Coordination of Freeway Ramp Meters and Arterial Traffic Signals (FOT) – Simulation Development

Dongyan Su, Graduate Student Researcher (GSR)
XY Lu, PATH, Project Manager and Principal Researcher

PATH, U. C. Berkeley
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Outlines

• Field Data Collection and Processing
• Simulation modeling
• Model Calibration
• Control Strategy Implementation
• Performance Analysis
• Further Simulation Development
• Next Step
The Studied Intersection
Field Data Collection and Processing

• Video Data at Taylor Intersection
  – 04/03/12 (Tuesday) ~ 75 min from 4:50pm
  – 05/14/12 (Monday) ~ 80 min from 4:40pm
  – 05/17/12 (Thursday) ~ 90 min from 4:30pm

• Video Data Processing:
  – Manually Counted the Following Traffic State Parameters
    ➢ Vehicle count for each movement of Taylor Intersection
    ➢ Onramp Time Series Data
      – Inflow count
      – Outflow count
      – Ramp Meter Timing
      – Onramp HOV Lane vehicle count
    ➢ All aggregated to 5min and used for calibration
Field Data Collection and Processing

- PeMS Freeway Data at 3 VDS Locations
  - 5min aggregated Data
  - 30s raw data
  - Flow, speed and occupancy
Field Data Collection and Processing

- May 17
Field Data Collection and Processing

- Apr 03
Field Data Collection and Processing
--Freeway Flow

Flow (Vehs/Min)
48 Lane Points (100% Observed)
Mainline VCS 4021L7 - Taylor Street in-s-diaq - SB 87-S
Thu 05/17/2012 16:00:00 to Thu 05/17/2012 19:59:59

Flow (Vehs/Min)
48 Lane Points (100% Observed)
Mainline VCS 4021L7 - Taylor Street in-s-diaq - SB 87-S
Tue 04/03/2012 16:00:00 to Tue 04/03/2012 19:59:59
Field Data Collection and Processing
--Freeway Occupancy

[Graph showing occupancy (%) data over time.]

Occupancy (%)
48 Lane Points (100% Observed)
Mainline VDS 402137 - Taylor Street nm-s-diag - SR 67 S
Thu 05/17/2012 16:00:00 to Thu 05/17/2012 19:19:59

-- Additional graph below --
Field Data Collection and Processing
--Freeway Speed

![Graph showing speed data over time](image-url)
Simulation modeling

• Road Network Modeling
  – Freeway: both directions, Taylor and Julian.
  – Lane Extension for Total Travel Time Estimation

• Driver Behavior Model Selection
  – Aimsun default model: Gipps model

• Demand (OD table) Modeling base PeMS Data and Video Data
  – 5 min data;
  – General vehicles and HOV vehicles;

• Parameter Selection in Modeling
  – Reaction time: 0.6/0.7sec
  – Reaction time at stop: 1.2sec
Simulation modeling

- Parameter Selection in Modeling

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<tr>
<th>Name</th>
<th>Mean</th>
<th>Deviation</th>
<th>Min</th>
<th>Max</th>
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<td>Max Desired Speed</td>
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<td>1.5</td>
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<td>m/s²</td>
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<td>4</td>
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<td>0.3</td>
<td>0.6</td>
<td>2</td>
<td>Secs</td>
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</table>

After overtaking stay on fast lane: 99 %
Undertaking cases: 8 %
Impudent Lane Changing cases: 2 %
Sensitivity for Impudent Lane Changing: 1 %

Equipped Vehicles: 0 %
Cruising Tolerance: 0.8 m/s²
PCUs: 1
Model Calibration

• Freeway Section:
  – Comparison with PeMS 5min Data

• Arterial Intersection:
  – Compared with all movement video data

• Calibration Results Based on
  – 10 Replication Runs with Different Random Seeds
  – Intuitive View from Plot
  – Statistical Analysis
Model Calibration

- **Flow**
  - Compute the percentage of acceptable simulated flow
  - Aggregated flow in 5min
  - Freeway: detector at upstream of Taylor SB on-ramp, 1 lane available
  - Intersection: 8 movements
  - Criteria
    - 700vph < Flow < 2700vph, within 15%;
    - Flow < 700vph, within 100vph;
    - Flow > 2700vph, within 400vph;
Model Calibration

• Flow
  – May 17 data
    ➢ Freeway percentage: 73% (70%~80%), std = 3.5%
    ➢ Intersection percentage:
      – best movement: 99.5% (95%~100%), std = 1.6%, left-turn to NB on-ramp
      – Worst movement 67% (55%~80%), std = 8.2%, left-turn to SB on-ramp
  – Apr 03 data
    ➢ Freeway percentage: 75% (67%~83%), std = 6.8%
    ➢ Intersection percentage:
      – best movement 91.7% (83.3%~100%), std = 4.3%, left-turn to NB on-ramp
      – Worst movement 35% (25%~50%), std = 9.5%, left-turn to SB on-ramp
Model Calibration

• **Occupancy**
  – Compute mean square root error
  – Aggregated occupancy in 5min
  – Freeway: detector at upstream of Taylor SB on-ramp, 1 lane available
  – May 17 data: 9.9% (9.3%~10.2%), std = 0.35%
  – Apr 03 data: 8.3% (7.7%~8.8%), std = 0.44%

• **Speed**
  – Compute mean square root error
  – Aggregated speed in 5min
  – Freeway: detector at upstream of Taylor SB on-ramp, 1 lane available
  – May 17 data: 14.1% (13.8%~14.4%), std = 0.21%
  – Apr 03 data: 10.4% (9.7%~11.0%), std = 0.44%

• **Bottleneck**
  – Merge area of Taylor on-ramp

• **On-ramp merge behavior**
  – Looks acceptable
Model Calibration

- Freeway, May 17
Model Calibration

- Intersection, May 17

Intersection@Taylor, blue--video, red--simulated, green--error bound
Model Calibration

- Freeway, Apr 03

![Graph showing freeways flow, occupancy, and speed over time. The graph compares PeMS data, simulated data, and error bounds for specific times and locations.]
Model Calibration

• **Intersection, Apr 03**

![Graph showing traffic flow at Intersection@Taylor with blue-video, red-simulated, and green-error bound lines.](image)

- **WB Left Flow (vph):**
- **EB Left Flow (vph):**
Control Strategy Implementation

• Intersection: Optimal Timing Strategy
  – Minimize the weighted gap between desired green and given green for each movement;
  – Consider the minimum green time constraint;
  – Consider the storage of on-ramp;
  – Use a fix cycle length during the control period;
  – Use the same order of phases as current timing plan;
  – Green duration updates every cycle.

• Freeway: ALINEA
  – Adaptive ramp metering;
  – Based on estimation of traffic occupancy in merging area;
  – Use the measurement from detector located upstream of onramp, the PeMS detector;
  – Metering rate updates every 30sec;
Performance Analysis

• Parameters used
  – TTD (Total Travel Distance)
  – TTT (Total Travel Time)
  – Accumulated average delay in hours per km
  – Accumulated average stop time in hours per km
  – Accumulated average number of stops per km

• Results for default control and optimal timing + ALINEA RM
  – Mixed up: some replications are better and some are worse
  – Depending calibration results for the calibration: better calibration results usually have better performance in optimal timing strategy + ALINEA RM
Further Simulation Development

• Problem in Simulation Development:
  – Inadequate data:
    ✓ Video data is too short in time
    ✓ PeMS (or D4) data at VDS402117 (mainline upstream of merging) only has one lane (Ln 2) data
    ✓ No detailed San Pedros movement data – the dynamic interaction of the two intersections is unknown (resolution to be 3~5min)

• Next Step:
  – Extensive data collection at the two intersections necessary
  – Data collection at VSD402117 for other lanes necessary
    ✓ Needs help of D4 to fix the loop faults for other lanes
  – Data collection for merging area using video camera