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The Effect of Signal Settings on the Macroscopic Fundamental Diagram and its Applicability in Traffic Signal Driven Perimeter Control Strategies
Overview

• Introduction
• Research scope
• Methodology
• Results
• Discussion
• Conclusion
Introduction

MFD

• Relates accumulation to production
  • Accumulation: average weighted density \( A = \frac{\sum k_i l_i}{\sum l_i} \)
  • Production: average weighted flow \( P = \frac{\sum q_i l_i}{\sum l_i} \)
• Maximum production and optimal/critical accumulation are parameters of interest
Introduction

• MFD can be used in perimeter control strategies
• Perimeter control aims to hold back traffic in certain areas, in order to maximize production in another area
• One method to achieve this is by changing signal timings
• Research has found that changing signal timings changes the shape of the MFD
• Studies aiming to implement perimeter control, have not taken this effect into account yet
Research scope

- In what way do changes in traffic light settings at the arterial around a subnetwork, influence the shape of the MFD of the subnetwork and the arterial itself
Methodology
Simulation setup

- Simulation model (VISSIM):
  - Detailed node model
  - Individual signal timings for each intersection (static)
  - Rerouting possible

- Network and OD-matrix (Matlab):
  - Randomly generated street pattern and OD matrix in 3x3 km network
  - Network layout and signal timings are tuned to demand

- Simulations:
  - First simulations are run in order to construct a ‘basic’ MFD
  - Next simulations are run using different signal timings
Methodology

Inflow and outflow control

- Inflow control: Signal timings for flow from arterial to subnetwork are fixed to accommodate specific number of vehicles (100, 200, 300, 400, 500)
- Outflow control: Signal timings for flow from subnetwork to arterial are fixed
Results

Controlling subnetwork inflow

- Different signal timings result in differently shaped MFDs
- Improvement in production for subnetwork found at 200-400 veh/h
- Certain productions can be sustained over a large accumulation range
- 30,000 vehicles completing trip at 100 veh/h, in other cases 15,000 - 20,000
Results
Controlling subnetwork outflow

• Roughly same results as for controlling inflow
• Timings at which highest production is achieved (300-500), differs from inflow (200-400)
• 32,000-35,000 vehicles completing trip at 400-500, in other cases 25,000
Discussion

Improvements in traffic flow

- Improvements can be achieved over locally optimized signals
- Highest production does not always result in highest output
- Production of perimeter is higher than subnetwork
- For both control strategies output is maximized if as many vehicles as possible are kept within the perimeter
  - The perimeter is better capable in processing traffic and preventing gridlock
  - Formation of gridblocks in subnetwork easier
Discussion

Critical accumulation

- Accumulation at which production is maximized differs, given different signal timings
- Using critical accumulation of the original MFD as a control target results in a different (possibly lower) critical accumulation, resulting in even more congestion
- A-priori construction of MFDs for different signal timings needed

<table>
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<th>Control scenario</th>
<th>flow veh/h</th>
<th>$A_{crit}$ veh/lane-km</th>
<th>Perimeter veh/lane-km</th>
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Conclusion

• For two control types tested, no substantial differences in maximum production are found. However, higher outputs achieved with outflow control

• Keeping the perimeter at maximum production and keeping amount of traffic in subnetwork low generates best results

• Production can improve by changing signal timings

• Different signal timings can have a strong effect on the shape of the MFD, i.e. the maximum production and critical accumulation

• As critical accumulation differs for different signal timings, it cannot be directly utilized input for control strategies

• A-priori construction of MFD for different signal timings needed for (perimeter) control strategies
Questions?