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A Dynamic Intelligent Cellular Automaton Model for Evacuation Process with Obstacles and in Regard to Population Density

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ABSTRACT

In the present paper, we propose a dynamic cellular automaton (CA) model to simulate the evacuation process in a room with obstacles. To make this simulation more realistic, our strategy for updating the situation of each pedestrian in every step is not only based on the pedestrian interactions, placement of the doors and position of the obstacles, but also on the distribution of the crowd and field of Vision. In this approach each cell depending on the positions of the doors and obstacles has a static weight and depending on the pedestrians distribution has a dynamic weight. In order to describe our algorithm , simulation of the evacuation process of a theatre room and also a classroom are presented, then optimal pedestrians positions, field of vision and virtual exits width are discussed and these numerical results are compared with those obtained.

KEYWORDS: cellular automaton, floor field, Field of Vision, pedestrian, evacuation, Virtual Exit

1- INTRODUCTION

Model presented in [14] based reform model in [12] , that a dynamic two-dimensional Cellular Automaton model to simulate the evacuation process in a room with obstacle, to cover Problems and issues related to incomplete evacuation process in terms of non-uniform. In the above model a person is totally logical and simple in their decisions to select the appropriate exit, in addition to distance, amount of congestion would also contribute. But with a little hesitation in the revised model, conditions can be raised that some passers movements is irrational and unreasonable. Since this problem occurs in the improved model, in addition to the amount of congestion around the exit doors, road congestion to passers will also impact. For example, Environment related to the figure 1 is an example of conditions with its implementation we noticed that people choose red path environment for exit, while is not the same in the normal model.

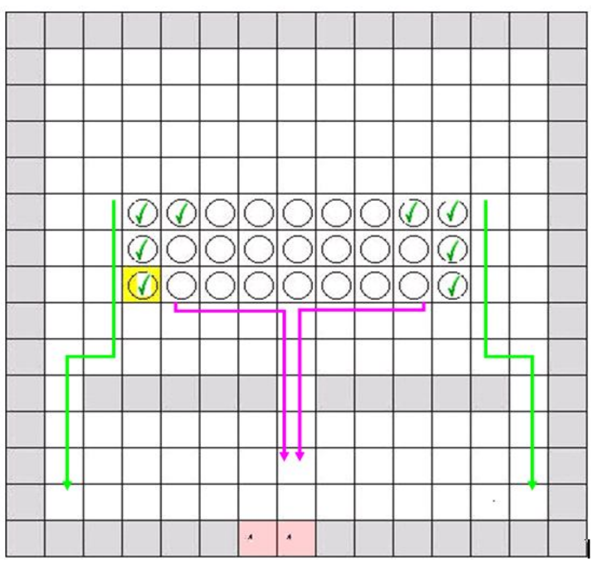

Figure 1: The environment consists of 15 × 15 cells with an exit door and 27 pedestrians

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Figures 2 and 3, respectively, model [12,13] after 5 and 10 stages on the environment is related to figure 1:

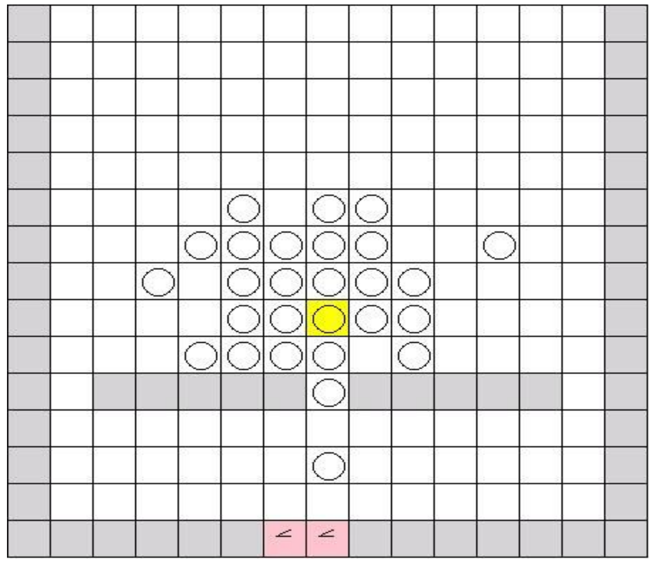


Figure 2: Environment related to figure 1 after the 5 stage, according to the model provided by Varas.

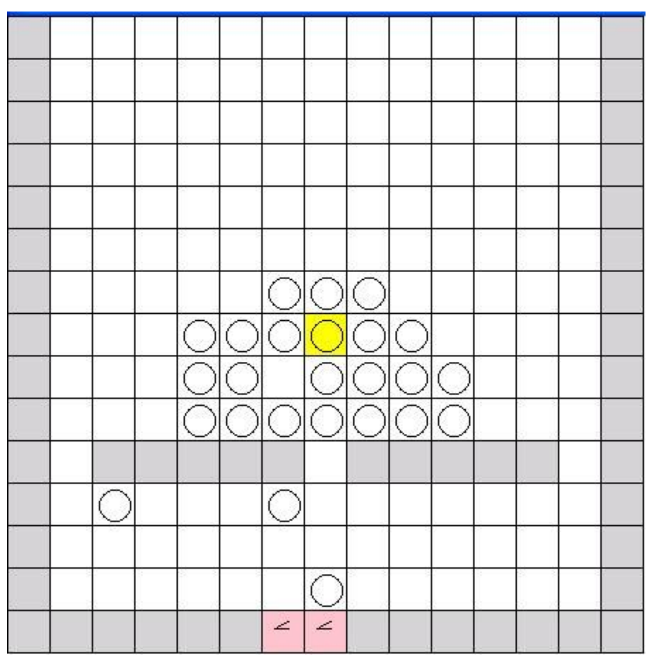


Figure 3: Environment related to figure 1 after the 10 stage, according to the model provided by Varas.

And against with 5 and 10 stage related to model presented in (see [1-10]) , [14] on environment of figures 4 we reach figures 4 and 5.

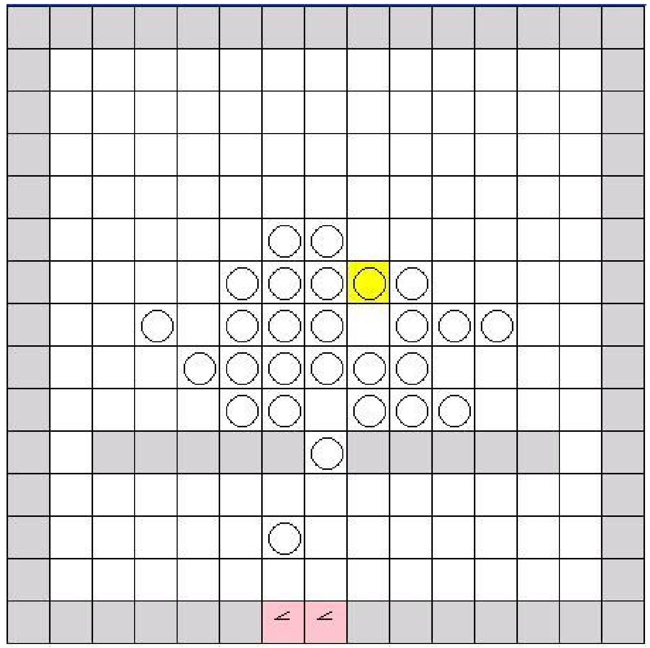


Figure 4: environment related to figure 1 after the 5 stage, according to the model provided in [14].

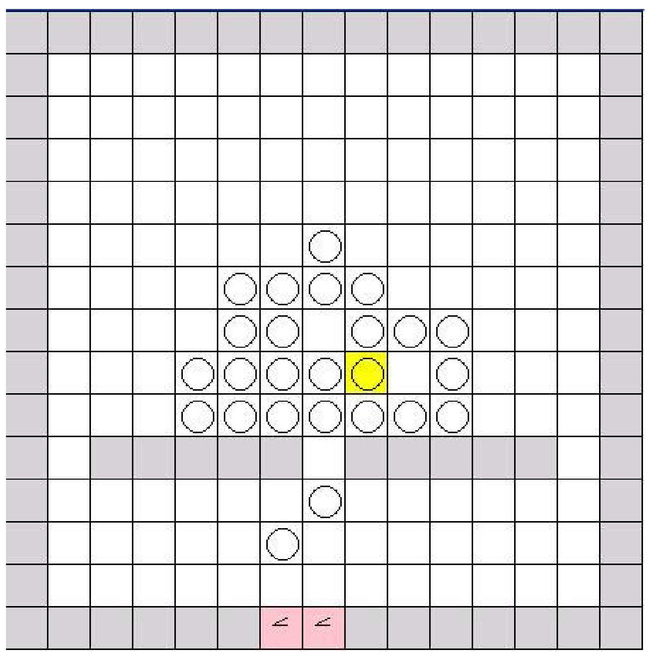


Figure 5: environment related to figure 1 after the 10 stage, According to the model provided in [14].

2 - Model description

Certainly in Figure 1, those persons that marked with green, has choose absurd way for evacuation, And it is better that some pedestrians, rather than choosing red path, use a path that includes side cell environment (green path), Although these cells are longer than red path, but if we consider the delay because of the pedestrians congestion on the red path, the red path is much better for some people.

In the next section, in addition to the parameters such as position of exit doors, pedestrian distribution, obstacle position . . . [11] other parameters as "Field of Vision" will consider. Before that, let us introduce the word "Virtual Exit". A set of cells to prevent the line between two separate call a virtual exit, As seen in the hypothetical environment of figure 6 we consider the cells between tow hypothetical barrier A_1 and A_2 as read exit and also as a virtual exit which the virtual exit is with width 2 cells. For further information, set of hypothetical barrier cells between cells E2, E1 or D1, E1 or E2, F2, are each virtual exit separately with a cell width.

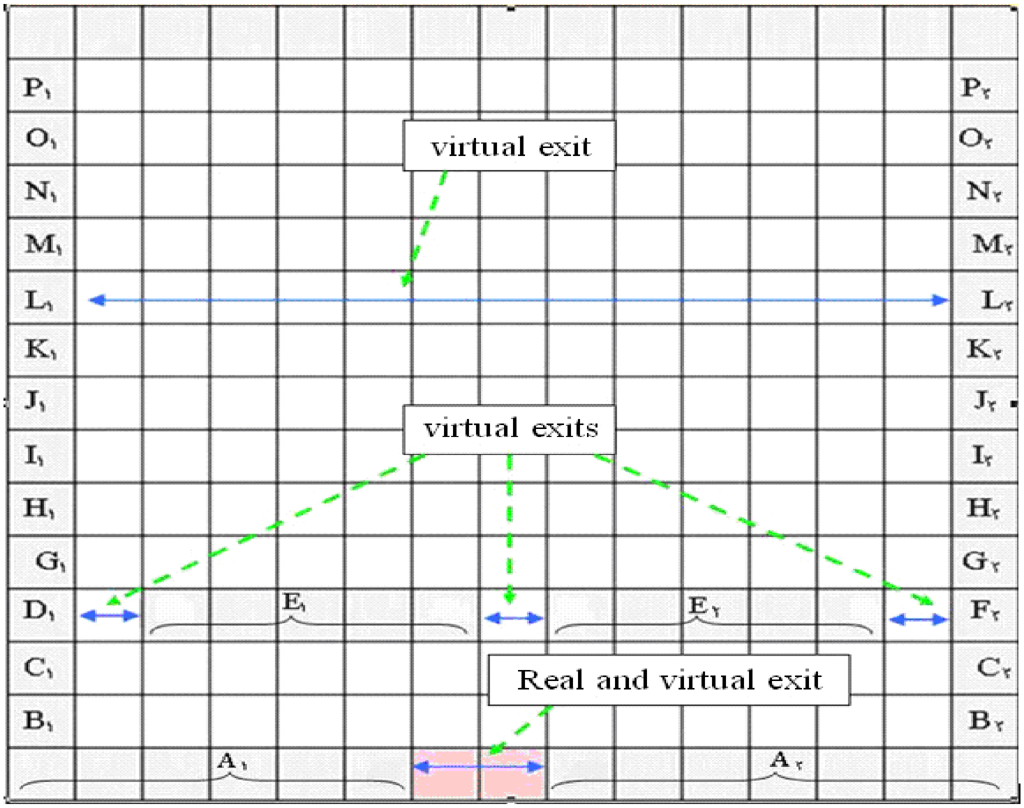


Figure 6: an environment in which the number of virtual exit have specified.

As in the past, we show Virtual Exit width A with d_A.

In order to consider the distribution of pedestrians during the evacuation process, we construct a dynamic floor field. Here the CA is equipped with an engine which processes the distribution and computes the weight of the cells in every step. In this model for determining the weight of a cell x with respect to a virtual exit A in the ith step $W_i^A(x)$, we consider two following parameters:

(i) $W_{statics}^A(x)$: The distance from x to virtual exit A.

(ii) $T_{i-1}^A(x)$: The required time need during the time i-1 which persons from the cell X get the virtual exit A. We set:

$$W_i^A(x) = \underbrace{W_{statics}^A(x)}_{\text{static weight}} + \underbrace{\alpha \, . \, T_{i-1}^A(x)}_{\text{dynamic weight}} \qquad (3.1)$$

Where:

$$T_i^A(x) \; \alpha \; \frac{\left|P_i^A(x)\right| + \frac{1}{2}\left|E_i^A(x)\right|}{d_A}$$

$$P_i^A(x) = \left\{ y \,\middle|\, W_{statics}^A(y) < W_{statics}^A(x) \text{ , } y \textit{ is occupied by a person in the ith step} \right\}$$

and:

$$E_i^A(x) = \left\{ y \,\middle|\, W_{statics}^A(y) = W_{statics}^A(x) \text{ , } y \textit{ is occupied by a person in the ith step} \right\}$$

Indeed $P_i^A(x)$ ($E_i^A(x)$) is the number of pedestrians which have less (equal) distance than (to) x from the door A in the ith step.

Concept of distance in the above formula, compared with other concepts presented so far have been a little different because previously distances than the main exit doors were calculated , but now to calculate distance for each pedestrian, we independently doing, first, determine the most appropriate virtual exit for each pedestrian and then calculate his distance to Virtual exit above.

But how to find appropriate virtual exit? We act as follows:

(a) . Determine all virtual exit of environment.
(b) . According to the algorithm presented in [14], for each person determines the appropriate exit.
(c) . A pedestrian may selected virtual exit are many, in between these virtual exits, the virtual exit that according Metrics presented in [14] is closer to the door will be chosen.

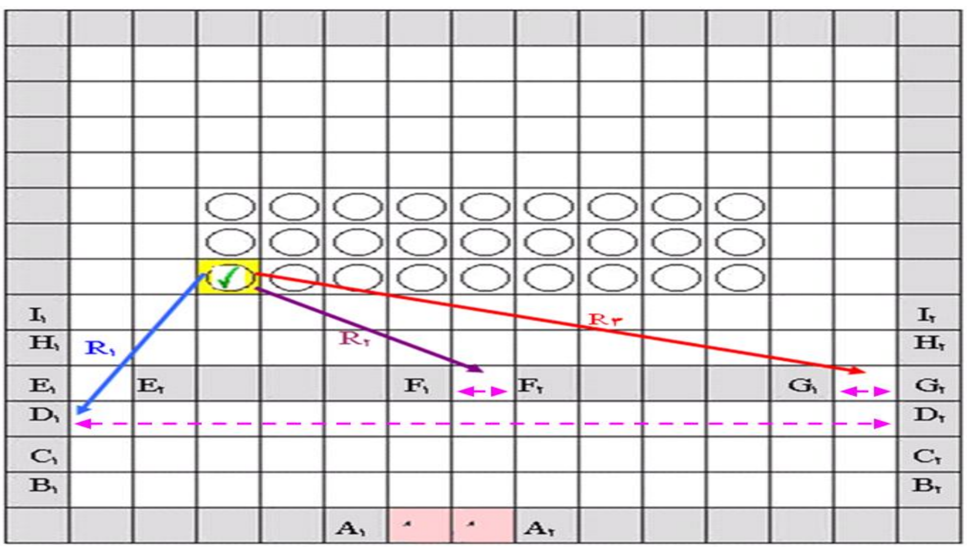


Figure 7: Paths, that pedestrian specified in green Aided them can go outside of environment.

In figure 7, for each specified pedestrian there are three path R_1 and R_2 and R_3, that virtual exit g is related to the path R_1, virtual exit f is related to the path R_2 and virtual exit d is related to the path R3.

Among them, virtual exit d as appropriate exit and path R_1 as appropriate path is selection. Therefore, to calculate the distance to the pedestrian specified, we consider the virtual exit D. It should be noted that, for each pedestrian in every phase of displacement, all the above steps are repeated independently. Figure 6 and 7 show respectively the simulation environment of figure 1 based on Model presented in [14] and the current model, after 5 and 10 steps. Their evacuation time according to above models, respectively, is 90 and 65 stage.

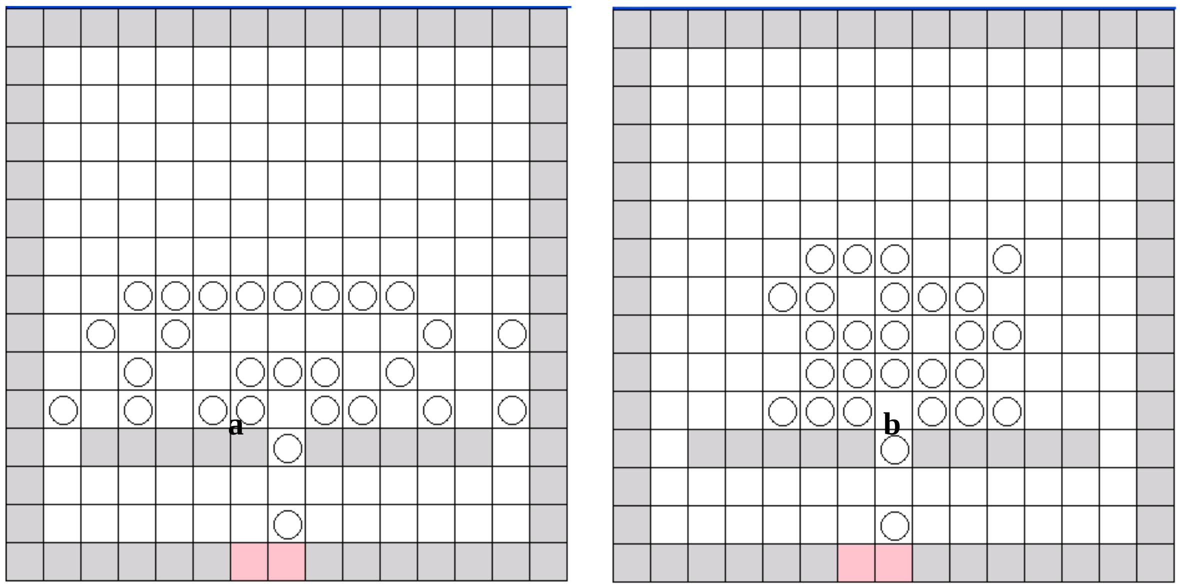
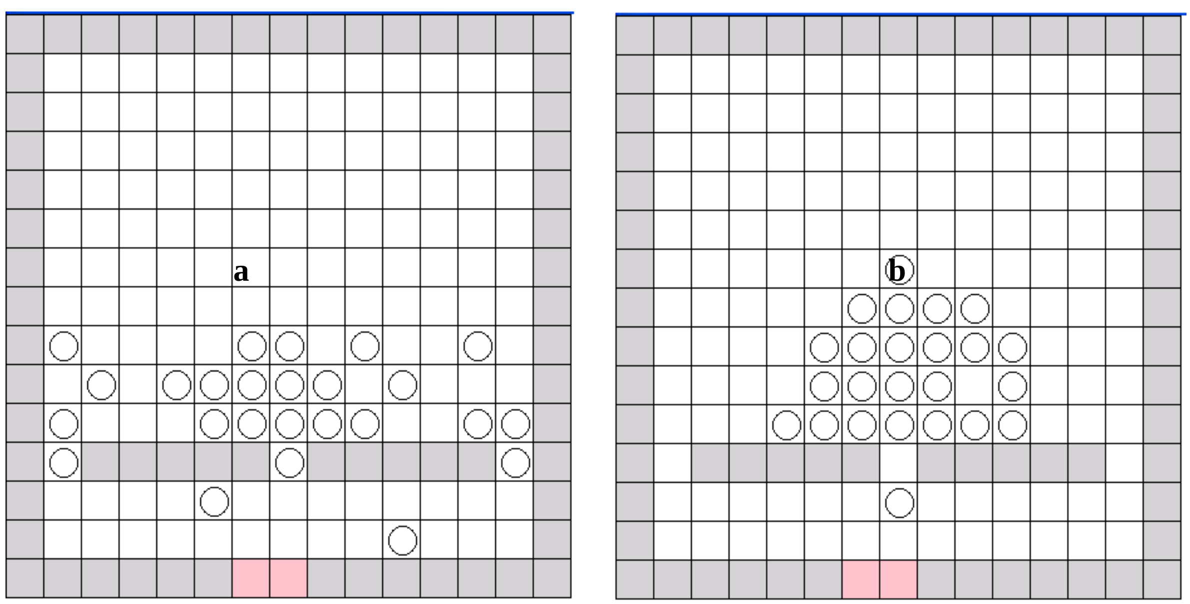


Figure 8: Figure 1 after 5 steps, according to model presented in [14] (a) and the current model (b).



Difference in the number of pedestrian who leave the environment in the early stages of implementation of the algorithm according to the above two models is not noticeable, But after a few implemented, the situation will change, and number of people who have left the environment will be more (Fig. 10).

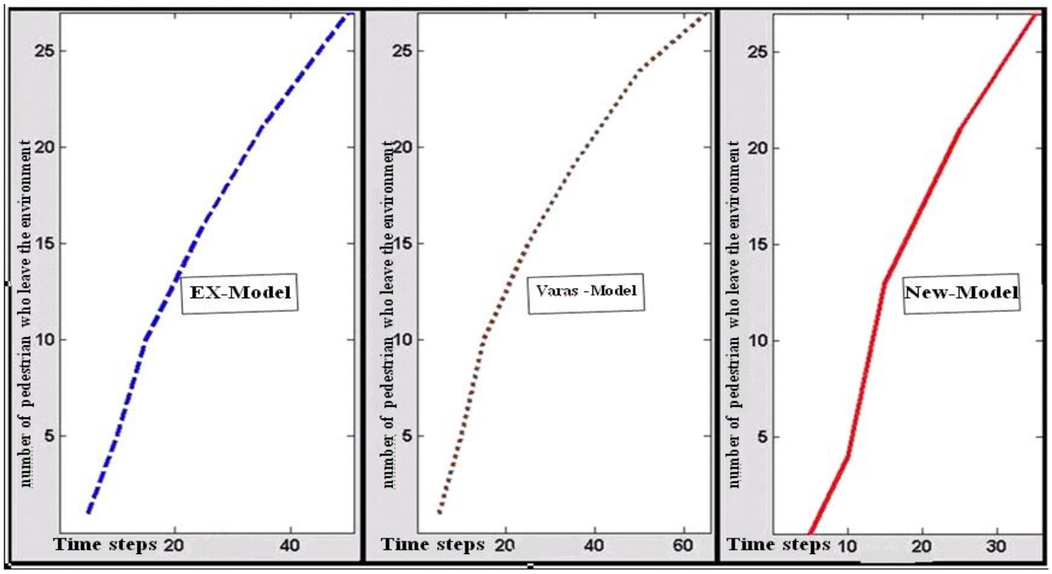


Figure 10: Comparison of evacuation time in figure 8 according to new model, Varas model and model presented in [14].

As shown in the figure, at first the new model, may act the same as the model the former model, but as more time passes the performance is determined.
In the following diagram, excellence model can be better understood.

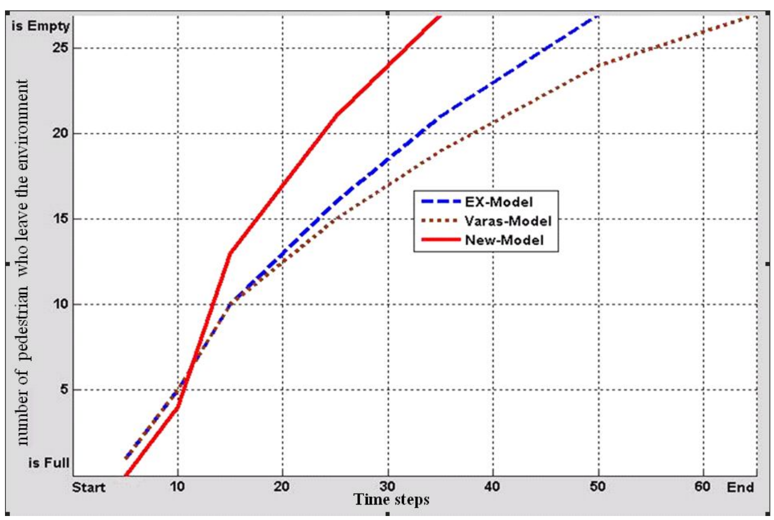


Figure 11: Comparison of evacuation time in figure 8 according to new model, Varas model and model presented in [14].

3 – Simulation results

In this section, we intend to compare current model and former models and investigate the effect of field of vision. Also we present the effect of this parameter on evacuation time. For this purpose we give two examples, and their performance in the above model will look precisely.

Example 1

In this example we consider theater look like figure 8 with 56 persons. Suppose for leaving the theater you should leave the theater and after passing the corridor, leave the building completely.

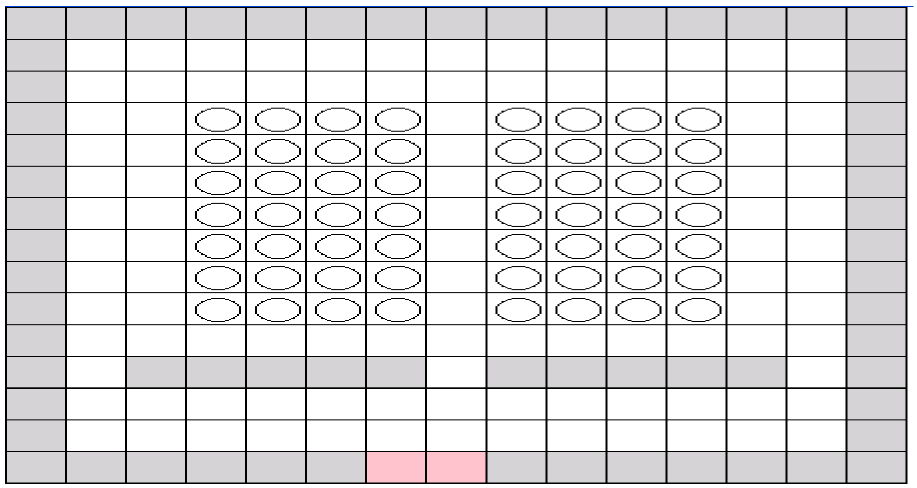


Figure 12: A theater with 56 persons.

To evacuation people in the environment according to the former model, we need 125 stages, but according to the current model we need 90 stages. As we said earlier, this difference due to the impact of field of vision is to find a suitable route, that reduces the amount of congestion in each path to be. After the necessary considerations, reached to diagrams of figure 13 and 14.

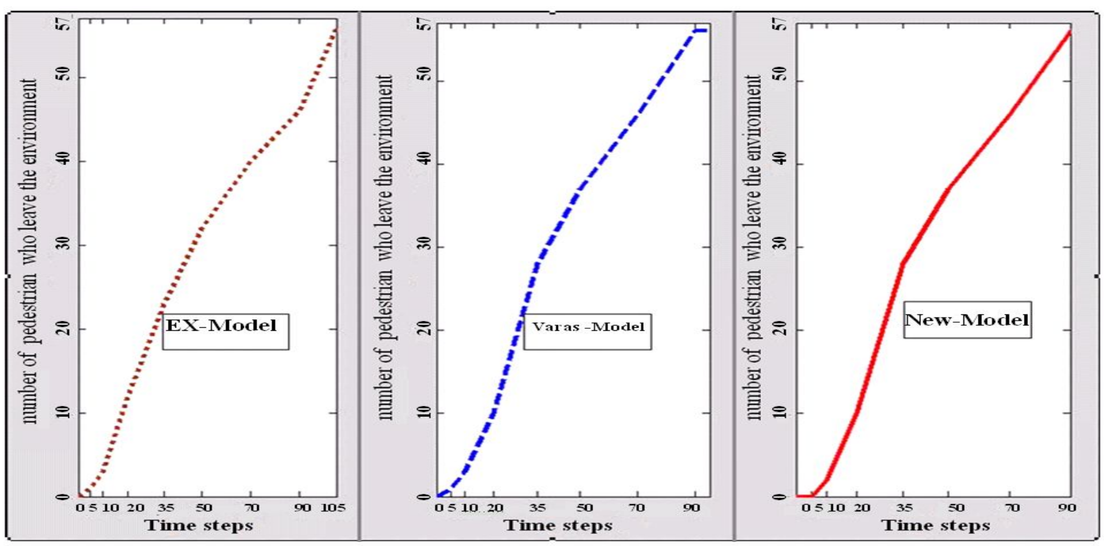


Figure 13: Comparison of evacuation time in figure 10 according to new model, Varas model and model presented in [14].

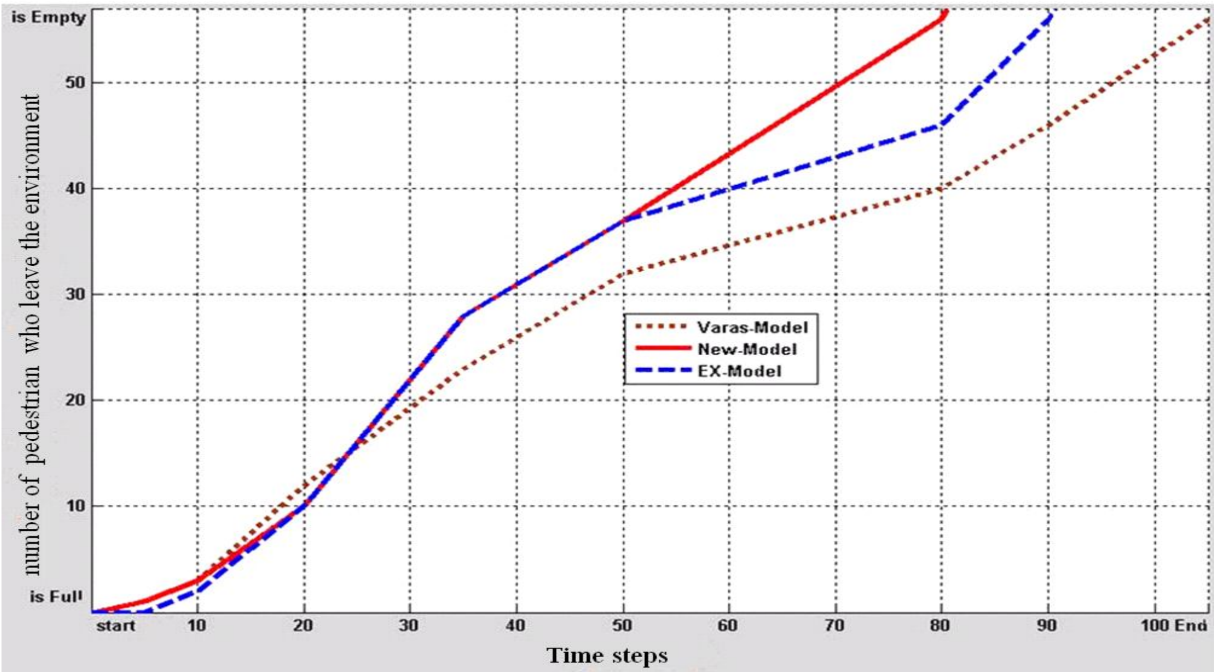


Figure 14: Comparison of evacuation time in figure 10 according to new model, Varas model and model presented in [14].

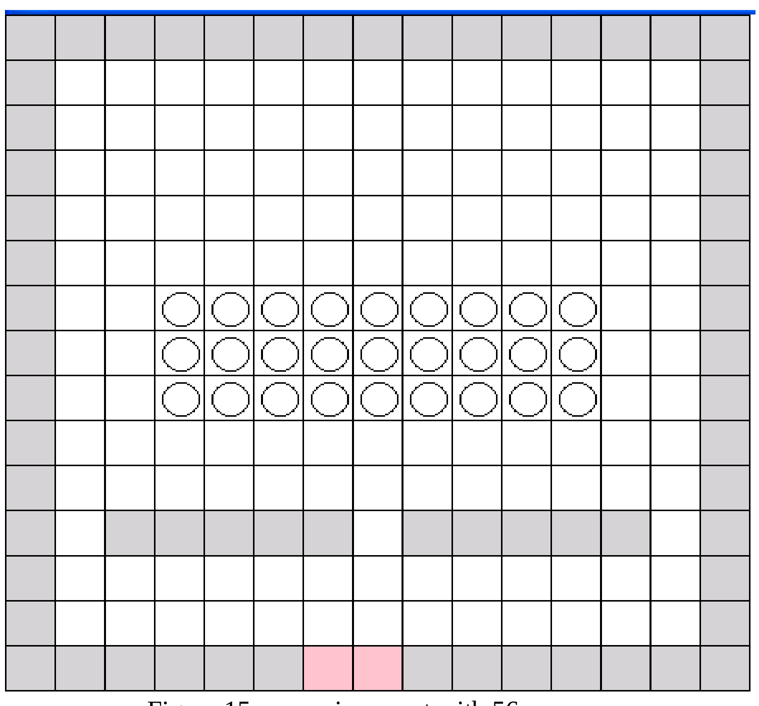


Figure 15: an environment with 56 persons.

After the necessary considerations, we reached to results similar to the Figure 10 and 11.

4- Conclusions

In this paper, a dynamic CA model was proposed to simulate the evacuation process with obstacles. The model has been designed in such a way that persons in every step consider the position of the obstacles, exit doors, virtual exit doors and distribution of the crowd and make the best decision for exit. Our simulations show that:

- ❖ The evacuation time in the dynamic case is efficiently less than the static case.
- ❖ If distribution of the pedestrians is uniform, then the static and dynamic models give the same results.
- ❖ The new model may not work well early run. But when continue to work, is much faster and more logical works than the two former models in [14].

REFERENCES

[1] A. Engel, The probabilistic abacus, *Ed. Stud. Math.* **6** (1975), 1-22.

[2] S.Wolfram, Computer software in Science and Mathematics, *Scientific American* **251** (September 1984), 188-203.

[3] T. Nagatani, The physics of traffic jams, Rep. Prog. Phys. 65 (9) (2002) 1331–1386.

[4] D. Chowdhury, L. Santen, A. Schadschneider, Statistical physics of vehicular traffic and some related systems, Phys. Rep. 329 (4–6) (2000) 199–331.

[5] B.A. Toledo, V. Mun˜ oz, J. Rogan, C. Tenreiro, J.A. Valdivia, Modeling traffic through a sequence of traffic lights, Phys. Rev. E 70 (1) (2004) 016107.

[6] Z. Daoliang, Y. Lizhong, L. Jian, Exit dynamics of occupant evacuation in an emergency, Physica A 363 (2005) 501–511.

[7] G.J. Perez, G. Tapang, M. Lim, C. Saloma, Streaming, disruptive interference and power-law behavior in the exit dynamics of confined pedestrians, Physica A 312 (2002) 609–618.

[8] D. Helbing, I. Farkas, T. Vicsek, Simulating dynamical features of escape panic, Nature 407 (2000) 487–490.

[9] S. Wei-Guo, Y. Yan-Fei, W. Bing-Hong, F. Wei-Cheng, Evacuation behaviors at exit in CA model with force essentials: a comparison with social force model, Phys. A 371 (2006) 658–666.

[10] I. G. Georgoudas, G. C. Sirakoulis, I. Andreadis, Modelling earthquake activity features using cellular automata, Mathematical and Computer Modelling 46 (2007) 124-137.

[11] P. R. Rinaldi, D. D. Dalponte, M. J. V´enere, A. Clausse, Cellular automata algorithm for simulation of surface flows in large plains, Simulation Modelling Practice and Theory 15 (2007) 315-327.

[12] A. Varas, M.D. Cornejoa, D. Mainemera, B. Toledob, J. Rogana, V. Mu˜noza, J.A. Valdiviaa, Cellular automaton model for evacuation process with obstacles, Physica A 382 (2007) 631–642.

[13] A. Varas, M.D. Cornejoa, D. Mainemera, B. Toledob, J. Rogana, V.Mu˜noza, J.A. Valdiviaa, Cellular automaton model for evacuation process with obstacles, Physica A 382 (2007) 631–642.

[14] R. alizadeh, A dynamic cellular automaton model for evacuation process with obstacles, Safety Science 49 (2011) 315-323.