Automaty komórkowe

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Modelowanie procesu ewakuacji

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6 czerwca 2024

Terry Pratchett, *Eryk*, Prószyński i S-ka (Warszawa, 2003)

Uciekam, więc jestem. A raczej: uciekam, więc przy odrobinie szczęścia nadal będę.

Social-force model [2] I

"The basic equation of motion for a pedestrian of mass m_j is

$$\frac{d\mathbf{v}_j}{dt} = \mathbf{f}_j^{(\mathrm{pers})} + \mathbf{f}_j^{(\mathrm{soc})} + \mathbf{f}_j^{(\mathrm{phys})}, \tag{1}$$

where

- $\mathbf{f}_j^{(\mathrm{soc})} = \frac{1}{m_j}\mathbf{F}_j^{(\mathrm{soc})} = \sum_{l \neq j} \mathbf{f}_{jl}^{(\mathrm{soc})}$ is the total (specific) force due to the other pedestrians.
- $\mathbf{f}_j^{(\mathrm{pers})}$ denotes a 'personal' force which makes the pedestrians attempt to move with their own preferred velocity $\mathbf{v}_j^{(0)}$:

$$\mathbf{f}_j^{(\mathrm{pers})} = \frac{\mathbf{v}_j^{(0)} - \mathbf{v}_j}{\tau_j}, \tag{2}$$

where τ_j reaction or acceleration time.

Social-force model [2] II

- ‘physical’ forces $\mathbf{f}_{jl}^{(\mathrm{phys})}$ become important in high density situations.” [1]
- “The most important contribution to the social force $\mathbf{f}_j^{(\mathrm{soc})}$ comes from the territorial effect, i.e. the private sphere.
- Pedestrians feel uncomfortable if they get too close to others, which effectively leads to a repulsive force between them.
- Similar effects are observed for the environment, e.g. people prefer not to walk too close to walls.” [1] “Describing the pedestrians as disks of radius R_j and position (of the center of mass) $\mathbf{r}_j$, the typical structure of the force between the pedestrians is described by

$$\mathbf{f}_{jl}^{(\mathrm{soc})} = A_j \exp\left[\frac{R_{jl} - \Delta r_{jl}}{\xi_j}\right] \mathbf{n}_{jl}, \tag{3}$$

Social-force model [2] III

with

- $R_{jl} = R_j + R_l$, the sum of the disk radia,
- $\Delta r_{jl} = |\mathbf{r}_j - \mathbf{r}_l|$, the distance between the centers of mass,
- $\mathbf{n}_{jl} = \frac{\mathbf{r}_j - \mathbf{r}_l}{\Delta r_{jl}}$, the normalized vector pointing form pedestrian l to j.
- A_j can be interpreted as strength, ξ_j as the range of the interactions." [1]

Cellural automata approach I

- "A natural space discretization can be derived from the maximal densities observed in dense crowds which gives the minimal space requirement of one person.
- Usually each cell in the CA can only be occupied by one particle (exclusion principle) so that this space requirement can be identified with the cell size.
- In this way, a maximal density of 6.25 P/m^2 leads to a cell size of 40×40 cm^2." [1]
- "The transition probabilities for all pedestrians depend on the strength of the floor fields in their neighbourhood in such a way that transitions in the direction of larger fields are preferred.

Cellural automata approach II

The dynamic floor field D_{ij}

corresponds to a virtual trace which is created by the motion of the pedestrians and in turn influences the motion of other individuals. Furthermore it has its own dynamics, namely through diffusion and decay, which leads to a dilution and finally the vanishing of the trace after some time.

The static floor field S_{ij}

does not change with time since it only takes into account the effects of the surroundings. Therefore it exists even without any pedestrians present. It allows to model e.g. preferred areas, walls and other obstacles." [1]

Cellural automata approach III

"Coupling constants

control the relative influence of both fields.

- For a strong coupling to the static field pedestrians will choose the shortest path to the exit. This corresponds to a 'normal' situation.
- A strong coupling to the dynamic field implies a strong herding behaviour where pedestrians try to follow the lead of others. This often happens in emergency situations." [1]

Varas et al. model [3] I

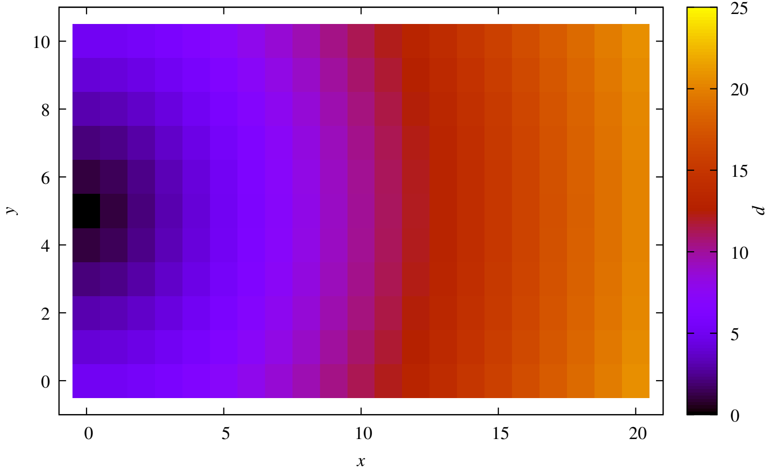
- "The room is divided in a rectangular grid. The exit door is assigned a value '1'.
- If a cell has value N, then adjacent cells in the vertical or horizontal directions are assigned a value $N+1$. We will allow diagonal movements, thus it makes sense to consider adjacent cells in diagonal directions. We assign them a value $N+\lambda$, with $\lambda > 1$. $(\dots)$ $\lambda = 3/2$.
- $(\dots)$ the minimum possible value is assigned to the cell in conflict.
- Then the third layer of cells is calculated, which is all cells adjacent to the second layer, and not in the first layer.
- The process is repeated until all cells are evaluated.

Varas et al. model [3] II

- Cells belonging to walls are given very high values of the floor field.” [3]
- “(Pedestrian) decides to move to the closest exit, that is, to the adjacent empty cell with the lowest floor field.
- If two or more neighboring cells have the same lowest floor field, a random number is used to decide the cell to which the person will intend to move.
- If two pedestrians intend to move to the same cell, this conflict is decided by throwing a random number. The winner moves, the loser does not. This, and the fact that a pedestrian cannot move to an occupied cell, are the only interactions between pedestrians.

Varas et al. model [3] III

- A certain amount of 'panic' is introduced, given by a probability (5% in our model) of the pedestrian to remain in his/her position even if he/she can move." [3]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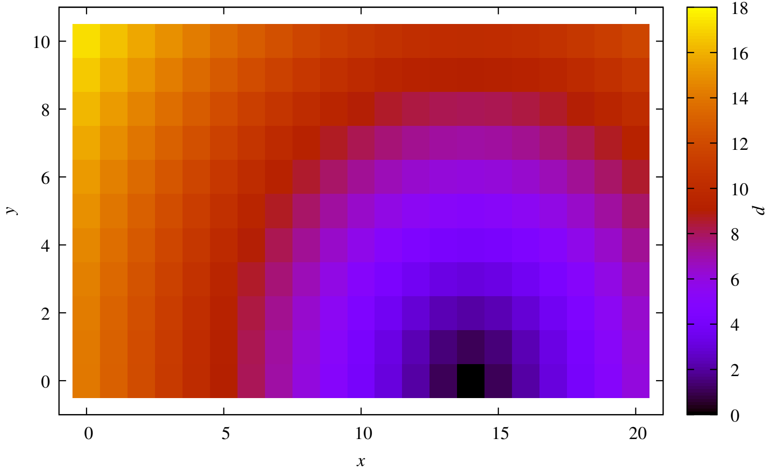
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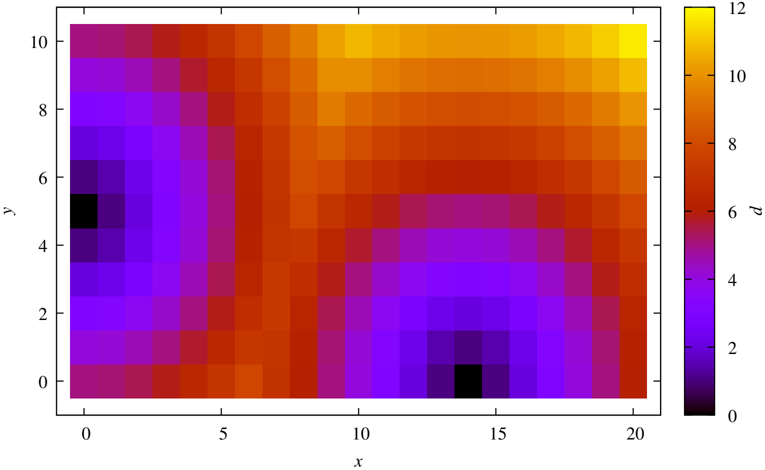
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Ewakuacja z połączonych pawilonów D-10+D-11

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Ewakuacja ze stadionu miejskiego

Aplikacja, Artur Wiśniowski

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plik konfiguracyjny

http://www.zis.agh.edu.pl/app/MSc/GridFinal.gdt

[1] A. Schadschneider, W. Klingsch, H. Klüpfel, T. Kretz, C. Rogsch, and A. Seyfried. *Evacuation dynamics: Empirical results, modeling and applications*. Ed. by B. Meyers. 2008.

[2] D. Helbing and P. Molnár. "Social force model for pedestrian dynamics". *Physical Review E* **51** (5 1995), 4282–4286.

[3] A. Varas, M. Cornejo, D. Mainemer, B. Toledo, J. Rogan, V. Muñoz, and J. Valdivia. "Cellular automaton model for evacuation process with obstacles". *Physica A: Statistical Mechanics and its Applications* **382**.2 (2007), 631–642.