Improving pedestrian dynamics by controlling pedestrian flows

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Outline

1. Introduction
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3. Results & case study
   - Proof-of-concept
   - Lausanne pedestrian underpass
4. Conclusion & next steps

Introduction

Context

Pedestrians suffer from congestion just as vehicles do:

- increased travel time,
- excessive density.

Which in turn can make you:

- be late for your job interview,
- despise traveling in public,
- miss your **connecting train** or plane,
- ...

Context

Higher capacity & faster PT services, to serve higher demand.

Context

Hub diversification (Lausanne, CH train station).

Motivation

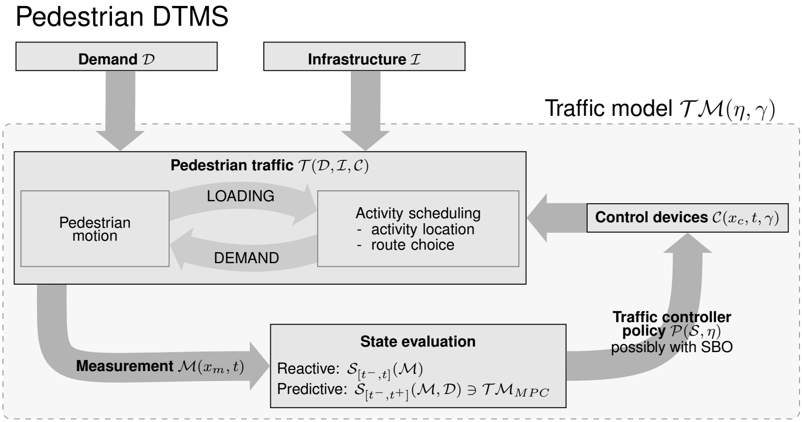
What measures can be taken ?

- Decrease pedestrian demand (counter productive !)
- Spread the load over time & space
- Influence pedestrian's routes
- ...

Simulation is needed to address the complexity of the problem.

Integrate management strategies specific to pedestrian traffic within a Dynamic Traffic Management System (DTMS).

Framework


Pedestrian DTMS
Demand $\mathcal{D}$
Infrastructure $\mathcal{I}$
Traffic model $\mathcal{TM}(\eta,\gamma)$
Pedestrian traffic $\mathcal{T}(\mathcal{D},\mathcal{I},\mathcal{C})$
Pedestrian motion
LOADING
DEMAND
Activity scheduling
- activity location
- route choice
Control devices $\mathcal{C}(x_c,t,\gamma)$
Traffic controller policy $\mathcal{P}(\mathcal{S},\eta)$ possibly with SBO
State evaluation
Reactive: $\mathcal{S}_{[t-,t]}(\mathcal{M})$
Predictive: $\mathcal{S}_{[t-,t+]}(\mathcal{M},\mathcal{D}) \ni \mathcal{TM}_{MPC}$
Measurement $\mathcal{M}(x_m,t)$

Strategies

What specific measures can be considered to impact dynamics:

- Adjustments to the PT schedule
- Control access to specific areas ⇒ gates
- Change link travel time ⇒ moving walkways
- Prevent counter flow ⇒ **flow separators**
- Attract pedestrians to specific locations

Existing strategies

Pedestrian management

- Little research on dynamic strategies.
- Some static measures (design) have be studied.

Road traffic management

- DTMS
- Ramp metering
- Perimeter control
- Variable message signs/ATIS
- Traffic lights
- ...

Proposed management strategy
Flow separators

Objective

Head-on-head "collisions" induce significant extra travel time.

$$\Downarrow$$

Reduce this counter-flow to a minimum.

$$\Downarrow$$

Dynamically allocate part of the available corridor width to each direction.

Setup

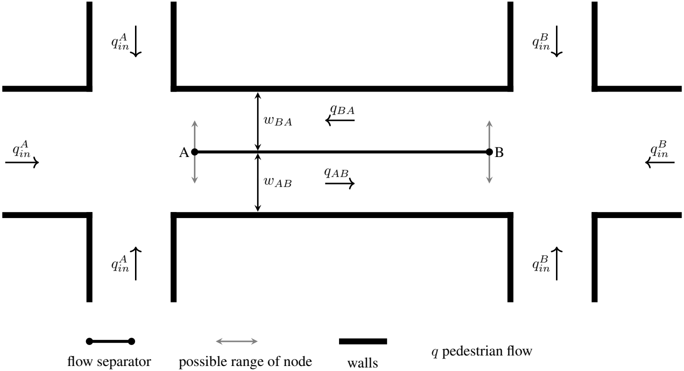


Figure: Schematic presentation of the devices used to separate the opposing flows. The inflow at each end determines the width available to each directed flow.

Width available for each direction is proportional to measured flows:

$$w_{AB}(t) = \begin{cases} w_{AB}^{min}, & \text{if } w \cdot \dfrac{q_{AB}}{q_{AB}+q_{BA}} \leq w_{AB}^{min} \\ w_{AB}^{max}, & \text{if } w \cdot \dfrac{q_{AB}}{q_{AB}+q_{BA}} \geq w_{AB}^{max} \\ w \cdot \dfrac{q_{AB}}{q_{AB}+q_{BA}}, & \text{otherwise} \end{cases} \qquad (1)$$

Results & case study

Case study setup

Proof-of-concept

- Single straight corridor
- Demand pattern: shifted sine-shaped flows

Pedestrian underpass

- Western pedestrian underpass in Lausanne's station.
- Demand from measured trajectories (VisioSafe data, 2013).

Case study setup

- Discrete event simulator combined with a
- disaggregate pedestrian motion model: NOMAD.

- Graph-based route choice (but no critical for now).
- Stochastic simulation $\rightarrow$ multiple runs.

Results & case study

Proof-of-concept

Infrastructure

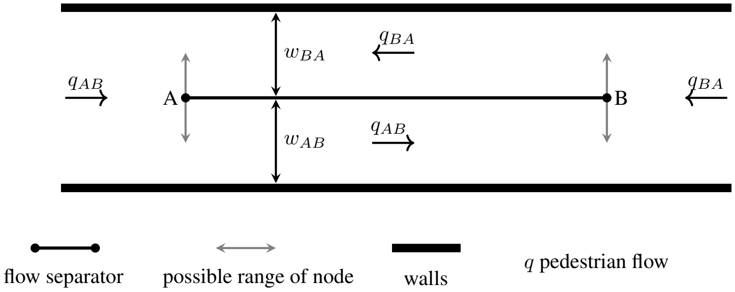


Figure: Dynamic flow separator.

Demand

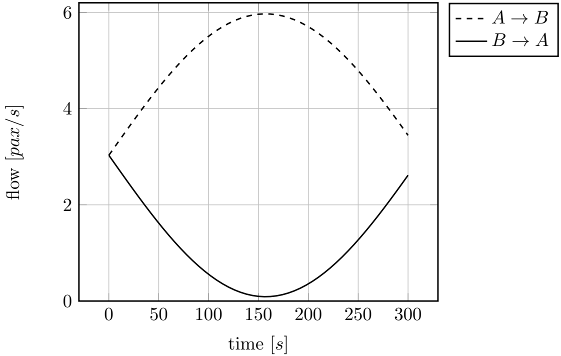


Figure: Demand pattern used to evaluate the flow separator.

Travel times

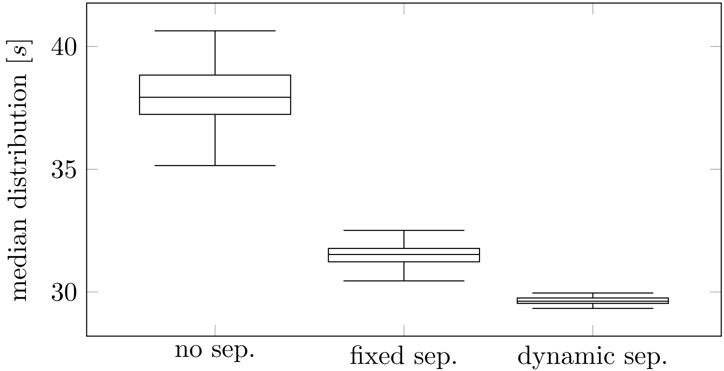


Figure: Median travel time distribution.

Travel time median - sensitivity to compliance

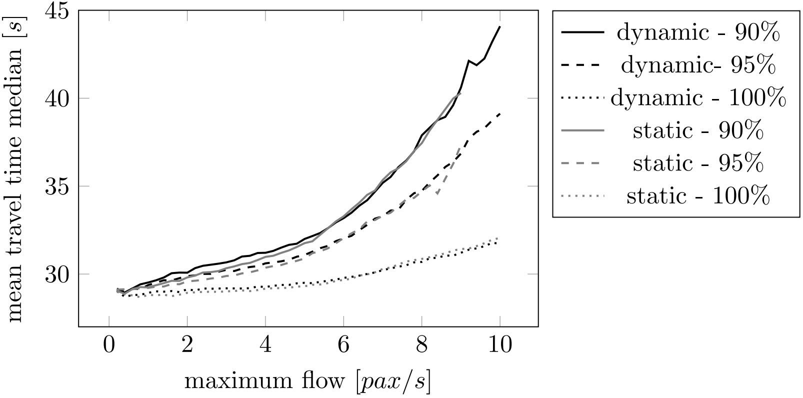


Figure: Travel time median as a function of demand.

Travel time variance - sensitivity to compliance

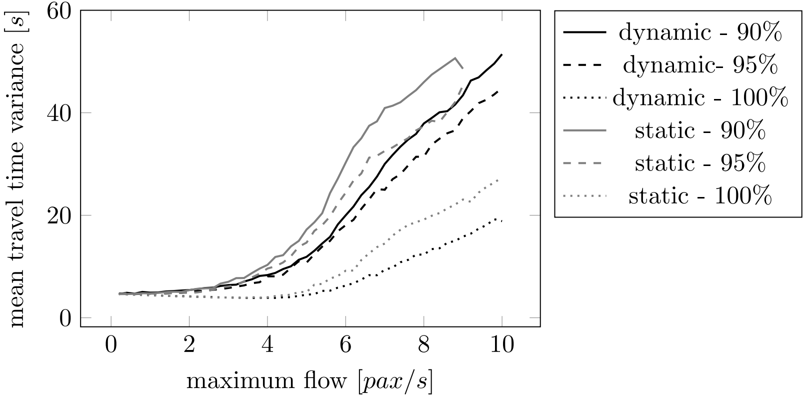


Figure: Travel time variance as a function of demand.

Results & case study

Lausanne pedestrian underpass

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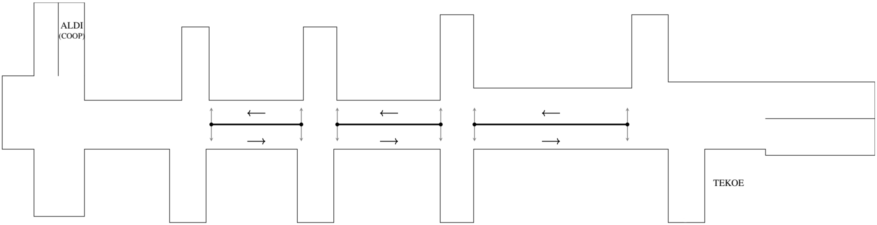
Infrastructure



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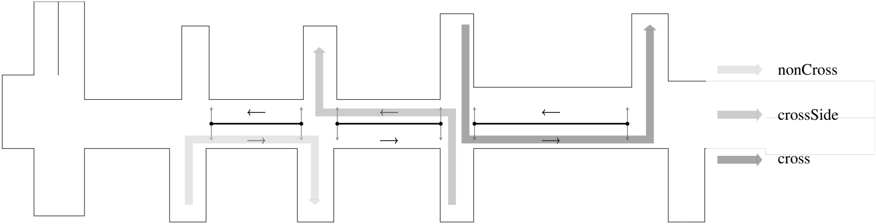
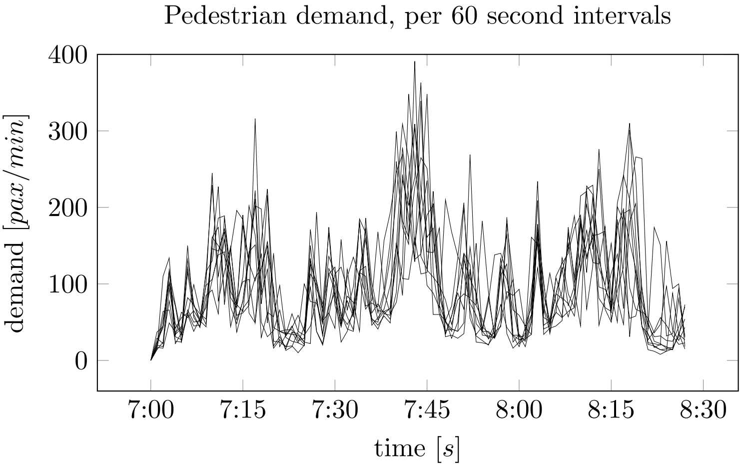
Infrastructure



Demand


Pedestrian demand, per 60 second intervals
400
300
200
100
0
demand [pax/min]
7:00
7:15
7:30
7:45
8:00
8:15
8:30
time [s]

Travel time

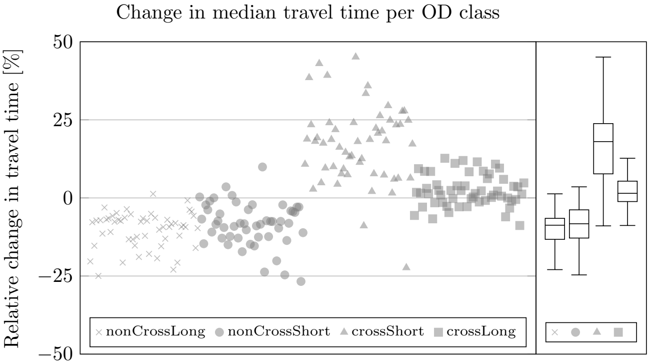


Figure: Journeys which don't involve crossing the corridor

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Travel time

Figure: Journeys which must cross the corridor

Conclusion & next steps

Conclusions

- Integration of one pedestrian control strategies in a DTMS.
- Flow separators significantly improves the travel time.
- Positive results in real-life case study.

Next steps

1. Investigate more complex control laws (improvement ?).
2. Model predictive control.
3. Simulation based optimization.
4. Dynamic control of accelerated moving walkways.

Thank you for your attention ! Questions ?

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