Emotion contagion model for dynamical crowd path planning

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An emotion contagion model for dynamical crowd path planning would allow for realistic and plausible simulation of crowd path planning and crowd behavior. Modeling agents' personalities using the OCEAN, or big five, personality trait model allows us to simulate a diverse crowd that reacts to the environment in different ways, while also affecting neighboring agents and their path planning.

Dynamic crowd path planning | Crowd behavior | Simulation | Emotion contagion

1. Introduction

Efficient crowd path planning is crucial in various real-world applications, from urban transportation management to emergency evacuations. The *Emotion Contagion Model for Dynamical Crowd Path Planning* article presents an innovative approach by integrating emotional dynamics into crowd behavior modeling, offering a nuanced understanding of how individual emotions influence collective movement patterns.

This article aims to reproduce the results of the original study to validate its findings and explore potential improvements. We would like to see the effect of an agent's emotion memory and how adding an independent panic parameter, distinct from the already existing aggressiveness in that it causes agents to no longer follow the optimal path according to their personality, would affect the simulation.

2. Methods

Related work. The *Emotion Contagion Model for Dynamical Crowd Path Planning* article will be the main starting point for our work. The main approach to crowd path planning in the article is shown on the Figure 1.

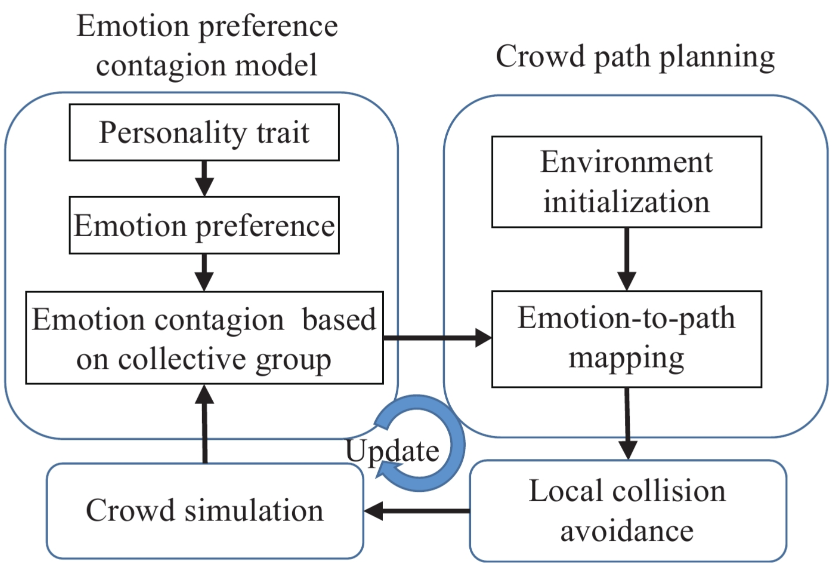

Figure 1. The emotion contagion model as proposed by the source article [1].

The source article proposes generating agents with distinct values for the five OCEAN traits: openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism. Based on those factors, agents are then assigned an initial distance preference P_d and an initial velocity preference P_v. Agents have larger distance preferences if their personality factors are simple, aggressive, and fragile (corresponding to OCEAN factors: O−, E−, A+), and agents have larger velocity preferences if their personality factors are variable, energetic, and functional (corresponding to OCEAN factors: C−, E+, N+). If an agent has a large distance preference, its velocity preference is usually smaller, and vice versa. An agent with a larger velocity preference will seek to find less crowded paths even at the cost of the distance being longer, while those with a larger distance preference will stick to a path even as it becomes crowded. An emotion contagion mechanism further enhances the model by allowing emotional states to spread among neighboring agents, mimicking the way emotions such as stress or calm influence a group. A dampening factor regulates this contagion to ensure an agent's inherent personality traits are at least partially preserved. The model incorporates a strategy where a least expected-time objective function is used to dynamically select paths, factoring in both environmental variables and agents' emotional states and preferences [1].

The other aspect of the article is the emotion contagion. For that purpose, the simulation requires a method to define collective clusters among the agents to determine which of them will be mutually affected. Agents are defined as being collective neighbors if they share similar motion and have a mutual goal. Information is contagious between neighboring agents in the same group and is affected by the distance between agents and the difference between emotion preferences. Additionally, agents may be affected by environmental contagious sources, such as a fire disaster [1].

The *Simulation of crowd dynamics in pedestrian evacuation concerning panic contagion: A cellular automaton approach* article describes how panic could influence the path planning of the agent. The authors propose a model where panic is contagious and it negatively impacts the ability of the agent to find an exit.[2]

Proposed improvements. A second improvement that we propose is adding **Panic contagion** to the simulation. Each agent would have a panic parameter and a panic susceptibility parameter, where panic inhibits the ability of the agent to move to its goal. As the panic parameter increases, the agent movement would become more and more random.

It would also be possible to explore how the **clustering algorithm** described in the article performs when compared to generalized community detection algorithms, such as Leiden, Walktrap, or (Fast) Label Propagation.

We believe to have found **an error in the source article** with its equation:

$$d_{ori}(i,j) = |arccos(vel_i) - arccos(vel_j)|$$

which does not appear to be a operation that can be performed on a vector, so we instead propose:

$$d_{ori}(i,j) = |atan2(vel_{i_y}, vel_{i_x}) - atan2(vel_{j_y}, vel_{j_x})|$$

where we obtain the correct angle θ from the x-axis [3] for each of a pair of agents and then subtract the angles to obtain the difference between their orientations. [1]

3. Results

We have implemented a basic simulation showing the effects of the clustering algorithm. Figure 2 shows multiple runs of the clustering algorithm.

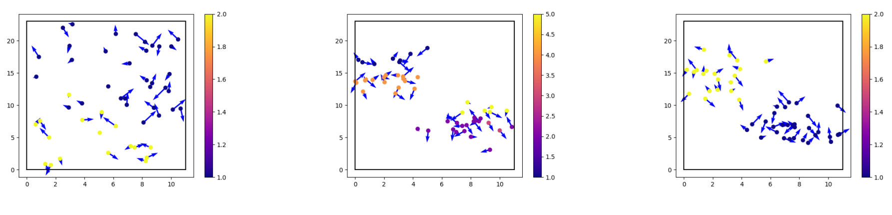

Figure 2. Example runs of clustering according to association with the closest neighbor with a higher degree. The implementation is currently slightly unstable, but it may suffice for the purpose of emotion contagion. The leftmost subfigure represents agents with positions initialized uniformly, while the two to the right represent agents with positions initialized with a bimodal Gaussian distribution.

For each exit we constructed a graph of shortest paths, called navigation graph. Every such graph is a tree or a forest with roots among the nodes belonging to an exit. Graph represents shortest paths from all possible positions on the grid to one of the exits. An example graph is shown in the Figure 3.

4. Discussion

At this stage, we have implemented a simple simulation workflow where we can define the environment in the text format and then run the simulation with specified number of agents. By the next submission deadline, we plan to have implemented the simulation from the original article in its entirety, as well as specifying how to integrate the proposed additions to its model.

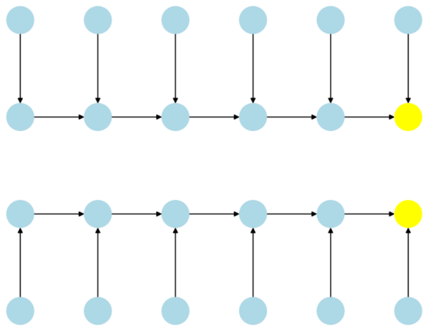

Figure 3. Example navigation graph for a grid of dimensions 4 times 6. Yellow nodes represent an exit of width 2.

Bibliography

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2. Wang GN, Chen T, Chen JW, Deng K, Wang RD (2022) Simulation of crowd dynamics in pedestrian evacuation concerning panic contagion: A cellular automaton approach. *Chinese Physics B* 31(6):060402.
3. Organick E (1966) *A FORTRAN IV Primer.* (Addison-Wesley).