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Learning mid-term human navigation through crowds

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Abstract This article presents a method for modeling and predicting sequences of human decisions during a crowd navigation task. We focus on the mid-term navigation, i.e., where navigation is modeled as a sequence of traversed gaps between people. By leveraging data from a virtual reality experiment, the method divides the space into triangles using Delaunay triangulation the vertices of which are humans forming the crowd. A binary classifier is used to predict a participant's sequence of traversed triangle edges. The goal is to find a minimal configuration that effectively models human trajectories, balancing prediction accuracy and model complexity.

Keywords Human navigation, Crowd Modeling, Prediction, Multi-scale algorithm, Decision sequences

1 Introduction

Crowd simulation consists of proposing algorithms to reproduce, imitate, understand or predict the behavior of (human) crowds in various situations. This work focuses on microscopic approaches whose simulation models detail individual movement, and are based on the principle that inter-individual interactions are able to account for phenomena emerging at the macroscopic scale of the crowd. By exploring recent surveys in the field [5], we find that the simulators most frequently focus on the case of pedestrian simulation. Individual trajectories are calculated by taking into account two main elements: the 'motivation', or desired destination of the agents, and local interactions, the main one being collision avoidance between agents. The desired destination generally results from a trajectory planning stage which allows, for example, the presence of obstacles in the environment to be taken into account. Collision avoidance results from the adaptation of this plan on a local scale, for which there are a very large number of solutions. It is worth noting that the mid-term scale is rarely taken into account in simulation models. Yet this would make it possible to establish dynamic strategies for adapting long-term navigation plans, beyond a single purely local vision. Some work does exist, however, such as that of Julien Bruneau, who shows that constructing a trajectory as a sequence of multiple interactions makes it possible to improve the realism of simulations [6]. Similarly, Andrew Best, with his DenseSense algorithm, models density-dependent behavior by simulating trajectories that respect speed/density relationships [2], while W. Van Toll proposes a topological approach to resolve conflicts between global planning and local collision avoidance [4]. The work presented here is in line with these ideas. We seek to propose a method that is capable of reproducing human medium-term navigation strategies. To do this, we introduce the idea that navigation within crowds can be modeled as a sequence of gap crossings. In this idea, a trajectory is a sequence of points of passage between 2 individuals. We are seeking to establish an approach that is capable of reproducing the strategy of human navigation, i.e. reproducing real human trajectories of movement in a crowd. To do this, we have a dataset that we present in the following section, as well as our method for learning the strategy from this data.

2 Data and methods

To address the problem of learning mid-term navigation strategies in crowds, we modeled computing a Delaunay triangulation of which vertices are humans in the crowds. This method optimally divides the space into triangles, maximizing angles and avoiding overly elongated triangles. Delaunay triangulation is particularly suited to our context as it effectively captures the spatial relationships between humans. Our method is tested on data were acquired during an experiment conducted by Martin and colleagues[3],

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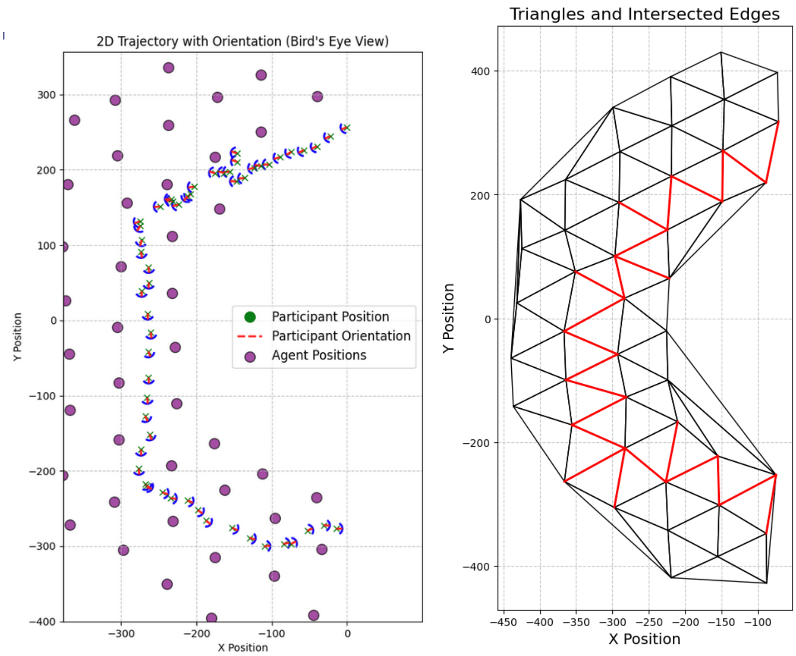

Figure 1: Left: example of a trajectory (green crosses) through a crowd of humans (purple disks) recorded in a Virtual Reality environment. Right: Crowd modeled as a Delaunay triangulation, and result of path prediction (traversed triangle in red)

in which participants had to walk through a circular corridor and navigate through stationary agents in virtual reality (VR). This experiment aimed to understand whether the appearance of the stationary agents influenced the participants' navigation. These data allow for the complete trajectories followed by the participants in the virtual environment to be recreated for each condition (varying density) and with the position of all stationary agents. The problem then reduces to solving the participant's navigation within an independent triangle to understand their local choice. Subsequently, we can recursively develop their navigation across all triangles to obtain their global trajectory, guided by the person's distant goal. In the case of semicircle data, the trajectory is guided by the tangent to the circle. The method used for learning is a binary classifier, which takes as input the edge through which the participant passes and predicts the edge through which they will exit (to their right or left). In the first implementation, the input data for the algorithm to learn the exit label (right or left) are the geometric features of the triangle. Each triangle is transformed into the same base to eliminate the orientation bias in the data. Thus, the model does not learn directly from the global coordinates of the problem but rather locally. This problem is egocentric as the trajectory prediction is relative to the participant's frame of reference. Using this approach, we aim to capture the participants' local decisions and chain them coherently to form a sequence of choices that achieve a global objective. The goal of this method is to find the optimal parameters, i.e., the fewest parameters possible, necessary for accurate modeling. By varying the depth at which we evaluate the succession of triangles, we seek to determine the minimal configuration that achieves a reliable prediction of the participant's navigation choices. This approach aims to balance the complexity of the model with the precision of the prediction, ensuring that the model remains lightweight and efficient.

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