Outline

– Data collection needs and motivation
– Technology classification
– Data collection issues
– Data collection
  – Speed
  – Volume
– Accuracy issues
– Way forward
Data collection needs

- Traffic data collection form an essential part of any road traffic related monitoring, management and modelling
- Traffic data collecting methods have been evolving considerably under growing pressure for improving traffic management, and the access to real-time traffic information is becoming routine worldwide
- Use of traditional on-road/contact based devices/sensors (e.g. inductive loops) for collecting data is necessary
- It is not however sufficient because of their limited coverage and expensive costs of implementation and maintenance
- Last few years we have been witnessing the emergence of alternative data sources, for example based on GPS embedded mobile phones etc.
- Drone based data collection methods help collect data on long stretches of the road

Motivation

- How are these relevant in Road safety?
  - Conflict analysis
  - Safety audits
  - Setting speed limits
    - Speed violations
Vehicular traffic sensing technologies

Classification: intrusive/contact based

- Inductive-loop detectors
  - Inductive-loop detectors are widely used at intersections with traffic-actuated signals, freeway entrance with automatic ramp metering, highway segments monitored by traffic counting programs, and entrances of gated parking facilities.

- Pneumatic road tubes
  - Pneumatic tubes are portable traffic data collection devices and are ideal for short-term traffic engineering studies

- Piezoelectric sensors
  - the sensors are placed in a groove along roadway surface of the lane(s) monitored.
Classification: based on location

- **With the vehicle (Mobile Sensor)** - GPS receivers, acoustic/ultrasonic sensors, mobile phones
- **At a point (Point Sensor)**: All contact/non-contact (intrusive/non-intrusive) devices: Flow rate (volume), Speeds and headway
  - Volume: Hand tallies, Pneumatic tubes, Video Cameras and Loop Detectors
  - Speeds: Laser Speed guns
  - Time Headways: Dictaphones, Loop detectors, and Video Cameras

Classification: based on location

- **Over a Short Section** : Flow: A pair of detectors (inductive loops) spaced 5-6 m apart or Video Camera (small range),
  - Occupancy: Loop detectors
- **Along the length of the road (Space Sensor)**: Flow and Occupancy – video camera, drone, helicopter, satellite: Density
  - Density: Most difficult to measure; Aerial photography or from cameras mounted on tall buildings; Video camera can be used for indirect calculation of densities
Induction-loop detectors

- Data collected: classified counts, vehicle speeds, headways

Penumatic tubes

- Data Collected: instantaneous speed, direction of flow, volume, vehicle classification, and the time of day associated with each data sample
Classification: Remote/non-contact based

- **Microwave radar:**
  - this technology can detect moving vehicles and speed (Doppler radar).
  - It records count data, speed and simple vehicle classification and is not affected by weather conditions.

- **Ultrasonic and passive acoustic:**
  - these devices emit sound waves to detect vehicles by measuring the time for the signal to return to the device.
  - The ultrasonic sensors are placed over the lane and can be affected by temperature or bad weather.

Classification: Remote/non-contact based.... contd.

- **Ultrasonic and passive acoustic:**
  - The passive acoustic devices are placed alongside the road and can collect vehicle counts, speed and classification data.
  - They can also be affected by bad weather conditions (e.g. low temperatures, snow).

- **Video image Processing System (VIPS):**
  - video cameras record vehicle numbers, type and speed by means of different video techniques e.g. trip line and tracking.
  - The system can be sensitive to meteorological conditions.
Manual counts

Passive/Active infra red

- TIRTL TRANSMITTER
- TIRTL RECEIVER
Microwave radar

Ultrasonic sensors/Passive Acoustic

- vehicle counts, speed and classification data.
- Distance from obstacles – park assist – in passenger cars
Global positioning systems

- The Global Positioning System (GPS) is widely used in automotive navigation and traffic engineering studies such as traffic time studies.
- Cell phones are equipped with positioning functionalities, and hence they are considered in the same category of GPS.

Aerial/Satellite Imaging

- The captured aerial photos contain snapshots of traffic on roadways, from which spatial traffic data such as spacing (i.e. spatial separation between two consecutive vehicles), vehicle counts over a segment of roadway, and traffic density can be obtained.
- In addition, analysis of consecutive aerial photos may yield information about vehicle speeds and further mean traffic speed.
**RFID Technology**

- The RFID (Radio Frequency Identification) tag is able to record and the IDs of equipped vehicles and time-stamp the arrival of such vehicles.

![RFID Technology Diagram](image1.png)

**Video image processing system (VIPS)**

- Similar to inductive-loop detectors, the VIPS monitors a point of roadway
- To collect (classified) traffic counts, vehicle instantaneous speed, headway
- Drones/quadcopters – video of desirable quality

![VIPS Diagram](image2.png)
Drone video

Ni (2016)
Why VIPS?

– Highly reliable +
– Online processing (embedded systems) +
– Offline processing +
– Exhaustive log of the data +
– AI/ML based data extraction and analysis +
– Time consuming for details extraction –
– Robust embedded systems –

Speed

• Speed measurements
  – Trap length
  – Speed guns
  – Other

Histogram: Frequency Distribution (Spot Speed)
Field Techniques for Volume Studies

- Wide variety of techniques and equipment that can be used to count vehicles as they pass a point
- Technology vs. need
- Often for quick counts the inexpensive manual counts are preferred. Manual counts can easily discern
  - Vehicle occupancy
  - Turning movements at intersections
  - Vehicle classifications

Volume/flow

- AADT
- ADT
- AAWT
- AWt
Accuracy issues: Comparison of Devices - contact based

<table>
<thead>
<tr>
<th>INTRUSIVE /CONTACT BASED DEVICES</th>
<th>PRIME USE</th>
<th>ACCURACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductive loop detectors</td>
<td>General purpose</td>
<td>96.5%</td>
</tr>
<tr>
<td>Pneumatic tubes</td>
<td>Temporary in-city counting</td>
<td>65-72%</td>
</tr>
<tr>
<td>Piezo-sensors</td>
<td>Classification and WIM</td>
<td>93%-95%</td>
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</tbody>
</table>

Comparison of Devices: non-contact based

<table>
<thead>
<tr>
<th>NON-INTRUSIVE DEVICES</th>
<th>PRIME USE</th>
<th>ACCURACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave radar</td>
<td>General purpose</td>
<td>96% (NEAR LANE)</td>
</tr>
<tr>
<td>Infra-red</td>
<td>Vehicle count</td>
<td>99.5%</td>
</tr>
<tr>
<td>Laser scanning beam</td>
<td>Precise classification</td>
<td>80%-95%</td>
</tr>
<tr>
<td>Video Detector</td>
<td>Classification and count</td>
<td>95%</td>
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</table>
General Comparison of devices

<table>
<thead>
<tr>
<th>Detector Type</th>
<th>Volume/Count</th>
<th>Speed</th>
<th>Classification</th>
<th>Occupancy</th>
<th>Presence</th>
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<tbody>
<tr>
<td>Inductive Loop</td>
<td>✓</td>
<td>✓ 18</td>
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<tr>
<td>Magnetic</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Active Infrared</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
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<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
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</table>

Note: (1) Speed can be measured by dual-loops with a known distance apart, or by algorithms with a single-loop assuming the length of the detection zone and vehicle.
(2) Advanced detector cards can measure classification using “vehicle signature.”
(3) Speed and classification measurement by magnetic detectors requires two units.
(4) Passive infrared sensors with multi-detection zone capability can measure speed.

- High capital costs
- Low O & M costs
- Highest capital cost - machine vision sensor on corridor
- Lowest capital cost – infra red passive sensor
- Highest O & M cost – CCTV video camera
- Lowest O & M cost – Induction-Loop detectors
Way forward

- Customization
- Rigorous testing
- Accuracy aspects
- Traffic densities
- Installation and up time
- O & M Costs

References

- Ismail, K.A. Application of computer vision techniques for automated road safety analysis and traffic data collection, PhD Thesis, University of British Columbia, 2010
- Klein, L.A. Sensor Technologies And Data Requirements For ITS, Artech House, Boston, 2001
- Ni, D. Lecture Notes In Traffic Flow Theory, University of Massachusetts Amherst, USA, 2012