Using Camera Imagery to Measure Visibility & Fog

FY2001

FHWA Review

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Motivation

Thousands of Cameras Deployed Along America’s Highway System

• Potential transportation uses:
  – Additional surface sensor for verifying visibility/fog
  – Alert travelers to unsafe conditions (via VMS)
  – Prioritize which cameras are displayed to TMC (or to web users)
  – Alert maintenance crews when a camera is covered/blocke
Goals

- Automatically Measure Visibility and Detect Fog Utilizing Standard Visible Camera Imagery

Visibility (East): 1 km : +0.1 km

Roadway Conditions: Partially Snow Covered

Precipitation: Moderate Snow

Visibility (West): 0.2 km : +0.1 km

Fog: Heavy Fog : Thickening

Roadway Conditions: Clear

Precipitation: None

Fog Description

Heavy
Moderate
Light

Visibility (km)

>10
>5
1-5
0.0-1.0
How far can I see?

- Taconic Ridge Line: 6.7km
- Hangar: 0.2km
- Near Ridge: 2.1km
- Road: 0.030km
- Gas Tanks: 0.042km
Algorithm Flow Chart

1. Image Capture
2. Lighting Correction
3. Edge Detection
4. Image Registration
5. Normalized Edge Extraction
6. Fog Algorithm
7. Trend Algorithm
8. Sensor Problems
9. Weather Detection
10. Visibility Algorithm

(30 day average)

Placeholders for future development
Visibility Algorithm

Assumptions:
- Stationary camera
- Initially only daylight images
- Focus on visibility < 10km (and particularly < 1km)
- Known min and max range

Normalized Edge Extraction

Edges of interest

Edge Mean

Edge Median

Image Power

Edge Power

Max Edge Power

Consensus

Visibility
- Value
- Direction
- Confidence
Camera
- Status

Unexpected Edges

Status
Multiple Determination Techniques

Edge Detection Image

Mean & Stdev (Grayscale)

Mean R=0.68
Stdev R=0.63
Power R=0.61
## Video Visibility – Preliminary Tests

<table>
<thead>
<tr>
<th>Video Estimated Visibility (km)</th>
<th>&lt;1</th>
<th>1-5</th>
<th>5-10</th>
<th>≥ 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>28</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-5</td>
<td>1</td>
<td>24</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>5-10</td>
<td>0</td>
<td>10</td>
<td>64</td>
<td>32</td>
</tr>
<tr>
<td>≥ 10</td>
<td>0</td>
<td>46</td>
<td>174</td>
<td>663</td>
</tr>
</tbody>
</table>

Mt. Greylock, MA Images 7/1-10/31/2000
Archiving State DOT Camera Imagery

- Archived Since 4/2001
- Every 20 minutes

Utah (SLC) 150+ Cameras

Colorado (6-8 Cameras)

Wyoming (6 Cameras)
Final Status - Future Efforts

Final Status

- Overall algorithm specified at a high level
  Visibility estimates have been generated
  Fog and covered/blocked image detection are in concept stage

- An experimental version developed in IDL (software package)
  Initial success for visibility (>70% CSI for all ranges, >90% CSI <1km)

- However, work still required for generic application of algorithm to new sites/images and proof-of-concept for other detection algorithms

Future Work

- There is no FHWA funding for this project in FY02

- MIT/LL will continue some development with internal funds

- State DOTs expressed interest in both the warning function (particularly fog) and system maintenance potential (broken/blocked cameras) of the system