Data fusion for traffic flow estimation at intersections

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Outline

Part I Motivation and idea

Part II Data Fusion Concept

Part III Application and Discussion
Part I

Motivation and idea
Why data fusion?

Good coverage of **space**
- mobile detectors
  - floating car data
  - mobile phone data
  - ...

Good coverage of **time**
- stationary detectors
  - inductive loops
  - video
  - infra red
  - ...

**Evolving technologies**
- automatic video detection
- blue tooth
- ...

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Data Fusion for traffic flow estimation at intersections – Wolfermann, Kuwahara, Mehran – IWTDCS 2011
The application

• Mobile and stationary detectors have been fused before.
• But not at intersection level.

• The story about the importance of signalised intersections in urban networks.

• Signal control is based on turning ratios ever since.

• But who knows the turning ratios?

• Soon we will
Data sources for the fusion

- **Mobile detectors**
  - Floating Car Data (FCD)

- **Stationary detectors**
  - e.g. inductive loops

- **Historic data**
  - used to fill the gaps in time and space

- **Network context**
  - vehicles do not disappear magically...
  - every simulator uses this information
Data output of the fusion

• **Available data**
  - Floating Car Data (FCD)
  - detector data
  - historic data
  - network layout

• **Desired information**
  - OD on intersection level (traffic flow for all movements)
  - resolution 1 h (better 15 min)

\[ q = 1 \text{ veh/time} \]
Part II

Data Fusion Concept
The concept in a nutshell

- **combine as many data sources** as are available and seem useful
- **bridge the gap of unknown turning volumes at intersections** by using **Floating Car Data**
- use **historic data** in case no current data is available
- weight the different data sources according to their **reliability**

**Kalman Filter**

- estimates true values
- estimates **uncertainty** of the predicted value
- computes a weighted average of predicted values and measured values
- minimises the error covariance (for white noise)
Kalman Filter

Initialisation (start condition)

Predict (process)

Update (measurements)

Detector data

FCD

Penetration rate

FCD based traffic flow

Historic traffic flow

Network context

$t = 1$

$t = t + 1$
Illustration of Kalman Filter

- **Prediction**
- **First update (FCD)**
- **Second update (Historic data)**
- **Third update (Network context)**

FCD Estimate

- HD more reliable
- FCD more reliable

Traffic flow

- t - 3
- t - 2
- t - 1
- t
- t + 1

Time:

\[ t = t + 1 \]
Network context
Error terms

- **Historic data**
  - variance of historic data
  - clustering!

- **FCD**
  - variance of penetration rate
  - detector reliability?

- **Network context**
  - reliability of estimates from adjacent intersections
Part III

Application and Discussion
Application overview

• fictitious data
  → true values are known for evaluation

• elasticity tests for different parameters
  – traffic flow variation
  – penetration rate
  – detector reliability
  – representativeness of probe vehicles

• simple two intersection “network”

• Monte Carlo simulation to avoid random results
Application

- FCD Estimates
- Historic Data
- Filter output

Stream 2

Traffic Flow (veh/5 min)

Time (15 min interval)
Application

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FCD Estimates
Historic Data
Filter output
True values
Confidence interval

Traffic Flow (veh/5 min)

Time (15 min interval)
Application

- penetration rate ↓

bad estimates by FCD

no FCD, historic data only
Application

- penetration rate
- flow variation

Wrong judgment of measurement variation?

Confidence interval
Application

![Graph showing traffic flow estimation at intersections](image)

- **Traffic volume (veh/15min)**
- **Time (15min intervals)**

Legend:
- Update 1
- Final
- Cumulative Error (Update1)
- Cumulative Error (Final)
- Update 2
- True Data
- Cumulative Error (Update2)
Discussion

• more **data sources** useful

• how to judge the **measurement reliability**?

• high **penetration rate** crucial (> 10 %)

• good **clustering technique** for historic data required

• combination with **flow simulation** desirable

• evaluation of **real data** dito

**a promising concept if sufficient FCD is available**