Detector-Health Classification for Quality Control of Traffic Counting Data (at MnDOT)

NATMEC, 2018
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Outline

• Background
• Theoretical basis
• Implementation
• Conclusion
MnDOT Regional Traffic Management Center (RTMC)

• Congestion management
• TC highway ramp metering
• Real-time travel time DMS
• MnPass, Smart lanes
• Incident management (FIRST trucks)
• Provides on-line access to traffic data
MnDOT RTMC Detector Data

• RTMC detector data are presently produced by 7,832 detectors consisting of mostly loop detectors and few radar detectors (Wavetronix)

• RTMC data are well tuned for applications in real-time traffic monitoring and management, travel-time estimates, incident management, etc., all related to traffic operations.

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• MnDOT Offices on Planning and Data Analysis (TDA): Uses the RTMC data for traffic forecasting/planning (ATR and Short-Duration Counts, etc).

• RTMC do not provide quality control information on their detector data (not available)

• Transportation planning and forecasting prefers use of reliable, high-quality data

• Identification of detector data quality was needed for MnDOT TDA, and thus a project entitled “Improve Traffic Volume Estimates from RTMC” was created.
Counting programs derived from RTMC Detector Data

Automatic Traffic Recorder (ATR)

Short-Duration Count (SC) Data
Present Data Quality Control at MnDOT

• A counting station is defined using three sets of detectors that have equivalent traffic flow: primary, secondary, and tertiary
• If the primary set contains missing values, secondary set is selected.
• If the secondary set contains missing values, tertiary set is selected.
• The final counting value is chosen from the set with least missing values if all have missing data.
• The log file contains missing statistics, imputed values, etc.
ATR, SC Station Definition Files

• **ATR** – ATRDets20160101.txt
  - 301,3,T,P,3176,3177,3178,3179,6986,S,2638,2639,2640,2641,2642,6984,T,2643,2644,2645,2646,3180,6984,End
  - 301,7,T,P,3218,3219,3220,3221,6985,S,2663,2664,2665,2666,3217,6983,T,2658,3222,3223,3224,3225,6987,End

• **Short-Duration Count (SC) Data** – SCDets20170118.txt
  - 9835,3,T,P,1532,1533,1534,1531,1535,S,1537,1538,1539,1540,1541,-1536,END
  - 9835,7,T,P,1609,1610,1611,1614,1612,S,1603,1604,1605,1606,1607,-1608,END
Detector Health Classification

Level 4: Healthy (H)

Level 3: Tolerable (T)

Level 2: Impaired (I)

Level 1: Non-functional (N)

Level 0: Off-line (O)

Level -1: Unknown (?)
Detector Health Parameters (single Detector)

- **Consecutive Zero Volume/Occupancy** \( (\text{conZeroVol, conZeroOcc}) \) --- Total number of 30 second time slots of consecutive zero volumes or occupancy extending 10 or more minutes

- **Negative Volume/Occupancy Counts** \( (\text{negVolCnt, negOccCnt}) \) --- Total number of 30 sec timeslots with negative volume or occupancy

- **Occupancy lock on** \( (\text{occLockOn}) \) --- Total number of 30 second time slots extending 10 or more minutes with \( 99 < \text{occ} \leq 100 \) percent

- **Zero volume on non-zero occupancy** \( (\text{zvolOnOcc}) \) --- Total number of 30sec time slots in which the slots have zero-volume on a non-zero occupancy
Detector Health Parameters, Cont.

- **Over Count** (*overCnt*) --- Total number of 30 second time slots with vol > 25.
- **Constant Volume/Occupancy** (*constVol, constOcc*) --- Total number of 30 sec timeslots with a non-zero constant volume or occupancy (same repeated value)
- **Nonzero Volume on Low Occupancy** (*volOnLowOcc*) --- Total number of 30 second time slots with vol>1 when 0≤occ≤0.2%
- **Vol/Occ Ratio Violation** (*volOccRatio*) --- Total number of 30sec time slots which violate the acceptable range of vol/occ ratio
- Total 14 parameters are used.
Conservation-of-Vehicles (COV) Principle (applied for station)

- The total number of vehicles counted by the upstream station should be counted by the downstream station at some future point in time if no exits or entrances exist.
- Vehicles on roads are generated by vehicles entering the road and removed by exits.
- **COV principle is used to determine equivalent traffic flow stations**
- **COV test is used for determining good data (rather than for finding defective detector)**
Determination of equivalent traffic flow stations using COV

- For the Up_Sta, the equivalent volume is given by:
  \[ \text{Equiv}_{\text{Up Sta}} = \text{Up Sta vol} + \text{Entrance}_1 \text{ vol} - \text{Exit}_1 \text{ vol} = \text{Cur Sta vol} \]

- For the Dn_Sta, the equivalent volume is given by:
  \[ \text{Equiv}_{\text{Dn Sta}} = \text{Dn Sta vol} - \text{Entrance}_2 \text{ vol} + \text{Exit}_2 \text{ vol} = \text{Cur Sta vol} \]
## Detector Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Auxilliary detector</td>
</tr>
<tr>
<td>B</td>
<td>HOV bypass</td>
</tr>
<tr>
<td>G</td>
<td>Count frame meter (number of greens)</td>
</tr>
<tr>
<td>M</td>
<td>Merge detector of ramp</td>
</tr>
<tr>
<td>P</td>
<td>Passage detector</td>
</tr>
<tr>
<td>Q</td>
<td>Ramp queue meter</td>
</tr>
<tr>
<td>V</td>
<td>Speed trap</td>
</tr>
<tr>
<td>X</td>
<td>Exit Detector of ramp</td>
</tr>
<tr>
<td>D</td>
<td>Shoulder</td>
</tr>
<tr>
<td>R</td>
<td>Reversible</td>
</tr>
<tr>
<td>HT</td>
<td>HOT lane</td>
</tr>
<tr>
<td>CD</td>
<td>Collector/Distributor lanes (local-express lanes)</td>
</tr>
<tr>
<td>H</td>
<td>HOV lane</td>
</tr>
<tr>
<td>O</td>
<td>Bus only lane</td>
</tr>
<tr>
<td>“”</td>
<td>Blank, main lane default or not defined</td>
</tr>
</tbody>
</table>
COV in Entrance Ramp
Detector Health Classifier

- Test 1
- Test 2
- Test N

Detector Health-Level Classifier

- Healthy
- Tolerable
- Impaired
- Nonfunctional
Detector Health System Is Implemented as a Client-Server Software Model

**detHealth_App**: provides user interfaces for retrieval of health parameters from database, visualization of the data, computation of AADT, and analysis of traffic and diagnostic information.

**detHealth_Daily**: runs daily through a Windows task scheduler (no manual maintenance is required). At each run, it computes detector health parameters for all detectors and COV data for the day and then uploads the data to the MySQL database.
detHealth_Daily.exe

- Daily computation of detector health parameters
- Upload of the daily parameters to MySQL database
- Automatic run through Windows scheduler
- Tools for manual run of a user provided period
- Tools for database connectivity, data upload, and presence tests
- Produces daily csv file that matches the database table
- If the database computer fails, the database table can be restored using the archived daily csv file
Classification thresholds are programmable
Detector Health Classification: Jun-06-2018

Health Status of the Day

Selected Detector = I-35,NB,4457

Historic Data of the Selected Detector

Percent
Healthy=50.7%; Tolerable=11.1%; Impaired=20.8%; Off-line=16.8%; Number of Category G Detectors = 491
Daily Traffic Volume (80 days, ending 2018-Jun-06)
All r_nodes in metro_config.20180607.xml
All r_nodes in metro_config.20180607.xml
Conclusion

• Daily qualification of each detector health is stored on database
• 14 parameters per detector assist quantization of data quality
• 5 Health-level Classification is provided for simple decisions: Healthy, Tolerable, Impaired, Nonfunctional, and Off-line
• COV principle is used to compute high-quality counting data
• detHealth_app can run remotely from any location inside the MnDOT firewall
• More application developments and improvements are in the process by working together with MnDOT
Questions are guaranteed in life; Answers aren't.