Factors Influencing Freeway Traffic Upstream of an Incident

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Outline

• Incident Effects on Freeways
• Scope
• Methodology
• Application and Results
• Conclusions
Effect of Incidents

• On Freeway Traffic
  ✓ Formation of increased density areas upstream of an incident

• On Road Safety
  ✓ Increased density → high risk areas → Increased secondary incident likelihood

Previous Research

• Static effect of incidents to traffic
  ✓ Setting thresholds e.g. 15 minutes in the future and 2 km upstream
  ✓ Detect secondary accidents based on these thresholds

• Dynamic Approaches
  ✓ Duration of incidents, secondary accidents detection
Examine the effects of incident occurrence on freeway traffic

• Define indicators to describe the evolution of a traffic disturbance related to an incident

• Develop explanatory relationships of the spatio-temporal extent of the incident’s influence to traffic with
  ✓ Geometry, incident and weather related factors
Problem Formulation

Every incident may create a disturbance on traffic flow propagated upstream of the incident’s location.

Assumptions

• Disturbance as a Latent Variable

• Indicators
  ✓ maximum length $L_{max}$ and duration $T$ of a disturbance formed upstream of an incident

• Predictors
  ✓ traffic, weather, geometry and incident specific factors
Methodology

Structural Equation Model
Multiple Indicators-Multiple Causes (MIMIC) latent variable model
The available data

• Attica Tollway: a 65.2 km urban motorway.
  ✓ 1287 accident records (2007-2010)
  ✓ volume and speed from loop detectors

• METEONET network
  ✓ (http://meteonet.chi.civil.ntua.gr/en/divs.html)
    o developed and operated by NTUA.
    o Rainfall episodes related to accident data records
## Description of Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance Time</td>
<td>Continuous</td>
<td>The incident duration in minutes</td>
</tr>
<tr>
<td>Collision Type</td>
<td>Categorical</td>
<td>0 to 4, from less to more severe</td>
</tr>
<tr>
<td>Nr. Lanes</td>
<td>Categorical</td>
<td>1 to 3, 1: 1 lane, 2: two, 3: more than 2</td>
</tr>
<tr>
<td>Nr. Vehicles</td>
<td>Categorical</td>
<td>1 to 3, 1: one vehicle, 2: two vehicles, 3: more than 2 vehicles involved</td>
</tr>
<tr>
<td>Heavy Vehicle</td>
<td>Categorical</td>
<td>0 to 1 (Heavy Vehicle involved)</td>
</tr>
<tr>
<td>Travel Speed</td>
<td>Continuous</td>
<td>Travel speed (km/h) at the occurrence of the incident</td>
</tr>
<tr>
<td>Hourly volume</td>
<td>Continuous</td>
<td>Hourly volume (veh/h/lane) at the occurrence of the incident</td>
</tr>
<tr>
<td>Rainfall Intensity</td>
<td>Continuous</td>
<td>Rainfall at the occurrence of the incident in mm/10min</td>
</tr>
<tr>
<td>Alignment</td>
<td>Categorical</td>
<td>0 to 1 (curve)</td>
</tr>
<tr>
<td>Downstream Geometry</td>
<td>Categorical</td>
<td>0 to 4, 0: no special geometry, 1: adjacent to tunnel, 2: adjacent to toll, 3: adjacent to entrance/exit, 4: more than one</td>
</tr>
<tr>
<td>Upstream Geometry</td>
<td>Categorical</td>
<td>0 to 4, 0: no special geometry, 1: adjacent to tunnel, 2: adjacent to toll, 3: adjacent to entrance/exit, 4: more than one</td>
</tr>
</tbody>
</table>

October 23-25, 2013, Rome, Italy
Description of Data

Estimation of the temporal and spatial extend of incident’s influence to traffic

\[ x^{(jam)}_{up}(t) = L_{i+1} - \int_{t}^{t} \frac{q_{0}^{(i)}(t) - q_{min}}{\rho_{max} - \left( q_{0}^{(i)}(t)/w_{0}^{(i)}(t) \right)} \, dt \]

\[ x^{(jam)}_{down}(t) = L_{j} - \int_{t}^{t} \frac{q_{out}^{(j)}(t) - q_{min}}{\rho_{max} - \left( q_{out}^{(j)}(t)/w_{max}(t) \right)} \, dt \]

ASDA Model

Dynamic spatiotemporal boundaries of incident effect to traffic

Empirical Speed Threshold Algorithms

October 23-25, 2013, Rome, Italy
Description of Data

Information on:
1. the disturbance propagation length and duration
2. Secondary accident occurrence
October 23-25, 2013, Rome, Italy
Results

• $T$ is a stronger indicator than $L_{\text{max}}$.

• A negative relationship with the latent influence of the accident
  ▶ Speed
  ▶ Rainfall intensity

• A strong positive relationship with the latent influence of the accident
  ▶ Type of the accident (secondary or not)
  ▶ Alignment (on a curve or not)
  ▶ Entrance/exit ramps upstream of the accident location

• Weaker positive relationship
  ▶ Traffic volume and the clearance time of an accident.
Results

• Predictors of Clearance Time

  ✓ Involvement of trucks in the accident

  ✓ Number of blocked lanes

  ✓ Existence of tolls adjacent to the area of the accident
Conclusions

• Quantitatively assess the effect of incidents to freeway traffic

• Methodology
  ✓ Multivariate tool
  ✓ Structural equation modeling
  ✓ Traffic disturbance introduced as a latent variable

• Factors
  ✓ Primary traffic flow conditions and rainfall intensity
  ✓ Alignment and upstream geometry
  ✓ Type of incident
Conclusions

• Towards an online decision making mechanism to improve freeway operations with safety implications

✓ Traffic specific measures for filtering traffic and affecting short-term demand

✓ Online safety management
  o Predict high risk areas prone to secondary accidents occurrence
  o Informing road users on imminent high risk conditions on freeways
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