Aerial Data Collection for Intersection Evaluation

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Outline

• Framework
• Data Collection
• Applications
  • Intersection LOS
  • Signal Operations
  • Queue Lengths
  • Vehicle Trajectories
Framework

Equipment → Processing → Data Gathering → Decision System

Feedback & decisions

Sensor media

Transportation Flows
**Framework**

**Media:** Video and camera images

**Research effort:** Use video and camera images, image processing and algorithms to measure traffic variables

**Major characteristic:** We are no longer restricted to point detection, and we can use a spatial detection paradigm.

**Goal:** Improve efficiency of transportation system by integrating remotely sensed data with ground-collected data
Data Collection
Intersection LOS Analysis

Measure traffic parameters directly from video and still images

- Queue lengths
- Saturation flow rate
- Arrival type / Arrivals during green (with signal data)
- Right turns on red

New technologies facilitate data collection and reduction

- Ability to see all movements simultaneously
- Advanced image processing tools available
Intersection LOS Methodology

- Based on ITE and HCM field data procedures

1. DETERMINE
   - Intersection geometry
   - Lane groups

2. COUNT STOPPED or QUEUED VEHICLES

3. COUNT DEPARTING VEHICLES

4. ESTIMATE STOPPED or QUEUING DELAY

5. ESTIMATE CONTROL DELAY

6. ESTABLISH LOS
Intersection LOS Methodology

- Aerial video allows more frequent sampling compared with traditional methods
- Manual or automated data reduction possible
Intersection LOS Methodology

- Compute stopped or queuing delay
  \[ d_i = A \times \frac{I \times \sum_{i=1}^{n} V_{S_i}}{V_i} \]
- Control delay = f(stopped or queuing delay)
  Can use HCM or ITE procedure
- Determine LOS

<table>
<thead>
<tr>
<th>LOS</th>
<th>Control delay (s/veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>\leq 10</td>
</tr>
<tr>
<td>B</td>
<td>&gt;10 – 20</td>
</tr>
<tr>
<td>C</td>
<td>&gt;20 – 35</td>
</tr>
<tr>
<td>D</td>
<td>&gt;35 – 55</td>
</tr>
<tr>
<td>E</td>
<td>&gt;55 – 80</td>
</tr>
<tr>
<td>F</td>
<td>&gt;80</td>
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</table>

Source: HCM 2000
Intersection LOS Experiments

Objective: Apply the proposed methodology and compare the results with the standard HCM analysis
Intersection LOS Experiments

• Three helicopter flights (AM peak, mid-day and PM peak)
• Sites: Two intersections on Speedway Boulevard, Tucson
• 3 minute study period (2 cycles)
  • Assumed to be representative of peak period
• Image scale (resolution): 1 ft/pixel
• 10 sec vehicle counting interval (with still camera)
  • Within range recommended by ITE and HCM
  • Preliminary tests show accuracy is not compromised
Intersection LOS Experiments

• Inputs to HCM analysis methodology
  • 15-min analysis period
  • Volumes: Observed volumes and RTOR (extrapolated)
  • From City of Tucson: Arrival type, saturation flow rate, etc.
  • Signal timing observed in the field
### Results

Euclid Ave and Speedway Blvd. PM Peak (5:30 pm)

<table>
<thead>
<tr>
<th>Approach</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
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<tbody>
<tr>
<td>Movement</td>
<td>L</td>
<td>T-R</td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>Number of lanes</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Control delay (s/veh)</td>
<td>35.1</td>
<td>40.8</td>
<td>63.1</td>
<td>50.9</td>
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<tr>
<td>LOS</td>
<td>D</td>
<td>D</td>
<td>D</td>
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<td>Control delay (s/veh)</td>
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<td>45.5</td>
<td>66.0</td>
<td>51.4</td>
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<tr>
<td>LOS</td>
<td>D</td>
<td>D</td>
<td>E</td>
<td>D</td>
</tr>
</tbody>
</table>

**HCM ANALYSIS METHODOLOGY**

| Control delay (s/veh) | 40.9 | 27.2 | 50.9 | 133.8 | 24.3 | 25.9 | 75.4 | 39.5 | 30.5 |
| LOS                | D    | C    | D    | C    | F    | C    | E    | D    | C   |
| Control delay (s/veh) | 28.8 | 110.4 | 68.5 | 33.2 |
| LOS                | C    | F    | E    | C    |
| Control delay (s/veh) |       | 69.7 |
| LOS                | E    |
Results

• Left turns:
  • Delay from HCM is 23% lower than from aerial imagery
  • Main discrepancy: Number of left turns executed in permitted phase (actual gaps < calculated gaps)

• Thru lanes (excludes thru and right shared lane groups):
  • In the average, delay was very similar
  • In some cases HCM overestimated delay
  • Reason: Observed saturation flow rate (2150 veh/hr) greater than assumed rate; incremental delay was overpredicted
Results

• Right turns:
  • On average, observed delay was 15 sec less than from HCM
  • Cause: Aerial methodology measures delay for all right turning vehicles; HCM excludes RTOR
  • In HCM the capacity of lane group is limited to the protected phase

• Overall intersection:
  • Observed delay was 25% lower than estimated with the HCM
Signal Operations: Seattle RHODES Test
with M. Hallenbeck, F. Ladron
Signal Operations: Seattle RHODES Test

• Data Collection
  • Signal settings
  • Detector data
  • Aerial video and still images

• Analysis and Validation
  • Queue lengths
  • Delay estimates
  • Turning movement counts
Signal Operations: Seattle RHODES Test

Results: Aerial imagery comparison with detector data

• Higher saturation flow rates observed, compared with those assumed for signal settings

• Discrepancies in queue lengths due to detector locations, assumed saturation flow rates

• Turning movement counts are consistent
Image Processing for Queue Length Analysis
with A. Agrawal, R. Mothkuri

Goal: automate data reduction for queue lengths
Queue Length Methodology

1. Cropped Image
2. Image Segmentation
3. Median Filtering
4. Connected Component Analysis
5. Shape Analysis
6. Queue Length Estimation

- Queue Polygon
- Counting Vehicles in Queue
- Vehicles in Different Lanes
Image Analysis for Queue Lengths
Queue Length Estimates

Issues affecting accuracy:
- Resolution and scale of the image
- Accuracy of the cropping of the image
- Proportion of dark vehicles in the queue
- Angle of the road to the edge of the image
Vehicle Trajectories
with A. Shastry, K. Kadam, R. Schowengerdt, and P. Mirchandani

Idea: Generate individual vehicle trajectories

Method: Automated registration of frames, and tracking of vehicles in the image

Result: smooth point of view in imagery, and individual vehicle tracking
Framework

Data Collection

Video Image Processing

Trajectory Processing

Application Post-Processing

Raw Video

Vehicle in Image

Vehicle Position and Time

Registration

Vehicle identification

Vehicle tracking

Scaling

Road mask

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Intersection Video

Unregistered Video

Registered Video with Tracking
Conclusions

• Airborne imagery can be used for intersection analysis
  • View all approaches simultaneously
  • Allows collection of a wide variety of performance measures
  • Can be used to validate signal operations

• Automated queue length detection is possible

• Advanced techniques for vehicle tracking are available