Recent advancements in network-wide traffic operations

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Scales of traffic description

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

Flow

Density
Build up of congestion
Fitting a functional form

\[ P(A) = A*(c_1 + c_2A + c_3A^2) - c_4\sigma \]

Homogeneous traffic situation

Inhomogeneous traffic situation
Fitting a functional form

\[ P(A) = A^*(c_1 + c_2A + c_3A^2) - c_4\sigma \]
Fitting a functional form

Different traffic conditions

![Graph showing production and accumulation over inhomogeneity](image-url)
Empirical evidence

Accumulation =>

GMFD top view fit

Accumulation (veh/km/lane)
Suitable for any queuing application?
Further content

1) State estimation using the MFD
2) Controlling: perimeter control and internal control
3) Further effects: influences of pedestrians
Estimating the traffic state using the MFD
Estimating the traffic state

• Can we use the MFD for estimating the traffic state?
• In real life, not all data are known
• Detector data for some links, and (assume) floating car data for some vehicles
Detector speeds not representative
Method used:
Method used: construct MFD

Diagram: Traffic network with inputs Loop detector data and Vehicle Trajectories. MFD flow and density graph.
Method used: find traffic state based on speed

\[ q = k \cdot v \]
MFD found

Data fusion MFD with error bounds

Network Flow (vehicles/h)

Network Density (vehicles/km)

- Data-points
- MFD fit
- Errors at $2\sigma$ ($\sim$95%)
MFD found
Errors in speed
Errors in estimation
Errors in estimation
Examples for various speeds

- $V=15 \text{ km/h} \ (\mu=64.9, \sigma=8.4)$
- $V=25 \text{ km/h} \ (\mu=38.8, \sigma=5.9)$
- $V=35 \text{ km/h} \ (\mu=22.4, \sigma=4.9)$
- $V=45 \text{ km/h} \ (\mu=10.8, \sigma=4.4)$
- $V=55 \text{ km/h} \ (\mu=4.2, \sigma=3.0)$

**Graph:**

- Probability
- Density (vehicles/km)
What happens in incidents?

- 6 incidents modelled
- *What would happen to MFD?*
- What would happen to our estimation procedure?
What happens in incidents?

- 6 incidents modelled
- What would happen to MFD?
- What would happen to our estimation procedure?
- How can we find out?
Perimeter control or internal control
Perimeter control?
Perimeter control?
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 delays for different scenarios](chart.png)
Traffic states

• Limiting the flow also helps having an equal spread
Influences of pedestrians
Vehicular capacity with pedcrossings

- More crossings help
- No interaction effects taken into account
Spreading pedestrian load

• Spreading pedestrian load over more pedestrian crossings benefits drivers and pedestrians

• Extreme case: infinite number of pedestrian crossings, i.e. pedestrians can cross anywhere (but still have priority)
Pedestrian crossings
Analytics

- Capacity decreases with pedestrian flow and duration: \( f = q_{\text{ped}} T_{\text{cross}}^2 \)
- Upper and lower bound analytical
- Capacity estimated (0.2% off)
Simulation and estimation

- Various levels of pedestrian load
- Simulation and estimation
- Very accurate estimation
Crosswalks

• Non-perpendicular crossing increases the time on the road, so should be avoided => Use crosswalks
• Variables:
  - Average spacing between crosswalks
  - Std of spacing between crosswalks
  - Pedestrian flow
Result with crosswalks
Concluding remarks
Conclusions

• MFD is a very rich and promising field of research and application

• Next steps:
  - Include more modalities (cyclists?)
  - Build MFDs from data
  - Further work on dynamic modelling, and validate
  - Get it to work in practice!
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Further reading:


