Modelling Situations of Evacuation in a Multi-level Building

Hans Hardmeier Andrin Jenal Beat Küng Felix Thaler

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Problem statement

One level evacuation model well known
$\rightarrow$ Multilevel? i.e. ETH-CAB?
Goal: Tool to simulate evacuation in a given multilevel building.
Requirements of solution

- Efficient
- Flexible
- Realistic

Social Force Model

The social force model, introduced by Helbing is an agent based model to simulate pedestrians behaviour.
Described forces

- Desired Direction Force
- Interaction Force
- Wall Force

Desired Direction

Every agent targets the shortest possible path with a desired velocity to the closest exit.

$$f_D = \frac{v_i^0(t)\mathbf{e}_i^0(t) - \mathbf{v}_i(t)}{\tau_i}$$

- $v_i^0(t)\mathbf{e}_i^0(t)$: Desired velocity and direction
- $\mathbf{v}_i(t)$: Current velocity

Repulsive Interaction Force

All agents interact with each other when they get close. Prevent agents from penetrating.

$$f_{ij} = \{A_i exp[(r_{ij} - d_{ij})/B_i] + kg(r_{ij} - d_{ij})\}\,\mathbf{n}_{ij} + \kappa g(r_{ij} - d_{ij}) \triangle v_{ji}^t \mathbf{t}_{ij}$$

- $A_i exp[(r_{ij} - d_{ij})/B_i] \cdot \mathbf{n}_{ij}$: Exponentially increasing force with an repulsive effect, the closer agents get to each other.
- The other two summands contribute only to the force when agents overlap

Wall Force

The wall force fulfills the same purpose as the repulsive interaction force. Though prevents agents from penetrating walls.

$$f_{iW} = \{A_i exp[(r_i - d_{iW})/B_i] + kg(r_i - d_{iW})\}\,\mathbf{n}_{iW} - \kappa g(r_i - d_{iW})(\mathbf{v}_i \cdot \mathbf{t}_{iW})\mathbf{t}_{iW}$$

- Same as the repulsive interaction force between agents

Implementation

- General config files suitable for many buildings
- Color-coded bitmaps of floor plans
- All formulas implemented as proposed by Dirk Helbing
- Custom functions written in *C*
  - Fast Sweeping for path finding and wall interaction
  - 2D Range Tree for efficient inter-agent force computation
  - Bilinear interpolation to replace *MATLAB*'s built in interp2()
- Easily extendable code

Video demonstration

→ config1_frame.avi

Discussion

- Model works as expected
  - agents take shortest path towards exit
  - agents don't intersect with wall & each other
  - formation of crowds
- Stairs & exits are bottlenecks
- Simplified model: improvements possible
  - add 'intelligence' to the agents
  - add a 'panic factor'
  - use different agent velocities

Questions

- Thanks for your attention!
- Questions ?