IMPLEMENTATION OF PRE-SIGNALS FOR BUS PRIORITY

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Outline

• **Introduction**
• Background
• Types of pre-signals
• Operation of pre-signals
• Analytical and Empirical Evaluations
• Bounds of application
  • Pre-signals vs. mixed use lanes
  • Pre-signals vs. dedicated lanes
• Conclusions
Motivation

• Dedicated bus lanes can be used to give priority to buses to eliminate harmful interactions with cars
  • In urban setting this is typically done by converting an existing regular (i.e., car) lane to bus use only
  • However this might not always be feasible (or be the best solution)
• Bus delays can still be reduced without taking a lane fully away from cars, especially when bus flows are low.
  • Dynamic bus lanes
Research Question

• How can public transportation be prioritized while reducing the negative effects on general traffic?
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Background

- Dynamic bus lane strategies targeted at roadways:
  - Intermittent bus lanes (IBL) (Viegas and Lu, 2001; 2004)
  - Bus lanes with intermittent priority (BLIP) (Eichler and Daganzo, 2008)

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- Field tests:
  - Lisbon, Portugal → Increase bus speeds by 15-20 % (Viegas et al., 2007)
  - Melbourne, Australia → Increase in bus speeds not as significant as in Lisbon (Currie and Lai, 2008)
Background

- Other types of bus lanes also exist.
  - e.g., bidirectional bus lanes
- Used at a few locations in Switzerland:
  - Chamerstrasse, Zug

Goal

• Investigating the use of additional signals to provide priority to buses at signalized intersections.
  • i.e., pre-signals close to the main signal to allow buses to jump the car queues.
  • Cars can still use all lanes at the main intersection to fully utilize the capacity of the signal when buses are not present.
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Pre-signal

• Two implementations of such strategies found in Switzerland
  1) Langstrasse, Zurich - pre-signal which intermittently changes the allocation of one lane.
Pre-signal

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Operation of pre-signal
Direction changing pre-signal

• Two implementations of such strategies found in Switzerland

  2) Rapperswil, Jona – pre-signal which intermittently changes the direction of one lane
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Example configuration for a mains signal with a pre-signal
Operation of a pre-signal

When no bus is present:

Pre-signal

Main signal
Operation of a pre-signal

When no bus is present:

Pre-signal

Main signal
Operation of a pre-signal

When no bus is present:

Pre-signal

Main signal
Operation of a pre-signal

When bus is present:

Pre-signal

Main signal
Operation of a pre-signal

When bus is present:

Pre-signal

Main signal
Operation of a pre-signal

When bus is present:

Pre-signal

Main signal
Two parameters for implementation

Distance of the pre-signal from the main signal
Two parameters for implementation

Distance of the pre-signal from the main signal

Such that the main signal capacity can be fully utilized

\[ d = \text{Main signal capacity/jam density} \]
Two parameters for implementation

Duration of the red time at the pre-signal:
Two parameters for implementation

Duration of the red time at the pre-signal:
Such that the last queued car at the pre-signal will also be the last queued car at the main signal
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*Red time at pre-signal* is then a function of:
- *Saturation flow at pre-signal*
- *Saturation flow at main signal*
- *Red time at main signal*
- *Demand rate*

Can be:
- Pre-determined
- Dynamically measured
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Evaluation of pre-signals

- The theoretical car and bus delays incurred at an intersection with a pre-signal are theoretically determined with the use of:
  - Queuing theory
  - Kinematic wave theory
- A total of 11 different queuing patterns based on different bus arrival times are determined to model the car queues
- The theoretical model is then compared to data collected at Langstrasse, Zurich
## Empirical Results

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## Analytical Predictions

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Comparison of theoretical model to empirical data

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% of delay encountered upstream of the pre-signal:
- Empirical: 77%
- Analytical: 81%
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- **77%**
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**Error: -1.5 %**
Comparison of theoretical model to empirical data

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Error: ~ 0%
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Error: 16%
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Domains of application

- Compare the **total person hours of delays of the system (buses and cars)**:
  - Pre-signals
  - Mixed use lanes
- Determine **ratio of bus occupancy to car occupancy** for which the system-wide delays become equal.
Domains of application

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Headway = Cycle Length = 1.5 minutes, Total number of lanes = 3
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• Pre-signals can provide lowest overall system-wide person hours of delay for a wide range of bus occupancies
  • Even if not so, can improve bus operations not only in terms of travel times but also for reliability

• Barely over saturated situations are problematic for pre-signals

• The number of implementations of these strategies can be widely extended to provide bus priority
Thank You
Questions?