Improving the Quality of Motorcycle Travel Data Collection

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Research Objectives

- Develop methodology for determining MC count locations
- Determine the accuracy of selected detection systems
Major Research Activities

- Literature review
- Agency engagement
- Field data collection
- Data analysis
- Documentation
Background

- **Motorcycle Crashes**
  - In 1997 MCs were 5% of total traffic fatalities
  - In 2009 MCs were 14% of fatalities
  - MC crashes 37 times more likely to result in fatalities than auto crashes
  - Rate of increase in fatalities exceeded MC registrations and estimated VMT

- **Motorcycle Counts**
Technology Selection Criteria

- Accurate in all weather and light conditions
- Reasonable cost
- Simple to install and operate
- Adequate technical support
- Non-intrusive desired
- Covers full lane width
Field Data Collection and Analysis

- Inductive loops/piezoelectric sensors
- Magnetometers by Sensys Networks
- Multi-technology system by Migma
- Tracking video by TrafficVision
- Transportable Infrared Traffic Logger (TIRTL)
Test Locations

New Ulm, TX

College Station, TX

Daytona Beach, FL
S.H. 6 Test Facility

- North
- South
- TxDOT TPP
- LPL AVC
- Standard ADR-6000 Inductive Loops
- Deep ADR-6000 Inductive Loops
- College Station SH6 TTI Test Site
- Concrete Pad (enclosed by fence) with 3 large traffic cabinets
- 3-M Microloop 3 in Bores
- SPP
- G4 & HD 18 ft high On Pole
- 40 ft pole with 2 mast arms Lower 20 ft high pper 40 ft high
- Camera
- Merge Sign
- Weather station APCC S/N 347 in Cabinet
Inductive Loops/Piezos (L-P-L)

- Piezoelectric sensors
  - MSI “BL” sensors 11 ft long in each lane
  - Installed at 90 degrees
  - Possible equipment problems
Magnetometers

- Communicates wirelessly
- Battery life in the sensor node 10 yrs
- Improvements since early MC tests
  - Requires two stations for speed and length
  - Sensitivity settings
  - Place three per station
Multi-Technology System

- Designed specifically for MCs
- Initially designed as pedestrian detector
  - Infrared camera
  - Visible light stereo camera
  - Acoustic sensor
- 2d phase SBIR underway
Hybrid Sensor

Source: Migma Systems, Inc.
Sensor Signals

Stereo Images

Thermal Image

Acoustic Signal

Source: Migma Systems, Inc.
Motorcycle Detection Using Stereo Camera

- Disparity map is estimated from a pair of stereo images. Motorcyclist is windowed out and detected through human body 3D features. Motorcycle is detected if motorcyclist is detected.

Source: Migma Systems, Inc.
Motorcycle Detection Using IR Camera

- Thermal signatures of motorcycles and vehicles are different and can be used for their discrimination.

Source: Migma Systems, Inc.
Video Detection

- Can provide image of roadway
- Accuracy compromised
  - Inclement weather
  - Shadows
  - Artifacts on lens
  - Camera motion
  - Vehicle occlusion
- Light transition periods
TIRTL

- Accurate for MC (& non-MC) detection
- Classifies all 13 FHWA classes
- Non-intrusive
- Low power consumption
- Portable or fixed
- Cost competitive
## Equipment Results Summary

<table>
<thead>
<tr>
<th>Technology</th>
<th>MC Accuracy</th>
<th>Non MC Accuracy</th>
<th>Cost per lane</th>
<th>Portability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Two-lane</td>
<td>Four-lane</td>
</tr>
<tr>
<td>Loop/piezo</td>
<td>45%(^a)</td>
<td>95%</td>
<td>$16,500</td>
<td>$15,250</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>75%</td>
<td>95%</td>
<td>$10,204</td>
<td>$15,964</td>
</tr>
<tr>
<td>Multi-technology</td>
<td>50%</td>
<td>N/A</td>
<td>$3,000</td>
<td>$6,000</td>
</tr>
<tr>
<td>TrafficVision</td>
<td>75%</td>
<td>95%</td>
<td>$15,000</td>
<td>$15,000 (^b)</td>
</tr>
<tr>
<td>TIRTL</td>
<td>95%</td>
<td>98%</td>
<td>$13,425</td>
<td>$13,425 (^c)</td>
</tr>
</tbody>
</table>

\(^a\) Low accuracy might be due to equipment problem.

\(^b\) Assumes one system can cover four lanes.
Data Collection Protocols - Results

- **Objective**
  - Confirm hypothesis that crashes are reasonable predictor of count sites

- **Method**
  - Use ArcGIS to develop map of crash locations and current count sites

- **Findings**
  - Spatial distribution of MC crashes is associated with spatial distribution of MC traffic
Data Collection Protocols

- Correlation of MC crashes with MC counts
  - Texas results

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Motorcycle Crash Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unweighted</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.253*</td>
</tr>
<tr>
<td>All vehicles</td>
<td>0.193*</td>
</tr>
</tbody>
</table>

* N = 545; p<0.001
Data Collection Protocols

- Correlation of MC crashes with MC counts
  - Michigan results

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Motorcycle Crash Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unweighted</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.266*</td>
</tr>
<tr>
<td>All</td>
<td>0.332**</td>
</tr>
</tbody>
</table>

*N=101; p<0.005
**N=101; p<0.001
Michigan results: weekday vs weekend

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Crash Frequency</th>
<th>Traffic Volume Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Motorcycle</td>
</tr>
<tr>
<td>Weekday</td>
<td>Unweighted</td>
<td>0.302*</td>
</tr>
<tr>
<td></td>
<td>Weighted</td>
<td>0.467**</td>
</tr>
<tr>
<td>Weekend</td>
<td>Unweighted</td>
<td>0.279*</td>
</tr>
<tr>
<td></td>
<td>Weighted</td>
<td>0.462**</td>
</tr>
</tbody>
</table>

*N=51 (weekday); N=50 (weekend), p<0.05

**N=51 (weekday); N=50 (weekend), p<0.001
Conclusions

- Conclusions
  - Improving motorcycle VMT accuracy
    - Selecting appropriate locations
    - Choosing the best technology
Recommendations

- TIRTL results
  - Classifies according to FHWA Scheme F
  - Can be portable or fixed
  - Cost per lane is competitive
  - Modifications make it even better

- Supplemental research
  - Verify accuracy of TrafficVision, Migma, and TIRTL in inclement weather
  - Loop/piezo equipment problems
  - Magnetometers require three nodes per station
Recommendations

- Based on four states:
  - Crash sites are reasonable representation of count sites
  - Need count data weekend vs. weekday
  - Use weighting factor based on distance measured along count roadway
  - Needs further testing in other states
Contact Information

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Issues Involved in MC Detection

- Motorcycle definition
- Spatial and temporal factors
- Lane discipline
- Vehicle size
- Vehicle occlusion
Motorcycle Definition

- FHWA uses two categories
  - Large motorcycles with 2 or 3 wheels
  - Mopeds and scooters (requiring registration)
- Some states define in other ways
  - 2 or 3 wheels in contact with the ground
  - A seat or saddle with sidecar/trailer
  - A handlebar
  - No enclosure for operator
  - By size: engine HP or wheel diameter
Spatial & Temporal Factors

- State methods might not be valid
- Investigate spatial/temporal differences
  - Weekdays
  - Weekends
Lane Discipline

- Detector must cover the entire lane width
- Shoulder detection
- Between rows of cars (lanes)
Vehicle Size

- Current Harley-Davidson WB: 63-66 in
- Subcompact Smart ForTwo WB: 73.5 in
- Other subcompacts WB: 2-3 ft longer

Conclusion
- Easier to distinguish by magnetic length
- MCs have magnetic length 3 ft shorter than physical length
Vehicle Occlusion

- MCs are often occluded by tall vehicles
RESEARCH APPROACH
Data Collection Protocols

\[ C_w = \frac{100,000 \cdot C_r}{D_a} \]

- Where:
- \( C_w \) = Weighted crashes.
- \( C_r \) = Raw crash frequency.
- \( D_a = \{\sum_1^n d\}/n \) = Average distance from crashes to nearest count station.
## Inductive Loop/Piezo Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Span</th>
<th>Ground Truth</th>
<th>Detected MC/Actual</th>
<th>Detection Accuracy</th>
<th>Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Simple</td>
<td>Overall</td>
<td></td>
</tr>
<tr>
<td>June 30, 2012</td>
<td>11:00-12:00</td>
<td>Video/ADR-6000</td>
<td>5/6</td>
<td>88.3%</td>
<td>66.7%</td>
</tr>
<tr>
<td></td>
<td>09:00-10:00</td>
<td></td>
<td>2/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 1, 2012</td>
<td>11:00-12:00</td>
<td>Video/ADR-6000</td>
<td>0/3</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>09:00-10:00</td>
<td></td>
<td>0/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 3, 2012</td>
<td>11:00-12:00</td>
<td>Video/ADR-6000</td>
<td>4/24</td>
<td>16.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:00-12:00</td>
<td></td>
<td>10/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 21, 2012</td>
<td>00:00-24:00</td>
<td>ADR-6000</td>
<td>104/191</td>
<td>54.45%</td>
<td>99.76%</td>
</tr>
<tr>
<td>July 22, 2012</td>
<td>00:00-24:00</td>
<td>ADR-6000</td>
<td>76/154</td>
<td>49.35%</td>
<td>99.76%</td>
</tr>
<tr>
<td>July 23, 2012</td>
<td>00:00-24:00</td>
<td>ADR-6000</td>
<td>41/73</td>
<td>56.16%</td>
<td>99.82%</td>
</tr>
<tr>
<td>Feb. 8, 2013</td>
<td>13:00-15:00</td>
<td>Video/ADR</td>
<td>20/102</td>
<td>21.05%</td>
<td>98.46%</td>
</tr>
</tbody>
</table>

\(^a\) PV: per-vehicle.
# Magnetometer Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Span</th>
<th>Ground Truth</th>
<th>Detected MC/Actual</th>
<th>Detect. Acc.</th>
<th>Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 30, 2012</td>
<td>--</td>
<td>ADR-6000</td>
<td>TBD/TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>July 1, 2012</td>
<td>--</td>
<td>ADR-6000</td>
<td>TBD/TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Feb 22, 2013</td>
<td>15:00-16:00</td>
<td>Rec. Video</td>
<td>11/18</td>
<td>61.0%</td>
<td>PV(^a)</td>
</tr>
</tbody>
</table>

\(^a\) Per vehicle.
## Migma Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Span</th>
<th>Ground Truth</th>
<th>Detected MC/Actual</th>
<th>Detection Accuracy</th>
<th>Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 19, 2012</td>
<td>09:00-12:00</td>
<td>Video</td>
<td>143/206</td>
<td>69.42%</td>
<td>PV</td>
</tr>
<tr>
<td>Sept. 5, 2012</td>
<td>09:20-10:30</td>
<td>ADR-6000</td>
<td>26/45</td>
<td>57.80%</td>
<td>--</td>
</tr>
<tr>
<td>Sept. 21, 2012</td>
<td>17:00-22:00</td>
<td>ADR-6000</td>
<td>21/46</td>
<td>45.65%</td>
<td>PV</td>
</tr>
<tr>
<td>Sept. 22, 2012</td>
<td>17:00-20:00</td>
<td>Video</td>
<td>13/22</td>
<td>59.09%</td>
<td>--</td>
</tr>
<tr>
<td>Sept 23, 2012</td>
<td>17:00-20:00</td>
<td>Video</td>
<td>6/21</td>
<td>28.57%</td>
<td>PV</td>
</tr>
</tbody>
</table>
# TrafficVision Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Span</th>
<th>Ground Truth</th>
<th>Detected MC/Actual</th>
<th>Detection Accuracy</th>
<th>Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 18 (day)</td>
<td>15:00-20:40</td>
<td>Video</td>
<td>111/168</td>
<td>66.07%</td>
<td>93.77%</td>
</tr>
<tr>
<td>May 18 (night)</td>
<td>20:40-21:00</td>
<td>Video</td>
<td>9/12</td>
<td>75.00%</td>
<td>--</td>
</tr>
<tr>
<td>May 19, 2012</td>
<td>09:00-12:00</td>
<td>Video</td>
<td>98/233</td>
<td>42.06%</td>
<td>92.58%</td>
</tr>
<tr>
<td>June 30, 2012</td>
<td>10:00-12:00</td>
<td>Video</td>
<td>14/18</td>
<td>77.78%</td>
<td>99.96%</td>
</tr>
<tr>
<td>July 1, 2012</td>
<td>11:00-12:00</td>
<td>Video</td>
<td>2/3</td>
<td>66.67%</td>
<td>99.92%</td>
</tr>
<tr>
<td>July 3, 2012</td>
<td>09:00-12:00</td>
<td>Video</td>
<td>46/50</td>
<td>92.00%</td>
<td>99.90%</td>
</tr>
</tbody>
</table>
## TIRTL Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Span</th>
<th>Ground Truth</th>
<th>Detected MC/Actual</th>
<th>Detection Accuracy</th>
<th>Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 18, 2012</td>
<td>13:00-18:46</td>
<td>Video</td>
<td>129/134</td>
<td>96.27%</td>
<td>PV</td>
</tr>
<tr>
<td>Oct. 20, 2012</td>
<td>07:30-09:30</td>
<td>Video</td>
<td>709/744</td>
<td>95.30%</td>
<td>PV</td>
</tr>
</tbody>
</table>
CONCLUSIONS AND RECOMMENDATIONS