A hybrid and multiscale approach to model and simulate mobility in the context of public event

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Support systems for urban events: Multicriterial integration for openness and safety

- Joint research project:
  Cooperation between research and practice

- Research objective:
  Research about the safety of public events

- Practical objective:
  Support for the planning of large public events

Butenuth et al. (2011), Integrating pedestrian simulation, tracking and event detection for crowd analysis
What did we do?

- Hybrid simulation of an event course
- Simulation models from different scales
- Shuttle bus optimization-simulation
  - network flow model
- Pedestrian dynamics
  - agent based models
Why pedestrian dynamics simulations?

- 2000 deaths\(^1\) costs by crowd disasters
  - E.g. Loveparade 2010 in Duisburg

- Simulation of human walking behavior
  - Experiments difficult / impossible
  - Can predict dangerous situations

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\(^1\) Hughes (2002), A continuum theory for the flow of pedestrians

Helbing, Mukerji (2012), Crowd disasters as systemic failures: analysis of the Love Parade disaster
Pedestrian behavioral levels\textsuperscript{[1]}: strategic layer

- Selection of a target
- Where do we want to go?

\textsuperscript{[1]} Hoogendoorn and Bovy (2004), Pedestrian route-choice and activity scheduling theory and models
Pedestrian behavioral levels\textsuperscript{[1]}: tactical layer

- Selection of a route
- On which way do we reach our target?

\textsuperscript{[1]} Hoogendoorn and Bovy (2004), Pedestrian route-choice and activity scheduling theory and models
Pedestrian behavioral levels\cite{Hoogendoorn and Bovy (2004)}: operational layer

- Motion of the pedestrian along the selected route
- How do we walk on our route?

\[\text{Operational Layer}\]
Hybrid modeling

- **Macroscopic Scale**
  - network, aggregated parameters
  - low spatial resolution & computational effort

- **Mesoscopic Scale**
  - grid, discrete pedestrian
  - medium spatial resolution & computational effort

- **Microscopic Scale**
  - continuous system, discrete pedestrian
  - high spatial resolution & computational effort
Multiscale approach to combine all three scales

- Overall simulation of a public event
- Arrival to the event (macroscopic)
  - simulation of shuttle buses
- Event process (mesoscopic)
  - pedestrian dynamics with cellular automaton
- Critical situations (microscopic)
  - continuous simulation of pedestrian dynamics
The shuttle bus simulation (macroscopic)

- Dynamic network flow model
  - optimized schedule for shuttle buses

- Shuttle bus simulation
  - based on optimized schedule
  - optimized according to total waiting time
  - error-prone schedules are discarded
Pedestrian dynamics simulations (micro- & mesoscopic)

- **Strategic layer**
  - Destination Choice Model\textsuperscript{[1]}
    - cognitive modeling

- **Tactical layer**
  - Unified Routing Model\textsuperscript{[2]}
    - combines routing approaches

- **Operational layer (meso)**
  - Cellular Stock Model
    - stock based movement

- **Operational layer (micro)**
  - Social Force Model\textsuperscript{[3]}
    - potential-field based

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\textsuperscript{[1]} Based on Kielar, P. M., Bormann A. 2016. Modeling pedestrians’ interest in locations: A concept to improve simulations of pedestrian destination choice and Kielar, P. M.; Handel, O.; Biedermann, D. H.; Bormann, A.: Concurrent Hierarchical Finite State Machines for Modeling Pedestrian Behavioral Tendencies
\textsuperscript{[2]} Kielar, P. M., Biedermann, D. H., Kneidl, A., Bormann A. 2016. A Unified Pedestrian Routing Model Combining Multiple Graph-Based Navigation Methods
\textsuperscript{[3]} Helbing, D., Farkas, I. J., Molnar, P., Vicsek, T. 2002. Simulation of pedestrian crowds in normal and evacuation situations
Coupling of the microscopic and mesoscopic scale

- TransiTUM Model\textsuperscript{[1]}
  - combines arbitrary models
  - based on transition zones

Coupling of the mesoscopic and macroscopic scale

- Shuttle buses as arrival traffic
  - determines pedestrian inflow

- Pedestrians influence shuttle buses
  - time delay by exiting passengers
  - more realistic simulation

- Data exchange necessary
  - Communication Protocol
Case Study: Back to the Woods music festival

Photos: © VABEG Event Safety
Case Study: Back to the Woods music festival

- Back to the Woods
  - 5000 visitors
  - Campus Garching

- Arrival Traffic
  - depends mainly on subway

- Simulation scenario:
  - subway breakdown
  - shuttle buses have to substitute
Thank you for your Attention!

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