The impact of counterflow on pedestrian walking times

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Outline

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).

ALOCCARS
SNAP BAR - BILLARD
k kiosk
SUBWAY
APERTO
PHARMACIE SUN STORE
WESTERN UNION WU moving money for better
DHL
Pouly
LOST & FOUND

SIX

Motivation

What measures can be taken ?

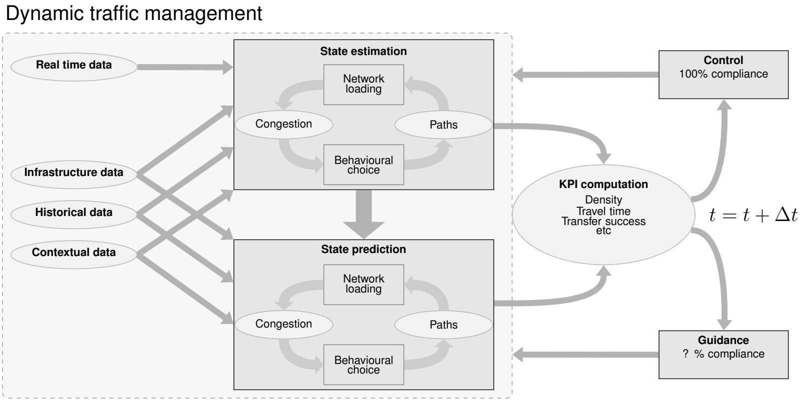
- Decrease pedestrian demand (counter productive !)
- Spread the load over time & space
- Influence pedestrian's routes
- ...

Simulation is needed to address the complexity of the problem.

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

Dynamic traffic management systems

DTMS


Dynamic traffic management
Real time data
Infrastructure data
Historical data
Contextual data
State estimation
Network loading
Congestion
Paths
Behavioural choice
State prediction
Network loading
Congestion
Paths
Behavioural choice
KPI computation
Density
Travel time
Transfer success
etc
Control
100% compliance
Guidance
? % compliance
$t = t + \Delta t$

Dynamic traffic management systems

Road DTMS

Road DTMS: Traffic models

Microscopic

VISSIM (Fellendorf and Vortisch, 2010), car following model (Newell, 2002), CA (Nagel and Schreckenberg, 1992), etc.

Mesoscopic

GK (Hoogendoorn and Bovy, 2001), (Burghout et al., 2006), etc.

Macroscopic

LWR (Lighthill and Whitham, 1955), METANET (Papageorgiou et al., 2010), CTM (Daganzo, 1995), etc.

For a general overview see (van Wageningen-Kessels et al., 2015)

Road DTMS: Control strategies

Ramp metering

Papageorgiou et al. (1991); Hegyi et al. (2005)

Variable speed limits

Papageorgiou et al. (2008); Lee et al. (2006); Hegyi et al. (2005)

Signalized intersections

Little et al. (1981); Lo (1999)

Variable message signs

Wardman et al. (1997); Erke et al. (2007)

Perimeter control

Ramezani et al. (2015); Keyvan-Ekbatani et al. (2013)

Dynamic traffic management systems

Pedestrian DTMS

Pedestrian DTMS: Traffic models

Microscopic

Campanella et al. (2014); Helbing and Molnár (1995), ...

Mesoscopic

Hänseler et al. (2017), ...

Macroscopic

Hänseler et al. (2014); Hoogendoorn et al. (2014), ...

For a general overview see (Duives et al., 2013)

Pedestrian DTMS: Control strategies

Flow regulation for light rail

Zhang et al. (2016)

Demand regulation

Abdelghany et al. (2012)

Static design & offline

Hassan et al. (2014); Zhang et al. (2017), ...

Evacuation & special events

Zhang et al. (2016); Bauer et al. (2007), ...

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

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

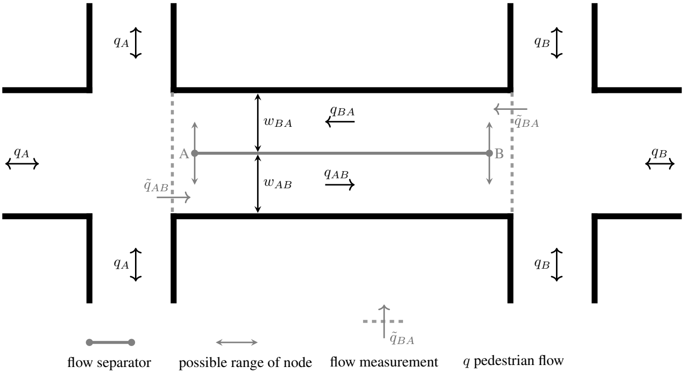


Figure: Schematic presentation of the devices used to separate the opposing flows. The inflow at each end determines the width available to each directed flow.

Width available for each direction is proportional to measured flows:

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

Results & case study

TRANS-FORM

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

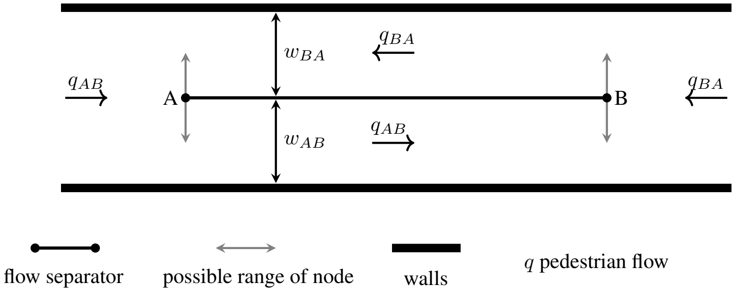


Figure: Dynamic flow separator.

Demand

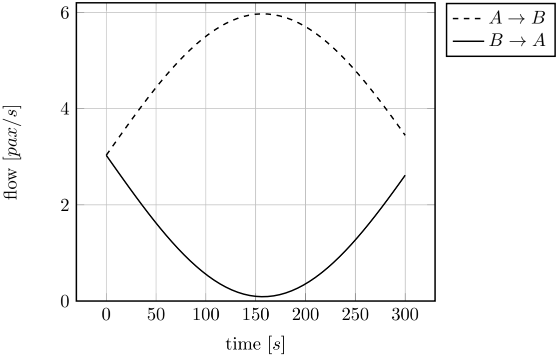


Figure: Demand pattern used to evaluate the flow separator.

Travel times

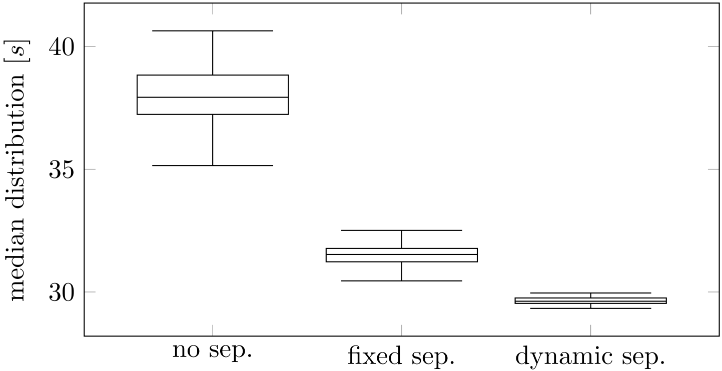


Figure: Median travel time distribution.

TRANS-FORM

Travel time median - sensitivity to compliance

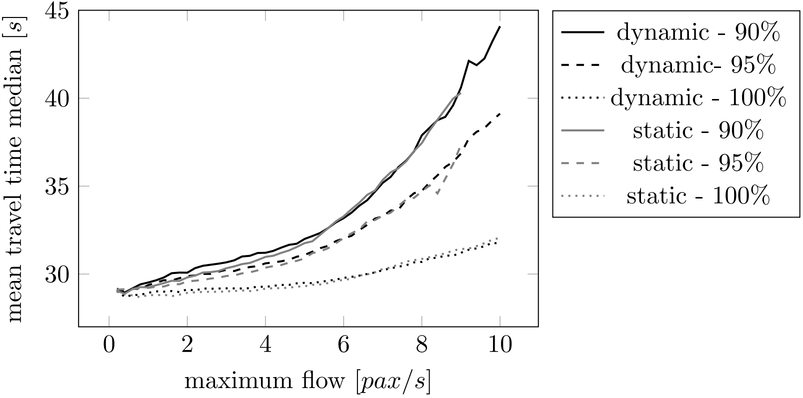


Figure: Travel time median as a function of demand.

Travel time variance - sensitivity to compliance

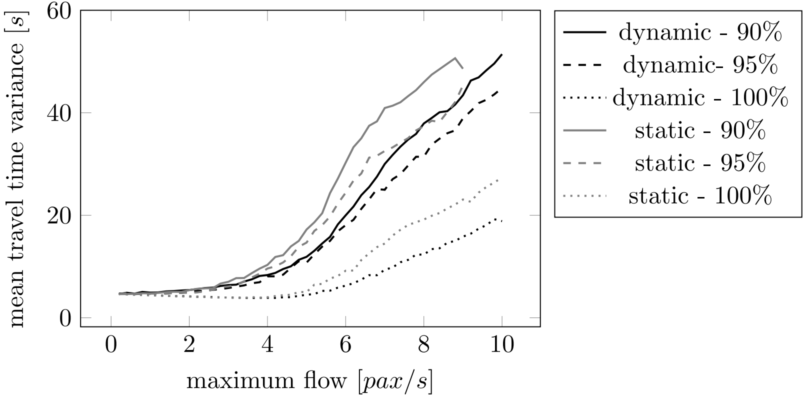
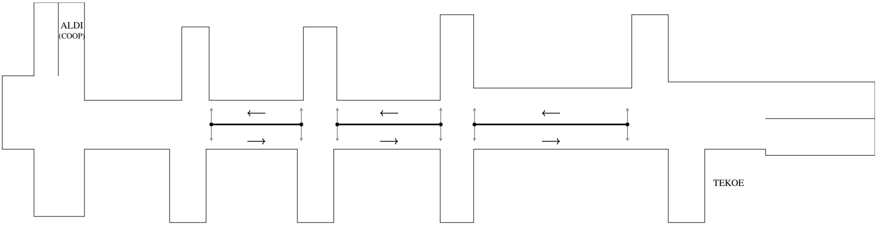


Figure: Travel time variance as a function of demand.

Results & case study

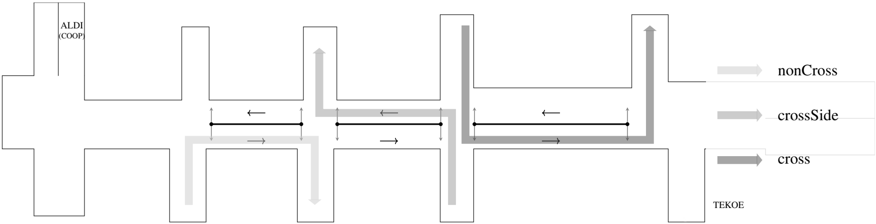
Lausanne pedestrian underpass

Infrastructure

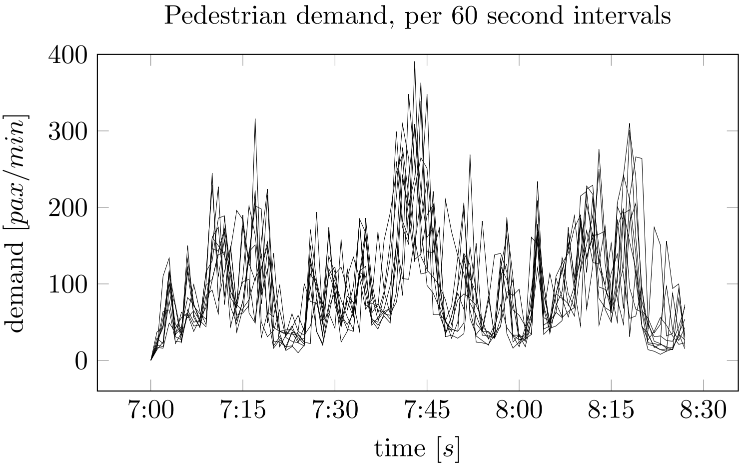


TRANS-FORM

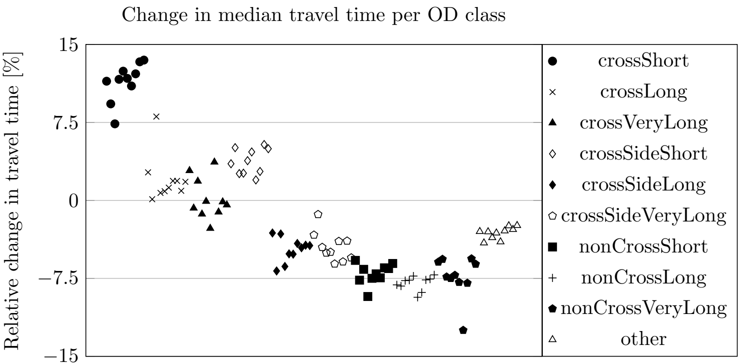
Infrastructure



Demand

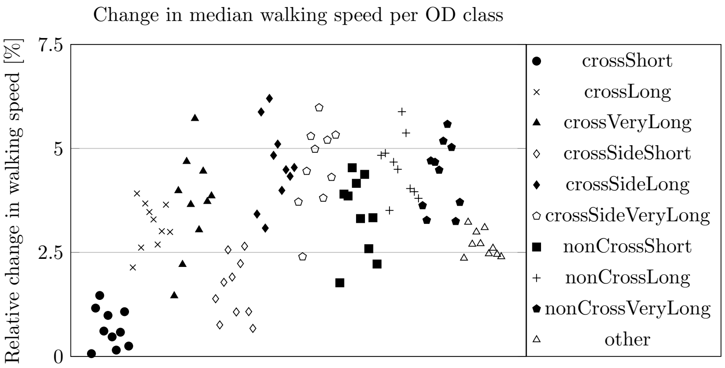

Pedestrian demand, per 60 second intervals
400
300
200
100
0
demand [pax/min]
7:00
7:15
7:30
7:45
8:00
8:15
8:30
time [s]

Travel time - original OD



TRANS-FORM

Walking speed - original OD



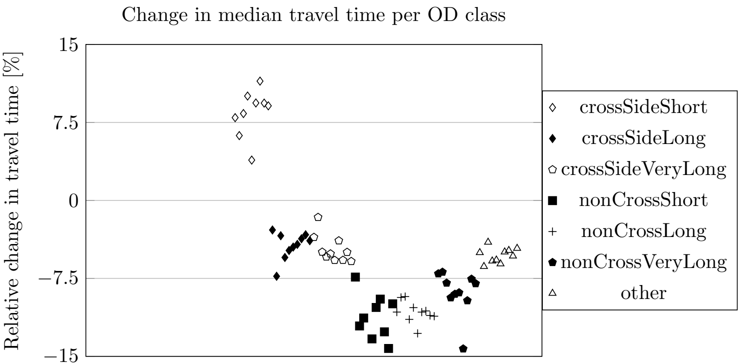
Adapting ODs

With the flow separators, the OD pattern would change

$\Downarrow$

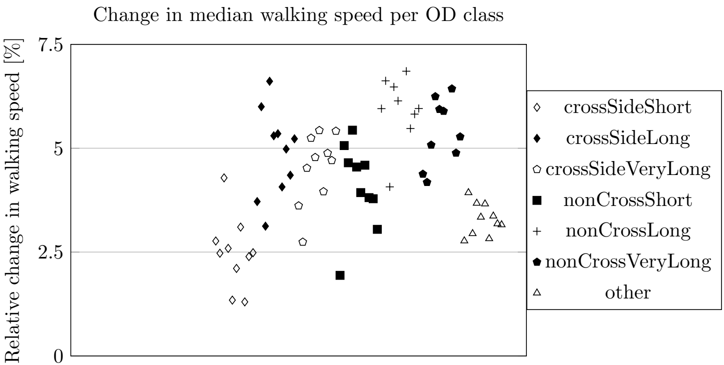
Pedestrians will take the shortest path.

Travel time - adapted OD



TRANS-FORM

Walking speed - adapted OD



Conclusion & next steps

Conclusions

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

Next steps

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

Thank you for your attention ! Questions ?

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