Heterogeneous Agents in Cellular Models of Pedestrian Flow

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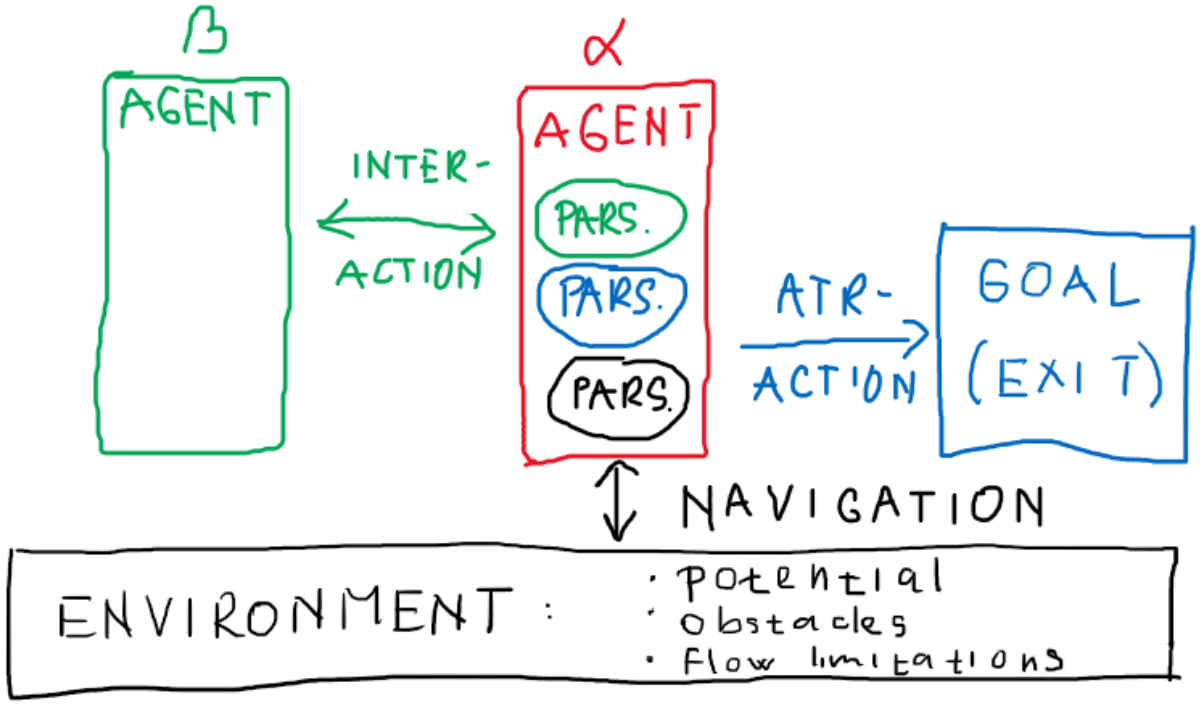
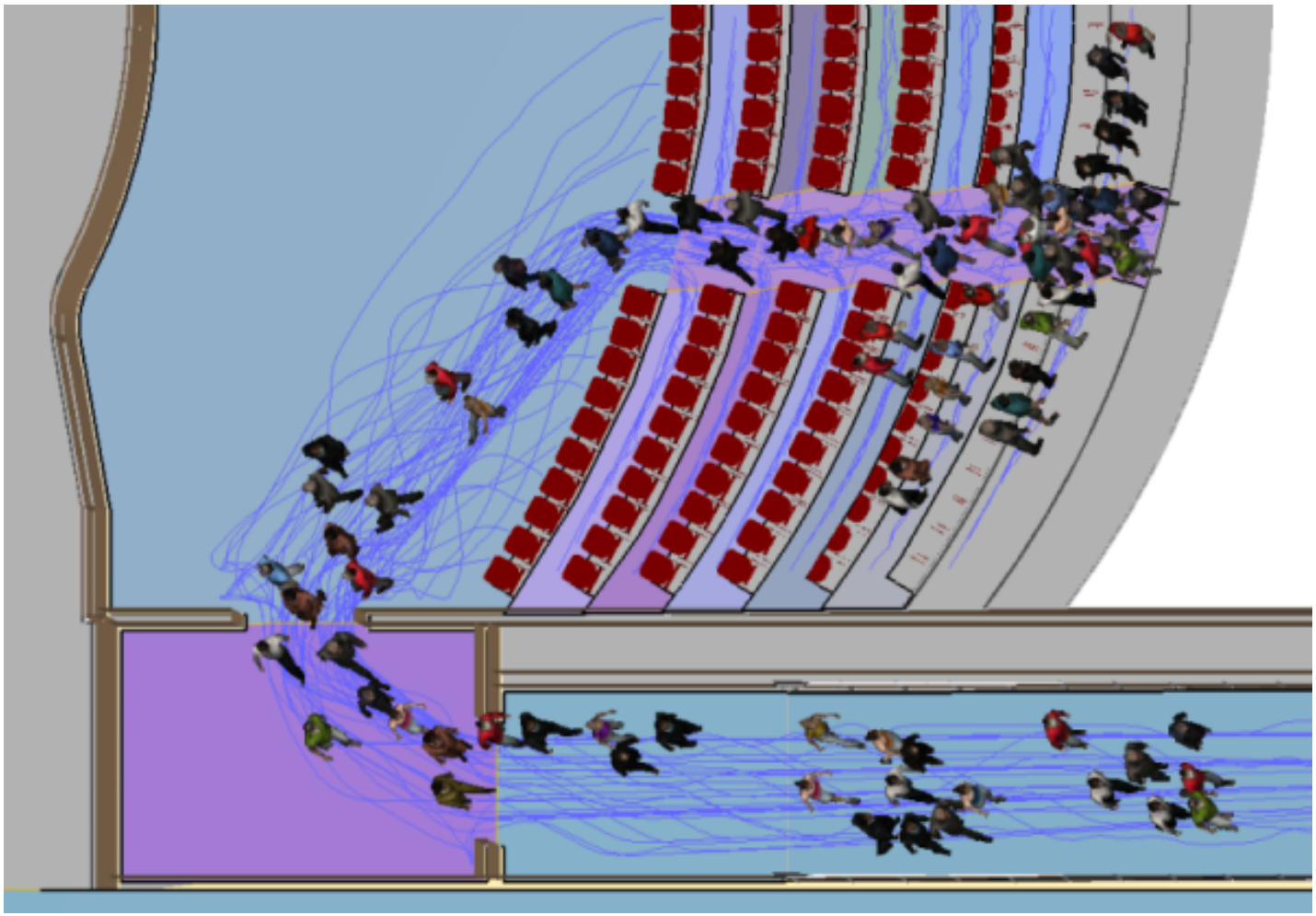
Scope of the talk

Evacuation model components



- Heterogeneity in parameters related to Navigation, Attraction, Interaction.
- Is the heterogeneity necessary?
- How to implement it?

Microscopic Agent-Based Models of Pedestrians



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[1] PathFinder, Thunderhead eng.

Social Force Model for Pedestrian Dynamics

Dirk Helbing and Péter Molnár. Phys. Rev. E 51 (1995)

Newtonian equations of motion

$$\ddot{\boldsymbol{x}}_\alpha(t) = \boldsymbol{F}_\alpha^{(\text{mot})} + \boldsymbol{F}_\alpha^{(\text{int})} + \boldsymbol{F}_\alpha^{(\text{env})} + \boldsymbol{F}_\alpha^{(\text{ext})}$$

- Attraction to the exit

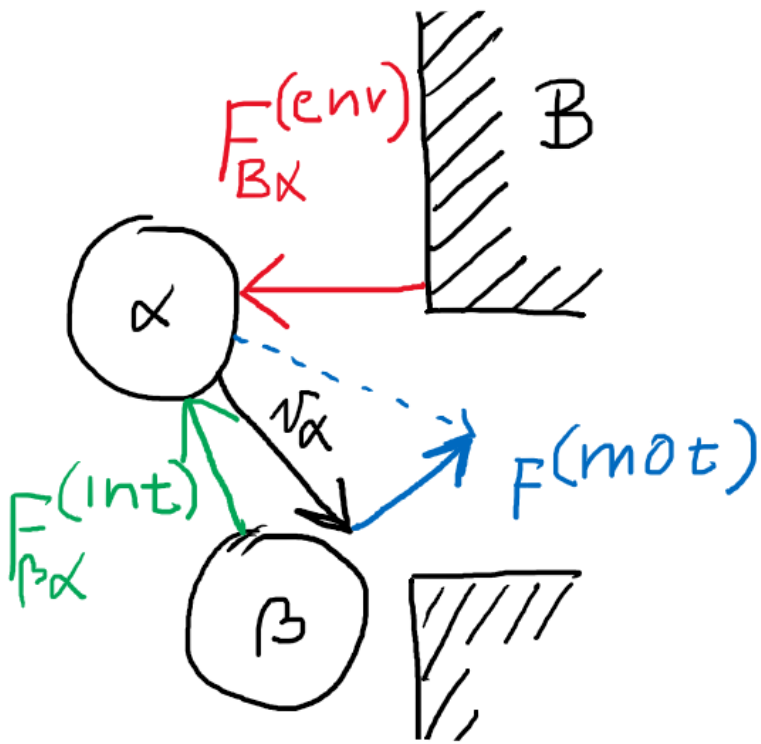
$$\boldsymbol{F}_\alpha^{(\text{mot})} \propto v_\alpha^0 \boldsymbol{e}_\alpha - \boldsymbol{v}_\alpha$$

- Repulsion from others

$$\boldsymbol{F}_\alpha^{(\text{int})} = \sum_{\beta \neq \alpha} \boldsymbol{F}_{\beta\alpha}^{(\text{int})}$$

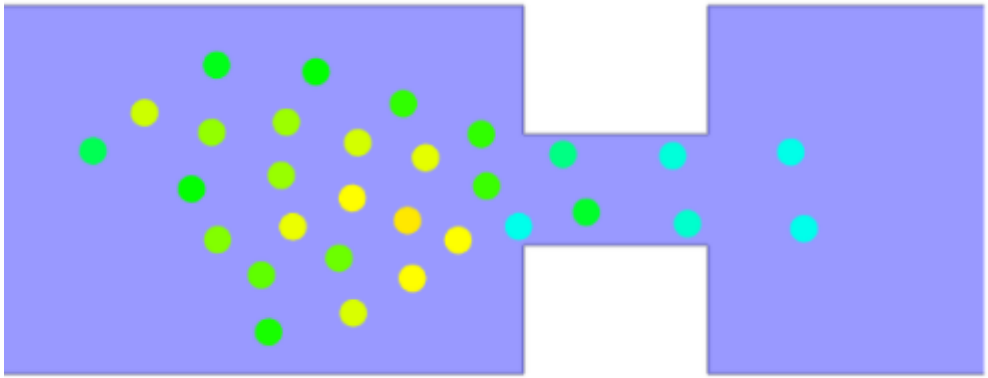
- Repulsion from obstacles

$$\boldsymbol{F}_\alpha^{(\text{env})} = \sum_{B} \boldsymbol{F}_{B\alpha}^{(\text{env})}$$



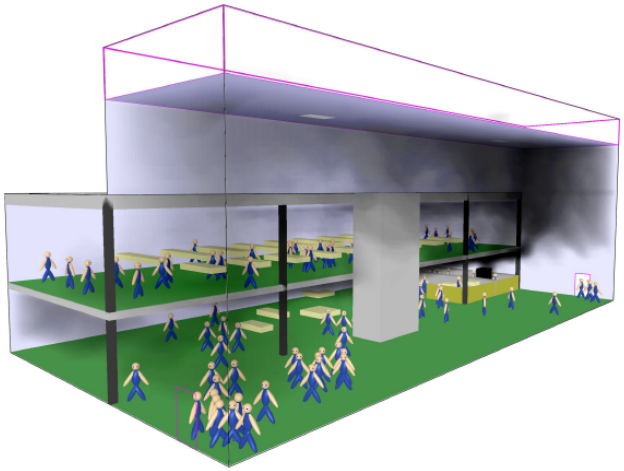
Implementation of Social Force Concept

JuPedSim – open-source simulator from JSC



- Generalized Centrifugal Force Model
- Collision-free Speed Model
- Collision avoidance left to the “Forces”

FDS+Evac – commercial evacuation software

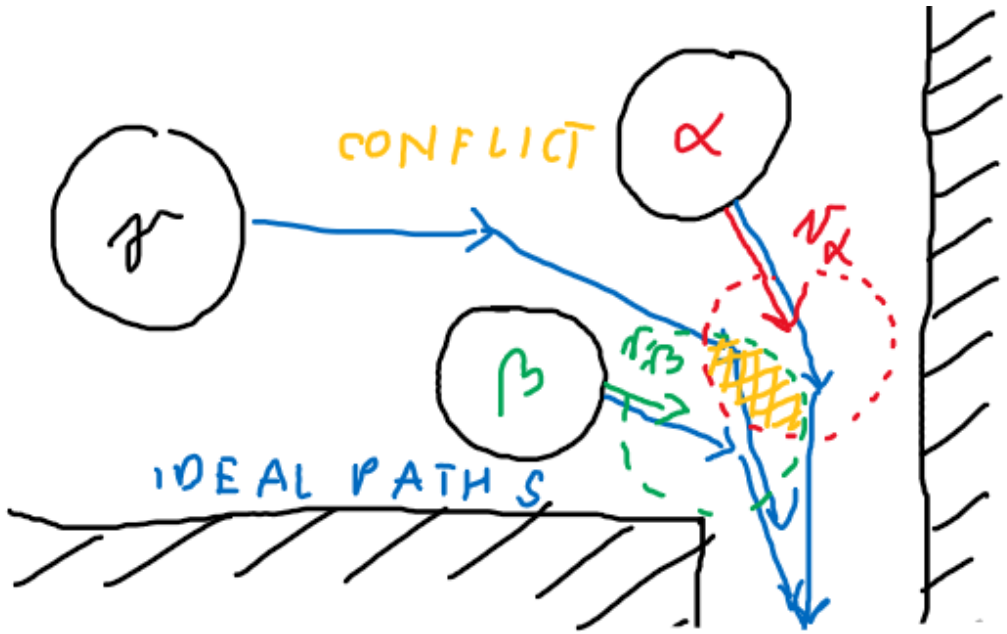


- Helbing Social-Force model
- Collison avoidance rules added
- Fire and human interaction

Path-Navigation and Floor-Field models

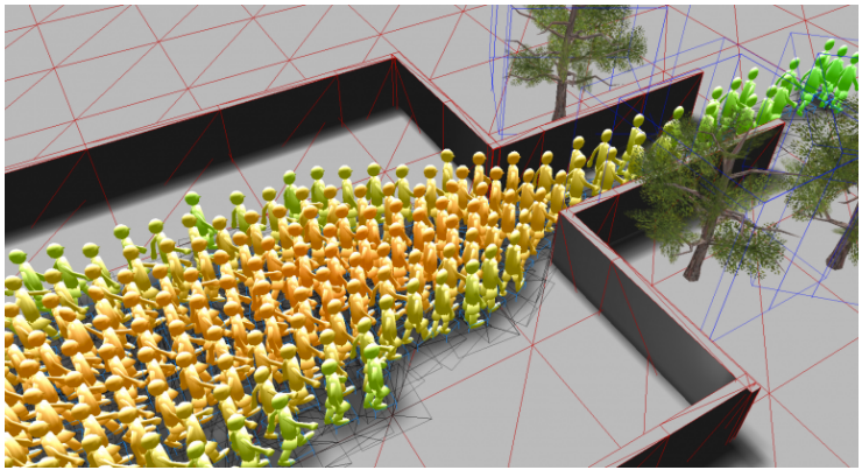
Navigation + Avoiding colissions + Solving conflicts

- Agent chooses direction along ideal path (navigation mesh, potential gradient).
- Agent adjusts its speed based on state of the neighbourhood (obstacles, density, other agents).
- Agents choosing to enter the same cell “negotiate”.



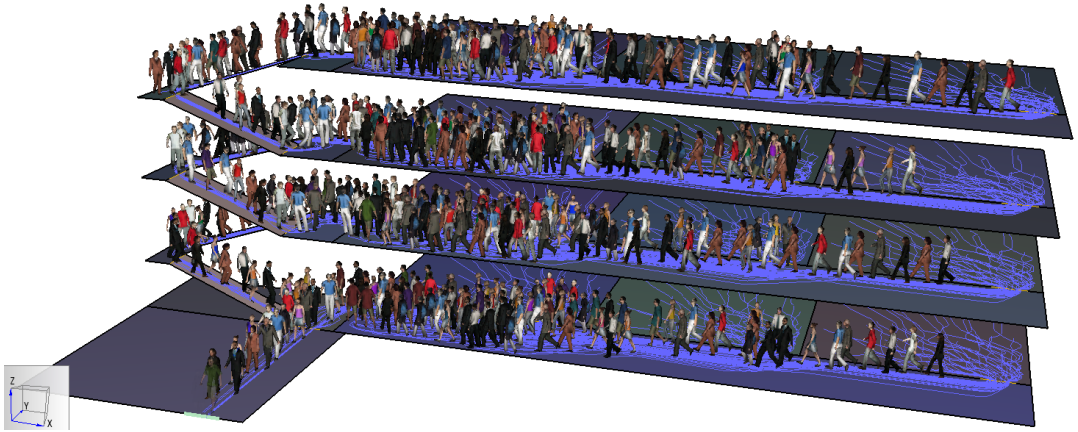
Implemtation of Path-Navigation Models

VADERE – open-source simulator from Munich University of Applied Sciences



- Optimal Steps Model
- Behavioral Heuristics Model
- Navigation using floorfield potential

PathFinder – commercial evacuation software from Thunderhead eng.



- Path navigating concept
- Navigation mesh
- Collision avoidance + conflict solution algorithm

Cellular models

A. Kirchner and A. Schadschneider, Traffic and Granullar Flow'01 (2002)

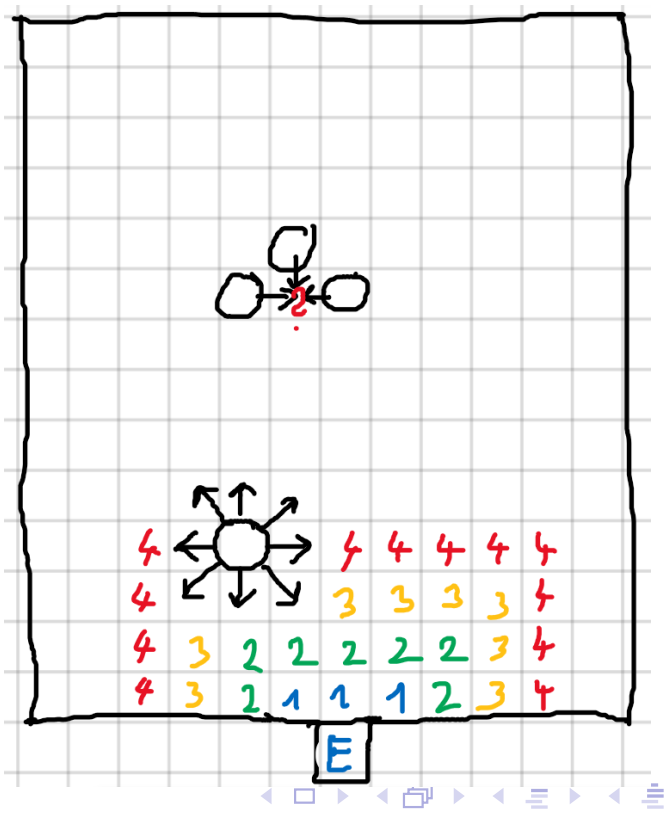
Floor-field cellular automata for pedestrian dynamics

$$P(x \to y \,|\, N) \propto \sum_F \exp\{k_F F_y\}$$

- Navigation to exit based on floor-field S

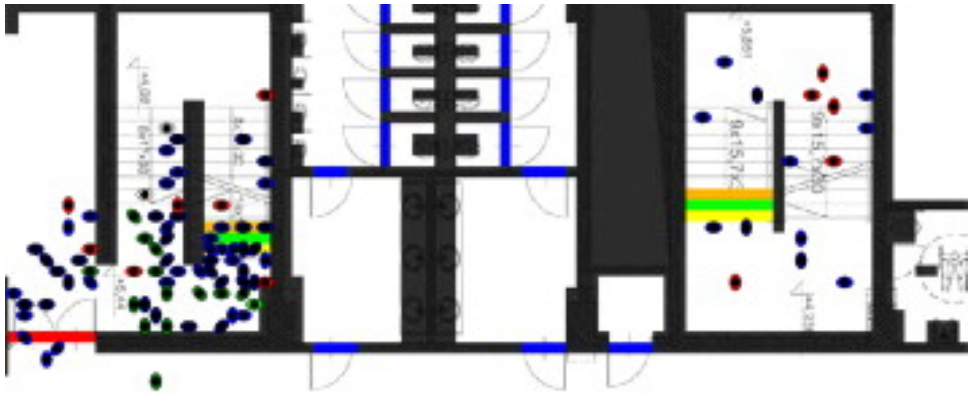
$$P(x \to y \,|\, N) \propto \exp\{-k_S S_y\}$$

- Conflict - more agents choosing the same target cell
- Hardo-core repulsion or "longer interaction"
- Rule-based



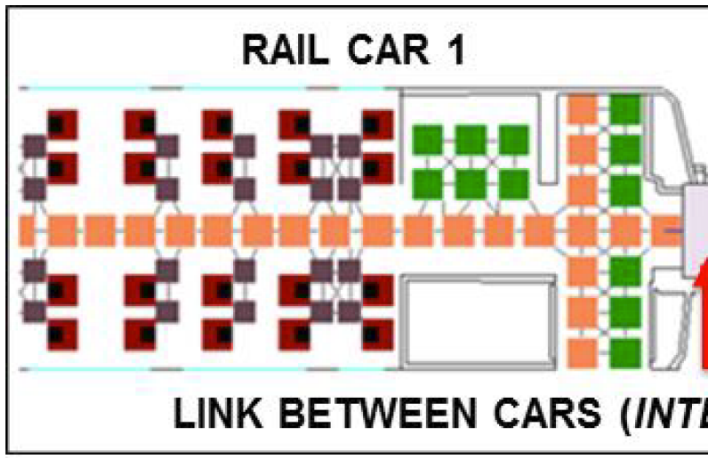
Implementation of Cellular models

Social Distance Model – academic model from AGH University, Krakóv



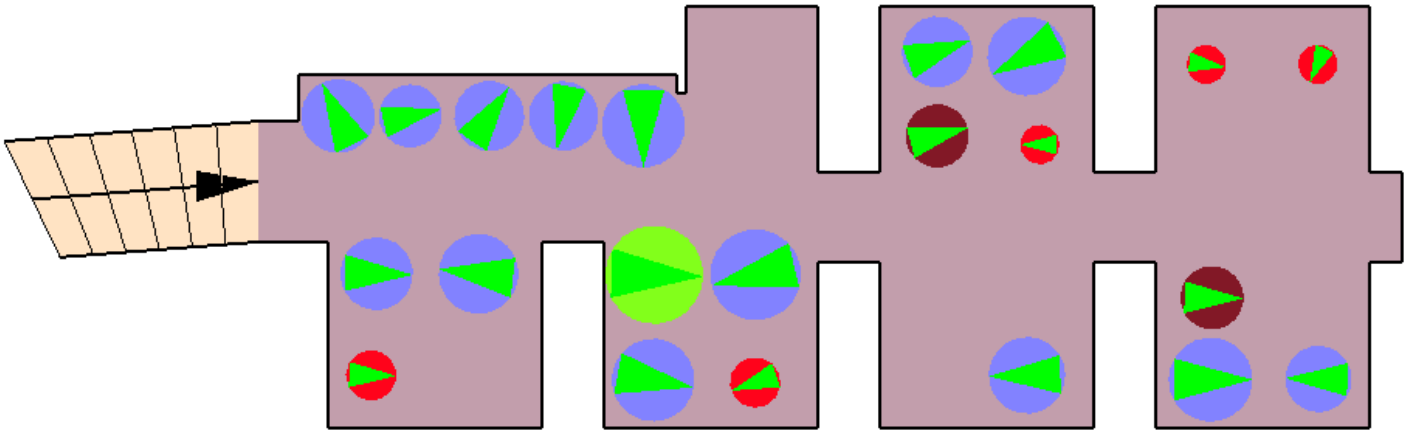
- Allianz Arena Munich, Wisla Krakow
- Finer lattice + Proxemics inspired repulsion

Exodus – commercial evacuation software from University of Greenwich



- BuildingExodus, TrainExodus, PlainExodus, ...
- Strictly rule based
- Waiting times and similar from measurements

Heterogeneity of Agents



Heterogeneity in Velocity and Size

Typical for space continuous models

Heterogeneity by variance of parameters

- Desired velocity

$$v_\alpha^0 \sim \mathcal{N}(\mu_v, \sigma_v^2)$$

- Agent radius/shape

$$R_\alpha \sim \mathcal{N}(\mu_v, \sigma_R^2)$$

- Acceleration parameters

$$a_\alpha \sim \mathcal{U}(a_{\min}, a_{\max})$$

Heterogeneity by introduction of different groups

- Adults, Children, Seniors
- Without or with limitations, or hendicap

Velocity and size in cellular models

Size - finer grid

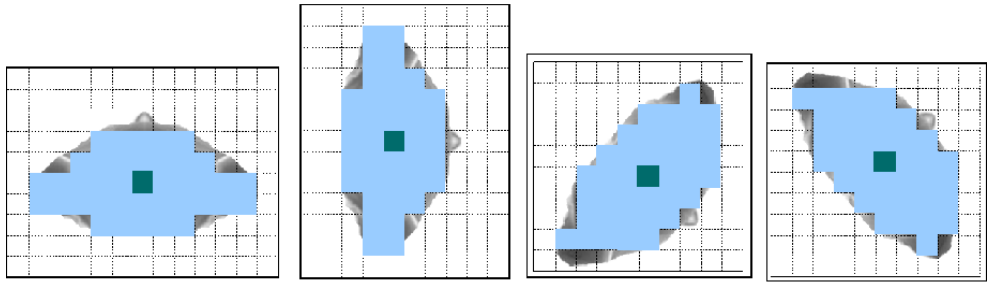
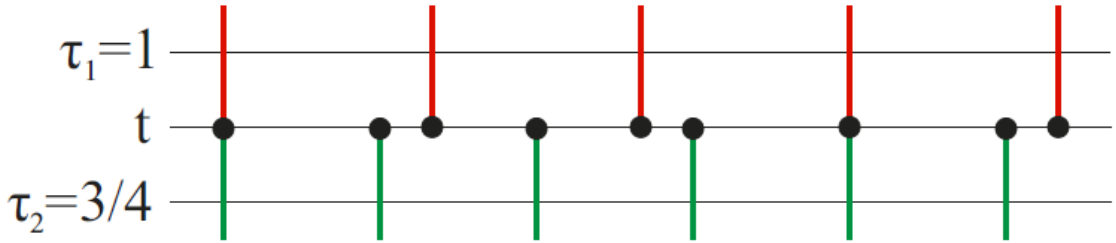


Figure 2: Sample pedestrian maps for different orientations

Velocity - asynchronous update



Different strategies for passing through the crowd

Hrabák, Bukáček and Krbálek. Tramsportmetrica A (2018)

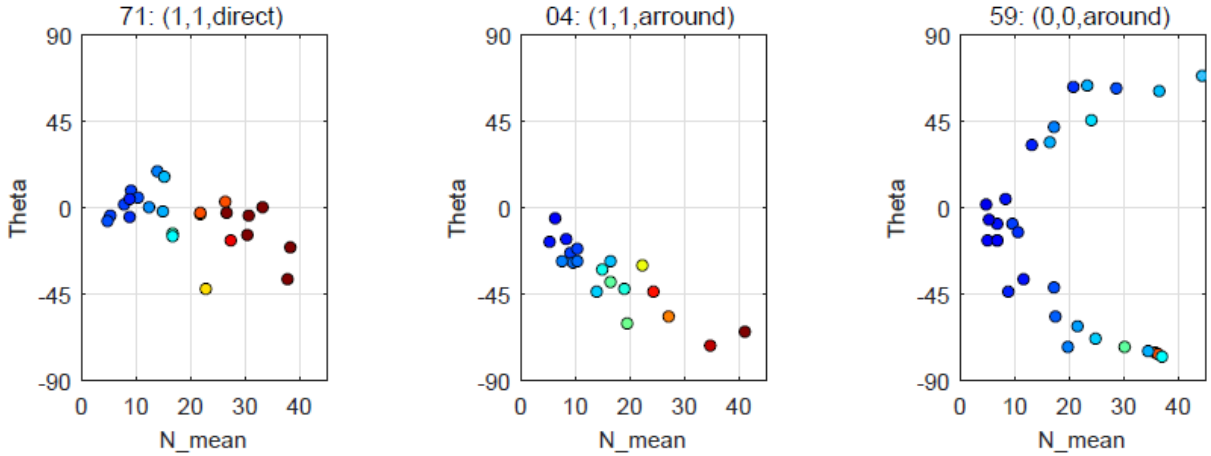
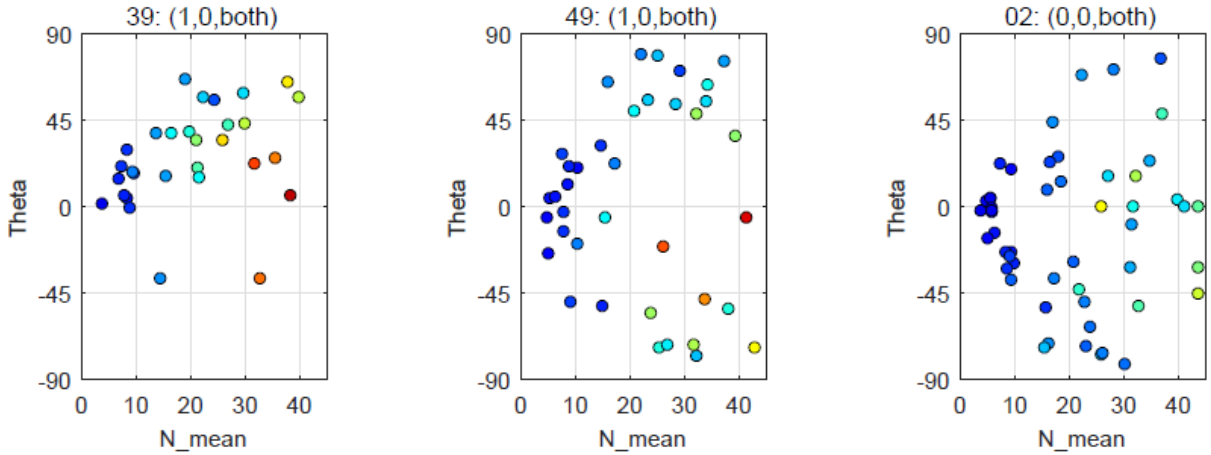
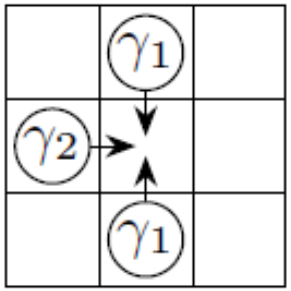


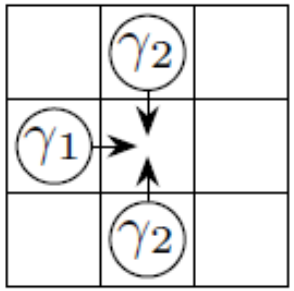
Figure 14. $\vartheta - \bar{N} - TT$ graphs for three representatives of studied strategies. Colormap reflects TT and is the same as in Figure 13

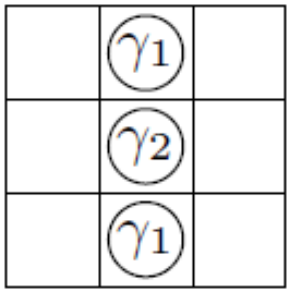


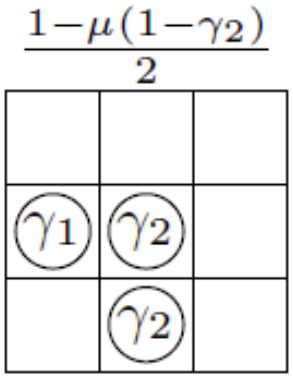
Agressiveness

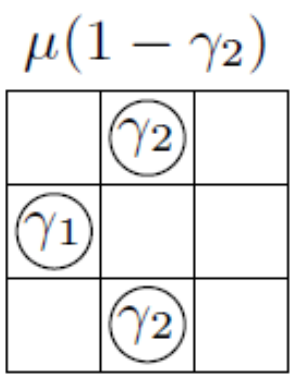
A way of winning conflicts

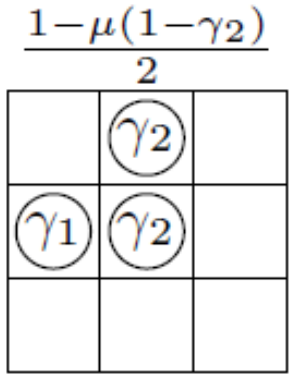






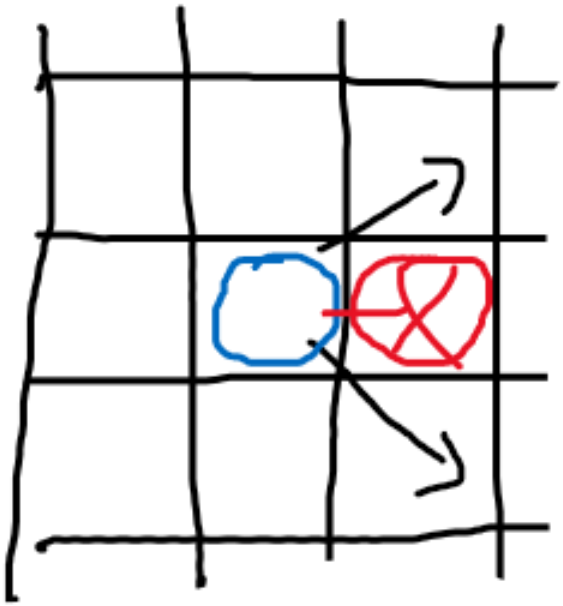


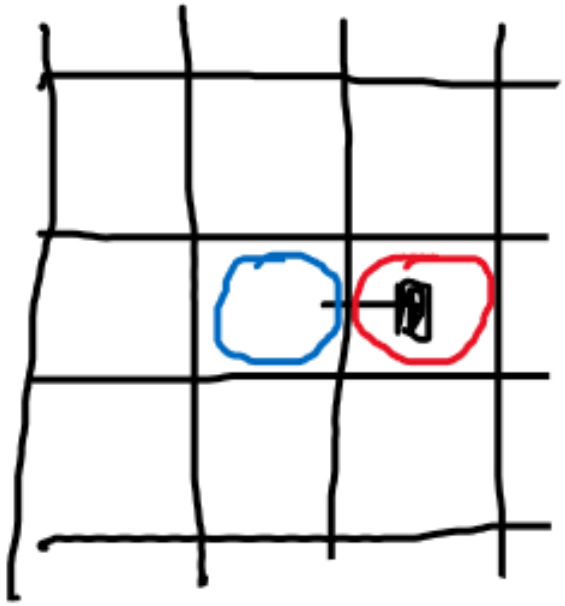




Choice of the target cell

Two strategies





To be continued ...