Understanding the Potential for Video Analytics to Support Traffic Management & Operations

National Rural ITS Conference – Branson, MO
August 2014
ENTERPRISE Program

Program Goals

• Facilitate rapid progress in the development and deployment of ITS technologies

• Accelerate the systematic advancement of selected ITS projects

Members carry out ITS projects and activities including fundamental research, technology development, demonstration, standardization, and deployment.
What is Video Analytics?

“Video Analytics” – Refers to the capability of analyzing video feeds to determine events that are not based on a single image.

Commercially available Video Analytics systems process video streams from traffic cameras to:

- **Collect Traffic Data**: Volumes (vehicle counts), speeds, & vehicle classifications
- **Detect Incidents and Create Alerts**: Stopped/slow vehicles, wrong-way vehicles, wildlife, debris
Why Use Video Analytics?

<table>
<thead>
<tr>
<th>Challenges</th>
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<tbody>
<tr>
<td>• Difficult to monitor conditions in rural areas</td>
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<tr>
<td>• Challenge for TMC operators to monitor multiple camera views simultaneously</td>
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<tr>
<td>• Vehicles traveling the wrong way introduce safety hazard</td>
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<table>
<thead>
<tr>
<th>Opportunities</th>
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<tbody>
<tr>
<td>• Utilize existing camera infrastructure</td>
</tr>
<tr>
<td>• Potential to use Video Analytics for multiple purposes (traffic data collection, incident detection)</td>
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</table>
## Why Evaluate Video Analytics?

<table>
<thead>
<tr>
<th>Project Goals</th>
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<tbody>
<tr>
<td>• Investigated potential of Video Analytics as a tool for:</td>
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<tr>
<td>- Traffic data collection</td>
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<tr>
<td>- Incident detection</td>
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<tr>
<td>- Wrong-way vehicle detection</td>
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<tr>
<td>• “Proof of Concept” evaluation to understand current state of practice</td>
</tr>
<tr>
<td>- How accurate? How effective? How useful?</td>
</tr>
<tr>
<td>- Compared to traditional methods/technologies: Loop detectors, radar, reported incidents, visual observation</td>
</tr>
<tr>
<td>• Not a comparison of vendors’ products</td>
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</table>
“Virtual Test Bed” Deployment Sites

- **Des Moines, IA**
  - Incident Detection

- **Cedar Rapids/ Iowa City, IA**
  - Traffic Data Collection
  - Incident Detection

- **Ontario, CA**
  - Traffic Volumes

- **Kansas City, MO/KS**
  - Traffic Data Collection

- **Ames, IA**
  - Wrong Way Detection Test-bed
Deployment Conditions

Tested in “Real World” Conditions
- Existing camera infrastructure
- Typical TMC practices and workflow

Conditions Not Controlled to Ensure Optimum Performance
- Camera settings & system configurations not always ideal for video processing (doing this could affect viewing ability)
- Normal panning/zooming of cameras
- TMC operations did not allow for constant monitoring and re-configuring of Video Analytics. Efforts made to adjust systems as much as practical.
INCIDENT DETECTION
Cedar Rapids - Rural Deployment
7 cameras instrumented - 2 vendors
Incident Detection

Des Moines Deployment – Urban / Suburban
15 cameras instrumented – 1 vendor

(Approx. 12% of Des Moines freeway network “coverage” with Video Analytics)
Incident Detection

Variation in Camera Views (examples)

Incident Types Detected by Video Analytics

• Stopped Vehicle / Debris in Road
• Slow Traffic / Congestion
• Pedestrian
• Wrong-Way Vehicle
# Incident Detection

## Results:

<table>
<thead>
<tr>
<th>Highest Level of Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stopped Vehicle / Debris:</strong> 72% alerts validated, 23% not validated, 5% unable to determine (81 alerts during a 44-day period)</td>
</tr>
<tr>
<td><strong>Stopped Vehicle / Debris – Remove False alarms from Object in View:</strong> 0% “false alarms” (26 alerts during a 21-day period)</td>
</tr>
<tr>
<td><strong>Slow Vehicle/Congestion:</strong> 30% alerts validated, 33% not validated, 37% unable to determine (1111 alerts during a 44-day period)</td>
</tr>
<tr>
<td><strong>Pedestrian in Road:</strong> None observed</td>
</tr>
<tr>
<td><strong>Wrong-Way Vehicle Movements:</strong> None observed</td>
</tr>
</tbody>
</table>
Incident Detection

Results

Factors that Impacted Performance

- Objects in the field of view
- Weather events / moisture on camera lens
- Headlight glare on roadway during nighttime lighting conditions

Factors that Did Not Appear to Impact Performance

- Camera position (zoom level, angle to roadway)
- Inaccurate configuration of Video Analytics to roadway lanes (e.g. camera panning)
Comparison of Detection Alerts to Agency Reported Incidents

- It is likely that Video Analytics detected a number of incidents that were not observed by agency staff, indicating that Video Analytics can be an effective tool for supplementing existing mechanisms to alert operators.
- Strategic selection of camera locations along a coverage area will optimize usefulness of Video Analytics.
TRAFFIC DATA COLLECTION:
Iowa/Kansas City Deployments
Traffic Data Collection

Traffic Data Types:
• Volumes (Vehicle Counts)
• Average Speeds
• Vehicle Classifications

<table>
<thead>
<tr>
<th>Classification Categories from Video Analytics</th>
<th>Corresponding FHWA Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycles</td>
<td>Classifications 1</td>
</tr>
<tr>
<td>Cars</td>
<td>Classifications 2-3</td>
</tr>
<tr>
<td>Small Trucks</td>
<td>Classifications 4-7</td>
</tr>
<tr>
<td>Large Trucks</td>
<td>Classifications 8-13</td>
</tr>
</tbody>
</table>
Traffic Data Collection

Analysis Approach

• Data collected in 15-minute increments
• Video analytics outputs compared to outputs from DOT detectors (loops and radar)
• Absolute Percent Difference (Abs % Diff) Calculation:
  o Calculate 15 min. period difference from DOT data
  o Convert it to absolute difference (remove any ‘-’)
  o Compute Percent Difference
  o Result is Abs % Diff.
• Caveat: Night-time traffic is often very low volumes. Abs % Diff. is not as meaningful
## Traffic Data Collection

### Results: Highest Level of Performance
(All results shown are average % Diff for one week)

<table>
<thead>
<tr>
<th>Traffic Volumes:</th>
<th>Vehicle Speeds:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day:</strong> 9% Avg. % Diff. (<em>carries reasonable expectation of repeatability</em>)</td>
<td><strong>Day:</strong> 2% Avg. % Diff (<em>carries reasonable expectation of repeatability</em>)</td>
</tr>
<tr>
<td><strong>Night:</strong> 17% Avg. % Diff. (<em>Does not</em> carry reasonable expectation of repeatability)</td>
<td><strong>Night:</strong> 6% Avg. % Diff (<em>carries reasonable expectation of repeatability</em>)</td>
</tr>
</tbody>
</table>

### Vehicle Classifications:
- “Motorcycles” (FHWA Classification 1): Avg. % Diff of 24% at night
- “Cars” (FHWA Classifications 2-3): Avg. % Diff of 13% daytime
- “Small Trucks” (FHWA Classifications 4-7): Avg. % Diff of 44% daytime
- “Large Trucks” (FHWA Classifications 8-13): Avg. % Diff. of 23% daytime
# Traffic Data Collection

## Results

<table>
<thead>
<tr>
<th>Factors that Impacted Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low light / dark conditions</td>
</tr>
<tr>
<td>• Camera position (proximity to traffic, zoomed out, angled to roadway)</td>
</tr>
<tr>
<td>• Weather events that reduce image quality</td>
</tr>
<tr>
<td>• Inaccurate configuration of video analytics to roadway lanes</td>
</tr>
<tr>
<td>• Camera settings (e.g. shutter speed, max gain)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors that Did Not Appear to Impact Performance</th>
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</thead>
<tbody>
<tr>
<td>• Position of camera relative to direction of traffic (e.g. counting headlights vs. tail lights at night)</td>
</tr>
</tbody>
</table>
TRAFFIC DATA COLLECTION:
Ontario Ministry of Transportation (MTO) Deployment
Traffic Data: MTO Deployment

MTO Deployment – Focus on Volumes

- 13 cameras instrumented at 4 Locations
- Data collected in 15-minute periods
- Video recorded for 1 week at each camera, sent to video analytics vendor for processing
- Manual counts conducted for comparison
- Manual counts compared to video analytics data outputs to compute percent error
### Traffic Data: MTO Deployment

#### Results:

<table>
<thead>
<tr>
<th>Type of Comparison</th>
<th>Configuration/Setting</th>
<th>% Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time of Day</strong></td>
<td>Day¹</td>
<td>9.1%</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>7.9%</td>
</tr>
<tr>
<td><strong>Camera Angle</strong></td>
<td>Side</td>
<td>9.4%</td>
</tr>
<tr>
<td></td>
<td>Overhead</td>
<td>6.5%</td>
</tr>
<tr>
<td><strong>Camera Type</strong></td>
<td>Axis</td>
<td>7.5%</td>
</tr>
<tr>
<td></td>
<td>Cohu</td>
<td>9.6%</td>
</tr>
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</table>

¹ ‘Day’ analysis was PM peak (16:30-17:30)
Traffic Data: MTO Deployment

Results:

1. Camera based counting system is appropriate if:
   - Overall Accuracy within 10% is acceptable
   - Vehicle Classification is not critical

2. Camera based counting system may not be suitable if:
   - Counts are to be conducted in work zones or areas with high stop-and-go traffic
   - Accuracy within 5% is required
   - Vehicle Classification is needed
   - Night-time accuracy is important
Lessons Learned:
1. Engage in discussions early with camera vendors
2. Standard definition cameras are actually better
3. Ambient light surrounding cameras should be taken into consideration for camera locations

Next Steps:
MTO will be undertaking additional data collection assignments utilizing video analytics beginning this fall and continuing through next summer
WRONG-WAY VEHICLE DETECTION
Wrong-Way Vehicle Detection

Controlled Test: Nov. 2013 in Ames, IA

• 3 vendors/technologies at 3 separate freeway ramps
• Ramp closures to test various conditions
• Detections conveyed via email, web interface, or on-site computer interface
• Recorded “detection” or “non-detection”
## Wrong-Way Vehicle Detection

### Highest Level of Performance Achieved

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Detection Rate</th>
<th>Test Drives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Daytime Test</strong></td>
<td>100%</td>
<td>12</td>
</tr>
<tr>
<td><strong>Nighttime Test</strong></td>
<td>83%</td>
<td>12</td>
</tr>
</tbody>
</table>

### Factors that Impacted Detection Rate

- Nighttime / Low Light Conditions
- Slow Speeds

### Factors that Did Not Appear to Impact Detection Rate

- Color/Size of Vehicle
- Lane Position (consistent position, shoulder, and/or weaving)
EVALUATION FINDINGS
State of Practice for Video Analytics is ready to meet many agency needs.

- Dedicated and/or fixed cameras may be warranted, especially for traffic data collection
- Video Analytics may not serve all purposes simultaneously (e.g. a camera used for incident detection may not be optimal for traffic data collection)
- Important to follow vendor guidelines for camera selection, position, zoom level, etc.
- Recognize significant human component involved. Operator resources are required to monitor system settings and re-configure as needed.
Final Report: To be published - September 2014
www.enterprise.prog.org

Participating Agencies
• Iowa DOT
• KC Scout/Missouri DOT
• Ministry of Transportation of Ontario

Participating Vendors
• DRS Technologies, Inc.
• Iteris, Inc.
• Peek Traffic Corporation
• TrafficVision
• VideoIQ

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