Pedestrian management strategies for improving flow dynamics in transportation hubs

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Outline

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Comments after presentation

- Clarify my contribution: mgmt strategies and not mvmt model or act scheduling. Insist more on box structure.
- Framework which can be used with different codes
- Not spend too much time implementing
- Disaggregation process: when, how? Agg seems ok from SF
- Add event based framework, would clarify I think.
- Event based with mesoscopic?
- Really need define framework with plug/play structure.
Introduction

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Context

- Strong increase in public transport demand
- All PT services require an infrastructure for pedestrians to use the services → transportation hubs
- When many different services arrive at the same time in the hub → pedestrian congestion
Motivation

• Congested infrastructures are uncomfortable for users and possibly dangerous
• Variability in pedestrian travel times makes schedule adherence challenging
• Goal: keep good LOS and decrease trip variability
• Some possible actions to accomplish this (not all are recommended!):
  – Decrease pedestrian demand
  – Spread the load over time & space
  – Management strategies
  – Improve dynamics
  – ...
• How to know which ones are effective, feasible or financially manageable?
Motivation (ctnd)

• Need a framework for evaluating possible measures
• As many measures are expensive to put in place, a simulation framework should be available

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• Evaluate impact of management strategies for improving pedestrian flow dynamics

• Requirements
  – Management strategies
  – Pedestrian simulator
  – Measurement of impact
State-of-the-art

- Pedestrian movement models have been extensively covered in the past decade
- Activity scheduling models & route choice models exist for pedestrians
- but...
- Only some management/control strategies have been applied in transportation hubs
- Very few studies considering multiple strategies together

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- Develop a framework which uses management strategies as control variables for improving pedestrian dynamics
Management strategies
Management policies (control policies)

Many different elements can be considered:

- Direct flow control (barriers)
- Public transport schedule
- Moving walkways
- Businesses (shops)
- Information
- ...
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Direct flow control

What control strategies can be used for influencing the flows

- Restrict access to areas of infrastructure
- Block access to platforms until passengers have disembarked
- Create bi-directional flows using corridor separators
- Traffic lights
Moving walkways

How could moving walkways be used to control pedestrian flows?

- Control velocity
- Direction can be changed dynamically
- Control the number of people arriving (flow)

but...

- Heavy infrastructure
- User acceptance
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Management strategies
Soft strategies
Information

What type and when can information be provided to passengers:

- The connecting train will wait for $X$ minutes
- Inform passenger prior to arrival about the state of the system
- Suggest next connection based on congestion (will miss planned connection)
- Screens to inform of congestion inside train station
- Occupancy inside PT vehicles

all these elements require modelling compliance
Guidance

- (Dynamic) floor markings
- Attractors/POI (shops, ticket machines, kiosks, etc)
Simulation framework
Framework

Goal: develop a simulation framework which can measure the impact of management strategies.
Components which are required:

- Input (data, pedestrian demand)
- Pedestrian movement model
- Activity scheduling model
- Controller for management strategies
- Output (results: density, travel times, etc)

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Supply-demand interaction
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Simulation framework

Pedestrian movement models
Aggregate model (Network based)

Pedestrians are aggregated into flows, they are considered as a continuum.

+ No requirement of close interaction models
+ Lower computational cost
- Loose track of individual pedestrians
Disaggregate model (Social force model)

Pedestrians are considered individually

+ Fine control over pedestrian characteristics
+ Precise modelling of interaction (pedestrians and environment)
+ A pedestrian is "followed", dynamically update destination
+ Convenient for individual decision making (activity scheduling)
- Can be expensive to compute
Social force model

We decided to use the social force model (at least for now)

- activity choice → agent-based is conceptually easier
- can use parameters from literature
- result precision
- interactions with attractors/POI can be done
- calibration using specific data for case study will be considered
Simulation framework

Activity scheduling
Route choice

Utility maximization:
- highly customizable framework
- agent specific parameters
- generalized cost $\rightarrow$ multiple components

Some decisions agents can take:
- choose their route
- take a different PT service
- choose to buy a coffee (or something else)
- simply wait
Simulation framework

Train induced flows
Model

From PT vehicle to pedestrians: a disaggregation process

- PT vehicle based events
- Applicable to many different measurable quantities
  - flows: cumulated counts or arrival rates (y)
  - densities
  - occupation

\[ \tilde{y} = \sum_{r,s} f(t; \gamma_{r,s}, t_{r,s}) + \varepsilon \]

with \((r, s)\) a vehicle, \(f\) a function linking the vehicle to pedestrian quantities, \(\gamma_{r,s}\) parameters specifying \(f\), \(t_{r,s}\) the vehicle arrival or departure time and \(\varepsilon\) the random error term
Simulation framework

Key performance indicators
How to measure change

To quantify the impact of a policy, indicators need to be defined:

- Travel time: slower travel times can indicate higher congestion
- Velocity: Deviation from a passenger’s free flow speed
- Density: Higher densities can imply a lower LOS
- Transfer success: the fewer people miss their connection, the better
Case study
Lausanne’s train station

Empirical tracking data on current Lausanne station:
- Detailed data which can be used for calibration.
- Train induced flows have been developed.
- Aggregate dynamics can be observed.
- Probabilistic fundamental diagrams can be characterized.

The new Lausanne station is considered for framework case study:
- Three pedestrian underpasses
- Shops
- Longer trains & platforms
- New metro line
Lausanne’s train station

Figure: Current station, [Hänseler, 2016].

Figure: Future station, [SBB, 2017].
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• Integrative framework with different components $\rightarrow$ flexibility.

• Ultimately, use as optimization tool for pedestrian infrastructure.

Next steps:

• Implement pedestrian movement model.
• Implement activity choice model.
• Controller formulation.
• Calibration ?
Thank you!

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References
Pedestrian simulation events

- PedFlows
  - GeneratePedestrian
  - VehicleArrival
    - PTINF
      - GeneratePedestrian
  - MovePedestrians
  - ComputeRoutes
    - MovePedestrians
Management strategy events

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Model - flow specification

- Piecewise linear (PWL) function specifying the cumulated unloading flows

\[
f(t) = \begin{cases} 
0 & t < t_{r,s} + \Delta t_{r,s}^{lag} \\
\alpha_{r,s} \cdot t & t \in (t_{r,s} + \Delta t_{r,s}^{lag}, t_{r,s} + \Delta t_{r,s}^{lag} + \Delta t_{r,s}^{flow}) \\
Q_{r,s} & t \geq t_{r,s} + \Delta t_{r,s}^{lag} + \Delta t_{r,s}^{flow}
\end{cases}
\]

\[
\Delta t_{r,s}^{flow} = \frac{Q_{r,s}}{\alpha_{r,s}}
\]
Model - route choice

- Pedestrians disembarking from trains choose an access ramp based on proximity, saturation and final destination.
- A priori guess: longer train spread demand over all access ways whereas short trains concentrate demand in the closest access ways.
Parameters

- For loading flows:
  - loading rate [ped/s]

- For unloading flows, train specific parameters:
  - unloading rate [ped/s]
  - disembarking passengers
  - dead time [s]

- Access way choice
  - logit model with travel time as utility