Literature survey of CA model on pedestrian movements

Group 12
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1.
C Burstedde, K Klauck, A Schadschneider, J Zittartz, Simulation of pedestrian dynamics using a two-dimensional cellular automaton, Physica A: Statistical Mechanics and its Applications, Volume 295, Issues 3–4, 15 June 2001, Pages 507-525, ISSN 0378-4371, http://dx.doi.org/10.1016/S0378-4371(01)00141-8.

In the literature, two dimensional cellular automation is utilized for simulating pedestrian dynamics. In contrast to old approaches that makes many assumption about human behaviors of pedestrians, this simulation model is good in a sense that it doesn't make any assumptions about human behavior except for that the pedestrian usually follows the trace of the person just before him. Also, it models the long range interaction between pedestrians. In the model, the maximal velocity of pedestrian is set to 1. And the for each pedestrian, it's defined that he could have 9 possible positions as matrix shown in the Figure X below. The probability of each possible move is composed of three parts – the pedestrian's preference, one dynamic floor and one static floor. The pedestrian's preference move is determined by his relative position to his destination. The static floor represents the positions in the 2D celluar automation that are more attracting, e.g. the exits to one destination. And the dynamic floor field is determined by trace of past pedestrians, which represents the long range interaction among the pedestrians. Finally, in addition to these general ideas about how to simulate pedestrian dynamics, the literature also provides much information about the rules and the details of simulation model. The useful information include the occupied area of a pedestrian in a dense population is about 40cm * 40 cm. Thus, the size of the cellular automation could be determined. Also, the average velocity of a pedestrian is about 1.3 m/s based on the literature. Combining with the average velocity above, the timestamp of the simulation could be set to 0.3s for each update.

$M_{-1,-1}$	$M_{-1,0}$	$M_{-1,1}$
$M_{0,-1}$	$M_{0,0}$	$M_{0,1}$
$M_{1,-1}$	$M_{1,0}$	$M_{1,1}$

Figure

2.
Schwandt, Minjie Chen Günter Bärwolff Hartmut. "Automaton model with variable cell size for the simulation of pedestrian flow." (2008).

This journal concentrates its attention on variable cell size within the automaton model when it's applied to simulations of pedestrian flow. The authors state that the variable cells are quite meaningful especially when pedestrain density and discrepancy of the flow-in and flow-out rates are highlighted in the scenario.
First, the paper has a review on the contributions the other researchers had made to the simulation problem, especially on the evolution of the CA models from maximum step length of a pedestrain equals to 1 to larger.
Then, the authors discribe their model in a more detailed way, which is also a M*N two-dimensional grid with each cell sizing 0.3*0.3m. However, the cell every pedestrain occupied could be at most 9 cells, which means 0.9m*0.9m. That is for keeping distances among pedestrians. The most important point is that the 8 cells around the central one could be deactivated or activated considering the traffic, or the particle density. In addtion, they could be partially or totally deactivated as the picture shown below. In this way, the cell size could be dynamically adjusted.

$$\mathrm{s} \in \{ \mathrm{d}, \mathrm{a} \}$$

d	d	d
d		d
d	d	d

$\imath = 1$

s	d	s
d		d
s	d	s

$0.5 \le \imath \le 1$

a	d	a
d		d
a	d	a

$\imath = 0.5$

a	s	a
s		s
a	s	a

$0 \le \imath \le 0.5$

a	a	a
a		a
a	a	a

$\imath = 0$

The way they determine whether to deactivate/activate a cell is also interesting. First, they derived a virtual index i, which is determined by the pedestrain density around, and hence they could tell how many cells should be deactivated/activated. Then, they employed an appropriate probability distribution to exactly determine the cell sizes.
Finally, the researchers did some experiments to test their new model. It turns out that the new model could help to simulate the pedestrains' behaviors in a more accurate way.

3.
Castellano C, Fortunato S, Loreto V. Statistical physics of social dynamics[J]. Reviews of modern physics, 2009, 81(2): 591.

The paper proposed a new idea to simulate the velocities of each pedestrian can be controlled technically by updating different time step interval (but the unit velocity b/t each unit time step is still the same.). The strategy of change of the cell state is Von Neumann neighbor setup, which update the cell state at current time depending on the four neighbor's and its own states at previous state. the strategy of pedestrin is that they tend to choose right-hand side if only blocked in the front, and that they have to stop and wait when blocked from the front, the left and the right (can not go back by default). the pedestrians with higher velocities are allowed to overtake other pedestrians with lower velocities towards the same direction. the author thought the priority of the overtaking is preferable to occur at left side rather than right side. the strategy of sequential update is shffled update, which radomly number every pedestrain from 1 to N in every update time-step (loop all pedestrians each time). there are two boundary conditions: periodic and open boundary. the advantage of this model is to use variable velocity and multiple boundary conditions to discuss the complex situations, which make the model of more reality. A reminder is that the transitional probabilities depends on the directions, not necessary to be equal. The periodic boundary condition is a good assumption to simulate the phenomena well which is consistent with the empirical observations.

Taylor D P, Wells J Z, Savol A, et al. Modeling boundary conditions for balanced proliferation in metastatic latency[J]. Clinical Cancer Research, 2013, 19(5): 1063-1070.

This paper provided a CA model including three modes of bi-directional pedestrian flow: 1, flows in derectionally separated lanes; 2, interspersed flow; 3, dynamic multi-lane flow. the bi-directional microscopic model concerns side stepping (lane changing), forward movement (braking, acceleration) and conflict mitigation (deadlock avoidance), which are similar as the movement types I read in last paper. and the update of movements is also affected by the cloest neighbor. the speed is assigned as 2,3,4 or follow a certain of distribution. the big different is that a free lane is attractive to both adjacent lane and pedestrians two cells away. conflict solution is just to use 50/50 random decision (that part we might be able to add more real condition to decide it such as consideration on the neighbors). An important concept is gap in this paper.

4.

Review:

The article Simulation of the Evacuation of a Football Stadium Using the CA Model PedGo describes a computer simulation that pretty related to our project: Pedestrian Traffic After a Football Game. Some concepts and methods from the article may be implemented to this project. In the article, quadratic cells of size 40cm2 is used to simulate a two dimensional cellular automaton model, where they may represent empty space, people occupied space, or non-accessible obstacle. Time is measured in discrete steps. People's orientation is dependent on signage and routes are simulated by distance information. Potentials are used to model complex geometries. Congestion is defined by the local density, marked by different color. Three different scenarios with different population are investigated, egress speed are compared between the three. This article presents a good example for crowd movement and evacuation processes in the way of easy handling and animation expression.
The article A review of the methodologies used in the computer simulation of evacuation from the built environment built a more complicated egress model to assess evacuation efficiency. Though not using CA model, they used 22 different models, taking into consideration the relation between people's behavior and occupants initial response to evacuate, group interactions in computer based analysis to understand how the population system likely to behave given pre-defined conditions. Normal distribution was assumed between probability and evacuation time. This article is not as relevant as the previous one, but the different aspects as of Psychological, Sociological, Physiological for the relationships of People-People, People-Structure, People-Environment could give us an idea of what to consider in our project.

References:

[1] Simulation of the Evacuation of a Football Stadium Using the CA Model PedGo by H. Klüpfel and T. Meyer-König
[2] A review of the methodologies used in the computer simulation of evacuation from the built environment by S. Gwynne, W.E. Galea, M. Owen, P.J. Lawerence, L. Filippidis