A Fuzzy logic-inspired model to simulate pedestrian dynamics in emergency and panic situations

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Crowds are a quite usual experience in everyday life. They are mostly safe but, in some cases, can be dangerous. Understanding competitive egress behaviours can be helpful in avoiding tragic events: effective egress models are useful both in designing large venues and in calculating their working conditions during emergencies. The simulation of pedestrian motions within an area in the presence of obstacles, and the description of factors that make the pedestrian able to determine autonomously the path to the target destination, are thus crucial problems in evacuation studies. Pedestrian motion is difficult to describe in terms of simple models, owing to phenomena like jamming and clogging, lane formation and oscillations at bottlenecks in counterflow or collective patterns of motion at intersections (Kirchner and Schadschneider, 2002). However, many interesting models have been developed, usually grouped into two main types: Cellular Automaton models and Social Forces models.

In this work we have developed an innovative approach based upon Fuzzy Logic that allows modelling, through verbal variables and linguistic rules, the imprecise manner of reasoning of humans in decision-making and in facing panic or emergency conditions.

The model was tested in multiple-exit and fire situations (Fig. 1) in the presence of fixed obstacles, so it has been compared to other existing models. The proposed model is also capable, in the case of multiple exits, of handling the choice behaviour taking into account the ‘herding behaviour’ factor. These facts make the author confident of the ability of the model to predict the egress dynamics in a quantitative and reliable way.

![Figure 1: Snapshots of the simulation: two exits room (a) and in the presence of fire (b) with 200 pedestrians.](image-url)
The developed application is based on a multi-threading approach in order to take advantage of the potential of actual multi-core architectures.

Each thread computes a single pedestrian’s position, so it represents a single pedestrian’s mind which works in parallel with the others. At the end of every single time step (iteration), threads are synchronized to acquire and display position data. This approach turns out to have more performance than a simple sequential approach, in which pedestrians’ positions are computed sequentially in time, making use of a single processor.

Table 1 shows evacuation times and computational results obtained for three different scenarios with 200 pedestrians.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Evacuation time (s)</th>
<th>Avg iteration time (s)</th>
<th>Total computation time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Exit</td>
<td>105</td>
<td>0.228</td>
<td>239.4</td>
</tr>
<tr>
<td>Two Exits</td>
<td>55</td>
<td>0.351</td>
<td>193.1</td>
</tr>
<tr>
<td>Two Exits with fire</td>
<td>99</td>
<td>0.365</td>
<td>361.4</td>
</tr>
</tbody>
</table>

The results obtained are encouraging, and push towards further developments.

References

