

Collision avoidance when people encounter each other at a bottleneck

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Abstract The study investigates the dynamics of pedestrians crossing a bottleneck, focusing on how people adjust their speed and route to pass through without colliding. By analyzing two datasets of pedestrian trajectories, the research examines factors such as angle, distance, speed differences, and external aspects like body mass and gender that influence how pedestrians decide who moves first. Additionally, the study explores the role of upper body rotation as a third option for collision avoidance mechanism when adjustments to the route and velocity are insufficient.

Keywords collision avoidance, bottleneck, experiment

Introduction

Knowledge of the dynamics of people crossing a bottleneck is of safety importance, since bottlenecks are a key point for pedestrian flows. However, the processes that lead to the participants arranging to pass the bottleneck are not yet understood to the extent that they are fully represented in models. When people encounter each other at a bottleneck coming from different directions, the order in which they pass through is determined very early on [1, 2] by adjustments in speed and changes in route. In pedestrian dynamics models this is commonly implemented as 'collision avoidance' e.g. [3, 4, 5] and allows several agents to maneuver past obstacles without colliding or to model the merging process in front of bottlenecks. The basis for the implementation is, at best, a consensus with reliable data. Data allowing an investigation of these processes exist only sporadically for test layouts without constraints [6], but not for bottlenecks.



Figure 1: Snapshot of Pedestrian Experiment, where five people encounter each other at a bottleneck from five different directions. Trajectories are shown in red.

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Datasets

We analysed 1800 trajectories from two bottleneck experiments in which 2 to 5 pedestrians encounter each other in a bottleneck, starting at different starting positions. Dataset 1 comes from experiments conducted with employees of the Jülich Research Centre in June 2021. For this dataset, trajectories as well as 3D motion data for each of the participants are available. Dataset 2 was conducted in the context of the CroMa experiments [7] in October 2021 with recruited participants. For this dataset, trajectories as well as shoulder rotation data are available.

Results

We therefore analyse the question of what determines whether a person either moves out of the way or changes their speed. The parameters shown will include the angle, distance and speed difference between the people, that are common parameters in 'collision avoidance' implementations. We will also show other statistical parameters influencing the process of pedestrians arranging the passing order of the bottleneck. This includes external aspects of the interaction that can be perceived by the participants like initial acceleration, body mass and gender of the participants involved in the encounter. Furthermore, we show an additional possibility of collision avoidance, which is used when adaptations in route and speed have not been sufficient: the rotation of the upper body.

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