Traffic state estimation in the presence of connected vehicles

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Motivation

Traffic congestion has a strong economical and social impact on our society.

Automated and connected vehicles will influence traffic flow, with an uncertain impact (positive or negative).

Automated and connected vehicles will actively influence traffic flow, via computing or receiving customised commands.

Several traffic management strategies have been proposed for both conventional and novel actuators.
Traffic management strategies

- Smart lane-changing strategies
- Traffic-adaptive ACC
- Smart intersection control and routing in road networks
Need for Traffic State Estimation

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Less than 100% connected vehicles: we need Traffic State Estimation (TSE)!

Namely, using a limited amount of information and some knowledge of the behaviour of our system, we can derive also unmeasured quantities.
Current measurements for TSE

How do we get such information today?

**Installation** of loop detectors, camera, radars, etc...

For accurate estimation (useful for traffic management), we need detectors every 1500 m – 2500 m (in motorways)

Detectors are expensive to install, expensive to maintain, suffer from systematic bias
Vehicle connectivity is appearing in various forms in the current traffic and, in the near future, it may enable overcoming several of the previously mentioned issues.
We assume that connected vehicles report their position and speed, as well as any other relevant information (acting as mobile sensors).

Our method aims at obtaining per-lane density and flow, allowing also for lane-based management policies and lane advices.

A limited amount of spot detectors, at strategic locations, is still necessary for accurate flow estimation.

We assume that a centralised Traffic Management Centre collects and processes the data.
TSE framework

Traffic System

Kalman filter for the estimation of $\rho_i$

Monitoring and Control Unit

$\hat{q}_1, \hat{\rho}_1, \ldots, \hat{q}_{N-1}, \hat{\rho}_{N-1}$
Case studies

We tested our method in several experiments
• using real and simulated data
• defining several scenarios involving different penetration rates of connected vehicles

Case study 1: NGSIM I-80 data

Case study 2: microscopic simulation using AIMSUN
Case study 1: NGSIM I-80 data

Penetration rate 100%

Penetration rate 5%
Case study 2: AIMSUN microsimulation

Ground truth

Estimates

Aalto University
School of Engineering
Conclusions

We propose a per lane traffic state estimation scheme, showing its capabilities via various experiments.

The estimation scheme captures the onset of congestion with accurate timing and reproduces reliably any challenging traffic conditions in space and time.

Density estimation is satisfactory even for low penetration rates.

Methodologically, we are extending our method by removing need for spot measurements.

Currently, we are looking for a possible field implementation.
Reference list


Thank you!

Questions?

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