Influence of Solar Glare on Traffic Flow

Kim, Hoyong  
Post Doctoral Fellow  
Department of Civil Engineering  
Missouri University of Science and Technology  
Rolla, Missouri, USA  
kimhoy@mst.edu

Baik, Hojong  
Assistance Professor  
Department of Civil Engineering  
Missouri University of Science and Technology  
Rolla, Missouri, USA  
baikh@mst.edu

Kim, Jisook  
PhD student  
Graduate school of GIS  
Pusan National University  
Busan, South KOREA  
kjisook@gmail.com
Content

- What is Sun Glare?
- Test Site and Data Collection

Computational Process
- Step 1: Solar Intensity
- Step 2: Traffic Data
- Step 3: Solar Intensity and Traffic Data

Evaluation of Solar Glare Influence on Traffic Flow
- Spatial and Temporal Relation between Sun Glare and Traffic Flow

Further Study
Does solar glare bother drivers?

Oh, it was a beautiful day, crystal clear. I was just driving normal, thought I could see everything well. I heard a thump. And when I looked in my rear-view mirror, I saw somebody on the ground. They say that it was sun glare. I had no vision of seeing anybody. But yet, somebody was there. I guess I blame myself every day still for it.

I've seen it at least a half dozen times in my career on the job where somebody has actually died as a result of the accident. You can't even count the number of accidents as a result of sun glare.

It's a familiar story. In California, a bus driver with sun in his eyes hits and kills a little girl. In New Jersey, a man blinded by the sun drives smack into an oncoming train. And in New York, glare is blamed when a truck driver accidentally hits a woman crossing the street. In fact, some cities are so worried, they're putting up new warning signs like this.

Note What is not visible is an approaching ambulance turning left and a Stop Sign!!

Source: http://www.sunposition.com/samples/sun_glare_driving.html
Study Area and Data Collection

- **Study Area**
  - Interstate highway
  - I-64: St. Louis Area

- **Data**
  - Road Data
    - Shape file
    - Polyline M
  - MoDOT TMS
    - Accident Location
    - Accident Date
    - Weather
    - Etc.
  - Traffic.com
    - Detector Location
    - 5 minute Speed
    - 5 minute Volume
    - Etc.

- **Tools**
  - ArcGIS
    - Select by Location
    - Select by Attribute
    - Buffer
    - Dynamic Segmentation
  - Matlab
    - Data Collection from TMS
    - Data Collection from Traffic.com
    - Calculate Intensity Time
    - Drawing Intensity Time Graph

- Detector Location
Computational Process

Step 1: Solar Glare Intensity
Step 2: Traffic Data
Step 3: Solar Glare Intensity and Traffic Data
How do we measure the intensity of Solar Glare?

- **Vertical Angle** = $F_n$ (slope of road segment, elevation of sun)

- **Horizontal Angle** = $F_n$ (direction of road segment, azimuth of sun)
**Driver’s Cone of Vision**

- **Vertical cone of vision**
  - Vertical sight angle: 15°
  - Minimum: 3.9 m for 2.1 m height
  - 6.2 m for 2.7 m height
  - Normal line of sight: 1.05 m

- **Horizontal cone of vision**
  - 10 degree
  - 40 degree

Elevation and Azimuth of Sun

- $h$ = elevation angle, measured up from horizon
- $z$ = zenith angle, measured from vertical
- $A$ = Azimuth angle, measured clockwise from North

Source: www.solsticeamateur.com/SolarGeneral.htm
Direction and Slope of Road Segment

\[ d = \text{Atan} \left( \frac{(X_{\text{end}} - X_{\text{start}})}{(Y_{\text{end}} - Y_{\text{start}})} \right) \]

\[ \theta = \text{Atan}(\text{rise}/\text{run}) \]
Calculation of Intensity Solar Glare

**Vertical Gap Angle**

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**Matlab**
- Calculate

**ArcGIS**
- Attribute Table
Solar Glare over 24 hours (x) 365 Days (y) (at a given segment of highway)

March 10th (70th)
8:40

July 15th (195th)
7:03~7:21 AM
Solar Glare over 24 hours (=x) 365 Days (=y) (at a given segment of highway)
Evaluation of Solar Glare Influence on Traffic Flow
Traffic Data

- **Every 5 minutes, each traffic detector collects**
  - Speed (mile/hr), Volume (veh/5-min), etc.

- **We need to use only normal days in the analysis**
  - i.e., we need to filter out special days that experienced accidents, bad weather, etc.

Source: http://www.sunposition.com/samples/sun_glare_driving.html
Traffic Data
(Data Filtering)

- **24-hour Speed at a given location**
  - Day 1: Normal day, Day 2: Day with accident

- **Weather**
  - Sunny
  - Rainy
**Traffic Data**
*(Accident Locations for Filtering)*

- **Accident Location**
  - MoDOT TMS
    - Accident Location
    - Accident Date
  - ArcGIS
    - Dynamic Segmentation

- **Filtering**
  - 1 mile Buffer from detector
  - Select by Location
## Traffic Data

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- **RAIN**: 2
- **CLOUDY**: 3
- **FREEZING**: 4
Intensive Solar Glare
(24-hr on all 52 Saturdays)
### Speeds with and without Sun Glare

<table>
<thead>
<tr>
<th>Intensity Time Group</th>
<th>Others Group</th>
<th>Available (25week)</th>
</tr>
</thead>
</table>

1. Calculate ‘without solar glare’ average volume (speed, speed variance, etc…) (ex: 16week, 5:00-5:05)
2. Calculate ‘with solar glare’ average volume (speed, speed variance, etc…) (ex: 9week, 5:00-5:05)

*Compare Two Speeds*
Comparison of Two Speeds

**T-test**
- For compare mean: paired-sample T-test
- Here $S_{x1x2}$ is the grand standard deviation

### Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Others</td>
<td>52.90</td>
<td>37</td>
<td>3.242</td>
</tr>
<tr>
<td></td>
<td>I·T</td>
<td>54.85</td>
<td>37</td>
<td>4.721</td>
</tr>
</tbody>
</table>

### Paired Samples Correlations

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Others &amp; I·T</td>
<td>37</td>
<td>.019</td>
</tr>
</tbody>
</table>

### Paired Samples Test

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Others - I·T</td>
<td>-1.951</td>
<td>5.677</td>
<td>.933</td>
<td>-3.844</td>
</tr>
</tbody>
</table>

- Probability(0.044) is less than significance level(0.05)
- Two group(intensity time and others) mean values are different under 5% significance level
Was the Speed Comparison Fair?

- Volumes show almost the same pattern.

- But, speeds are considerably different in with and without sun glare condition.
Any other Comparison?

- According to traffic safety researches, speed variance is highly correlated to rear-end crashes.
Conclusion and Further Study
Conclusion and Further Study

- In this study, we showed that
  - sun glare influences traffic speed.
  - Sun glare also increases speed variance. (Need to be more studies)

This study can be applied in
- Identification of hazardous locations and time due to solar glare
- improving the traffic control procedure

As a further study, the team is developing a user-friendly tool
Thank You