



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Lecture with Computer Exercises:
Modelling and Simulating Social Systems with MATLAB

Project Report

Pedestrian dynamics in long, narrow hallways

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Agreement for free-download

We hereby agree to make our source code for this project freely available for download from the web pages of the SOMS chair. Furthermore, we assure that all source code is written by ourselves and is not violating any copyright restrictions.

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I hereby declare that the written work I have submitted entitled

Pedestrian dynamics in long, narrow hallways

is original work which I alone have authored and which is written in my own words.*

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1 Abstract

Authors: Manuel Moser, Yannick Suter, Raffael Theiler

Title: Pedestrian dynamics in long, narrow hallways

In this project, we want to have a closer look at pedestrians in narrow hallways, motivated by a situation at Zurich main station. To do this, we simulate pedestrians with Matlab who walk according to some rules. We managed our agents to pass each other by, to look ahead a few meters and to decide where to walk next.

At first, we wanted to have a closer look at the pedestrian flux when the number of persons per minute entering is increased, when there are clearly more people moving in the same direction against a few in the other direction. Next, we wanted to analyze the influence of aggressive fast people in a rush, slowly moving obstacles and the influence of drunkard (randomized walking) on the pedestrian flux.

But soon, our attention turned more to building/creating everything on our own and less about a fast simulation of different situations.

The main outcome of our simulations was that pedestrians tend to get stuck or create jams as soon as there are lots of people trying to pass the same hallway. The exact same hallway can work smoothly if there are not too many people, but jams can arise quickly. And once a jam starts, it often spreads out because people have to stop and walk slower.

Finally, we arrived at the following conclusions: To improve the pedestrian flux, broadening a hallway is a superb solution. Therefore, at our situation scene at Zurich main station, it would be best if the hall users would try to leave more space for the pedestrians, and if the food shops Imagine and Nordsee wouldn't have chairs and tables outside.

2 Individual contributions

3 Introduction and Motivations

4 Description of the Model

5 Implementation

5.1 Simplifications

- x All our agents walk on their own, there are no groups of friends, families etc who stand together as much as possible.
- x The agents are not able to walk backwards, they only can see and walk 90° to each side.
- ? All have the same mean speed, size, ??
- ? Any other simplifications?

6 Simulation Results and Discussion

6.1 Goals

First, let's have a look at what our goals were. We planned to have a look at the pedestrian flux, how it can be improved and jammings be avoided. We furthermore wanted to have a closer look to what happens during rush-hours and in a situation when much more people are moving in one direction than in the other.

On the agent-based side of our model, we wanted to analyze the influence of aggressive fast people in a rush, slowly moving obstacles (eg. mothers with baby buggies) and the influence of drunkard (more or less randomized walking) on the pedestrian flux.

If everything went well, we also wanted to implement a static obstacle and see what happens.

6.2 Achievements

As soon as we started programming we realized there was a major point of importance about this work we all were aware of, but had forgot to put it in the project proposal. We all did not want to start with an already known program or algorithms, but build something "new". So we started off creating our logic function that would allow the agents to avoid crashing into other agents and not working with repulsive forces as for example Helbing (Quelle angeben, ist das älteste Paper) did.

Quite proudly, we can now say we managed to do this. Our idea of the agents "thinking ahead" by consulting where other agents are and not just being pushed around by repulsive forces worked.

We now are able to play with lots of input variables, the most important being number of agents entering the corridor per time and the agents' characteristics as size, speed and lots more.

A nice thing we built but did not originally plan to is that we planned to and did research on the situation as explained earlier in the long, narrow corridor in Zurich mainstation. But in our simulation, one can also change dimensions as length and shape of the walls easily.

6.3 Fundamental Questions

Our fundamental research questions were:

- How does the simulation behave in the following situations: rush hour, with obstacle, with very slow/fast agents, random path agent (drunkard)? Does it

run smoothly or will there be jams?

- How will our implementation of a rudimentary kind of "thinking ahead" affect the simulation? Will it work good or bad? Can we compare it to other implementations?
- Are there any group dynamics evolving as lane or group formation?

6.4 Comparing measurements

Saturday, Nov 17th, we did some quick measurements right at Zurich main station to have some data we could compare. Two measurements were taken, only some minutes lay between these, that was when we measured the length and breadth of our corridor. The measurements were:

- 1 The "boring" measurement: During 2 minutes 14 pedestrians headed tracks 3-18, and 20 pedestrians directed towards tram station "Bahnhofsquai". No problems at all, very fluently.
- 2 The "crowded" measurement: During 2 minutes, 41 pedestrians headed tracks 3-18, and 33 pedestrians directed towards tram station "Bahnhofsquai". People got stuck, ran into each other, had to walk stop-and-go-like.

7 Summary and Outlook

8 References

9 Want-To-Do-List

- info Mosi: Bild von HB Situation ist erstellt und im doc Ordner, ebenfalls noch 3 Bilder vom Oktoberfest hochgeladen, eins davon für Introduction.
- o Nicht drin als Ziel aber super um Aussagen zu machen: Plot mit: Gangbreite, Personen pro Zeit und dann: wie gut war der Fluss.
- o alle: wo HB-Plan rein? bei Implementation mit dem effektiven Modell oder bei Introduction?
- o alle: Simulation so wie HB (drei Teile), oder Durchschnitt (2.8m breit)? - sicher mal mit Schnitt beginnen. –¿ nur einen Bruchteil so lange, Schnitt breit.
- ! erwähnen (zB bei discussion), dass Imagine und Nordshizzle während Christkindmarkt jetzt die Tische/Stühle aus dem Weg räumen!
- 3 Fotos: Mosi selbst erstellt 09.10.2012
- situationplan: Ivo Steinacher erstellt 27.11.2012.

A Appendix

MATLAB HS2012 - Research Plan

Version info: the submitted and approved version, 2012-10-24 17h

- **Group Name:** Mayara
- **Group participants names:** Moser Manuel (Mathematics BSc, 3rd Sem), Suter Yannick (Chemistry BSc, 5th Sem), Theiler Raffael (Informatics BSc, 3rd Sem)
- **Project Title:** Pedestrian dynamics in long, narrow hallways

General Introduction

Annoyed by people rushing through the small corridor left in Zurich main station hall (the path between burger king and groups meeting point) during the Oktoberfest, market days, concerts and other occasions, we decided to have a look at pedestrian dynamics in hallways which are mostly crowded and narrow (3-4 meters in breadth) compared to normal days when the hall is empty, and where people walk through in opposite directions all the time. We want to have a look at how the pedestrian flux can be improved and how the walk-through time behaves during rush-hours, but also in the case of much more persons moving in one direction than in the other. Also, we want to have a look at the influences of aggressive, fast people in a rush, slowly moving obstacles like mothers with baby buggies and some drunkards, and try to figure out how to avoid jammings. Maybe we'll also implement a static obstacle to observe what happens. The simulation of problems like this will also help understand the phenomena of group dynamics which usually control and resolve such problems in real life.

The Model

We want to do an agent-based simulation of people moving through a long corridor (dimensions will be proportional to those encountered in our object, the Zurich main station). The people will primary want to move forwards at different speeds but also be able to move diagonally or even sideways if needed. A nice thing will be to try implementing agents being able to see some fields/meters ahead whether their path (assumed straight as long as possible) is free or not, and if they're about to crash into someone, try to avoid them. Independent variables in our model are the amount

of people per time arriving, the corridor and its obstacles and the characteristics of the agents like walking speed and aggressiveness. Dependent variables will be the amount of people leaving, which should in the end determine whether the people will be stuck or if they can get through. Should the amount of people leaving be smaller than those arriving (per time unit), one can expect a blockage. As a reference, we will use a simulation of a corridor without any obstacles and only few people. Then the collective success or failure of an other situation can be compared to this.

Fundamental Questions

- We try to simulate the pedestrian flux in the following different situations: Rush hour (danger of jamming), with an static obstacle, with aggressive/very fast or slow agents, random path agent (drunkard). Will the pedestrian flux run smoothly or will they block each other and be stuck?
- Will the implementation of a rudimentary kind of thinking/looking ahead help to avoid blockages? If possible, we may determine the limits for which the goal of passing is achieved with and without this implementation and compare them.
- Will there be group dynamics or similar behaviors of agents if they're only programmed to walk to the other side, each on his own?

Expected Results

We think that there will be lots of walking around left/right while trying to avoid other agents, and with rising amount of agents there will be more jams, this seems obvious. We think that in our simulation we'll have to deal with massive jams because the agents are not communicating with each other in any way. Implementation of "looking ahead" will probably improve the people flux but only to a limited range. Obstacles will also lead to more jams, whilst the drunkard simulation will for the amusement of our group.

References

Just some ideas where to get inspiration from:

- Project Suggestions - 16 - Pedestrian Dynamics - 5 papers - http://www.soms.ethz.ch/teaching/MatlabFall2012/projects/16-Pedestrian_Dynamics.zip - (01.10.2012)
- Mehdi Moussaid Publications - <http://mehdimoussaid.com/publications.html> (24.10.2012)

- Crowd-Flow-Optimization - FS2012 - <https://github.com/nfloery/crowd-flow-optimization> (01.10.2012)
- Train Jamming - FS2011 - https://github.com/msssm/Train_Jammin (01.10.2012)
- Airplane Evacuation / FS2011 https://github.com/msssm/Airplane_Evacuation_2011_FS (01.10.2012)

Research Methods

For our project, an agent-based model is the most satisfying because there we can really implement different speeds and directions. A disadvantage will be the complicated collision handling.

Other

For the measurements of the corridor, we'll go to the main station and measure it one afternoon when it's not fully crowded. We also could count the rate of incoming and leaving people during a rather relaxed afternoon and a crowded rush-hour.