Multi-agent Frame of Social Distances Model

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Abstract. The article focuses on a multi-agent frame of Social Distances model. It introduces characteristics of active and passive pedestrian behavior. It also presents possibility of using Social Distances model for complex modeling of pedestrian traffic. The presented model also includes a concept of familiar groups.

1 Introduction

Over the last years, a lot scientists and practitioners are looking for new realistic and effective models of pedestrian dynamics, for instance [1,2,3,5,9,8].

Social Distances model presented in [10] is an attempt at building realistic model which would take into consideration the principles of proxemics. The model applies the sociological theory of *Social Distances* introduced by E. T. Hall [6,7].

The model is based on nonhomogeneous CA and simultaneously it is also a multi-agent system. The principles of movement in this model depend on *an actual state of pedestrian*.

The aim of the article is twofold: to present generalization and extensions of Social Distances model and to highlight Multi-agent frame of the model.

1.1 Short Description of Social Distances Model

A pedestrian in the model is represented by an ellipse, whose center coincides with the center of the cell occupied by that person. A movement in the model is realized in Moore neighborhood of radius 1 per one time-step.

A person occupying the cell can take one out of four allowed positions: H, R, V and L which correspond to the turning of turning the ellipsis around by: ± 0, ± 45, ± 90 and ± 135 degrees respectively. The crucial issue is to establish the set of forbidden and allowed positions for all cells in Moore neighborhood of radius 1, each cell being occupied by one person [10].

Social areas are also represented as ellipses, but the eccentricities of both ellipses (pedestrian and social) area can differ, because "social configuration" in front of the person has much more influence on them behavior than the configuration behind them. Thus, geometrical centers of both the ellipses are

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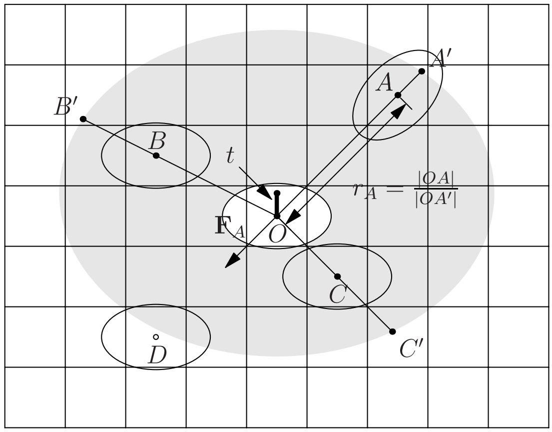

Fig. 1. Pedestrian O–observer, social area – grey ellipse and other pedestrians – "intruders"

different. The ellipse representing the social area is shifted forward along line of vision of the considered pedestrian by some distance t (see Fig. 1) [10].

The method of calculating the distance between the "observer" O and "intruders": A, B, C and D is presented on fig 1. If the intruder enters the social area of the observer (on Fig. 1 only A, B and C) the normalized distance r within the social area is calculated as a ratio of the distance between the centers of persons (e.g. $|OA|$) to the distance between the observer and the point of projection of the intruder's center on the boundary of the social area (respectively $|OA'|$). The normalized distance belongs to the interval $[0, 1]$.

The interaction between the observer and a single intruder is described by "social distance force" $\mathbf{F}_s$. The absolute value of $\mathbf{F}_s$ depends only on the normalized distance between them, $\mathbf{F}_s = F_i(r)$ where F_i is one of some assumed models for social distance force. $\mathbf{F}_s$ has reverse sense than the vector observer-intruder. The total social force affecting the observer is calculated simply as a vector sum of social forces calculated for each intruder (in the presented case: $\mathbf{F}_s = \mathbf{F}_A + \mathbf{F}_B + \mathbf{F}_C$) [10].

2 Adaptation of Social Distances for Complex Modeling of Pedestrians Traffic

Social Distances model was dedicated to pedestrian dynamics within a certain limited area (for instance passenger behavior in a tram). The model could be adapted for pedestrian traffic modeling in streets, shopping centers, restaurants and other facilities.

There are three possible states of each pedestrian in the model: *Go to*, *Wait in intermediate aim* and *Wait*. The only state when social distances have a direct influence on pedestrians is the *Wait* state. Every pedestrian in this state is under the influence of all other pedestrians.

When a pedestrian heads to an aim, we deal with the *active* state. In this case, the most important thing for the pedestrian is to *reach the aim*. This is confirmed by a simple observation: when we head to an exit on a crowded tram, we generally do not have a problem of violating our intimate area *for a moment*, because we would like to reach the aim (simply to leave a vehicle). An important issue in the model is choosing the aim (door, seat, table in restaurant) from a set of available aims using rules of proxemics.

Wait in intermediate aim is also classified as an active state. Why? Because we perform a specific activity (validating a ticket, eating a meal in a restaurant, sitting on a seat). Thus, in the model, the influence of social distances is not possible in this state, rules of proxemics are anticipated during process of choosing the aim.

Wait state is the *passive* state. It is observed when we stand on a tram, go up or go do down in a lift. The situations of talking with somebody in a street is also classified as passive. It is confirmed by an observation, that during longer period of "inactivity" we tend to situate (allocate) ourselves in the possibly most comfortable way, because we are under influence of social distances.

2.1 Rules of Movement

Rules of movement in the model depend on an actual state of pedestrian. In active state it is based on cellular automata (concept of intermediate aims and potential fields [10]).

In passive state a particular pedestrian could be under influence of others. It is a influence of a force (Social Distance force), but movement in this case is still realized in cellular automata lattice.

3 Familiarities in Social Distances Model

The previous version of the model took into consideration only repulsive forces. But according to the theory of proxemics, there is a need of introducing attractive forces for modeling "familiar" behaviors for instance for couples, parents and children or group of friends.

In the initial part of the simulation there is a need of point a leader of a familiar group. Because it is a frame of asynchronous CA. In the process of implementation the leader of a group is always placed in the list before other members. Thus, the leader makes movement as the first in the group. The members follow her/him maintaining a possibly short distance (including allowed configurations![10]). Group behavior is shown in each state: jointly reaching and profiting aims (neighbor seats, tables etc.) and jointly waiting in *Wait* state. If the group was divided during *Wait* state, attractive forces operate in the next time step in order to connect members.

4 Concluding Remarks

The distinction of two main states in pedestrian dynamics: *active* and *passive* make it possible to apply the rules of proxemics. During *active* state pedestrians anticipate reaching resources (seats) or they use these resources. In *passive* state pedestrians are under influence of Social Distances.

In the previous version of the model, only repulsive forces were applied. The current version brings a definition of familiar groups including a concept "follow a leader" with attractive forces.

A multi-agent frame of pedestrian dynamics simulation makes it more realistic and easier for interpretation.

References

1. Bandini, S., Manzoni, S., Vizzari, G.: Situated Cellular Agents a Model to Simulate Crowding Dynamics. Special Issues on Cellular Automata E87-D, 669–676 (2004)
2. Burstedde, C., Klauck, K.: Simulation of pedestrian dynamics using a 2-dimensional cellular automaton. Physica A 235, 507–525
3. Dijkstra, J., Jessurun, A.J., Timmermans, H.: A Multi-Agent Cellular Automata System for Visualising Simulated Pedestrian Activity. In: Proceedings of ACRI, pp. 29–36 (2000)
4. Dudek–Dyduch, E., Wąs, J.: Knowledge Representation of Pedestrian Dynamics in Crowd. In: Formalism of Cellular Automata. Proceedings of ICAISC. LNCS (LNAI). Springer, Heidelberg (2006)
5. Gloor, C., Stucki, P., Nagel, K.: Hybrid Techniques for Pedestrian Simulations. In: Sloot, P.M.A., Chopard, B., Hoekstra, A.G. (eds.) ACRI 2004. LNCS, vol. 3305, pp. 581–590. Springer, Heidelberg (2004)
6. Hall, E.T.: The Silent Language. Garden City, New York (1959)
7. Hall, E.T.: The Hidden Dimension. Garden City, New York (1966)
8. Narimatsu, K., Shiraishi, T., Morishita, S.: Acquisiting of Local Neighbour Rules in the Simulation of Pedestrian Flow by Cellular Automata. In: Sloot, P.M.A., Chopard, B., Hoekstra, A.G. (eds.) ACRI 2004. LNCS, vol. 3305, pp. 211–219. Springer, Heidelberg (2004)
9. Schadshneider, A., Kirchner, A., Nishinari, K.: CA Aproach to Collective Phenomena in Pedestrian Dynamics. In: Bandini, S., Chopard, B., Tomassini, M. (eds.) ACRI 2002. LNCS, vol. 2493, pp. 239–248. Springer, Heidelberg (2002)
10. Wąs, J., Gudowski, B., Matuszyk, P.J.: Social Distances Model of Pedestrian Dynamics. In: El Yacoubi, S., Chopard, B., Bandini, S. (eds.) ACRI 2006. LNCS, vol. 4173, pp. 492–501. Springer, Heidelberg (2006)
11. Wąs, J.: Cellular Automata Model of Pedestrian Dynamics for Normal and Evacuation Conditions. In: Proceedings of Intelligent Systems Design and Applications, Wroclaw, pp. 154–159. IEEE CS, Washington (2005)
12. Wąs, J.: Experiments on evacuation dynamics for different classes of situations. In: International Conference Pedestrian and Evacuation Dynamics – PED 2008, Wuppertal (in press, 2008)