A Prototype System for Truck Signal Priority using Video Sensors

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Outline

1. Motivation
2. Object Classification in Images
3. Experimental Results
4. Conclusion
Why Truck Priority?

• Benefits:
  • Reduce the cost of goods transportation.
  • Reduce red light running.
  • Encourage trucks to use specific truck routes.
  • Reduce emissions.

• This requires the ability to detect and track trucks.
Video Sensors

- Video sensors have distinct advantages:
  - they are easy to install (or can be already installed),
  - they are inexpensive,
  - they can provide rich traffic description (e.g. road user tracking),
  - they can cover large areas,
  - their recording allows verification at any later stage.
Detecting and Tracking Trucks

- Image Sequence + Camera Calibration
- Road User Trajectories
- Background Model
- Labeled Truck Images
- Truck Classifier
- Road User Classification
Object Detection in Images

• Two types of object description variables:
  • describing the appearance.
    – e.g. SIFT, HoG features.
  • describing the shape.
    – e.g. (3D-)models, moments.
Shape Description

- Extract a shape using background subtraction.

- Compute the moments of the shape.

\[ m_{p, q} = \iint f(x, y) x^p y^q \, dx \, dy \]

\( f(x, y) = 1 \) if the pixel at \((x, y)\) is in the foreground
\( 0 \) if the pixel at \((x, y)\) is in the background
Learn a Truck Classifier

- Using machine learning to learn a binary classifier (truck vs. other road users).

- The classifier returns a decision for each shape at each instant. A threshold $nDetections$ is used to detect a truck.
Experimental Results

X axis: 1-Recall\textsubscript{non-truck}
also called false alarm rate

Y axis: \textit{Recall}\textsubscript{truck}
also called true positive rate

DT: Decision Tree
RF: Random Forest
Experimental Results

- The recall for trucks reaches 78% to 95% on test data, with a false alarm rate below the 0.5% value used for the system simulation.

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<th>Time</th>
<th>Decision Tree</th>
<th>Full</th>
<th>Small</th>
<th>Recall</th>
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Experimental Results
Experimental Results: TkSP

- TkSP: green extension or red truncation.
- Conventional / Advanced TkSP: prediction of truck arrival time and queue dissipation time thanks to real-time tracking.
- Detection at 300m from the intersection.
- Simulation of the Knight St corridor in Vancouver B.C. (3 intersections with TkSP).
- The Advanced TkSP strategy outperformed conventional TkSP strategy.
Experimental Results: TkSP

- Especially effective
  - at two-phased intersections,
  - when traffic volume was less than that of the morning peak hour,
  - when truck proportion was equal to or less than 2%,
  - and when priority was not locked after a green extension or red truncation.

- Under the best conditions, average truck travel times were reduced by 9.16% and 0.93% in the peak and opposing directions, respectively.
Conclusion

● Prototype system for truck detection and tracking using video sensors.

● Tested on real world data: high recall for trucks, from 78% to 95%, and a false alarm rate below the 0.5% value used for simulation.

● Future work:
  ● classify all road users and include other description variables,
  ● multi-camera system.
Questions?