Data-Driven Approaches for Arterial Traffic Operations

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Yao’s Journey

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Board of Technical Registration

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SAINT LOUIS UNIVERSITY

THE UNIVERSITY OF ARIZONA

UNIVERSITY of VIRGINIA
Back to our Topic 😊
Bluetooth

Probe Vehicle Data

Real-Time Signal Timing Data

Video-based Sensors
Low-Cost Bluetooth Module

- Idea originated from Dr. Larry Head
Bluetooth Sensor Locations
(as of Mar. 24, 2016)
Bluetooth Sensor Detection Zone

Yao-Jan Wu, Yi-Chang Chiu, and Shu Yang (2016). Multi-modal Arterial Performance Measurement using Multi-source ITS Data, University of California Center ON Economic Competitiveness In Transportation (UCCONNECT)
Mode Classification

- K-nearest neighbor (KNN)
- Support vector machine (SVM)
- Genetic Algorithm and Neural Network (GANN)

Figure 8. Best Scenario Performance Differences of KNN, SVM, and GANN

Shu Yang and Yao-Jan Wu (2017), Travel Mode Identification Using Bluetooth Technology, Accepted by Journal of Intelligent Transportation Systems
Travel Time Decomposition

- Hidden Markov chain with Genetic Algorithm (HMMGA) approach
- Gaussian mixture model with GA (GMMGA)

Video-based Sensors
Detectors’ Location

Intersection: Speedway Blvd @ 6th Ave
Direction: Westbound
Demo Video

Speedway Blvd & Campbell Ave (EB)
Vehicle Classification

Speed Distribution (WB Ph6 Lane 3)

Speed Distribution (WB Ph6 Lane 4)

Acknowledgment: Simon Ramos
Study Site: Campbell Ave and Speedway Blvd

- **Approaches**
  - **NB & SB**
    - Two left-turn lanes
    - Three through lanes
    - One right-turn lanes
  - **WB & EB**
    - One left-turn lanes
    - Two through lanes
    - One right-turn lanes
Sensor Layout: Virtual Loops

Speedway Blvd & Campbell Avenue

Westbound

Eastbound

Southbound

Northbound
Summary of Data Analysis

- **231 days** of data are processed by
  - R Language
    - Every direction at same day
  - EXCEL Pivot Table
    - Different time
    - Different days
    - Different months
Speedway Blvd and Campbell Ave

Jan 18, 2017

Acknowledgment: Paul Burton
Results in EXCEL PivotTable

- 15-minute Intervals

See the EXCEL file for more details
Data Visualization
Using Excel Pivot Table

Speedway Blvd & Campbell Ave
Date Range: 1/18/2017 ~ 9/6/2017
Results in HTML File

Interactive Interface for Seven Intersection Data

http://stlttest.org/
Big Data Visualization

- HTML File using R (Improving...)
  - Operate Easily; Convenient; No Limitation
Flow Heat Map
Data Website (Beta Version)
Video Example (Version 2)

Speedway Blvd & Campbell Avenue
Date: 11/1/2017
Boxplot

Speedway@Campbell (EB, 1/18/2017 ~ 9/6/2017)

- E02L1
- E02L2
- E02L3
- E02L4
- ENLT05L1

15-min Flow Rate (veh/hr/lane) vs Time of Day

- Maximum
- Third quartile
- Median
- First quartile
- Minimum
Occupyancy

Boxplot

Speedway@Campbell EB (10/13/2017 ~ 11/09/2017 Weekday only)

E02L1

E02L2

E02L3

E02L4

ENLT05L1

Time of Day
Relationship between Volume and Occupancy

Speedway@Campbell EB (10-13-2017 ~ 11-09-2017 weekday only)
### Guideline

Only one sensor for both count and congestion detection.

<table>
<thead>
<tr>
<th>Detector Symbol</th>
<th>Detector Type</th>
<th>Parameters Collection</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td>![Red Square]</td>
<td>Volume Count @ Stop Bar</td>
<td>Volume***</td>
<td>Most Important - Traffic Count</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Classification*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occupancy*</td>
<td></td>
</tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>![Blue Square]</td>
<td>Presence Detector</td>
<td>Occupation* Volume*</td>
<td>Congestion Detection</td>
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<td></td>
</tr>
<tr>
<td>![Green Square]</td>
<td>Advance Detector</td>
<td>Occupation* Volume*</td>
<td>Congestion Detection</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Asterisk (*) shows the importance of the parameter.
Delay Estimation

- $\log(\text{StopTime/Voulme}) \sim \text{Direction} + \text{Lane} + \text{Occupancy_Presence}$
Protected/Permissive vs. Protected Only Left Turn Study

Credit: Aj@ TDOT and Alex Weber @ UA
Protected/Permissive vs. Protected Only Left Turn Study

Credit: Jim Robinson @ TDOT
Real-Time Signal Timing Data

Acknowledgments: Bob Hunt, Simon Ramos, Paul Burton
MaxView –
Event-based Data Collection
Common cycle length (8:00 AM -3:00 PM)

- Alvernon - Campbell : 120s
- Cherry - Main :100s

Running speed: 35 mi/h

Design Bandwidth

4/22/2015 13:30:00 to 4/22/2015 14:00:00

Synchro
(Deterministic Model)
Design Bandwidth vs. Real Bandwidth

Running speed: 35 mi/h

Common cycle length (8:00 AM - 3:00 PM)

- Alvernon - Campbell: 120s
- Cherry - Main: 100s

Real Bandwidth

Maxview
(Real-time Signal System)

4/22/2015 13:30:00 to 4/22/2015 14:00:00

Running speed: 35 m/h
Application:
Signal Timing Inconsistency Checking
Application: Pedestrian Analysis

Ped. Calls for Major Street Crossing (Hawk)

Utility frequency of Hawks

Speedway (between Main and Stone)
Real-Time Queue Length Estimation

Location and detector configurations of the selected intersections

Field observation

Estimation Model

Ground Truth

Real-Time Delay Estimation

Speedway & Cherry WBT total delay estimation

<table>
<thead>
<tr>
<th>Status</th>
<th>Commands</th>
<th>Videos</th>
<th>Comments</th>
</tr>
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<tbody>
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<td>Last/Cyc</td>
<td>Mode</td>
<td>Status</td>
<td>Time</td>
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<tr>
<td>100/100</td>
<td>Pattern B1</td>
<td>Coord</td>
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<td>Local</td>
<td>Master</td>
<td>Set Offset</td>
<td>Act. Offset</td>
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<td>54</td>
<td>70</td>
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<td>24</td>
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<td>2</td>
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<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Last</td>
<td>2</td>
<td>00</td>
<td>-</td>
</tr>
</tbody>
</table>

Graph showing total delay estimation from 9:00am to 10:00am with data points for different dates.
Study Site: Oracle Rd & Ina Rd

- 307 feet from stop bar
- Single-channel advance detector

- 311 feet from stop bar
- Single-channel advance detector

- 70 foot long presence detector

Acknowledgment: Simon Ramos, Jay Gomes
Max Queue Length Diagram

Sep. 28, Wednesday, 2016

- Queue with split failure
- Queue over advance detector
- Queue without split failure
- Trend lines
SR77 & Ina was operating an identical TOD signal plan during entire week 2016-09-26 to 2016-10-02
Communication Quality

Using communication event-based data from Maxview

Application 6: Impact of Comm Loss on Data Quality
Application: Preemption Analysis

https://youtu.be/gk9-I7T6SSI
Probe Vehicle Data
Visualizing Probe Vehicle Trajectories
Probe Vehicle-Based LOS

11/17/15 4:00-6:00 PM

Data source: UA
Grant/First Probe Vehicle-Based LOS

12/10/15 7:30-9:30 AM

12/10/15 4:00-6:00 PM

Data source: UA
Transit Data

- General Transit Feed Specification (GTFS)
- GTFS-realtime

http://suntran.com/tmwebwatch/
Transit Scheduling

- Parse GTFS-realtime data
- Calculate delays at bus stops (Arterial delay estimation)
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  - City of Phoenix now

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Thank you! Questions?

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