Monitoring Transportation Systems
Everyone Here or A Few Everywhere

Smart City X

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You can’t manage what you can’t measure
What is the most important development in transportation in the last decade?
What is the most important development in transportation in the last decade?
Outline

Sensor typology

Point Sensors

Spatial Sensors

Distributed Sensors

Perspectives
Sensor typology

Point Sensors

Spatial Sensors

Distributed Sensors

Perspectives
What is a sensor?

A sensor (also called detector) is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (today mostly electronic) instrument.

(Wikipedia)
What to measure?

- Users and vehicles
What to measure?

- **Users and vehicles**
- **What characteristics?**
  - *counts*, speed and occupancy rate
  - *classified* according to the user/vehicle characteristics: type, length, weight, etc.
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- **What characteristics?**
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- **presence** of users/vehicles for traffic control
- **events**: incidents, queueing, infractions, etc.
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- What characteristics?
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    - classified according to the user/vehicle characteristics: type, length, weight, etc.
  - presence of users/vehicles for traffic control
- events: incidents, queueing, infractions, etc.

Where and when?
Spatio-temporal coverage
Spatio-temporal coverage

\[ x(t) \]

\[ t_0 \]
Spatio-temporal coverage
Spatio-temporal coverage

\[ x(t) \]

\[ x(0) \]

\[ t_0 \]
Spatio-temporal coverage
Characteristics of the various methods

- Permanent or temporary
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- Online or offline use
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- Online or offline use
- Accuracy, robustness (calibration)
Outline

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Perspectives
Common methods

- Manual (counts)
Common methods

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- Pneumatic tubes
Common methods

- Manual (counts)
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- Inductive loops
Common methods

- Manual (counts)
- Pneumatic tubes
- Inductive loops
- Magnetic sensors
Common methods

- Manual (counts)
- Pneumatic tubes
- Inductive loops
- Magnetic sensors
- Radar
Common methods

- Manual (counts)
- Pneumatic tubes
- Inductive loops
- Magnetic sensors
- Radar
- Infrared sensors
Sensor typology

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Perspectives
Spatial sensors

- Aerial photos
Spatial sensors

- Aerial photos
- Satellite images

Figure 2 TerraSAR-X Traffic Measurement on the A4 Motorway West of Dresden, Germany
Spatial sensors

- Aerial photos
- Satellite images
- Video sensors
Spatial sensors

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Technologies for automated vehicle identification (AVI)

- Video-based automated license plate recognition (ALPR), used for cordon area congestion pricing (London and Stockholm)
- RFID tags used for toll collection (Singapore, Golden Ears bridge in Vancouver, A25 and A30 bridges in Montréal)
- Bluetooth and Wifi sensors
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What is the purpose?
Sensor typology

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Perspectives
Distributed sensors

- **Communication** technology + **localization** technology (GNSS) = area-wide, continuous traffic monitoring
  - vehicles/users + sensors = probes
  - crowdsourcing of the traditional floating car method
  - robust, “free”, real time data collection over the network
  - smartphones can be used to provide real time information back
Distributed sensors

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- Tracking of mobile phones

- Smartphones: projects Mobile Century and Millenium (Berkeley/Nokia), companies (INRIX, Google, TomTom)
Distributed sensors
• Constant progress of technologies, refinements
• “Old” technologies are still much in use, with new possibilities offered by computing, more storage and real time availability
• More and more sensors everywhere, communicating in real time = the Internet of things (IoT)
  • no mention of vehicles, a.k.a. connected “computers on wheels”
You can’t manage what you can’t measure
You can’t manage if you can’t archive, organize and process your data.
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- Importance of data processing and management
- The era of “big data” and data science
  - opportunities and challenges to solve problems that could not be solved previously
Questions?

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