-SIS personalized emotional contagion model for crowd evacuation.

1.2. Crowd simulation methods

Individuals have been attempting to diversify the movement behavior though psychological characteristics. For example, Refs. [8,9] simulated behavioral changes due to differences in personality. Liu Zhen [10] adopted the idea of intelligent individual to describe the individual behavior under the influence of emotion, and proposed a calculation method of emotional contagion. Kim et al. [11] put forward the crowd simulation method under the influence of dynamic psychology, which considered both the stable personality of individuals and the changes of crowd behavior when the environment changed. However, these models are mainly used to express the difference of individual movement in small groups rather than the large-scale crowd simulation.

Currently, there are two types of crowd evacuation model, macroscopic model and microscopic model. Macroscopic model takes global path planning and local collision conflict into account within a framework. Jiang et al. [12] used the global potential field model to simulate crowd evacuation. Wang et al. [13] proposed a crowd evacuation simulation method based on continuum crowd algorithm. Treuille et al. [14] presented a real-time crowd model based on the dynamic potential field. Narain et al. [15] introduced a novel constraint to model the large-scale behavior of the crowd, and accelerated inter-agent collision avoidance in dense scenarios. However, these methods have several drawbacks. First, they require high computational cost and large time consumption. Second, they do not consider the influence of emotion during crowd evacuation.

The microscopic model studies the crowd evacuation from the view of individual behavior, and balances its deficiencies in global search. At present, the most widely used crowd evacuation model is social force model [16], which can compute velocity and position of each individual and reproduce the phenomenon of "faster-is-slower" and "arching at the exit" in the process of evacuation. Many scholars have modified social force model for applying it to complex scenarios. Han et al. [17] introduced the information transmission mechanism into the social force model, and simulated pedestrian behavior in an emergency, especially when most pedestrians are unfamiliar with the evacuation environment. Ji et al. [18] combined the modified social force (MSFM) model and cellular automata (CA) model. Kretz et al. [19] invested under which circumstances, parameter choices, and model variants oscillations do occur and how this can be prevented. Johansson et al. [20] introduced the social force model to produce waiting behavior and presented a sensitivity analysis and provide sufficient criteria for stability. Yang et al. [21] added leaders to the crowd, and produced the attractive force that drove individuals to move toward the position of leaders. Sui et al. [22] added the cohesion among pedestrians and the nervousness factor based on the original social force, and simulated the evacuation process of passengers under emergency in subway station. Huang et al. [23] introduced the crowd's psychology repulsive force and direction changing force on the basis of the original social force model, and improved the model of crowd walking behavior for normal situation. Priscila Saboia et al. [24] evenly partitioned an area formed by an annulus around individuals into grids, and synthetically considered various factors, such as the angles between grids and targets, whether obstacles occupying grids and so on. Also, they calculated the weight of grids and determined the direction of motion at the next step. However, these corrections do not consider personality and emotion.