Introduction

- How to diagnose the safety of a location?
  - survey data about perceived safety
  - accident data from police records
  - surrogate measures of safety (SMoS) from conflicts
  - Total number of accidents/conflicts per site
  - Focus on accidents/conflicts traveling in certain directions:
    - Right turning cars and through cyclists
    - Left turning cars and through cyclists
    - Through cars and right/left turning cyclists

Background: Safety Analysis

Methods

- Direction-based accident analysis
  - Left turning cars and through cyclists have a higher risk of severe injury (Kaplan et al., 2014)
  - Right turning cars and through cyclists on the right side of the road have a higher risk of accident compared to left turning cars and cyclists on the left side of the road (Hendilund & Jørgensen, 2003; M. Räsänen & Summala, 1998; Summala, Pasanen, Räsänen, & Sievänen, 1996)

- Direction-based safety analysis based on SMoS
  - Perpendicular movement (Matsui, Okawa, Takahashi, & Hikosugi, 2015)
  - Right turning cars and through cyclists (Buch & Jensen, 2017)
  - Left turning cars and through cyclists (Madsen & Lahrmann, 2017)
Introduction

- Road users have been observed to behave differently for the same movements:

• Which specific maneuver involves the most unsafe interactions?

Background: Motion Pattern Studies

- Car motion patterns: automatic detection

(Mohamed, 2015)

Background: Motion Pattern Studies

- Road user trajectory: manual observation
- Cyclists’ desire lines (Copenhagen Design Co., 2017)

Background: Surrogate Safety Analysis

- Surrogate measures of safety
- Probabilistic surrogate measures of safety (Saunier et al. 2010)
Current Study in Context

- Propose a movement-based safety method to identify critical maneuvers
- Apply the probabilistic SMoS to identify the risk of all cyclist maneuvers
- The results can be used to propose better counter-measures to mitigate risky maneuvers

Methodology

1. Identify locations where cyclists make several maneuvers and control sites
2. Collect video data at these locations
3. Extract and classify road user trajectories from video data
4. Apply clustering algorithm to obtain motion patterns
5. Compute probabilistic SMoS for all interactions
6. Identify risky maneuvers by summarizing safety results per motion pattern

Methodology

Identify locations where cyclists make several maneuvers

Video analysis steps for obtaining classified road user trajectories
Methodology

- Motion pattern learning: clustering all trajectories into more homogeneous subsets using the longest common subsequence similarity measure

Results

<table>
<thead>
<tr>
<th>Direction of travel</th>
<th>Location</th>
<th>Motion pattern number</th>
<th>Number of cyclists</th>
<th>Number of interactions</th>
<th>Median TTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>NE</td>
<td>1</td>
<td>234 (100%)</td>
<td>51</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>2</td>
<td>15 (9%)</td>
<td>9</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>3</td>
<td>24 (14%)</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>4</td>
<td>52 (31%)</td>
<td>17</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>5</td>
<td>11 (7%)</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>6</td>
<td>12 (7%)</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>Discontinuity</td>
<td>NE</td>
<td>7</td>
<td>53 (32%)</td>
<td>10</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>NE</td>
<td>8</td>
<td>11 (7%)</td>
<td>5</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Conclusion

- Proposed movement-based safety analysis based on SMoS
- Highlights the most unsafe maneuvers
- Results in more informed mitigation strategies to eliminate unsafe maneuvers
- Observed more unsafe maneuvers at discontinuity locations compared to control sites

Limitations and Future Work

- Undesirable video recording conditions: wind and shadows
- Video processing limitations: tracking and grouping of road users
- Recommendations: increase the video quality
  - height of video camera
  - securing the cameras
- weather conditions control
- Apply method to more sites for different studies
Questions?

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