Modeling and Simulation of Pedestrian Behaviors in Transport Areas: The Specific Case of Platform/Train Exchanges

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***Abstract*—The RATP (Paris Public Transport System) needs a software to optimize the passengers' exchanges between the trains and the platforms in order to improve the train frequency and to reduce risks within passengers congestion. The SimTRAP prototype (Simulation of exchanges between TRains And Platforms) is an agent based model, using a microscopic approach, which is being built for this task.**

***Index Terms*—Agent based models, microscopic approach, self-organization, pedestrian behaviors.**

I. Introduction

WITH more than 1.8 billion passengers a year on its train network (in 2005), the RATP (Paris Public Transport System) is continuously confronted to problems of management of crowds. Concerned by the quality of service, the RATP manages this phenomenon by optimizing the various steps met in a trip. From this perspective, it started a plan aiming at modeling and simulating passengers' exchanges between a train and a platform. The resulting tool could help the company to optimize the arrangements on these spaces, to lower the risks of incidents like congestions or falls on tracks and therefore to higher trains frequency and general impression of people towards RATP. Improvements in the evacuation of trains and platforms could also be found.

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II. The Exchanges between Trains and Platforms

Most of the difficulties which may alter the functioning of trains services occur during the train / platform exchanges: congestions in front of doors, passengers who obstruct the closing of doors... These situations, magnified by the increasing density of passengers, increase the stopping time of the trains and therefore, cause delays.

Fig. 1. Congestion in front of doors during an exchange between a train and a platform

RATP specialists have been using models of simulation of exchanges for a long time. However, these models mostly belong to a macroscopic approach of the phenomenon: they are based on the management of crowds rather than the management of individuals (resulting in losses of precision, notably).

Our objective is to propose a microscopic approach, therefore focusing on individual behaviors, which would provide better estimates, both at micro and macro levels. More generally, we assume that pedestrian behaviors can be seen as a self-organized process, merely based on microscopic interactions in a constrained environment.

III. Modeling and Simulating Pedestrian Behaviors at Microscopic Level

Following [1], we identify five key issues to be addressed:

1. Defining a detailed environment with an adapted scale;
2. Reaching adapted spatial and temporal precision;
3. Managing a realistic number of simulated pedestrians;
4. Introducing physiological and behavioral heterogeneity;
5. Combining both local and global interactions.

N. Pelechano et al., in [2], distinguish three main types of modeling approaches: physical models, cellular automata models and rule based models.

1. Physical models, like the famous “Social Force Model” [3] and its recent extensions [2] are able to reproduce some of the self-organizing components of crowds behaviors, but require a large computation effort even for simple environments;
2. Cellular automata models [4]-[5] focus on local interactions between neighboring spatial entities, in which are included desired individual behaviors. They are easier to develop and run faster than the physical models. However, the homogeneous behavior of the individuals within spatial entities and the limitation of their interactions in relations of spatial nearness can not reflect the real pedestrian behaviors, as concludes [6];
3. Rule based models, like agent based models, are able to deal with more complex environments and behaviors [1]-[7]-[8].

Our SimTRAP prototype directly belongs to that last family.

IV. The SimTRAP Prototype (Simulation of exchanges between TRains And Platforms)

The two versions of SimTRAP we created deal with detailed environments (platforms and trains), composed of both static and dynamic objects (trains, doors and folding seats) and are built on the NetLogo system[1].

A. First approach

In this first version, all objects are defined by a point (their center) and a rectangular shape (their bounding box). Some of them have other attributes and can use procedures which allow them to move or which allow the passengers to interact with them:

- a door can open or close with a given speed and until a maximum size;
- a folding seat can open or close when a passenger is sitting on or leaving it;
- all objects of the train can move together with a given speed and a given direction;
- all seats can be free or not.

Passengers are represented by circular agents having, as a first approach, the same internal structure and behaviors. They are defined by their destination, their direction, their speed, their position, their field of vision.

Their destination is determined by their goal which is one of the following:

- Find a good location on the platform (standing or sitting) (1);
- Find a way to enter the train (2);

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[1] NetLogo: Web site: ccl.northwestern.edu/netlogo

- Find a good location in the train (standing or sitting) (3);
- Find a way to get of the train (4);
- Find a way to an exit of the platform (5).

The (1) to (3) goals are only for the "entering" passengers (starting with (1)) and the last ones for the "leaving" passengers (starting with (4)). (2) begins when the train opened its doors, (3) when a passenger entered in the train and (5) when a passenger got of the train. If a passenger has not any goal, he is waiting and does nothing.

The current destination, direction and speed of a passenger can be modified in some cases by the local density (according to the number of other passengers in his field of vision) and by obstacles (an object or a passenger). When an obstacle has been detected, a new direction is computed with a shortest path algorithm.

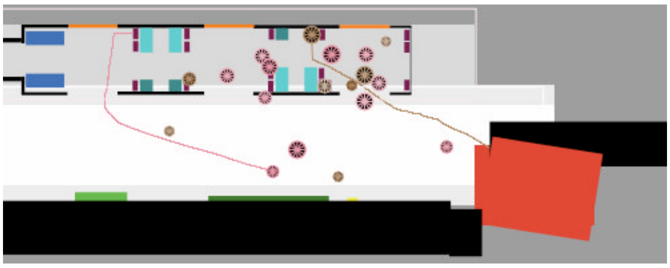

Fig. 2. Screenshot of the first version of SimTRAP showing passengers leaving and entering the train

B. Second approach

A second version of SimTRAP was created to improve the spatial precision. The rectangular and circular shapes used in the first approach were too approximative and not effective.

This time, all objects from trains and platforms which can be generated by the prototype, have exactly the same forms than in reality. Even the trains with two levels can be used in this model.

For this, we use the GIS extension of NetLogo which can load vertexes from a shape file (in which a fully detailed representation of a train or a platform is stored). Furthermore, the objects are here represented by a point (its center) and a list of its vertexes. Each vertex is linked with two other vertexes of the list in a specific order and knows its owner.

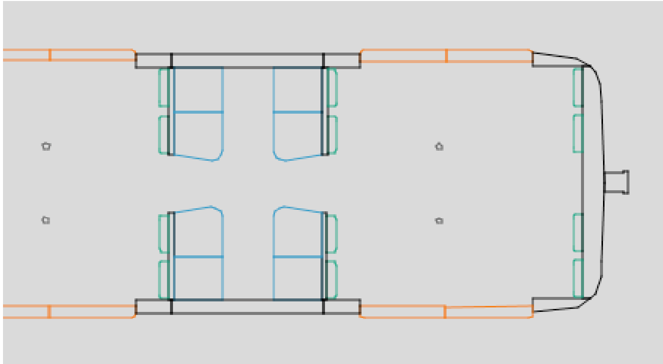

Fig. 3. Details of a train in the second version of SimTRAP

Passengers are represented here by an oval-shaped body and two shoulders (linked to the body). They are twice larger than thick, according to the canons of drawing, and are defined by their gender, which determines which one of the two given sizes they have to use (several men are larger than women).

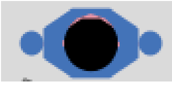

Fig. 4. Representation of a passenger in the second version of SimTRAP

For example, with these representations, tests of collision are easier (we can use some built-in procedures of NetLogo with its GIS extension).

V. First Results

The first version of SimTRAP allows testing scenarios, for a given set of parameters. For example, figure 5 shows the number of exchanges (passengers entering into plus passengers getting of the trains) in 5 seconds real time, when the number of passengers on the platform and in the train varies.

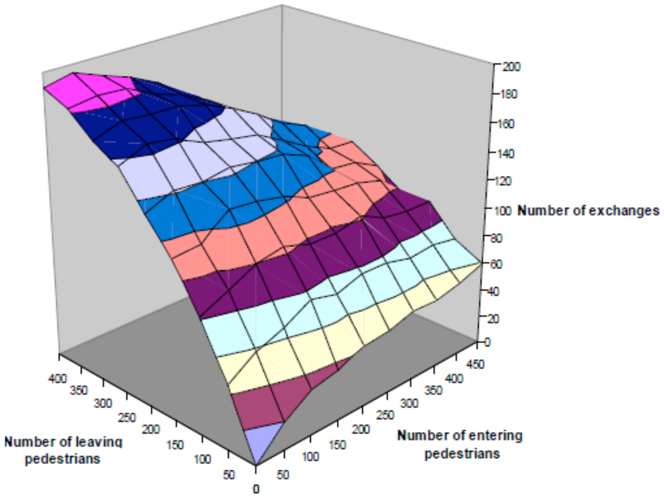

Fig. 5. Simulated number of exchanges in 5 seconds real time according to entering and leaving passengers (MP89 train).

Video analysis where also conducted, in order to calibrate some key parameters. Figure 6 shows the distribution of passengers waiting for the train, according to their distance to the entrance of the platform.

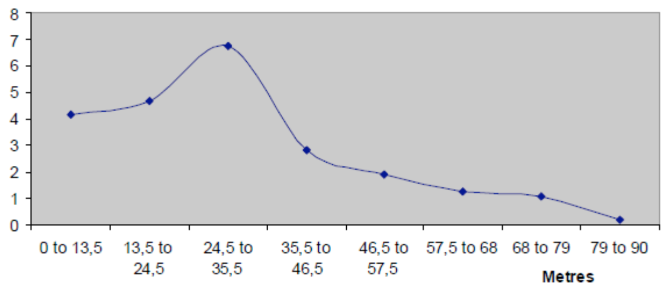

Fig. 6. Video analysis of the distribution of passengers on a given platform

The second version allows testing the capacity of a train. For example, table 1 shows a comparison between theoretical results and SimTRAP results of a test of capacity of a MF67 train (5 wagons). The passengers' characteristics used in these SimTRAP tests are:

- 47% men, 53% women;
- 62 cm for a man's broad;
- 55 cm for a woman's broad[2].

TABLE I
TEST OF CAPACITY OF A MF67 TRAIN (5 WAGONS)

	Theoretical results	SimTRAP results	Difference
Surface (standing zone)	113.8 m²	115.2 m²	1.2%
4 passengers/m² (standing + sitting)	575	582	1.2%
6 passengers/m² (standing + sitting)	806	813	1.1%
Max. passengers/m²	Never tested	1022 (7.8 p/m²)	

These tests prove that our environments are realistic. The results depend on the quality of the original maps, but even in the worst cases, the differences between theoretical and simulated capacities are not over 5%.

VI. ECO-PROBLEM-SOLVING

Today, we focus on the passengers' behaviors. We actually try to adapt the eco-problem-solving system, introduced by J. Ferber in 1989 [10].

In this system, the agents are reactive ones and have only two behaviors:

- they search for a state of “satisfaction” ;
- they flee from states in which they can not be satisfied.

In the case of the platform/train exchanges, the agents can be satisfied by modifying their standing or sitting location, but also by staying where they are and trying to pressure the close and disturbing passengers.

So, each agent computes two costs each time it is not satisfied anymore:

- a cost of displacement, which represents the “willpower” required to move to another location ;
- a cost of position, which represents the “willpower” required to stay at the same location.

The first cost is function of the attractiveness of the targeted location, the length of the planned path and the number of agents who are on it (and who must be disturbed).

The second cost is function of the attractiveness of the current location and the power of the disturbance generated by the neighboring passengers.

Like humans, the agents do not have an infinite “willpower”. We put a limit for each cost : when an agent's cost of displacement or position is beyond its limit, this person do not want at all to go to the targeted location or can not stay longer at the same place. If a passenger really has to move or to stay, because the other choice is worst, he will pressure much more his neighbors.

Some useful tips can be used with these rules. For example, if we want to set passengers' goal to “enter the train which just opened its doors”, we just have to put their cost of position beyond the limit while they are still staying on the platform (to do so, we could change the attractiveness of every places in the train by a much higher value and reduce the attractiveness of the platform).

Furthermore, the limits can be personalized for each agent. So, we can simulate more complex behaviors with an easier way. For example, selfish persons can be represented by agents whose limit of the cost of position is higher than the others' limit (the pressure does not disturb them much: they just want to stay at the same location).

This system has not been tested yet and still needs some improvements, but we can see that it offers some great possibilities.

REFERENCES

[1] A. Banos, A. Charpentier, “Simulating pedestrian behavior in subway stations with agents”, *Proceedings of the 4th European Social Simulation Association*, Toulouse, France, September 10-14, 2007, pp. 611-621.

[2] N. Pelechano, J. M. Allbeck, N. I. Badler, “Controlling individual agents in high-density crowd simulation”, *Eurographics 2007, ACM SIGGRAPH Symposium on Computer Animation*, 2007, 10 p.

[3] D. Helbing, P. Molnar, I. Farkas, K. Bolay, “Self-organizing pedestrian movement”, *Environment and Planning B, n°28*, 2001, pp. 361-383.

[4] V. Blue, J. Adler, “Emergent fundamental pedestrian flows from cellular automata microsimulation”, *Transportation Research Record, vol. 1644*, 1998, pp. 29-36.

[5] M. Muramatsu, T. Irie, T. Nagatani, “Jamming Transition in Pedestrian Counter Flows”, *Physica A: Statistical Mechanics and its Applications, vol. 267*, 1999.

[6] K. Teknomo, *Microscopic Pedestrian Flow Characteristics: Development of an Image Processing Data Collection and Simulation Model*, Ph. D. Dissertation, Tohoku University, Japan, 2002, 141 p.

[7] M. Batty, *Cities and complexity*, MIT Press, Cambridge, 2005, p. 565.

[8] S. Paris, J. S. Pettré, S. Donikian, “Pedestrian reactive navigation for crowd simulation: a predictive approach”, *Eurographics 2007, vol. 26, n°3*, 2007, pp. 665-674.

[9] ObEpi – Roche survey, “4e enquête épidémiologique nationale sur l'obésité et le surpoids en France”, 2006.

[10] J. Ferber, “Objets et agents : une étude des structures de représentation et de communications en Intelligence Artificielle”, Ph. D., University of Paris VI, 1989.