Automated Road Safety Analysis
Lund Universitet, Trafik och Väg

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February 23rd 2015
Outline

1. Introduction
2. Past and Current Research
3. Perspectives
My Journey to Transportation

My Journey to Transportation


2. 2001-2005: Ph.D. in Computer Science from Telecom ParisTech, working at INRETS on “Influence of traffic control in a signalized intersection on the risk of road users; Stream-based learning of safety indicators through data selection”
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Surrogate Measures of Safety

- Looking for measures of safety that do not require to wait for accidents to happen
- Hypothesis [Svensson and Hydén, 2006]: in the safety hierarchy, all events have a relationship to accidents (safety) that may be of different nature
- Automation using video sensors and computer vision
  - cheap hardware, open source software
The Particularities of our Approach

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- Develop an automated, robust and generic probabilistic framework for surrogate safety analysis
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  - improve existing indicator(s) before inventing new ones
Automated video analysis

Develop an **automated, robust and generic** probabilistic framework for surrogate safety analysis
- for **all types** of road users and road environments
- generalize the concept of **collision course**: importance of **motion prediction** methods
- improve existing indicator(s) before inventing new ones

Better understand **collision processes** and the similarities between interactions with and without a collision for safety estimation
Step 1: Video Data Collection
Step 2: Data Preparation

In particular, camera calibration: homography and distortion (if any)
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Step 3: Moving Road User Detection, Tracking and Classification
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Step 4: Motion Prediction
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- Sample size: 292.0
- Greatest density: 15.0
- Lane: 1
- $S = [3.34, 8.90]$ m
- Speed: $[0.3, 0.4]$ m/s
- DeltaTime: 60 frames
Step 5: Safety Indicators
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Using of a finite set of predicted trajectories, enumerate the collision points $CP_n$ and the crossing zones $CZ_m$. Safety indicators can then be computed:

$$P(\text{Collision}(U_i, U_j)) = \sum_n P(\text{Collision}(CP_n))$$

$$TTC(U_i, U_j, t_0) = \frac{\sum_n P(\text{Collision}(CP_n)) \cdot t_n}{P(\text{Collision}(U_i, U_j))}$$

$$pPET(U_i, U_j, t_0) = \frac{\sum_m P(\text{Reaching}(CZ_m)) \cdot |t_{i,m} - t_{j,m}|}{\sum_m P(\text{Reaching}(CZ_m))}$$
Step 5: Safety Indicators

Past and Current Research

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Step 5: Safety Indicators

![Graph showing expected evolution, motion pattern prediction, normal adaptation prediction, and constant velocity prediction of time-to-collision (TTC) over time.](image-url)
Step 6: Interpretation

- **a)**
  - Probability vs. TTC
  - "High risk" and "Low risk" zones
  - Observed collisions

- **b)**
  - Cumulative Probability vs. TTC
  - Safety gain

- **c)**
  - Probability vs. TTC
  - "High risk", "Medium risk", and "Low risk" zones
  - Observed collisions

- **d)**
  - Cumulative Probability vs. TTC
  - Ambiguous conditions
Step 6: Interpretation

Maximum Collision Probability

Minimum TTC
Step 6: Interpretation

Histogram of Before-and-After TTC

- TTC Before
- TTC After

Histogram of Before-and-After DST

- DST Before
- DST After

Histogram of Before-and-After PET

- PET Before
- PET After

Histogram of Before-and-After GT

- GT Before
- GT After

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Step 6: Interpretation

Traffic Conflicts
Step 6: Interpretation

Cumulative Observations (%)

TTC observations (seconds)

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### Step 6: Interpretation

<table>
<thead>
<tr>
<th>Model I. Cycle track on the right vs. no cycle track</th>
<th>Number of Observations = 2880</th>
<th>Log likelihood = -1420</th>
<th>Pseudo R² = 0.264</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cycle Track on Right</strong></td>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td></td>
<td>0.4303</td>
<td>0.1297</td>
<td>3.32</td>
</tr>
<tr>
<td>Turning-Vehicle Flow for 15s before to 15s after</td>
<td>-1.4089</td>
<td>0.0551</td>
<td>-25.56</td>
</tr>
<tr>
<td>Number of Lane on the Main Road</td>
<td>-0.2354</td>
<td>0.0654</td>
<td>-3.60</td>
</tr>
<tr>
<td>Bus Stop</td>
<td>0.2658</td>
<td>0.1336</td>
<td>1.99</td>
</tr>
<tr>
<td>Cut-off 1</td>
<td>-6.6884</td>
<td>0.2836</td>
<td>-25.56</td>
</tr>
<tr>
<td>Cut-off 2</td>
<td>-3.8927</td>
<td>0.1968</td>
<td>-20.74</td>
</tr>
<tr>
<td>Cut-off 3</td>
<td>-2.5246</td>
<td>0.1812</td>
<td>-1.38</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Model II. Cycle track on the left vs. no cycle track</th>
<th>Number of Observations = 4803</th>
<th>Log likelihood = -3241</th>
<th>Pseudo R² = 0.288</th>
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</thead>
<tbody>
<tr>
<td><strong>Cycle Track on Left</strong></td>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td></td>
<td>-0.1618</td>
<td>0.1186</td>
<td>-1.36</td>
</tr>
<tr>
<td>Bicycle Flow for 10s before</td>
<td>0.0827</td>
<td>0.0302</td>
<td>2.74</td>
</tr>
<tr>
<td>Turning-Vehicle Flow for 15s before to 15s after</td>
<td>-1.3938</td>
<td>0.0342</td>
<td>-40.79</td>
</tr>
<tr>
<td>Cut-off 1</td>
<td>-7.4890</td>
<td>0.2074</td>
<td>-37.56</td>
</tr>
<tr>
<td>Cut-off 2</td>
<td>-3.5944</td>
<td>0.1243</td>
<td>-29.50</td>
</tr>
<tr>
<td>Cut-off 3</td>
<td>-2.0168</td>
<td>0.1132</td>
<td>-18.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model III. Cycle track on the right vs. cycle track on the left</th>
<th>Number of Observations = 6567</th>
<th>Log likelihood = -4030</th>
<th>Pseudo R² = 0.291</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cycle Track on Left</strong></td>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td></td>
<td>-0.5351</td>
<td>0.0921</td>
<td>-5.81</td>
</tr>
<tr>
<td>Bicycle Flow for 10s before</td>
<td>0.6000</td>
<td>0.0268</td>
<td>2.23</td>
</tr>
<tr>
<td>Turning-Vehicle Flow for 15s before to 15s after</td>
<td>-1.3544</td>
<td>0.0304</td>
<td>-44.52</td>
</tr>
<tr>
<td>Number of Lane on the Main Road</td>
<td>-0.1592</td>
<td>0.0660</td>
<td>-2.41</td>
</tr>
<tr>
<td>Number of Lane on the Turning Road</td>
<td>0.3855</td>
<td>0.1144</td>
<td>3.37</td>
</tr>
<tr>
<td>Cut-off 1</td>
<td>-7.7501</td>
<td>0.3077</td>
<td>-25.56</td>
</tr>
<tr>
<td>Cut-off 2</td>
<td>-3.7916</td>
<td>0.2684</td>
<td>-14.26</td>
</tr>
<tr>
<td>Cut-off 3</td>
<td>-2.2953</td>
<td>0.2650</td>
<td>-8.64</td>
</tr>
</tbody>
</table>

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Step 6: Interpretation

Cluster 1 - 23.1% (28/121)
Cluster 2 - 42.7% (35/82)
Cluster 3 - 0.0% (0/8)
Cluster 4 - 42.1% (8/19)
Cluster 5 - 38.5% (5/13)
Cluster 6 - 11.5% (6/52)
Step 6: Interpretation

Cluster 1 - 19.4\% (13/67)

Cluster 2 - 38.2\% (55/144)

Cluster 3 - 33.3\% (3/9)

Cluster 4 - 5.0\% (1/20)
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Open Questions

- How can we aggregate indicators over time and space (and severity), without hiding information?
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- How can we compare the various methods and indicators?
- How do we validate the methods? With respect to what?
- How do we account for exposure? Conflicts are, by definition, not exposure [Hauer, 1982]
Other Projects

- Automated calibration and validation of traffic micro-simulation based on video observations
- Lighting and safety
- Traffic monitoring, probe data
- Naturalistic driving studies
- Vehicle automation
Some Proselytizing: Open Science

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  - We should share our code, at least freely with the research community, ideally as open source software, to collaborate with other researchers to improve their (open source) methods.
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- Internet is an enabler for sharing data and tools (software):
  - we should share our code, at least freely with the research community, ideally as open source software, to collaborate with other researchers to improve their (open source) methods.
  - we should share our data, use benchmarks to compare to other methods (collaboration with Lund).
Collaboration with Tarek Sayed (UBC), Karim Ismail (Carleton), Marilyne Brosseau, Mohamed Gomaa Mohamed, Paul St-Aubin (Polytechnique Montréal), Luis Miranda-Moreno, Sohail Zangenehpour (McGill), Aliaksei Laureshyn (Lund)

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Questions?