PeMS, Berkeley Highway Lab System, Data Fusion and Future Data Needs

TRB Workshop on Data Fusion
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Outline

- PeMS – Application
- BHL (Berkeley Highway Lab) System
- Lesson Learned and Experience Gained
- What We Need in Future
PeMS Application

- **Data Source and Application:**
  - 30 second raw data
  - Lane by lane 5 minutes aggregated data: flow, occ., speed
  - Hourly and Longer Time LOS (A, B, C, D, E, F)
  - Speed/Occupancy plot
  - Bottleneck Information
  - Vehicle Hours of delay
  - CA Yearly VHT/VMT
  - Lost productivity (Lane-Mile-Hours)
  - Dynamic Maps/ Google maps
  - AADT/Peak Hours
  - CHP Incidents Data
PeMS Applications: Detector Healthy

California > Detector Health

Summary | Timeseries | Samples Collected
---|---|---
Date: Apr 4 2009
Group By: District
Owner: All

Station Types: Coll/Dist, HOV, On Ramp, Fwy-Fwy, Off Ramp, Mainline

Show Values As: %, Count

% Working
- Good (76.23%)
- Bad (23.77%)

Suspected Errors
- Line Down (7.68%)
- Ctrl Down (28.61%)
- No Data (19.98%)
- Insufficient Data (5.81%)
- Card Off (28.27%)
- High Val (7.19%)
- Intermittent (4.25%)
- Constant (0.02%)
- Feed Unstable (0.00%)

Status by District

<table>
<thead>
<tr>
<th>District</th>
<th># Det</th>
<th>% Good</th>
<th>% Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1720</td>
<td>78.6</td>
<td>21.4</td>
</tr>
<tr>
<td>4</td>
<td>4627</td>
<td>73.3</td>
<td>26.7</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>39.1</td>
<td>60.9</td>
</tr>
<tr>
<td>6</td>
<td>189</td>
<td>91.0</td>
<td>9.0</td>
</tr>
<tr>
<td>7</td>
<td>9131</td>
<td>66.1</td>
<td>33.9</td>
</tr>
<tr>
<td>8</td>
<td>1846</td>
<td>83.4</td>
<td>16.6</td>
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<tr>
<td>10</td>
<td>666</td>
<td>96.5</td>
<td>3.5</td>
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<tr>
<td>11</td>
<td>3418</td>
<td>87.2</td>
<td>12.8</td>
</tr>
<tr>
<td>12</td>
<td>5020</td>
<td>83.3</td>
<td>16.7</td>
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<tr>
<td>Totals</td>
<td>26,640</td>
<td>76.2</td>
<td>23.8</td>
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<table>
<thead>
<tr>
<th>Suspected Error</th>
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</thead>
<tbody>
<tr>
<td>Line Down</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>1.8</td>
</tr>
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</table>
PeMS Applications: Congestion Pie

Causal Breakdown of Delay (veh-hrs)

<table>
<thead>
<tr>
<th>Fwy</th>
<th>Total Delay (veh-hrs)</th>
<th>Potential Reduction</th>
<th>Excess Demand</th>
<th>Accidents</th>
<th>Miscellaneous</th>
<th># Lane Points</th>
<th>% Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR1-N</td>
<td>34,146</td>
<td>7,239</td>
<td>1,286</td>
<td>1</td>
<td>25,621</td>
<td>117,000</td>
<td>49.9</td>
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<tr>
<td>SR1-S</td>
<td>31,872</td>
<td>0</td>
<td>0</td>
<td>1,831</td>
<td>30,040</td>
<td>128,700</td>
<td>32.7</td>
</tr>
<tr>
<td>SR2-E</td>
<td>20,971</td>
<td>171</td>
<td>553</td>
<td>19</td>
<td>20,228</td>
<td>690,300</td>
<td>43.0</td>
</tr>
</tbody>
</table>
BHL (Berkeley Highway Lab) System

- Loop Data
- Video Data
Loop Data – Loop Location

The Berkeley Highway Laboratory

Emeryville, CA

Berkeley, CA

Powell St
Ashby Ave
University Ave
Gilman St

San Francisco Bay

Emeryville Tower (camera location)

primary video surveillance region

secondary video surveillance region

= paired loop detector station in each lane

1-9: Loop Station ID
Loop Data – Real-time and Archived Data

- Sub-second Data: Inductive loop on and off time instant
- Update rate 1Hz but contains $\frac{1}{60}[s]$ information: loop on/off time instant
- Used to estimate:
  - Time Mean Speed at loop point
  - Distance Mean Speed for Harmonic Mean
  - Other aggregated data
- Real-time data available 24/7
- Archived for several years
Loop Data – Congestion Onset Detection

I-80E
Loop Data – Fusion with VII Probe Vehicle Data

- Directly speed estimation use filtered sub-second data
- No time aggregation – significant time delay reduction
- Detection based on line-wise and aggregated across all lane
  - Speed difference
  - Occupancy different
  - Consistence thresholds
  - Taken into account shock wave propagation speed
  - Can detect traffic congestion or flow drop within 1[m] with loop distance 500[m] - less time delay
  - Detection even quicker if loop distance is shorter
Loop Data – Fusion with Probe Vehicle Data

- For accurate speed and density estimation
Video Data: NGSIM Data - Next Generation Simulation
I-80, 05:15-05:30 pm, Lane 2

Lane 2

Lane 2

Lane 2
Lesson Learned and Experience Gained

- Sensor Characteristics and Limit
  - Inductive Loops/ Sensys sensors: fixed point measure, continuous in time; reliable if installed properly and communication system reliable
  - Video Camera: continuous in time, short range coverage, needs good algorithm for tracking and classification, large data
  - Microwave radar/Lidar/Infrared Sensors

- Communication System critical: link and protocol
Lesson Learned and Experience Gained

● VII Data:
  – Continuous in time and space form some applications
  – Both microscopic and macroscopic data available
  – Abundant vehicle on-board sensor (J-Bus) data
  – GPS (available on some cell-phone and GPS Map System)
  – Need to reduce time delay for practical application

● Future Solution – Fusion Data from Multiple Sources
  – Sensor fusion
  – Data Fusion
  – Filtering/aggregation according to application needs
  – Improving data quality
  – Reducing time delay in data processing

● Data to pass: local processing, use and reduction ➔ achieved
What We Need in the Future

- Integrated Corridor Management to Address
  - All Roads
  - All Modes
  - All the Times

- Active Traffic Management for Planning & Operation
  - Demand Manage
  - Capacity manage
  - Network Traffic Flow Manage
  - Data Supporting System
Overall Picture – Integrated ATM

Combined VSL & CRM for integrated mainstream and arterial traffic control

Bottleneck detection and management

Traffic Control Assistance Measures
Overall Picture – Integrated ATM

Traveler’s info for trip planning & routing

Demand manage

Capacity Manage

Combined VSL & CRM for integrated mainstream and arterial traffic control

Bottleneck detection and management

Traffic Control Assistance Measures

Driver advice or mandate on: speed limit, lane use limit, lane changing assistance/limit, shoulder use, HOV/HOT dynamic use, merging assistance, gap etc
Data Supporting System – Current Status

(a) Current Model of Traffic Data System

- PeMS / TMC
- Operation Applications
- Data Processing
- Planning Application
- Classified Database: Raw and Processed Data

- Sensor systems of Freeway Network
- Sensor systems of Arterial Network
- Long Range Communication passing raw data
Data Supporting System Requirement - Future

(b) Future Model of Traffic Data System

PeMS / TMC

Coordination of Operation

High Level Data Processing

Planning Application

Classified Database: Processed Data

Long Range Communication passing processed data (reduced)

Corridor Control Cabinet

Operation Applications

Data Processing

Classified Database: Raw and Processed Data

Short/medium Range Comm. passing raw data

Sensor Systems of a Corridor: Freeway + Arterials

Corridor Control Cabinet

Operation Applications

Data Processing

Classified Database: Raw and Processed Data

Short/medium Range Comm. passing raw data

Sensor Systems of a Corridor: Freeway + Arterials
Integrated Traffic Data System

- Hierarchical Structure Database at Different Level PeMS or TMC
- Synchronization in time and space (unified coordinate)
- Private and public data: synchronized and format standard
- Optimal combination of sensor types, locations, density
- Road-side and on-vehicle sensors
- Reliable communication systems for data passing
- Systematic sensor/communication fault detection & management
- Data cleansing, correction and imputation, filtering, and fusion
- Data application: Integrated Active Traffic Management, ATIS, performance measurement, strategic planning
Thank You!