2D discrete crowd motion model: Application to pedestrian flows in railway stations

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- Number and session name: session 3B, Technologies
• The 2D discrete crowd motion model
  – Non-smooth mechanics & Discrete Element Method

• Pedestrian flows in railway stations
  – Input data: line, station and platform levels…
  – Simulation & results: dwell time estimation
• Types of events: self-organized processes/evacuation/traffic control

• Environment representation: discrete

• Crowd representation: discrete (agents)

• Types of walks: normal/emergency

• Pedestrian geometry: 2D (3 DoF)

• Travelling strategies: shortest/fastest path
The 2D discrete crowd motion model

- Discrete Element Method (DEM)

Granular Media

Adaptation

Crowd

Non-smooth mechanics
(Frémont, 1995; Dimnet, 2002; Dal Pont and Dimnet, 2008)

- Interactions management: collision

The 2D discrete crowd motion model

- Interactions management: avoidance

  Repulsive forces

  Cognitive approach

- Walking strategy (long range): shortest path

Method based on static and dynamic fields. We implement a scalar function which increases with the distance to the destination point.
Pedestrian flows in railway stations

**Line level**

- **Train traffic data**
  
  Field measurements => **Headway = 6 min**

- **Passenger demand per train for Noisy-Champs station:**
  
  CapTA model => 59 for alighting / 304 for boarding

**Station level (1) : geometrical data**
**Station level (2)**

Hypothesis on the time schedule and pedestrians’ travelling strategies

Simulation starts

- $t = 0$

Train arrives

- $t = 4\,\text{min}$

Doors open

- $t = 5\,\text{min}$

Simulation ends

- $t = 6\,\text{min}$

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**Strategy n°1**: $0 \leq t_{\text{arrival}} \leq 4\,\text{min}$  
$v_1 = 1.15\,\text{m/s}$

**Strategy n°2**: $4 \leq t_{\text{arrival}} \leq 5\,\text{min}$  
$v_2 = 1.91\,\text{m/s}$

**Strategy n°3**: $5 \leq t_{\text{arrival}} \leq 6\,\text{min}$  
$v_3 = 3.28\,\text{m/s}$
Pedestrian flows in railway stations

Platform level: platform and train’s geometry

MI09 train

2D representation

MI09 2D model
Simulation of passengers alighting and boarding a train: Aggressive & polite strategies
Pedestrian flows in railway stations

Preliminary results for passenger demand and dwell time at Noisy-Champs station

<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boarding passengers</td>
<td>257</td>
<td>242</td>
</tr>
<tr>
<td>Alighting passengers</td>
<td>57</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>314</td>
<td>270</td>
</tr>
<tr>
<td>Dwell time (s)</td>
<td>27</td>
<td>35</td>
</tr>
</tbody>
</table>
Pedestrian flows in railway stations

Conclusions:

- Input data (observations + CapTA model) + 2D discrete crowd motion model
- Simulation’s assumptions
- Dwell time estimation: $8\% < \text{std} < 18\%$

Further developments:

- Refine the assumptions: time subdivision and pedestrians’ travelling strategies (by taking into account the age, the gender, the motives…)
- Study bigger and more complex stations (Marne-la-Vallée/Chessy, suburban train network + TGV OUIGO)
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THANK YOU

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