Large Scale Automated Analysis of Vehicle Interactions and Collisions

TRB Annual Meeting

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POLYTECHNIQUE
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Outline

Observation

1. Most approaches to road safety analysis do not rely on microscopic data collected in the field.
2. There are well-known issues with the traditional use of historical collision data:
   - attribution, rarity, quality, ethics
3. Davis and Morris [Davis and Morris, 2009] predict that the statistical models proposed in the Highway Safety Manual "will be replaced by models explicitly describing mechanisms underlying crash occurrence".

Motivation

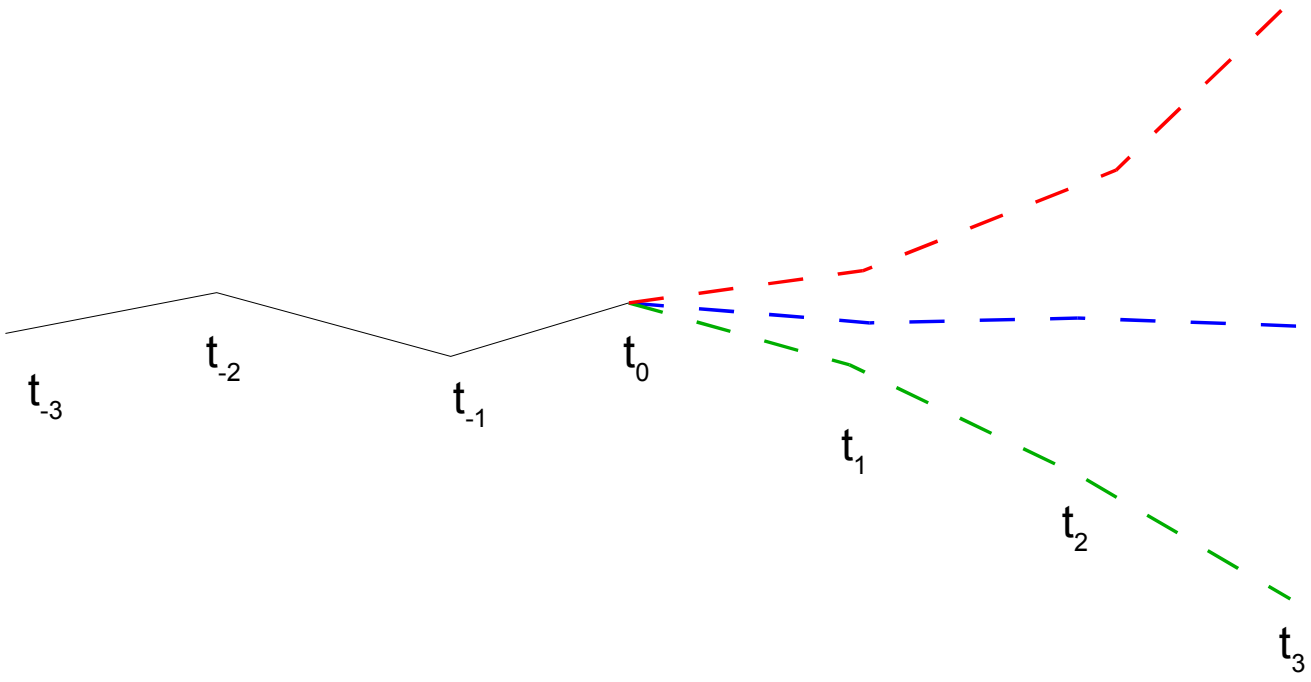
- Need for
  - proactive methods for road safety analysis relying on surrogate safety measures
  - more use of microscopic traffic data
- Surrogate safety measures, e.g. in traffic conflict studies, are collected with various levels of automation.
- The main bottleneck for these methods is that data is still mostly collected manually.

The Collision Course

"An observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged"
[Amundsen and Hydén, 1977]

- For two interacting road users, many chains of events may lead to a collision.
- Studying the probability of collision requires the ability to predict road users' future positions.
- Positions are predicted independently for each road user.

Extrapolation Hypothesis



An extrapolation hypothesis is defined by an observed trajectory H and an associated probability $P(H)$ that a road users will follow the trajectory [Saunier et al., 2007].

Probability of Collision

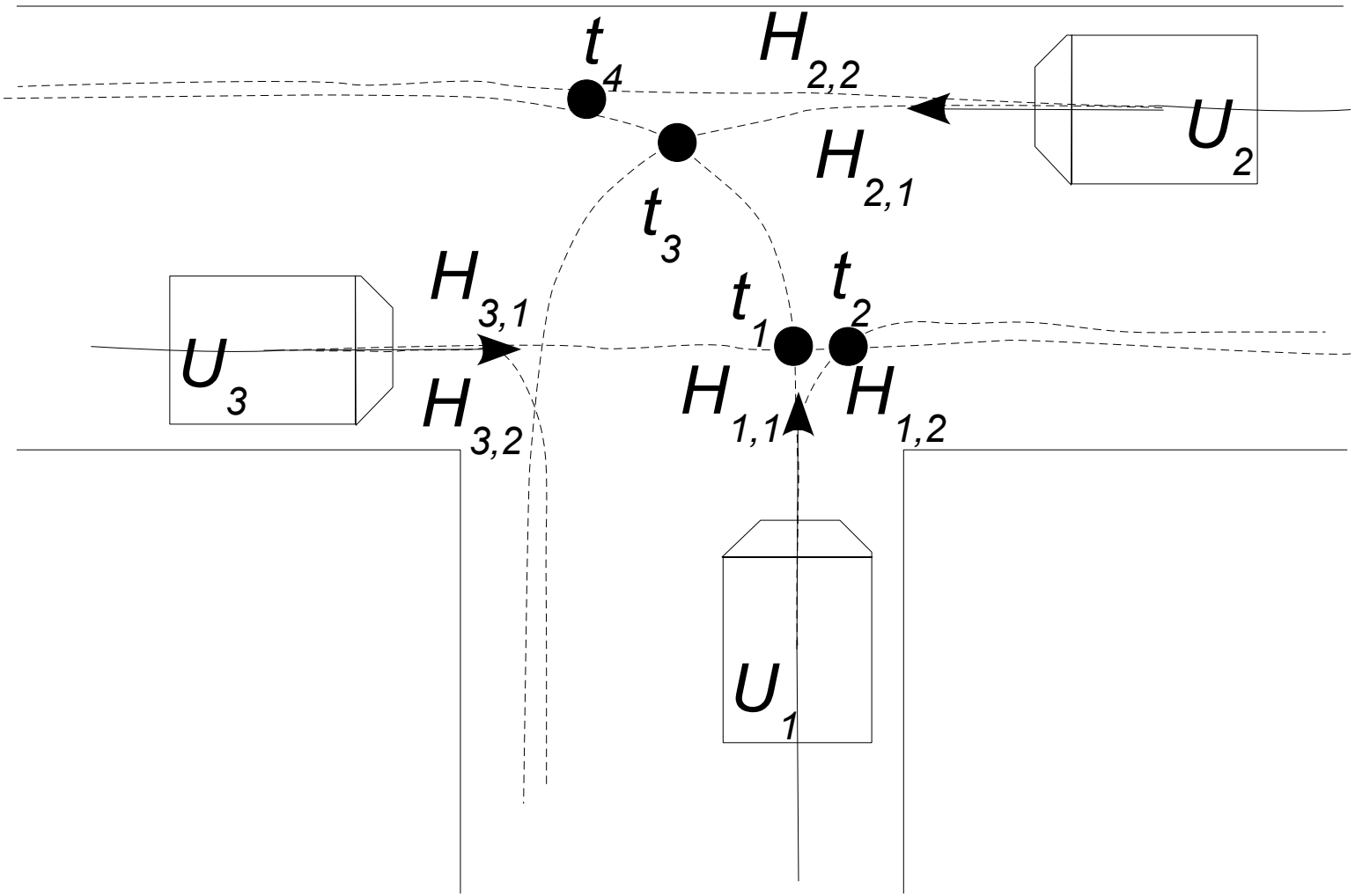
- The road users' predicted positions at each future instant $t \geq t_0$ are enumerated and the N_{CP} collision points CP_n are identified.
- The probability of collision is computed by summing the probabilities of reaching each collision point.

$$P(Collision(U_i, U_j)) = \sum_{1 \leq n \leq N_{CP}} P(Collision(CP_n))$$

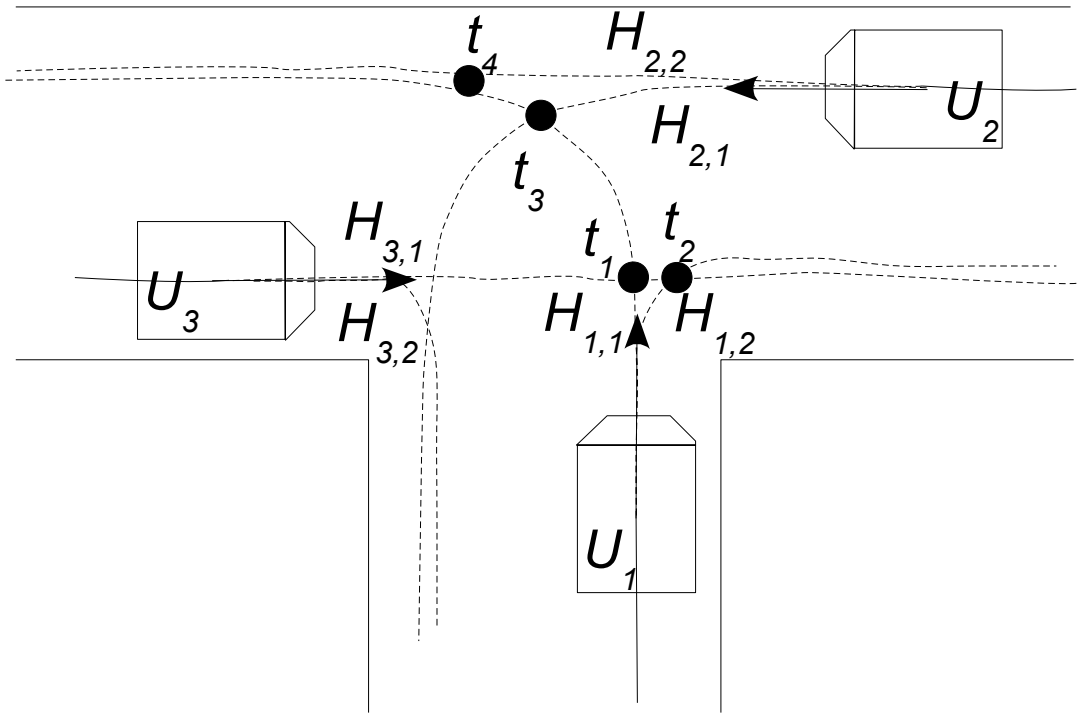
- The expected time to collision (TTC) can also be computed in this framework if there is at least one collision point ($P(Collision(U_i, U_j)) > 0$):

$$TTC(U_i, U_j, t_0) = \frac{\sum_{1 \leq n \leq N_{CP}} P(Collision(CP_n))\ t_n}{P(Collision(U_i, U_j))}$$

Simple Example

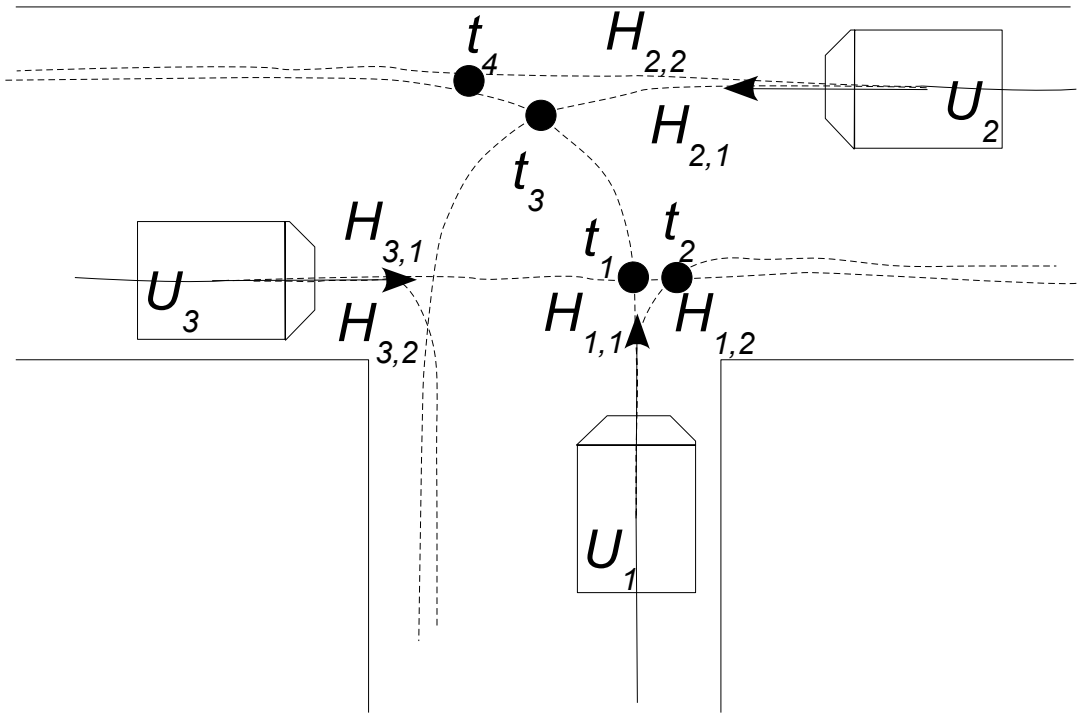


Simple Example



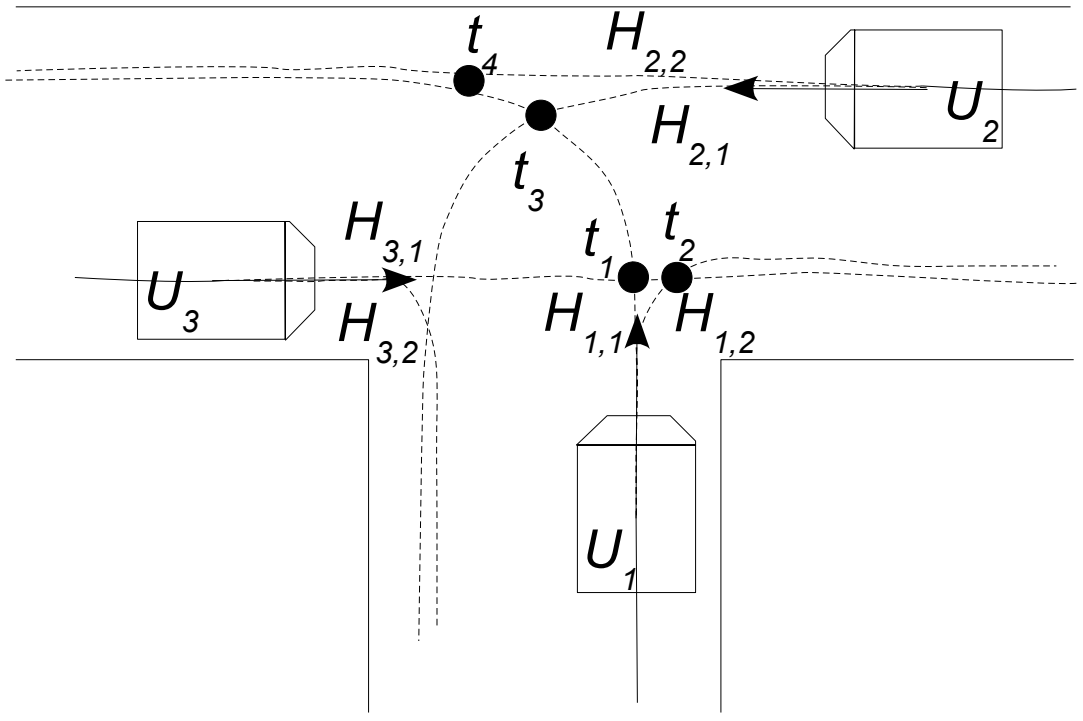
$$P(Collision(CP_1)) = P(H_{1,1})P(H_{3,1})$$

Simple Example



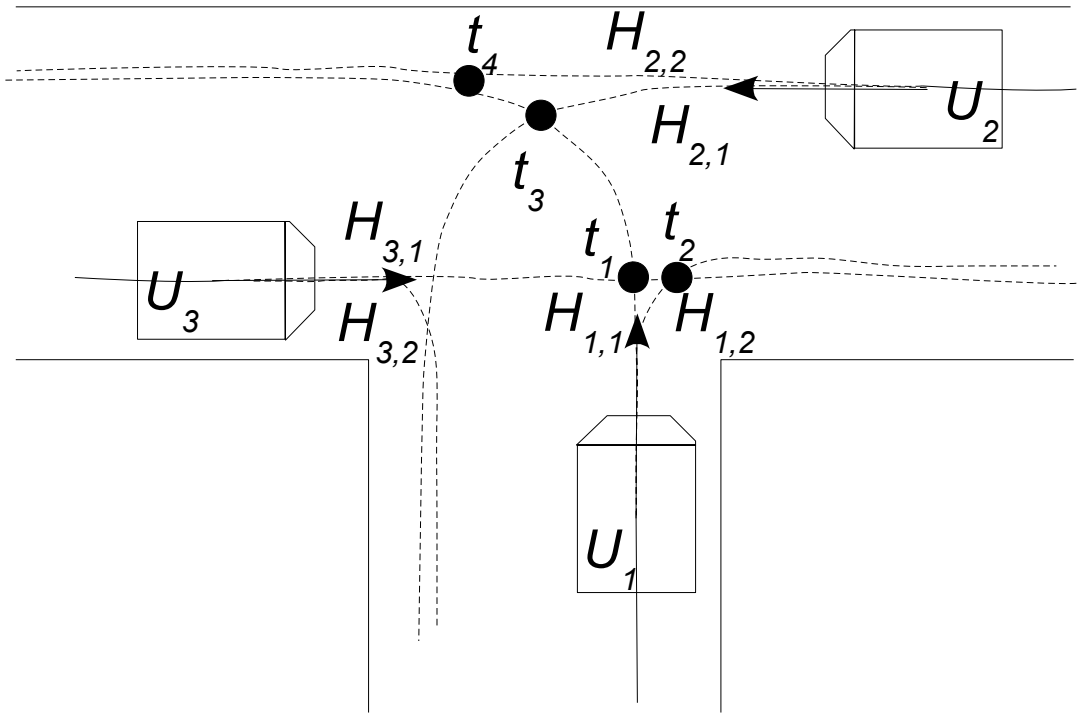
$$P(Collision(CP_2)) = P(H_{1,2})P(H_{3,1})$$

Simple Example



$$P(Collision(CP_3)) = P(H_{1,1})P(H_{2,1})(1 - P(Collision(CP_1)))$$

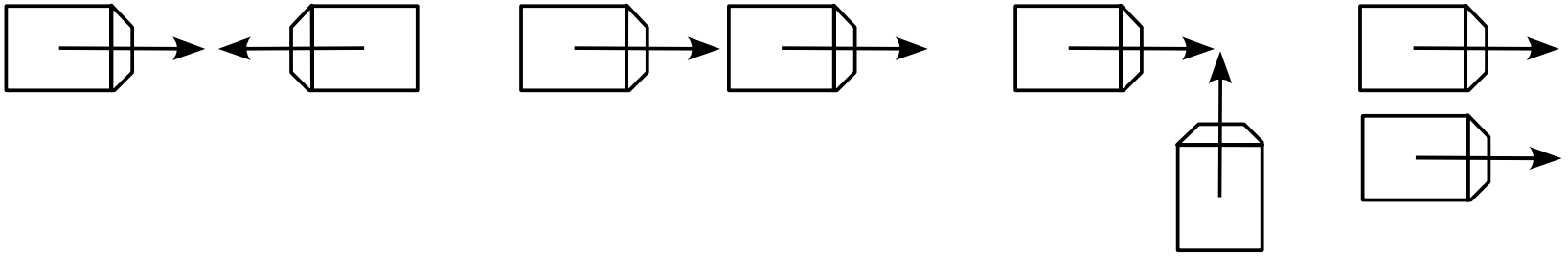
Simple Example



$$P(Collision(CP_4)) = P(H_{1,1})P(H_{2,2})(1 - P(Collision(CP_1)))$$

Interaction Categories

Categories: majority of instants in a given configuration

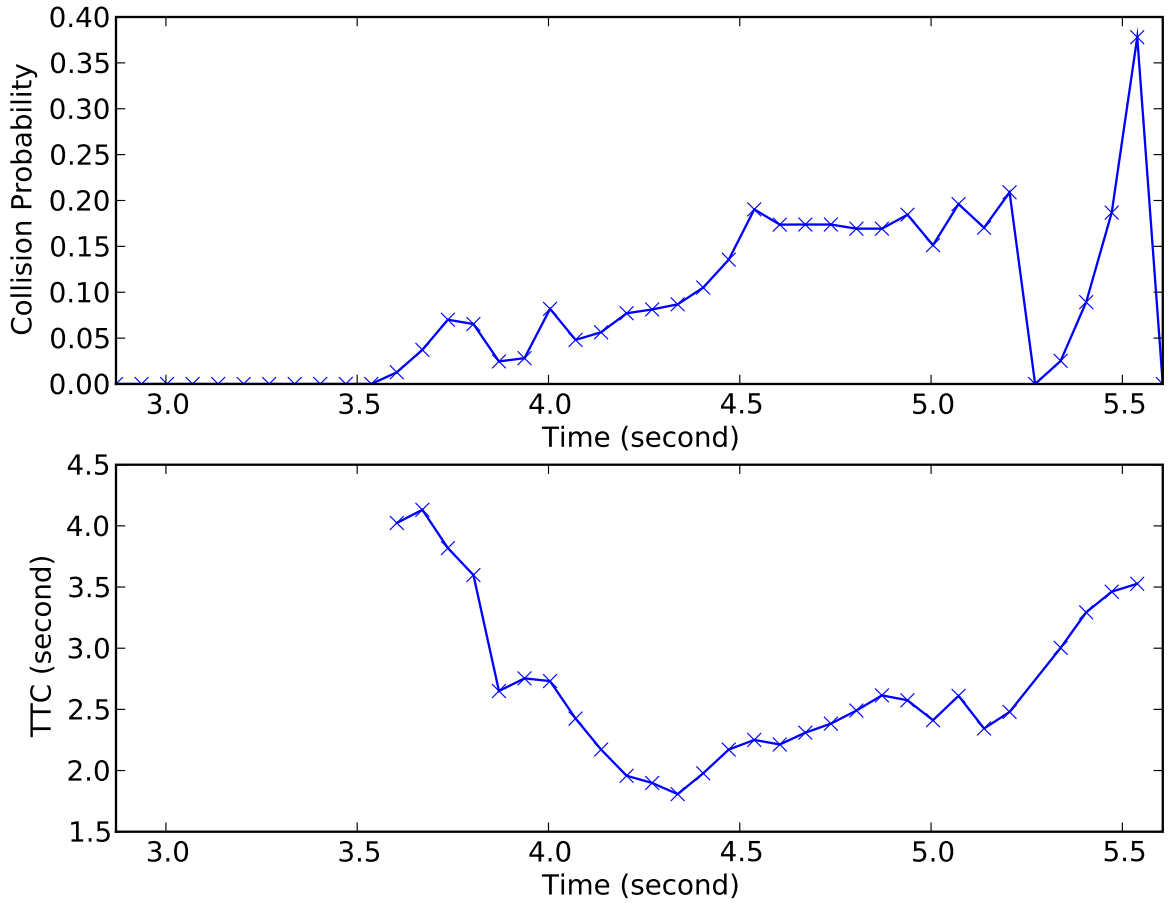


head-on rear-end side parallel

A Large Dataset

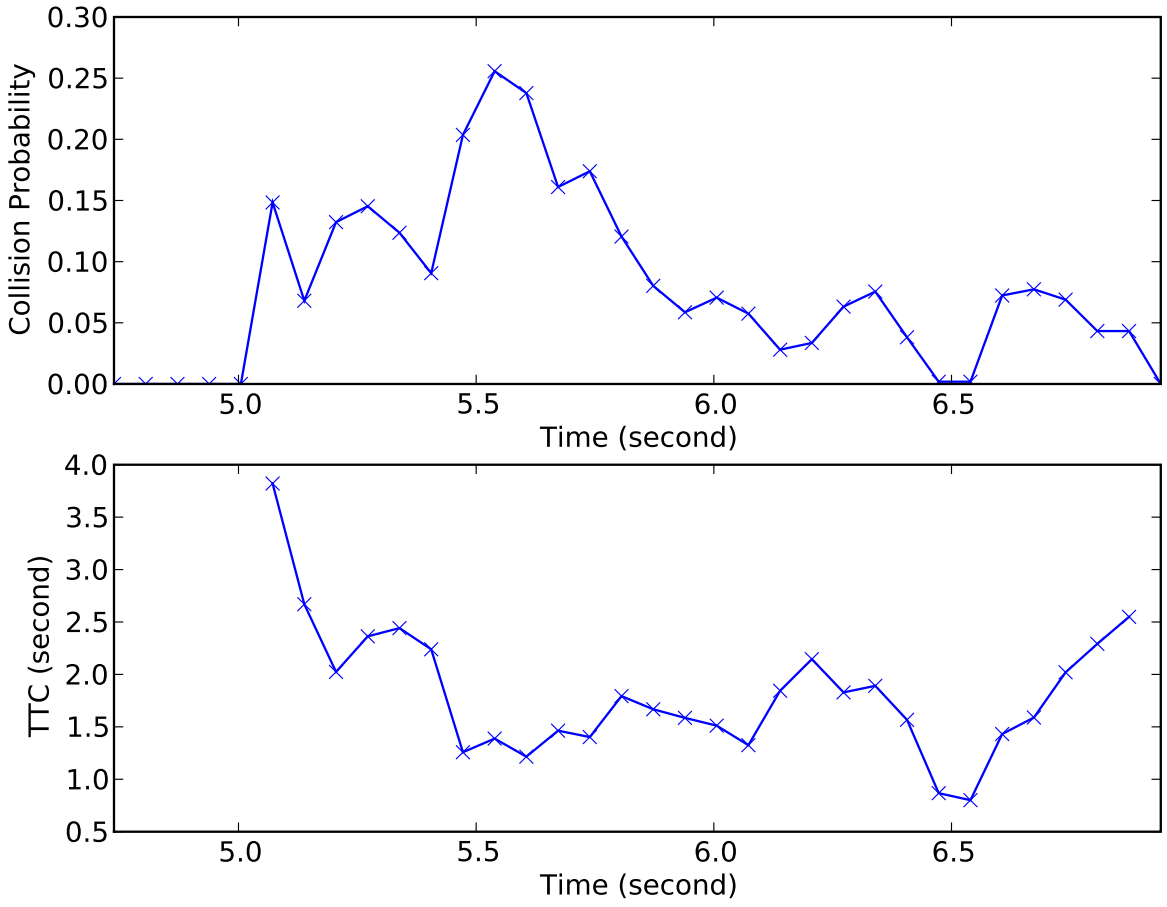
- Videos kept for a few seconds before and after the sound-based automatic detection of an interaction of interest
  - 229 traffic conflicts
  - 101 collisions
  - The existence of an interaction or its severity is not always obvious
  - The interactions recorded in this dataset involve only motorized vehicles
  - Limited quality of the video data: resolution, compression, weather and lighting conditions
- Calibration done using the tool developed by Karim Ismail at UBC [Ismail et al., 2010]

Severity Indicators



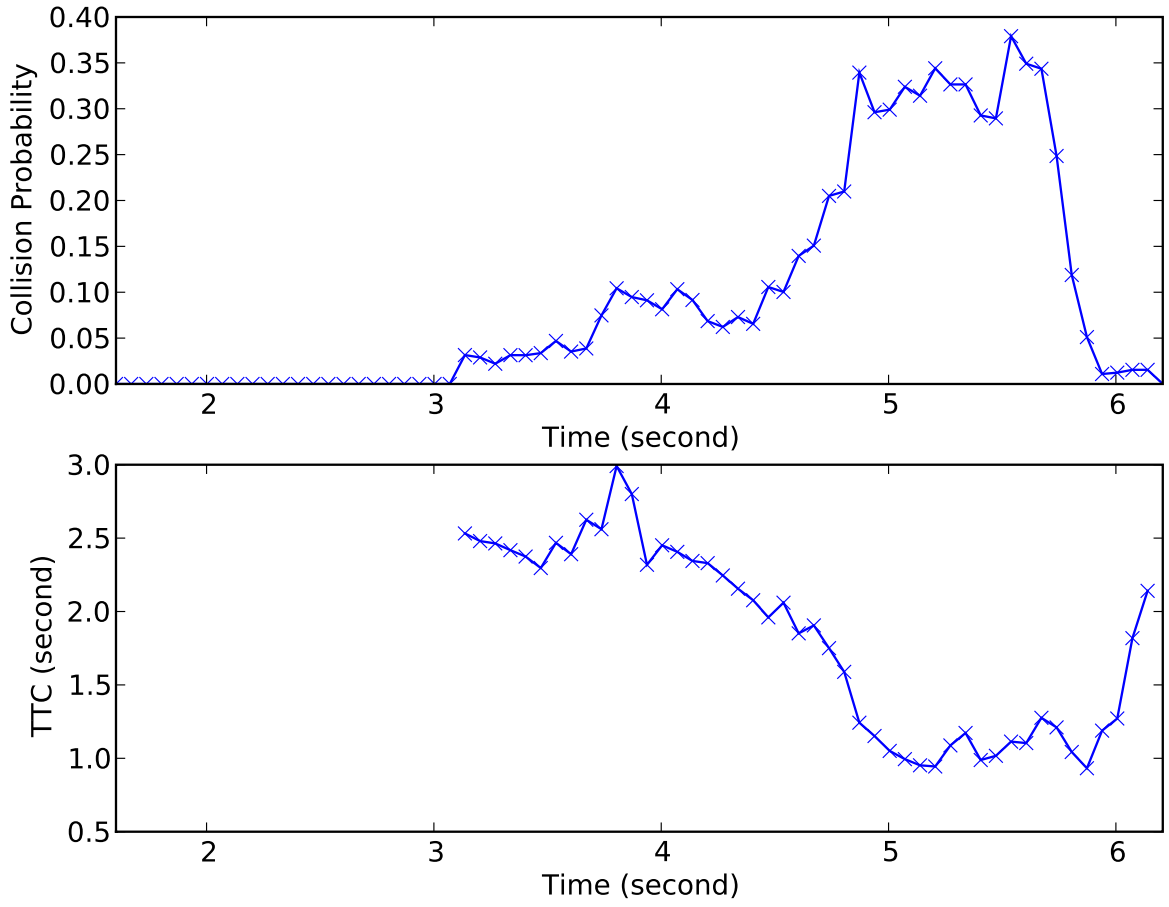
Side conflict

Severity Indicators



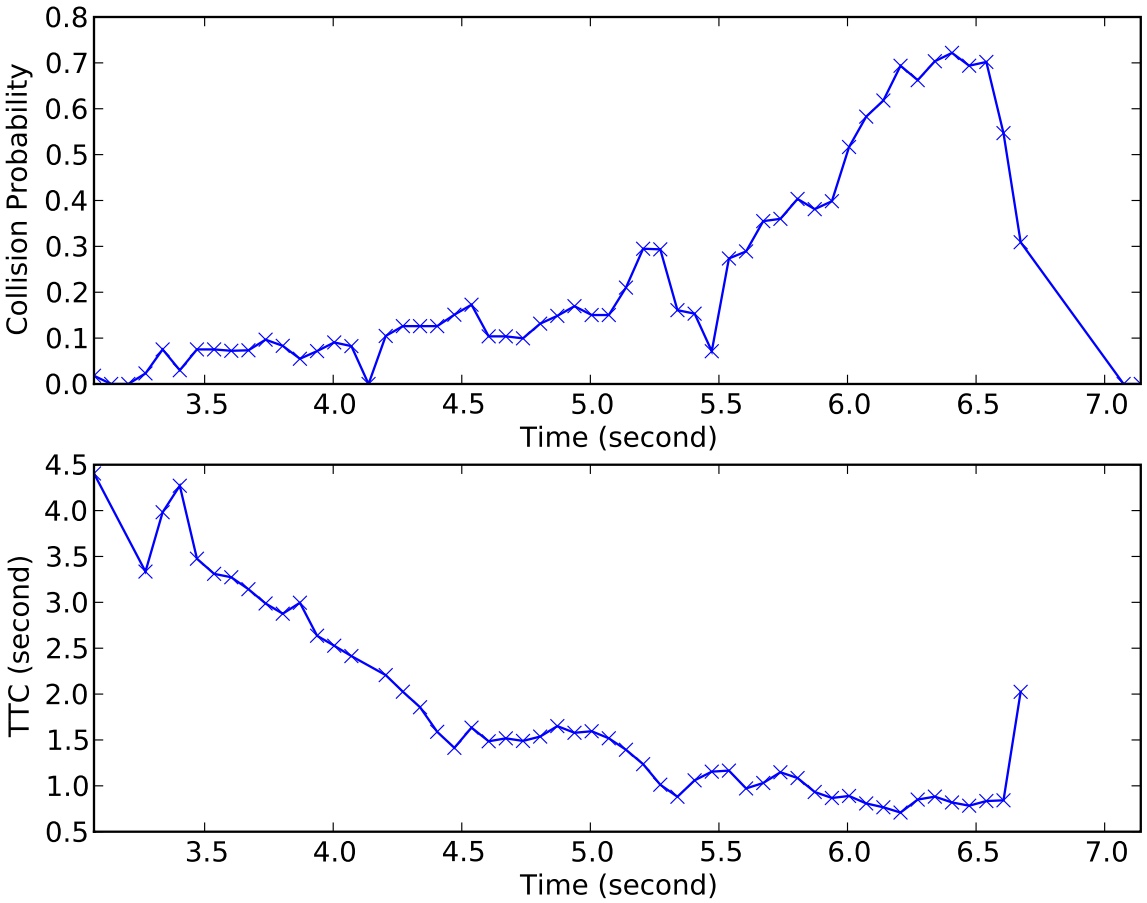
Side conflict

Severity Indicators



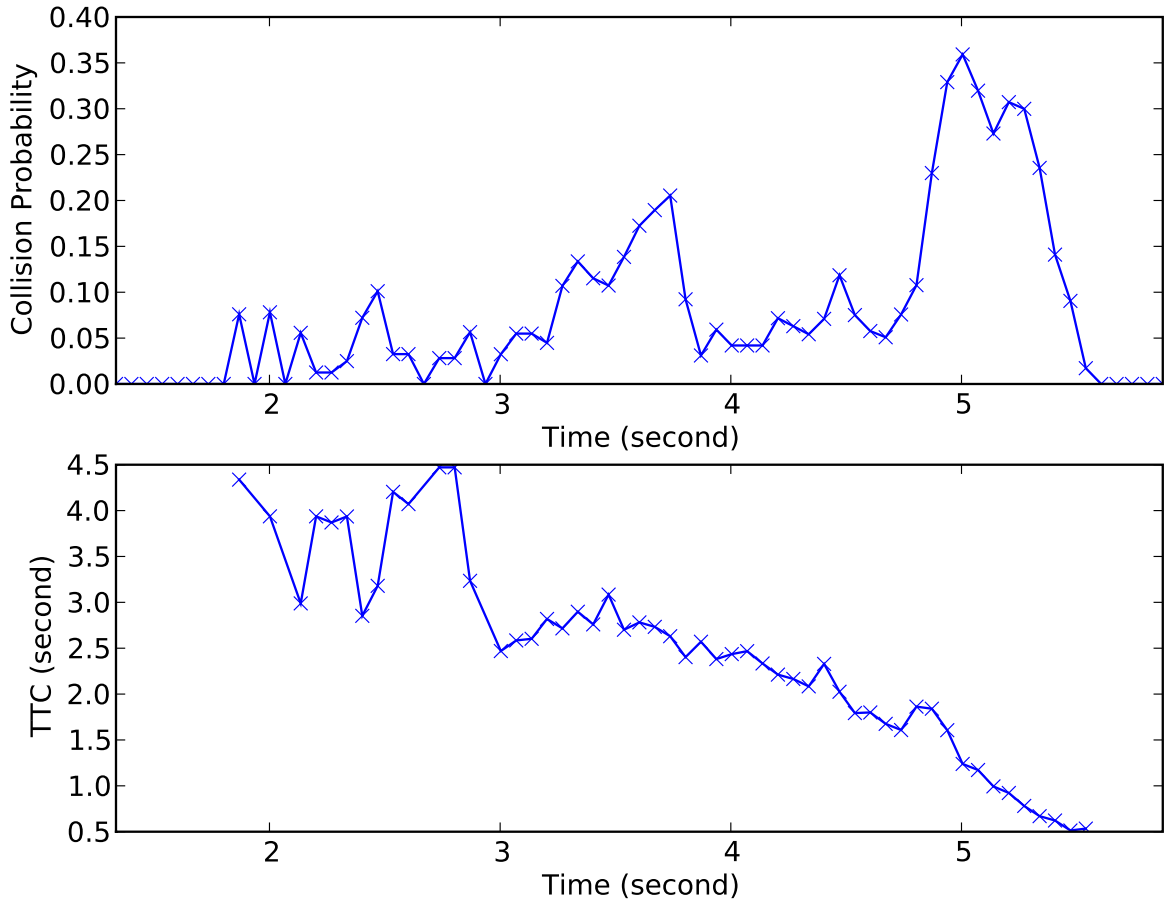
Parallel conflict

Severity Indicators



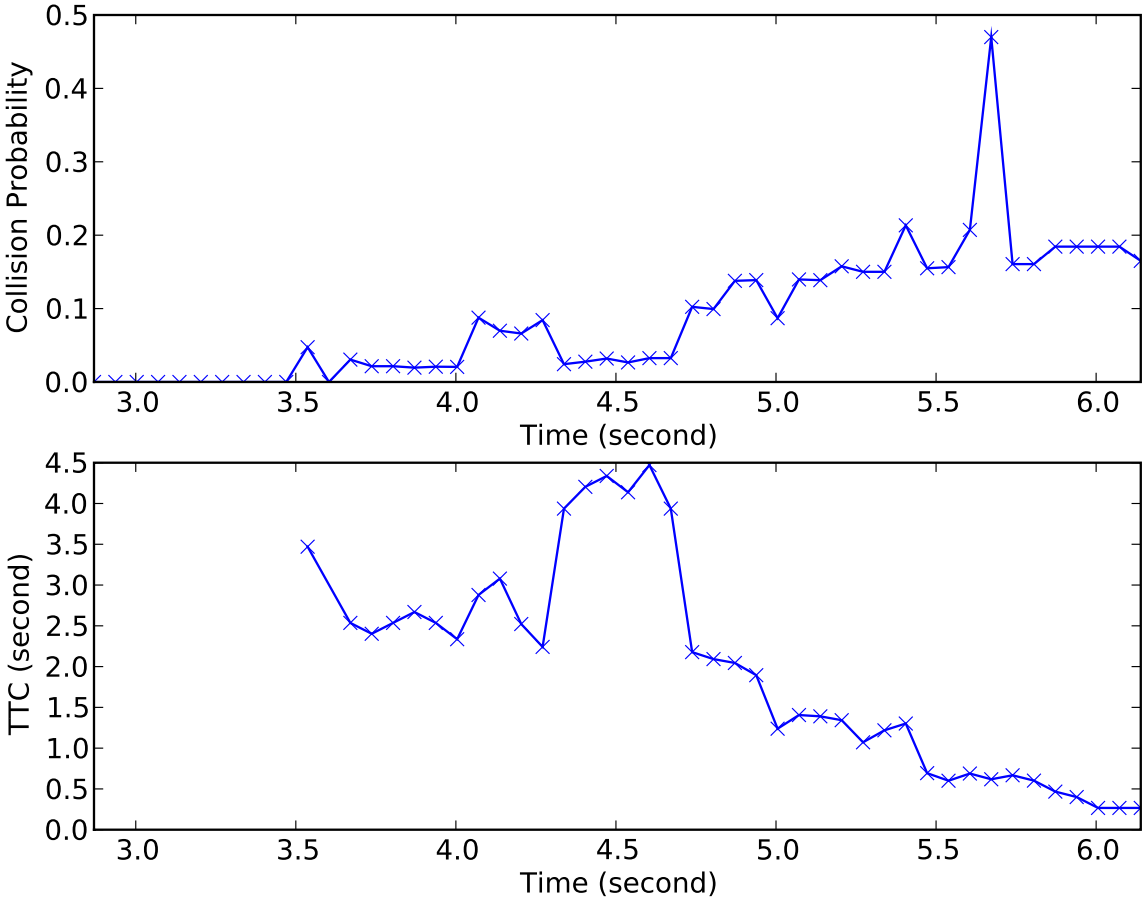
Side collision

Severity Indicators



Side collision

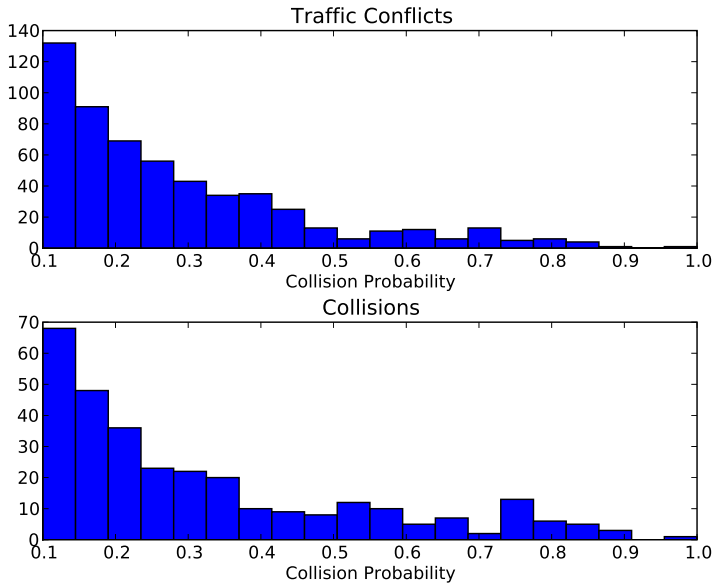
Severity Indicators



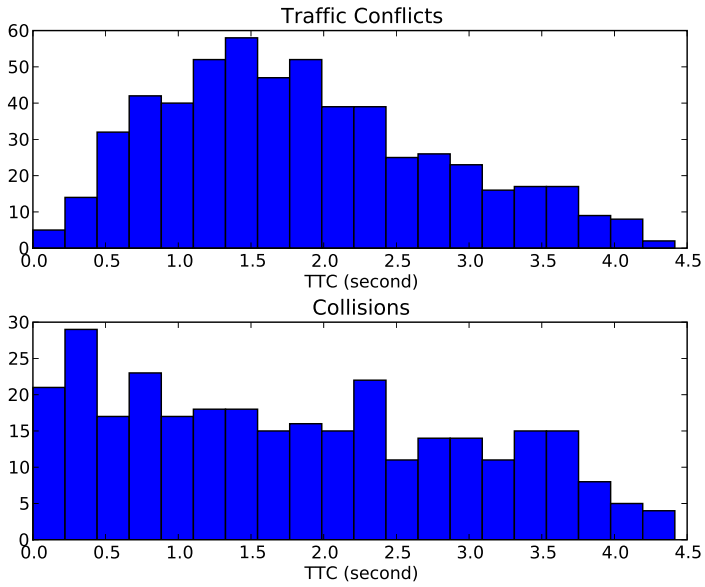
Parallel collision

Distribution of Indicators

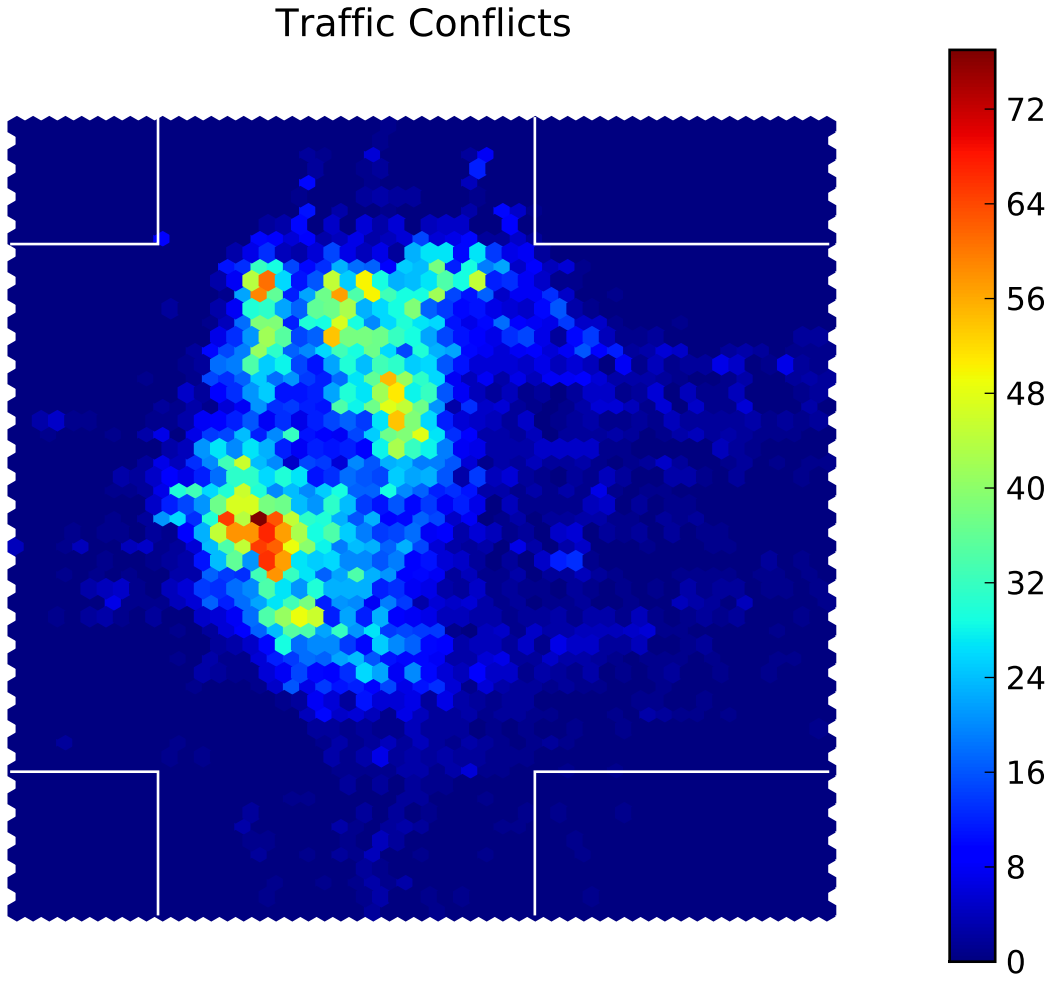
Maximum Collision Probability



Minimum TTC



Spatial Distribution of the Collision Points



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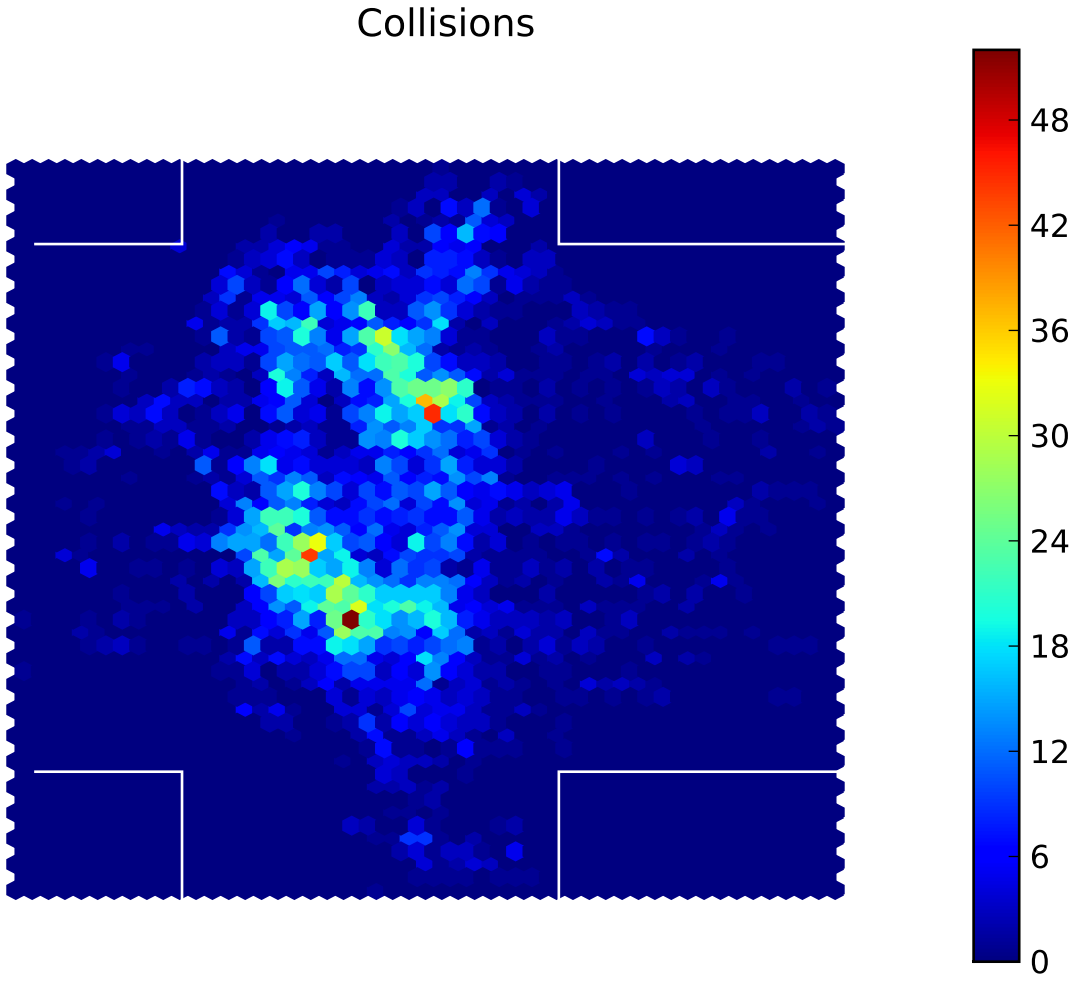

Conclusion

- Tools and framework for automated road safety analysis using video sensors
- Data mining and visualization for safety analysis
- Future work:
  - Improve the accuracy of the location and volume of road users
  - Validation of proactive methods for road safety analysis (Clark Lim and Tarek Sayed at UBC)
  - Understanding and modelling of the mechanisms that lead to accidents (École Polytechnique de Montréal)
- Need for more open science: data and code sharing
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Questions ?

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