Crow path planning : Emotion Contagion model enhanced with a Fuzzy Logic-Based Approach

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Abstract

Numerous models have been developed to simulate pedestrian crowd path planning, each introducing unique assumptions that influence their outcomes depending on the specific scenario examined. Our objective is to integrate two distinct approaches to construct a more comprehensive and realistic model. First, we will implement the model from Wu et al. [2024], which incorporates emotional contagion into agents' decision-making processes. We then aim to enhance this model by reformulating its decision rules using fuzzy logic, based on the methodology presented in Xue et al. [2017]. This approach enables our model to account for both the social environment and the fuzzy boundaries of real-world spaces. By providing a more accurate representation of these factors, we expect our model to yield more relevant behavioral predictions, drawing on insights from the two original models.

1. Introduction

Crowd path planning has been an essential aspect of multi-agent simulation, particularly in dynamic environments such as evacuation scenarios or crowded spaces. Traditional methods often rely on rigid, objective-based path planning strategies, where agents choose paths based solely on distance or density, without accounting for the emotional states or personalities of individuals. These approaches include both macroscopic models, which focus on the overall movement of large groups, and microscopic models, which simulate interactions and behaviors of individual agents. Methods such as shortest distance and density-aware path planning have limitations in simulating real-world crowd behavior, as they fail to capture the nuances of agent interactions and psychological factors.

2. Related work

2.1. Emotion Contagion Model

To address these gaps, Wu et al. [2024] introduce a novel approach that defines emotion preferences based on personality traits, using the OCEAN model (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) to map personality to behavior.

These emotion preferences guide agents' path choices, balancing their preferences for *distance* and *speed*. An emotion contagion mechanism further enhances the model by allowing emotional states to spread among neighboring agents, mimicking the way emotions like stress or calm influence a group. A dampening factor regulates this contagion, stabilizing or intensifying emotional shifts based on the agent's inherent personality traits. To capture realistic dynamics like the "fast is slower" phenomenon—where attempts to speed up can lead to congestion and actually slow progress—and "path following," which reflects individuals' tendency to follow established paths, the model incorporates an emotion-to-path mapping strategy. This strategy uses a least-expected-time objective function to dynamically select paths, factoring in both environmental variables (such as path density and distance) and agents' emotional states and preferences. This comprehensive approach enables more human-like navigation and responses to complex environments, accurately mirroring the intricacies of crowd behavior.

2.2. Fuzzy-logic Model

An other way to solve those problems, proposed by Xue et al. [2017], is to integrate fuzzy logic into the multi-agent system in order to better represent uncertainty and imprecision in decision-making. This model differs from conventional approaches, which often rely on fixed values, by introducing more varied and realistic behaviors for each agent, based on their personality traits. To this end, the authors also use the OCEAN model. The personality traits influence each agent's preferences for speed, distance from others and decision-making in crowded situations.

Fuzzy logic is used here to translate personality traits into specific behaviors through fuzzy IF-THEN rules. For example, a highly extroverted agent will have a preference for fast movements, while a more introverted agent will be more cautious. Fuzzy rules allow personality values to be transformed into linguistic terms, such as "fast" or "close", in order to modulate behavior according to situations.

By simulating scenarios such as a room with a single exit or a corridor with obstacles, the proposed model shows that agents with varied personalities react differently, for example by choosing distinct trajectories or reacting differently to congestion. This model may be useful for analyzing the impact of personalities on crowd phenomena, particularly in emergency contexts.

3. Methods

Our goal is to merge the approaches of [Wu et al., 2024] and [Xue et al., 2017] mentioned above.

Initially, we aim to follow the methodology of the first paper to model emotional expression using agents. These agents derive two behavioral variables, *preferred distance* and *preferred velocity*, based on their OCEAN personality traits.

One limitation of this approach is that those rules rely on strict thresholds, which can lead to rigid categorization. Indeed, if a trait value exceeds a particular cutoff, the corresponding behavior is triggered, but any variation near this threshold is disregarded, potentially oversimplifying the agent behavior. For instance, if we consider the Openness of the agents, we observe that agents whose Openness is over 0.5 are considered Simple and reciprocally when Openness is strictly under 0.5.

To address this, we propose an alternative approach that incorporates *fuzzy logic*, adapting the methodology of the second paper. This approach applies fuzzy rules to enable a smoother transition between the agent's OCEAN scores and the behavioral variables : *preferred distance* and *preferred velocity*.

We expect this approach will enable agents to respond in a more realistic manner, improving their ability to model nuanced social interactions.

4. Results

5. Discussion

6. Conclusion

References

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