Counterflow Model for FDS+Evac Simulations

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Abstract

We present a new method for modeling counterflow situations in crowds. Agents, describing individual pedestrians, are set to avoid the moving directions where there is counterflow and prefer the directions with forward flow. Agents are also set to rotate their bodies in certain counterflow situations to move shoulder first. The model is implemented in the FDS+Evac simulation software. Test simulations show that it is able to create rather realistic simulations of counterflow.

Introduction

The crowd dynamics model of Helbing et al. [1] is widely used and has been found to realistically simulate many phenomena occurring in real crowds. One of the downsides of the model is that agents moving in opposite directions are unable to dodge each other, and thus, unrealistic collisions occur in counterflow situations.

We present a model for counterflow situations, where each agent observes its proximity and selects the moving direction with the smallest counterflow. Agents moving to the same direction create negative counterflow, and thus, the model also makes agents favor the directions with forward flow. The cross-sectional shape of a human body is elliptical, and thus, the rotational positions of agents may affect counterflow. We consider this by describing the agents' body dimensions with three overlapping circles [2, 3] and by setting the agents to move shoulder first in certain counterflow situations. For a detailed description of the model, see [4]. The presented collision avoidance model is implemented in the FDS+Evac simulation software [3, 5, 6, 7].

The Counterflow Model

In the counterflow model, agents frequently update their desired moving directions. Each agent has three options on each update: to go straight ahead, to dodge to right, and to dodge to left. The agents make the decisions by observing the area in front of them and by selecting the direction with the least counterflow. This is done by dividing the area into three overlapping sectors and by giving each sector a score according to locations and moving directions of the agents within the sector. The agents moving to the same direction increase the score of the sector and the counterflow-agents decrease it. On each step, the direction with the highest score is selected and set to be the desired moving direction of the agent in the Helbing et al. model. The range of the sectors varies between 1.5 m and 3 m, according to the velocity of the agent. The features of the model are illustrated in Fig. 1.

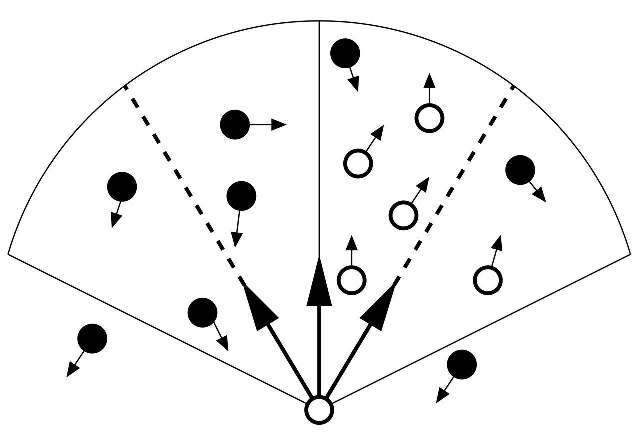

Fig. 1: Illustration of the three overlapping sectors of the counterflow model. The dashed lines are the edges of the middle sector. The large arrows are the options for the agent's desired moving directions and the small arrows denote the moving directions of the other agents.

Simulation Results

The performance of the counterflow model was tested with FDS+Evac-simulations in the IMO test geometry 8 [8], where a 2 m wide corridor connects two rooms. In the initial situation, 40 agents were located in both rooms and their goal was to pass the corridor to the other room.

Snapshots of the test simulations are presented in Fig. 2. When the counter-flow model is not applied, the two streams create an impassable jam in the corridor. Using the counterflow model, the flow in the corridor is rather smooth and all agents have passed the corridor in about 50 seconds.

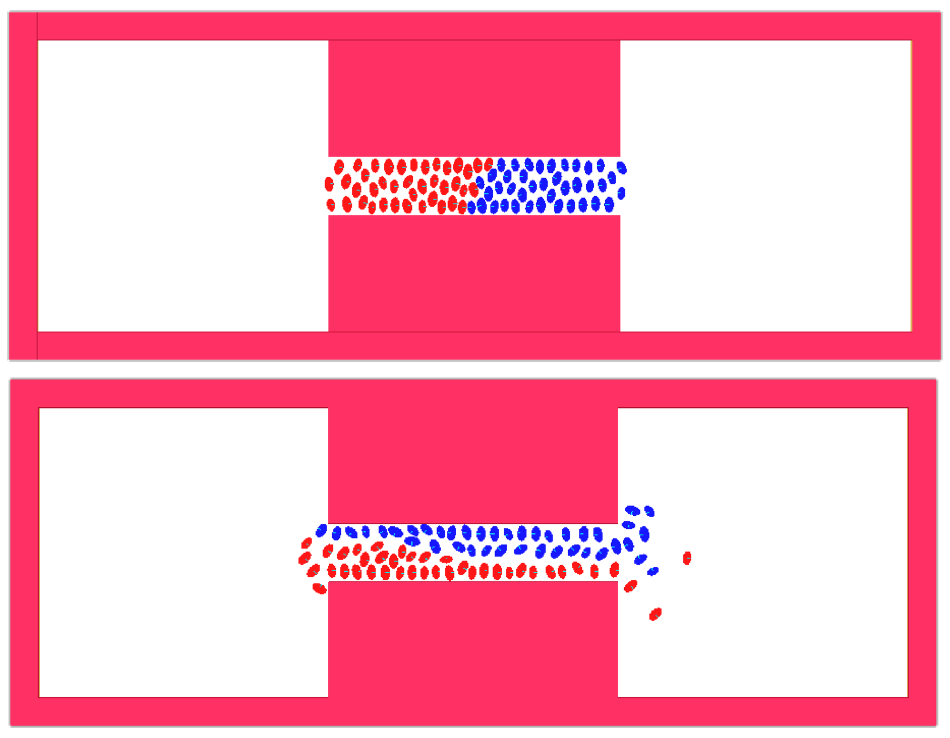

Fig. 2: Without the counterflow model (top), an impassable jam is created. Using the counterflow model (bottom), all agents are able to pass the corridor in about 50 seconds.

The results of FDS+Evac simulations were compared to an experimental data set by Isobe et al. [9]. The geometry of the experiment was a 12 m by 2 m corridor with 50% of the testees randomly located to the right half of the corridor and the other 50% to the left half. The testees in the right tried to move to the left and vice versa. The same experiment was ran with different numbers of people to analyze the effect of population density on the flow rates. The simulation results of the counterflow model match the experimental results very well, as presented in Fig. 3.

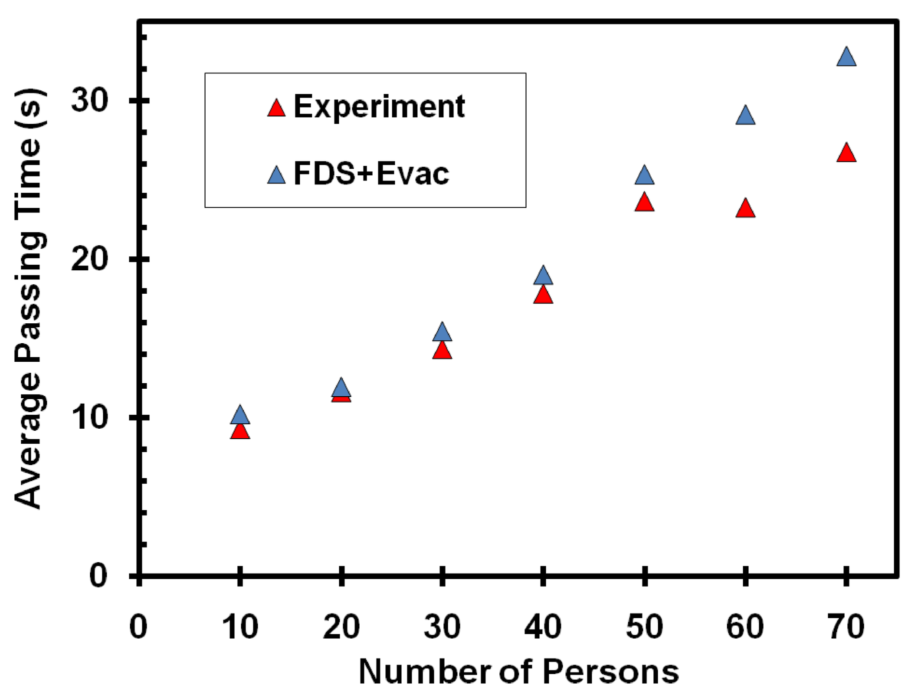

Fig. 3: Simulation results of FDS+Evac compared to experimental results of Isobe et al. [9].

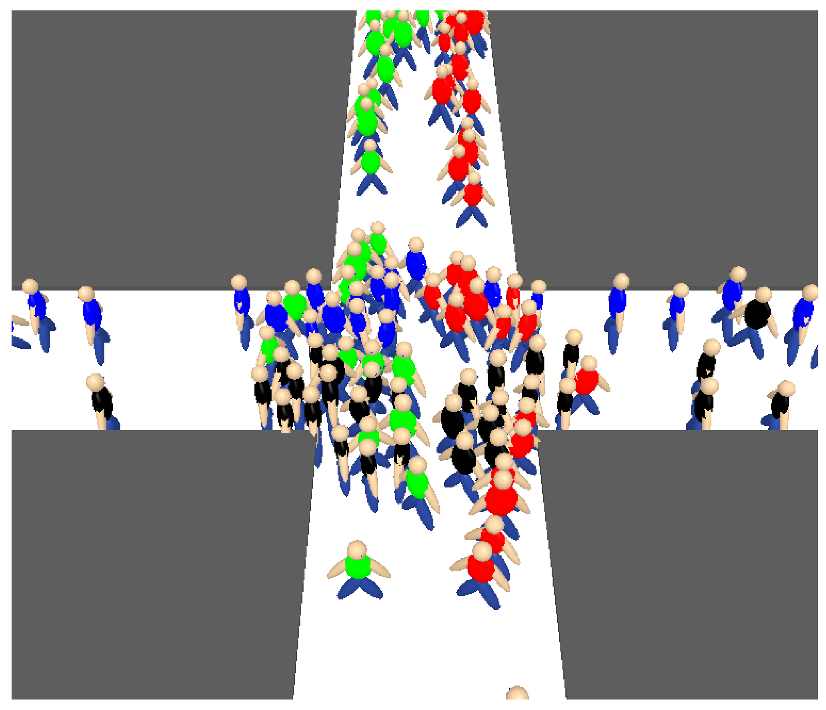

Fig. 4: The counterflow model is also able to create rather realistic behavior in a crossing with agents moving to four directions. The green agents are heading down, the red ones up, the black right, and the blue left.

Summary

In order to realistically model counterflow with the crowd dynamics model of Helbing et al., a method to describe the interaction between agents moving to opposite directions is necessary. We present a short-range model, where agents adjust their walking directions and rotate their bodies to avoid collisions with the oncoming agents. Test simulations show that the presented model is able to eliminate the unrealistic jams occurring with the original model.

Information on FDS+Evac is available on its web page [6]. FDS+Evac is a part of FDS (Fire Dynamics Simulator) and it is freely obtainable from a web page including the source code [10]. Thus, the model can be freely developed and improved by the fire engineering community.

Acknowledgements

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