The impact of counterflow on pedestrian walking times

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Improving pedestrian dynamics by preventing counter-flow.
Introduction

Improving pedestrian dynamics by preventing counter-flow.
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,
- ...

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Context

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

Hub diversification (Lausanne, CH train station).

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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

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Dynamic traffic management

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 + ∆t

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Dynamic traffic management systems

Road DTMS

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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

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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

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Objective

Head-on-head “collisions” induce significant extra travel time.

⇓

Reduce this counter-flow to a minimum.

⇓

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

\[
w_{AB}(t) = \begin{cases} 
  w_{AB}^{\text{min}}, & \text{if } w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}} \leq w_{AB}^{\text{min}} \\
  w_{AB}^{\text{max}}, & \text{if } w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}} \geq w_{AB}^{\text{max}} \\
  w \cdot \frac{q_{AB}}{q_{AB} + q_{BA}}, & \text{otherwise}
\end{cases}
\]  

(1)
Results & case study

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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 → multiple runs.
Results & case study

Proof-of-concept

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Infrastructure

Figure: Dynamic flow separator.

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Demand

Figure: Demand pattern used to evaluate the flow separator.
Travel times

Figure: Median travel time distribution.

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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.

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Results & case study
Lausanne pedestrian underpass

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Improving pedestrian dynamics by preventing counter-flow.
Infrastructure

Improving pedestrian dynamics by preventing counter-flow.
Demand

Pedestrian demand, per 60 second intervals

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Travel time - original OD

Improving pedestrian dynamics by preventing counter-flow.
Walking speed - original OD

Change in median walking speed per OD class

- crossShort
- crossLong
- crossVeryLong
- crossSideShort
- crossSideLong
- crossSideVeryLong
- nonCrossShort
- nonCrossLong
- nonCrossVeryLong
- other

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Adapting ODs

With the flow separators, the OD pattern would change

⇓

Pedestrians will take the shortest path.
Travel time - adapted OD

Change in median travel time per OD class

- crossSideShort
- crossSideLong
- crossSideVeryLong
- nonCrossShort
- nonCrossLong
- nonCrossVeryLong
- other

Improving pedestrian dynamics by preventing counter-flow.
Walking speed - adapted OD

Change in median walking speed per OD class

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Conclusion & next steps

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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.
Thank you for your attention! Questions?

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