

Evacuation Bottleneck

Simulating a Panic on a Cruise Ship

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Outline

Introduction

Models and Implementation

- Program Structure

- Input, Configuration

- Placement of New Agents

- Filled Exits

- Forces

Results

- Passenger Distribution

- Panic Level

- Outtakes

Summary and Outlook

Our Research Object

- ▶ Costa Voyager
- ▶ Capacity: 836 passengers
- ▶ 8 Rescue Boats
- ▶ In distress at sea in 2005



Source: <http://www.shipspotting.com>,
Picture taken by Roy Batty

Program Structure

1. Load configuration
2. Loop over simulation steps
 - 2.1 Place new agents
 - 2.2 Handle filled exits
 - 2.3 Progress agents with calculated forces
 - 2.4 Remove exited agents
 - 2.5 Plot current state (optional)
3. Plot and save final data

The Deck Plan

- ▶ Colormap
 - ▶ Allows any number of zones
- ▶ Scaling
- ▶ Greatly simplified



Source: <http://www.kreuzfahrtberater.de>

Configuration File

- ▶ Simulation parameters initialized from a file:
 - ▶ Deck configuration
 - ▶ Plotting options
 - ▶ Physical and behavioral parameters
- ▶ Simple syntax makes automated generation easy

Placement of New Agents

- ▶ Spawning zones as entering areas for agents
- ▶ In each step, remaining agents are tried to be placed
- ▶ If spawning zones are too full, new agents can only appear in later steps
- ▶ Nice model for steady inflow of agents

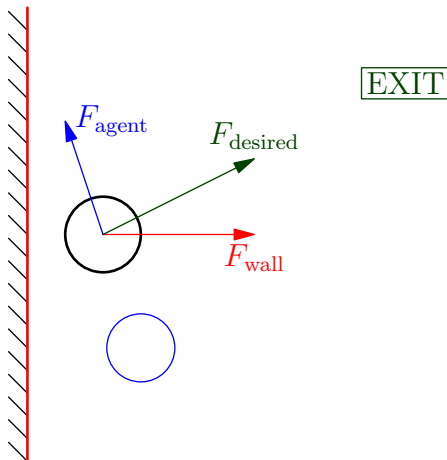
Filled Exits

- ▶ Rescue boats modeled with limited capacities
- ▶ If a boat gets full, agents need to be informed
- ▶ Two implementation approaches:
 - ▶ Instantaneous update
 - ▶ Gradual circle-shaped spreading of information

Forces

- ▶ As described in paper “*Simulating dynamical features of escape panic*” by Helbing, Farkas and Vicsek
- ▶ Three main forces act on agents:
 - ▶ Desired direction
 - ▶ Repulsion & friction between agents
 - ▶ Repulsion & friction from walls
- ▶ Motions calculated with Leap-Frog integration method

Forces: Sketch

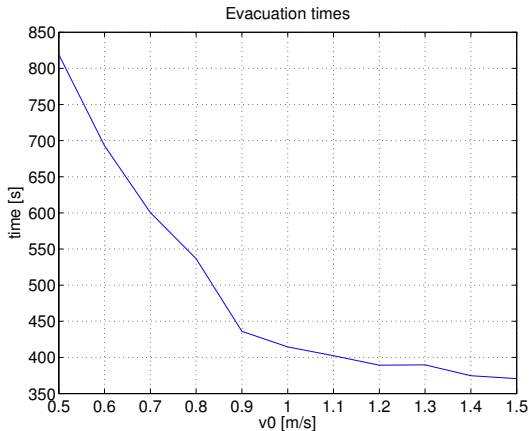


Distribution of the Agents to the Exits

- ▶ The distribution depends strongly on the geometry of the ship
- ▶ There was no case where the agents really spread over the exits
 - ▶ Weakness in the model
 - ▶ More realistic: Go for the shortest individual evacuation time
- ▶ Realistic update for propagation of information
- ▶ *Video*

Effect of Desired Speed on Total Evacuation Time

- ▶ We could reproduce the results from Helbing, Farkas and Vicsek for low panic levels
- ▶ High panic levels: Problem!



All the things you don't want to happen

- ▶ Agents were stuck in walls
 - ▶ Even the tiniest timesteps didn't help
- ▶ MATLAB does not behave as expected in batch mode
 - ▶ Simulation works in foreground, crashes in background
 - ▶ No error message, just silently writing crashdumps to home
- ▶ No reproducibility even with fixed random seed in our group
 - ▶ Different versions of MATLAB

Some points to take away

- ▶ The basic results could be reproduced
- ▶ The model is not very well suited for multiple exits
 - ▶ There should be a heuristic to decide for a direction
- ▶ Use the power of Open Source Software (OSS)!

You ask – We answer

- ▶ Now it's your turn