Large scale urban traffic operations:
theory, empirics and control

Victor L. Knoop
16 November 2016
Scales of traffic description

- Microscopic: individual level
- Macroscopic: road level
- Higher level: network level
Relationships variables

Flow

Density

- Relationship between flow and density.
Build up of congestion
Fitting a functional form

\[ P(A) = A*(c1 + c2A + c3A^2) - c4\sigma \]

Homogeneous traffic situation

Inhomogeneous traffic situation
Fitting a functional form

\[ P(A) = A^* (c_1 + c_2 A + c_3 A^2) - c_4 \sigma \]
Fitting a functional form

Different traffic conditions

![Graph showing production versus accumulation for different traffic conditions.](image)
Empirical evidence
Suitable for any queuing application?
Further content

1) Empirics of MFD
2) Controlling: perimeter control and internal control
Floating car data
Estimation of MFDs

- Control based on MFD
- How does the MFD look like?
  - often found from (micro)simulation or taxi data
  - Loop detector data is unfeasible
- Cont(r)act with Google
Detector speeds not representative
Available data

- Speeds via all mobile devices
- (Scaled) flow on the roads
- Road segments length typically ~100 meters
- Aggregation time 5 min
- Total: billions (i.e., exp(9)) rows of data!
- Segment size lacks assumed equal
Results

- Not in sheets on the internet...
Perimeter control or internal control
Perimeter control?
Perimeter control?
Aims for combinations

• Perimeter control: do not exceed the critical density
• Traffic lights: influence the internal flows (maximize)

• Combination:
  – Allow for inflow
  – Spread congestion evenly (i.e., reduce spread)
Control

- Lights for perimeter control
- Lights for internal control
Control schemes

• Perimeter control: do not let too many vehicles in:

\[ q_g(k) = q_g(k-1) - K_p \left[ TTS(k) - TTS(k-1) \right] + K_I \left[ TTS - TTS(k) \right] \]

• Lights for internal control: three versions
  – Fixed time
  – Volume-based
  – SCATS-like (adaptive)
Results

- Delays are lower for the gating situation
- Gating first, the rest comes later :-)

![Bar chart showing delay comparison between No gating and Gating]
Traffic states

- Limiting the flow also helps having an equal spread
Concluding remarks
Conclusions

- MFD is a very rich and promising field of research and application
- Next steps:
  - Include more modalities (cyclists?)
  - Further work on dynamic modelling, and validate
  - Get it to work in practice!
Thanks to:

- Kay Axhausen
- Mehdi Keyvan-Ekbatani
- Vikash Gayah
- Serge Hoogendoorn
- Netherlands Organisation for Scientific Research (NWO)
- European Research Council (ERC)
Further reading:


