Automated Proactive Road Safety Analysis

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ÉCOLE
POLYTECHNIQUE
MONTRÉAL

November 1st 2010

Outline

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A World Health Issue

Over 1.2 million people die each year on the world's roads, and between 20 and 50 million suffer non-fatal injuries. In most regions of the world this epidemic of road traffic injuries is still increasing.
(Global status report on road safety, World Health Organization, 2009)

A World Health Issue

TOTAL 2004

RANK	LEADING CAUSE	%
1	Ischaemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Lower respiratory infections	7.0
4	Chronic obstructive pulmonary disease	5.1
5	Diarrhoeal diseases	3.6
6	HIV/AIDS	3.5
7	Tuberculosis	2.5
8	Trachea, bronchus, lung cancers	2.3
9	Road traffic injuries	2.2
10	Prematurity and low birth weight	2.0
11	Neonatal infections and other	1.9
12	Diabetes mellitus	1.9
13	Malaria	1.7
14	Hypertensive heart disease	1.7
15	Birth asphyxia and birth trauma	1.5
16	Self-inflicted injuries	1.4
17	Stomach cancer	1.4
18	Cirrhosis of the liver	1.3
19	Nephritis and nephrosis	1.3
20	Colon and rectum cancers	1.1

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11	Nephritis and nephrosis	1.9
12	Self-inflicted injuries	1.9
13	Liver cancer	1.7
14	Colon and rectum cancer	1.7
15	Oesophagus cancer	1.5
16	Violence	1.4
17	Alzheimer and other dementias	1.4
18	Cirrhosis of the liver	1.3
19	Breast cancer	1.3
20	Tuberculosis	1.1

Source: World health statistics 2008 (http://www.who.int/whosis/whostat/2008/en/index.html)

Road Safety Analysis

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  - Insufficient data to understand the processes that lead to collisions
  - Reactive approach
- Need for proactive approaches and surrogate safety measures that do not depend on the occurrence of collisions

Surrogate Safety Measures

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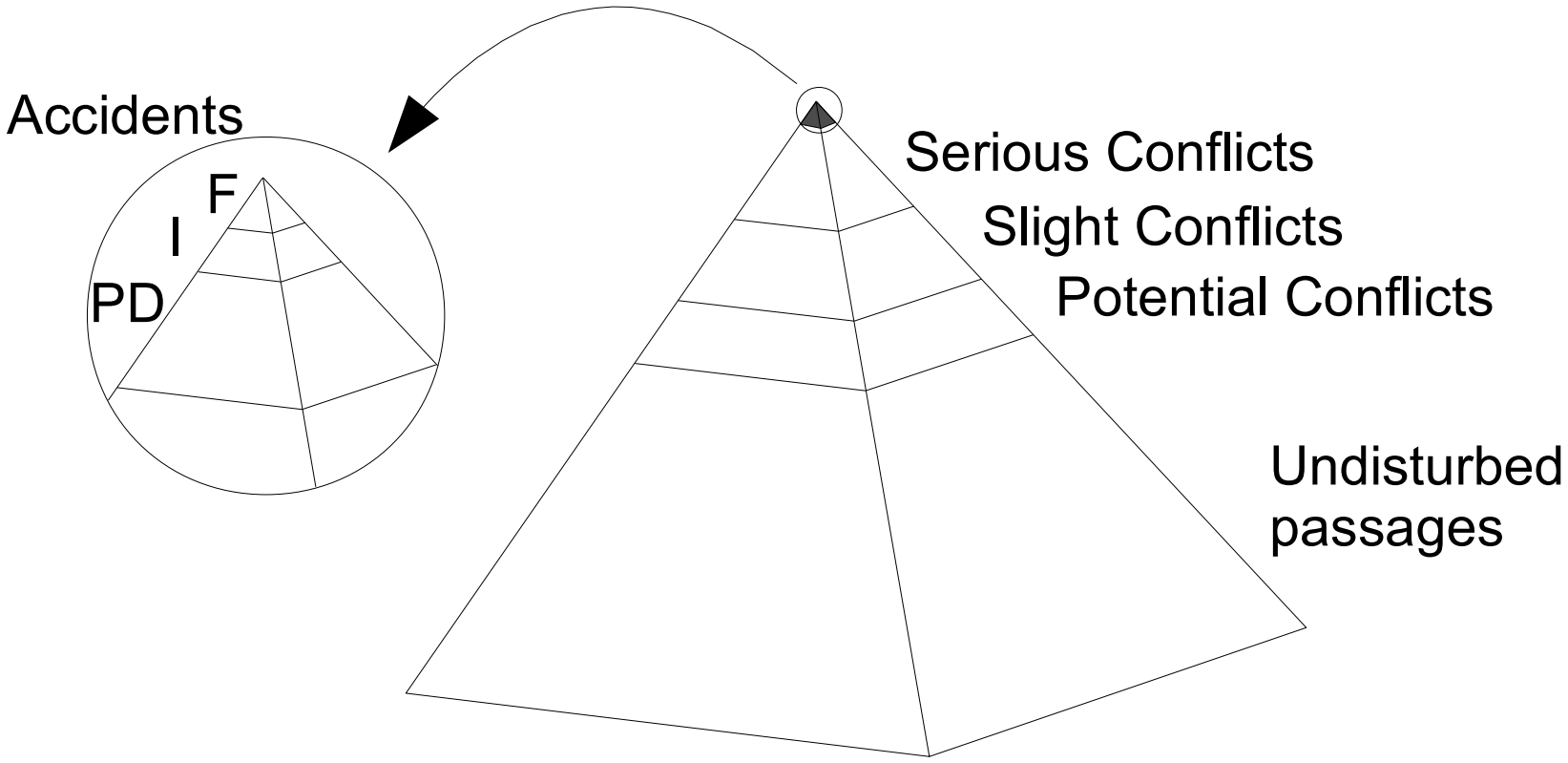
  - are correlated to collisions, logically and statistically
- A traffic conflict is “an observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged”
  [Amundsen and Hydén, 1977]

Automated Methods

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

Outline

The Safety/Severity Hierarchy



Various severity measures

The Collision Course

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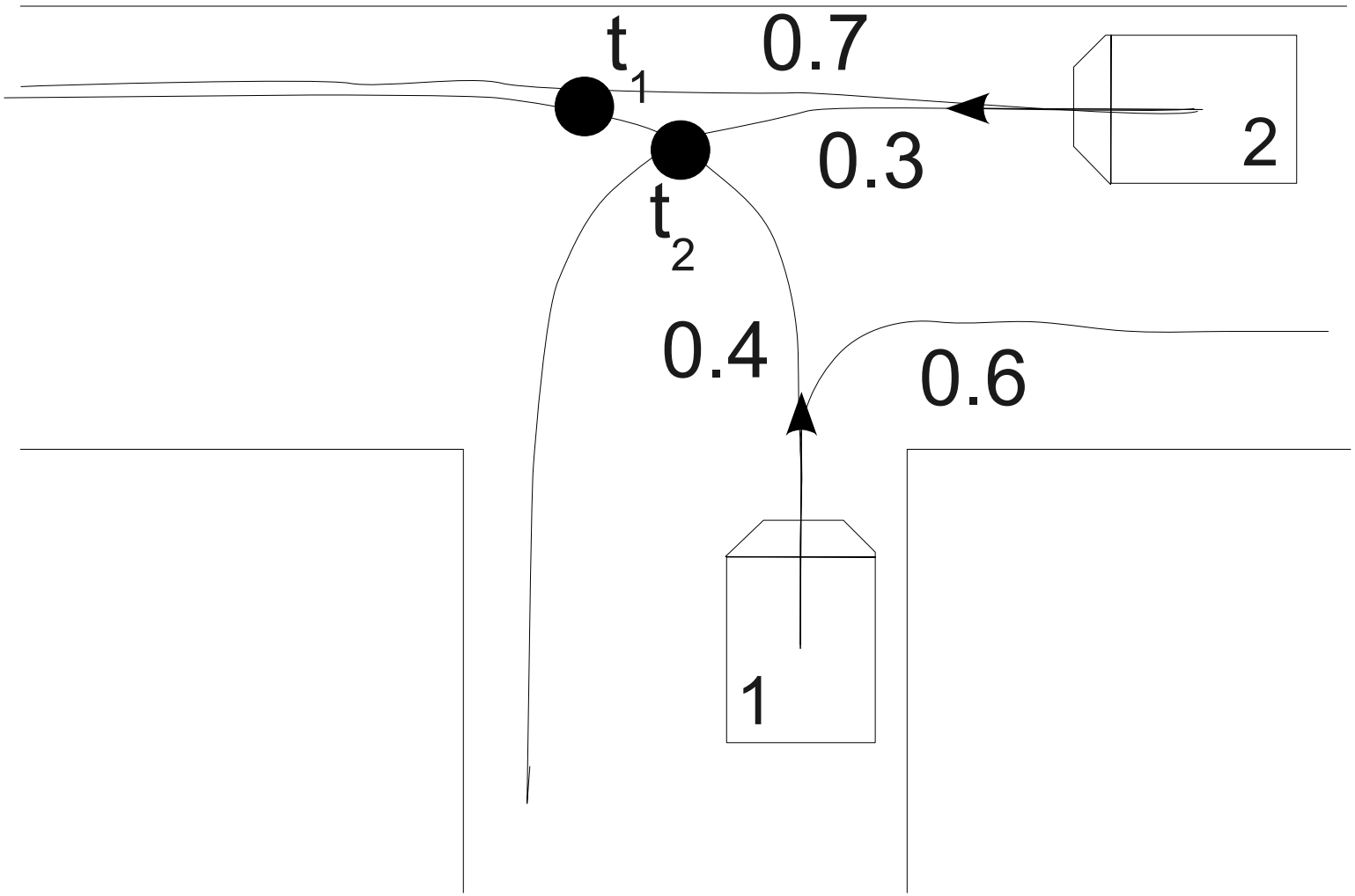
- For two interacting road users, many chains of events may lead to a collision
- It is possible to estimate the probability of collision if one can predict the road users’ future positions

Movement Prediction

- Learn road users' motion patterns (including frequencies), represented by actual trajectories called prototypes
- Match observed trajectories to prototypes and extrapolate

[Saunier et al., 2007, Saunier and Sayed, 2008]

A Simple Example



Collision Points

Using of a finite set of extrapolation hypotheses, enumerate the collision points CP_n. Severity indicators can then be computed:

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

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

[Saunier et al., 2010]

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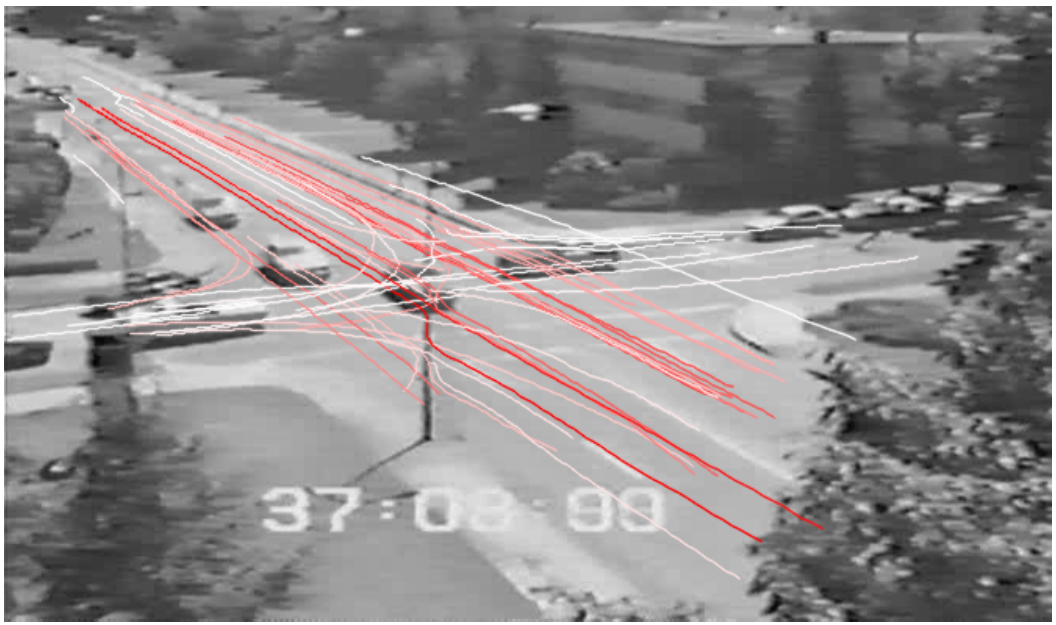
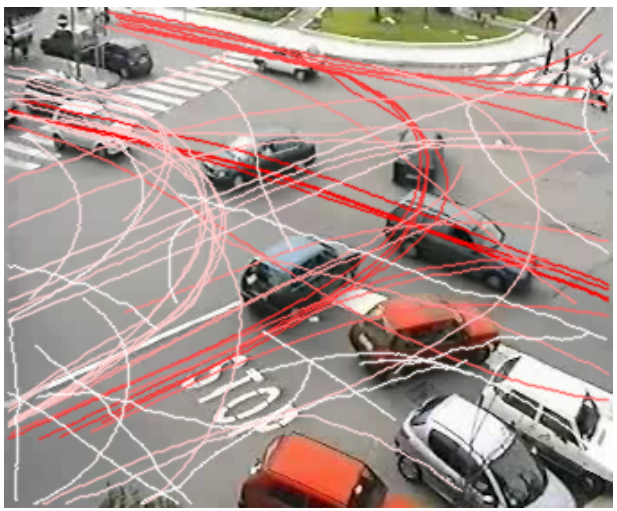
Motion Pattern Learning



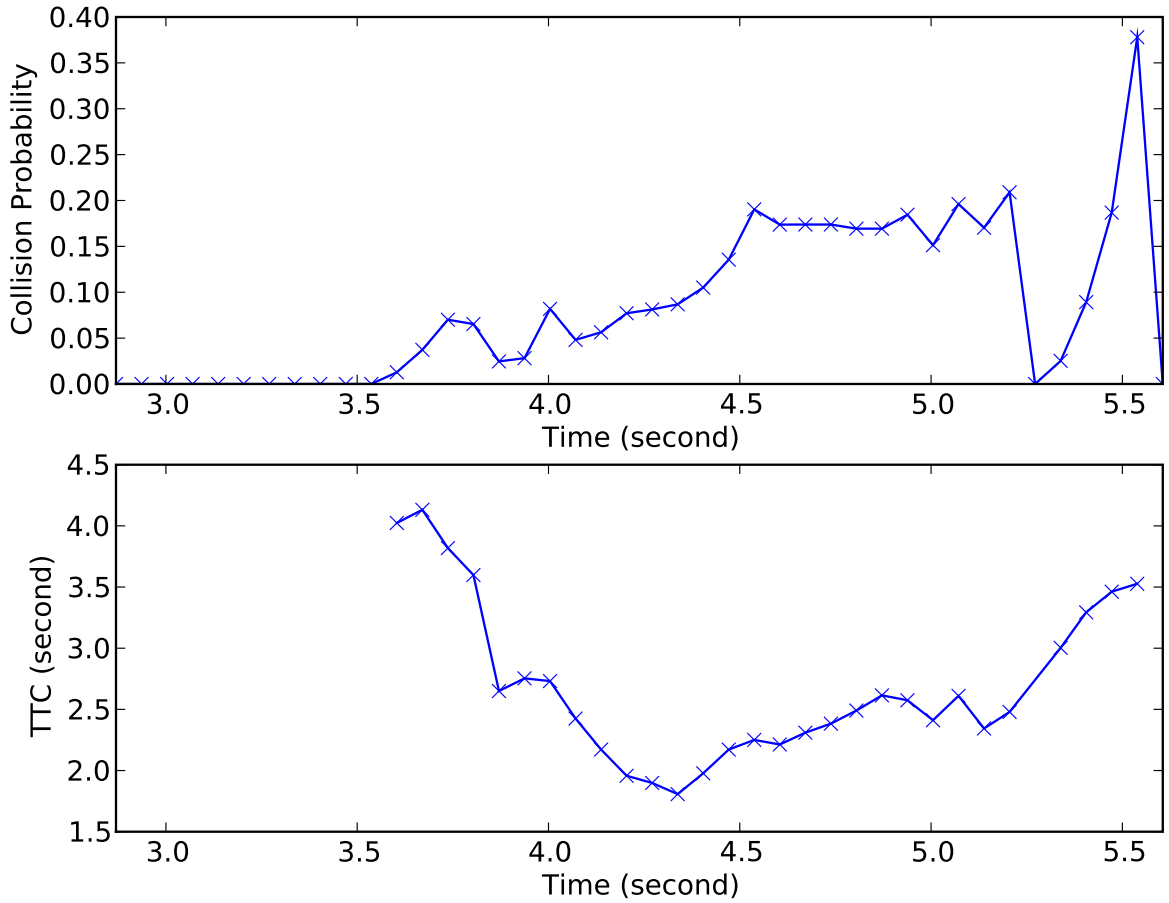


Traffic Conflict Dataset, Vancouver	Reggio Calabria, Italy
58 prototype trajectories (2941 trajectories)	58 prototype trajectories (138009 trajectoires)

The Kentucky Dataset

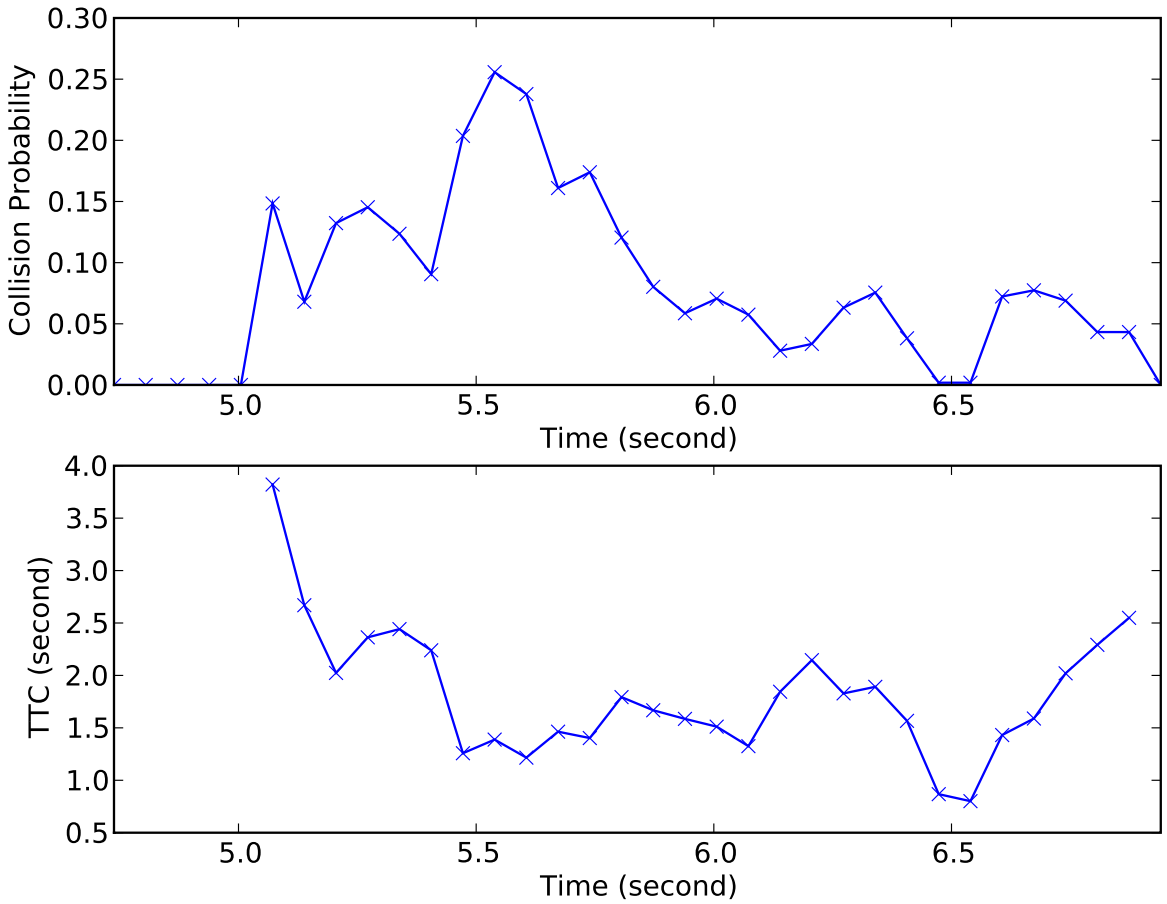
- Video recordings kept for a few seconds before and after the sound-based automatic detection of an interaction of interest
  - 229 traffic conflicts
  - 101 collisions
  - The existence of an interaction or its severity is not always obvious
  - The interactions recorded in this dataset involve only 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., 2010b]

Severity Indicators



Side conflict

Severity Indicators



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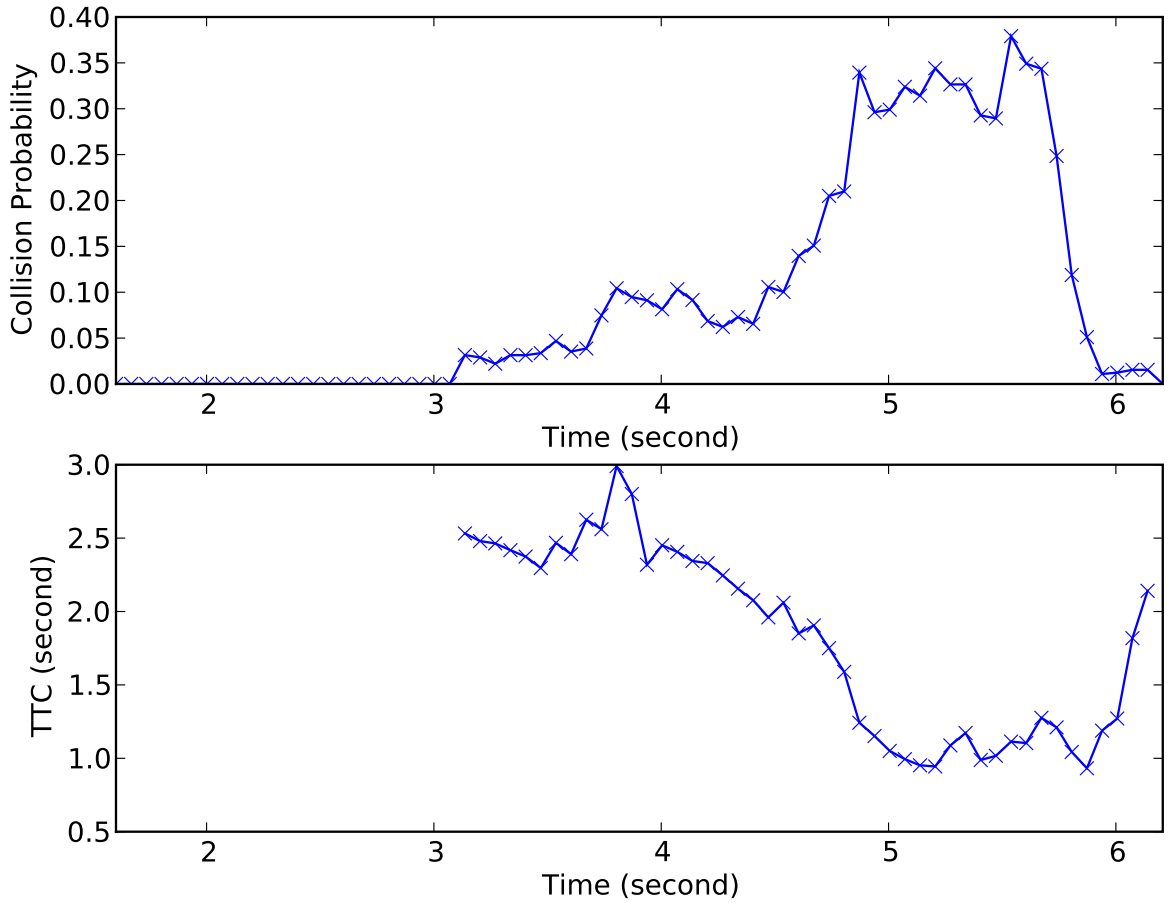
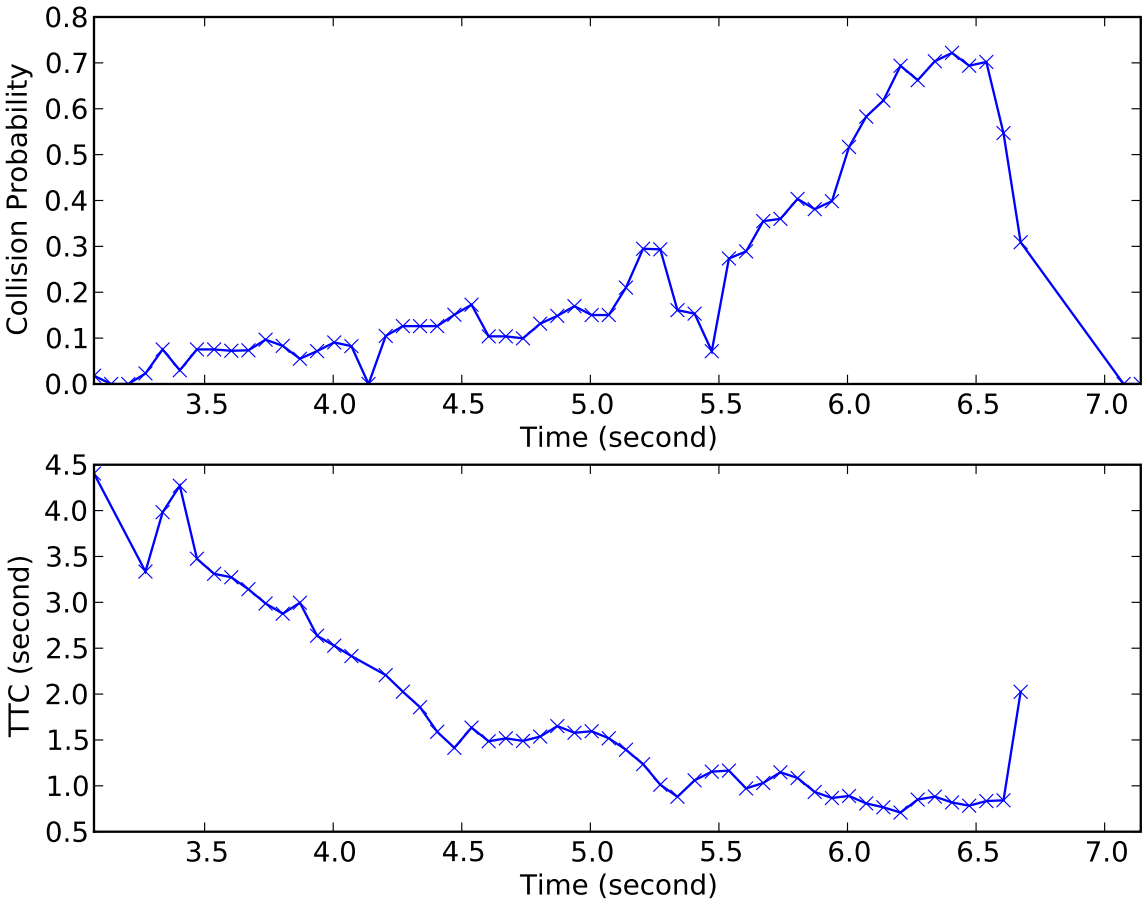


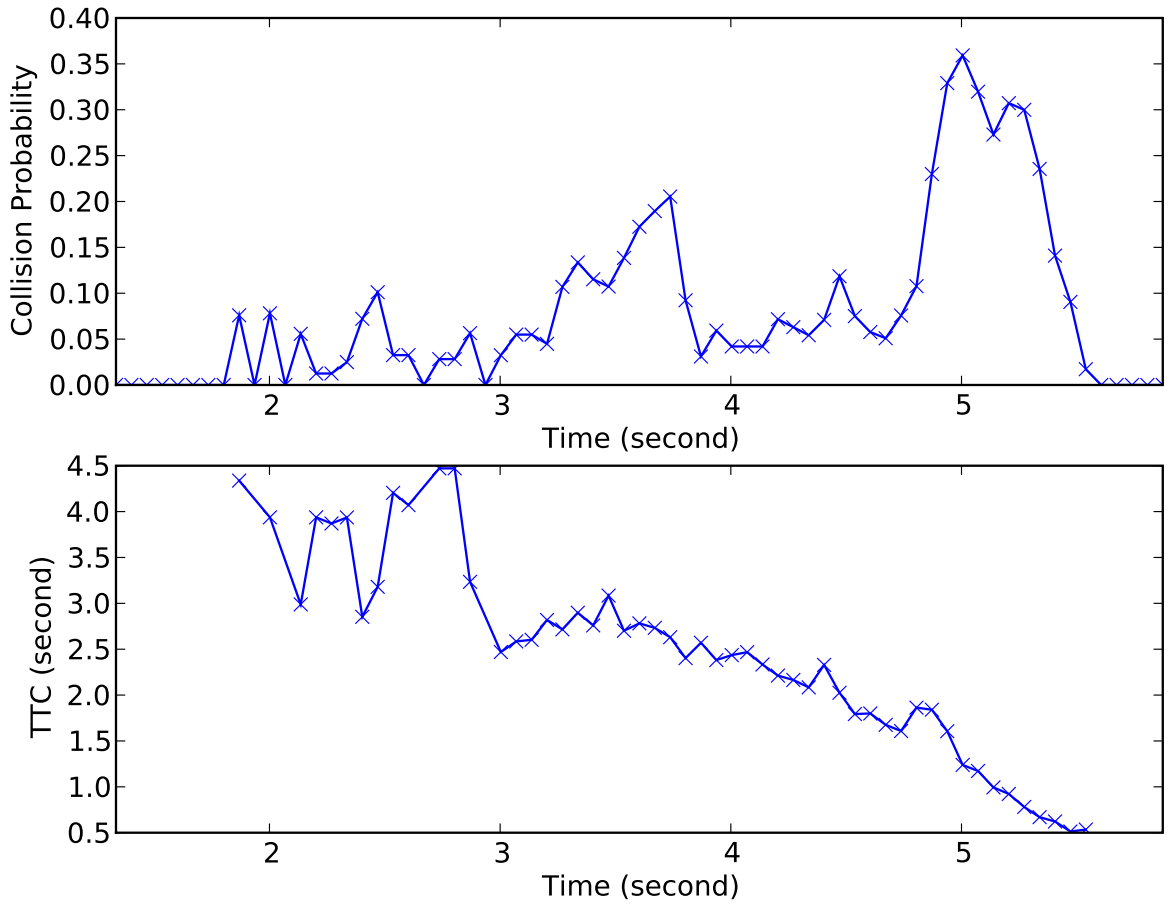
Parallel conflict

Severity Indicators



Side collision

Severity Indicators



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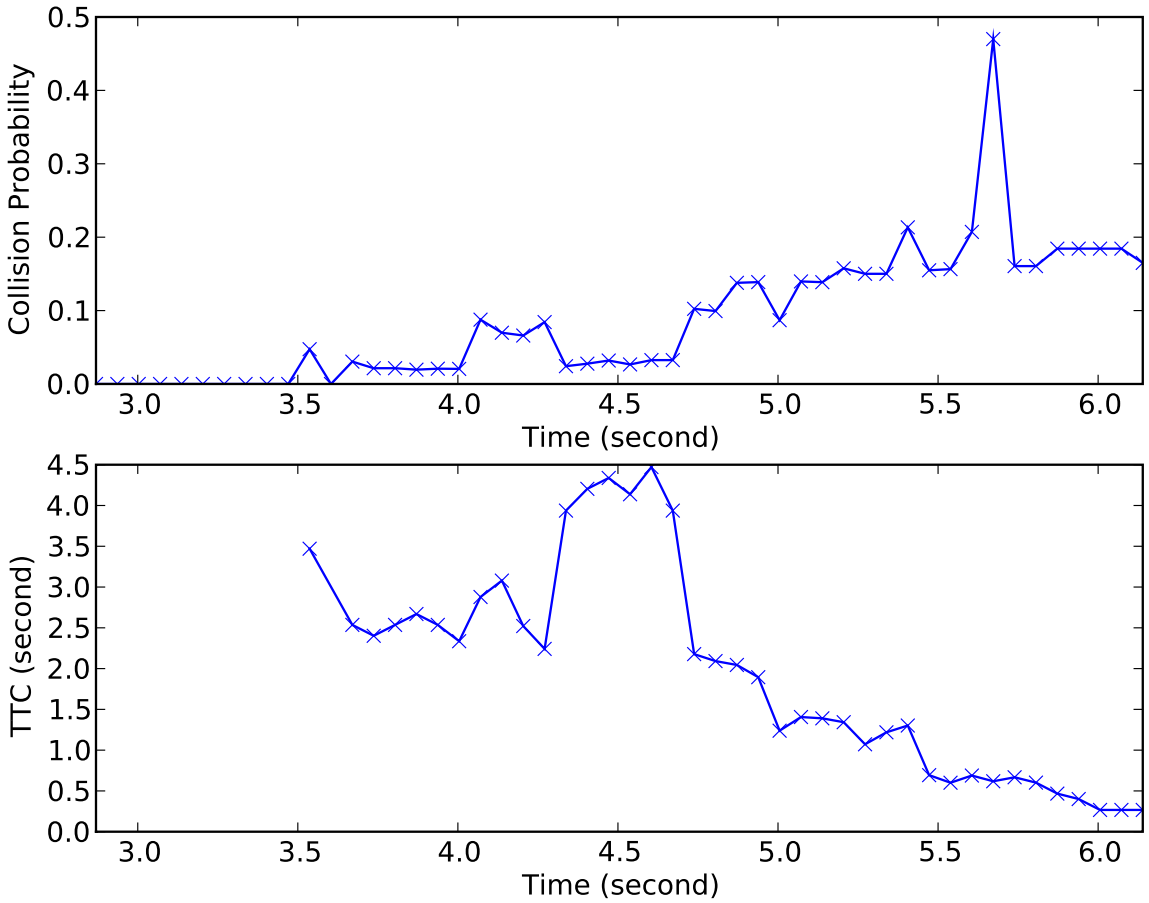
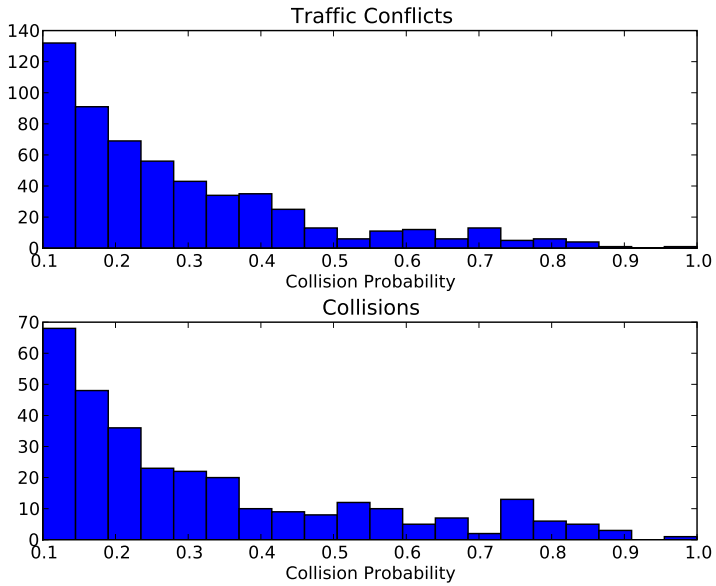


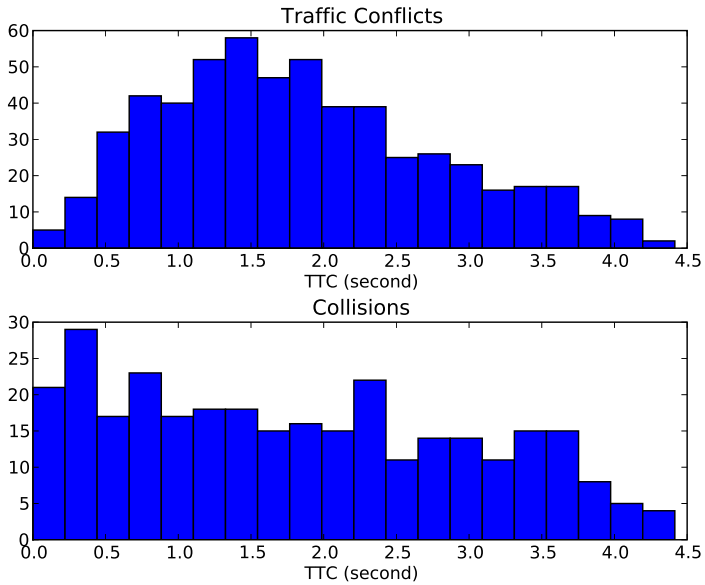
Parallel collision

Distribution of Indicators

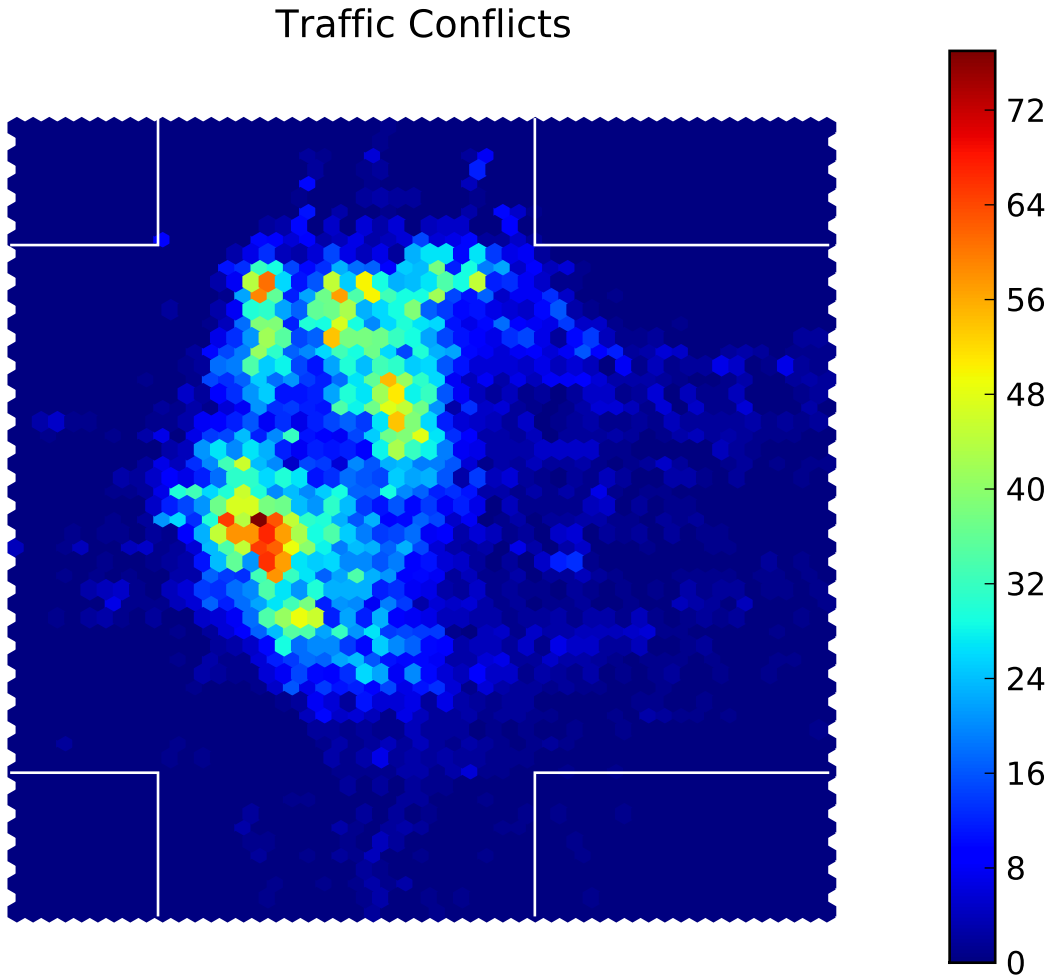
Maximum Collision Probability



Minimum TTC



Spatial Distribution of the Collision Points



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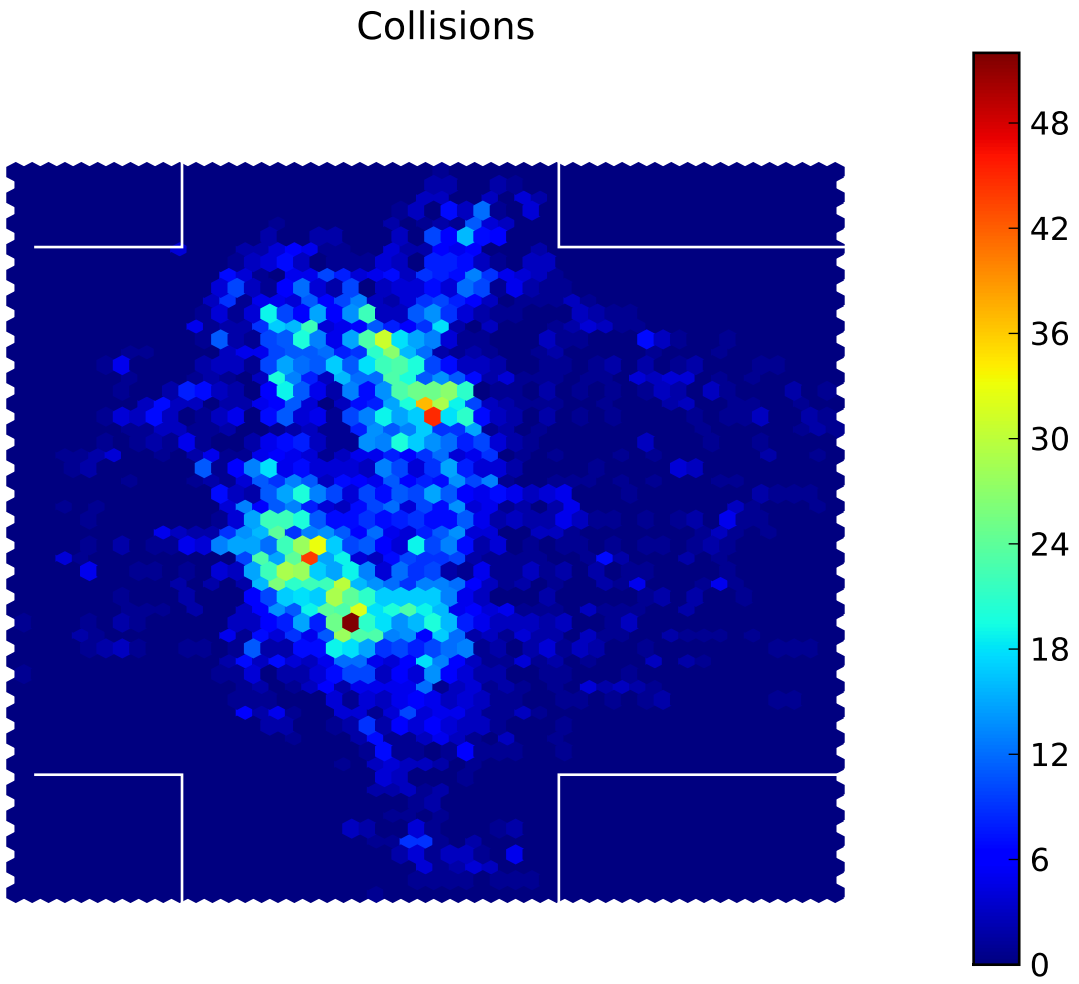
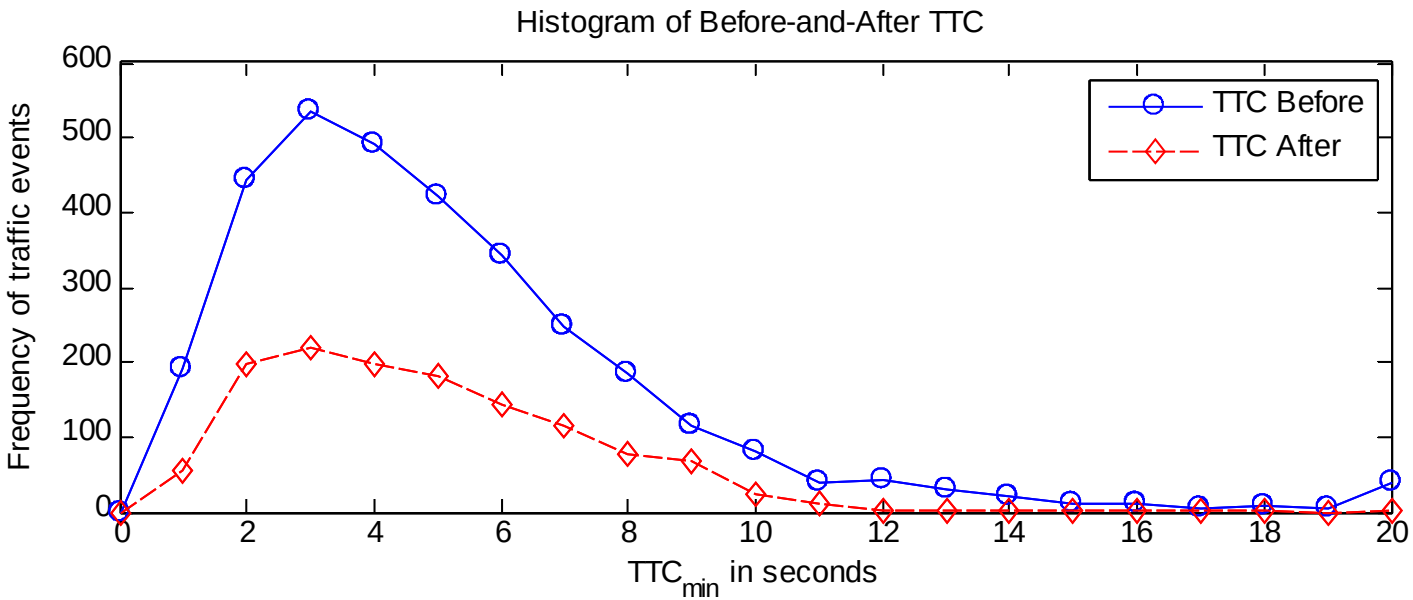


Study Before and After the Introduction of a Scramble Phase

Data collected in Oakland, CA [Ismail et al., 2010a]

Distribution of Severity Indicators



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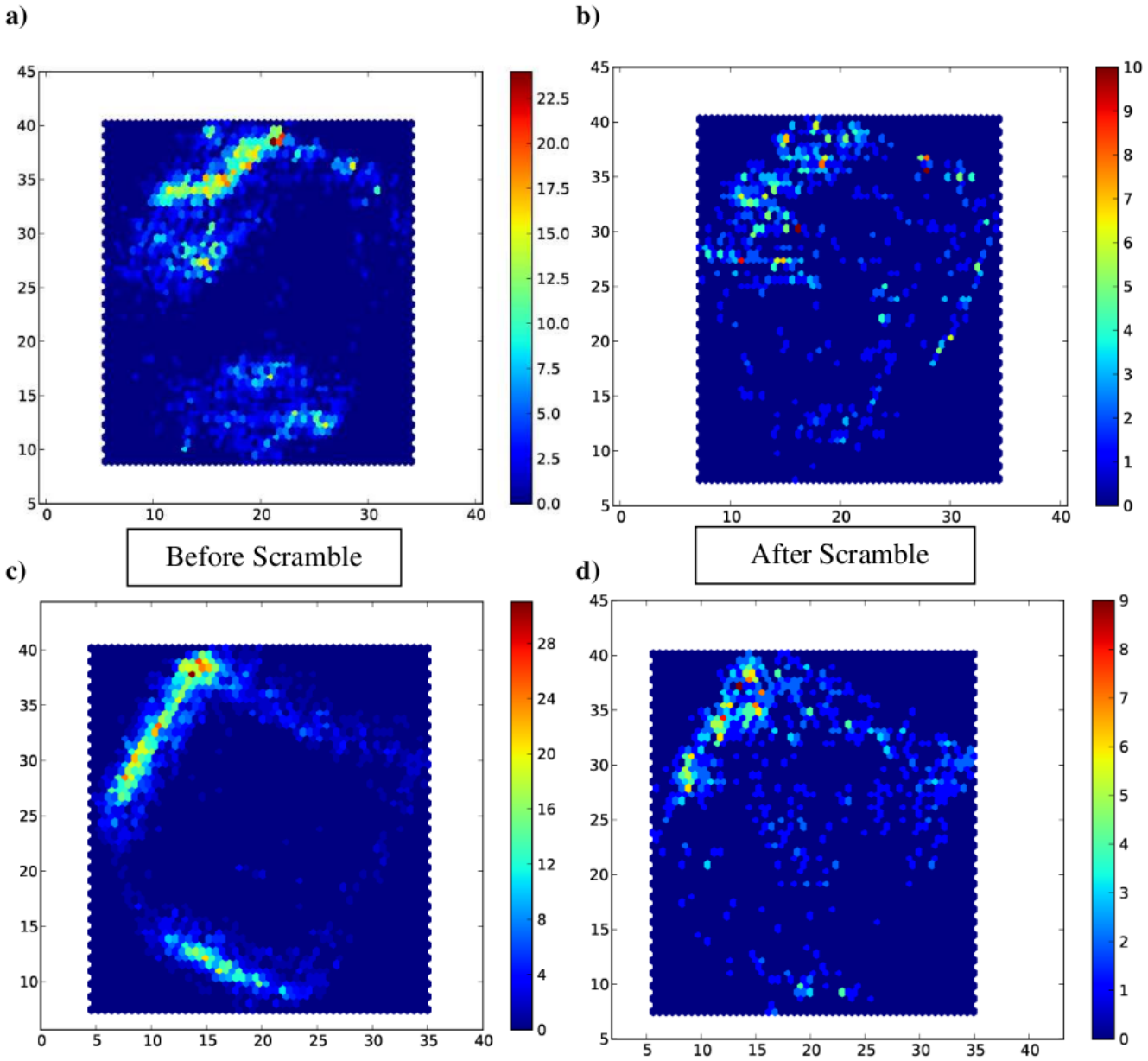

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Objectives

- Understand collision processes by studying the similarities of interactions with and without a collision (conflicts)

[Saunier et al., 2011]

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- There is some evidence that evasive actions undertaken by road users involved in conflicts may be of a different nature than the ones attempted in collisions [Davis et al., 2008]

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- Use of data mining techniques (k-means and hierarchical agglomerative clustering method) to cluster the data

[Saunier et al., 2011]

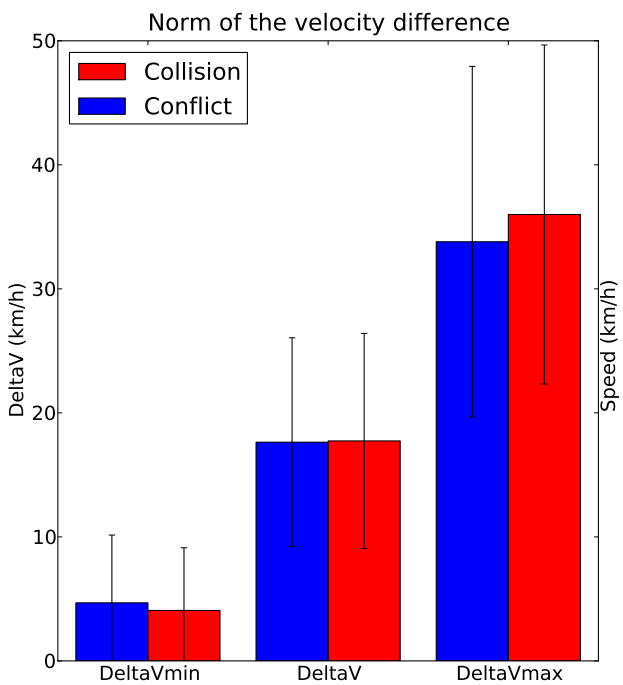
Description of Interactions

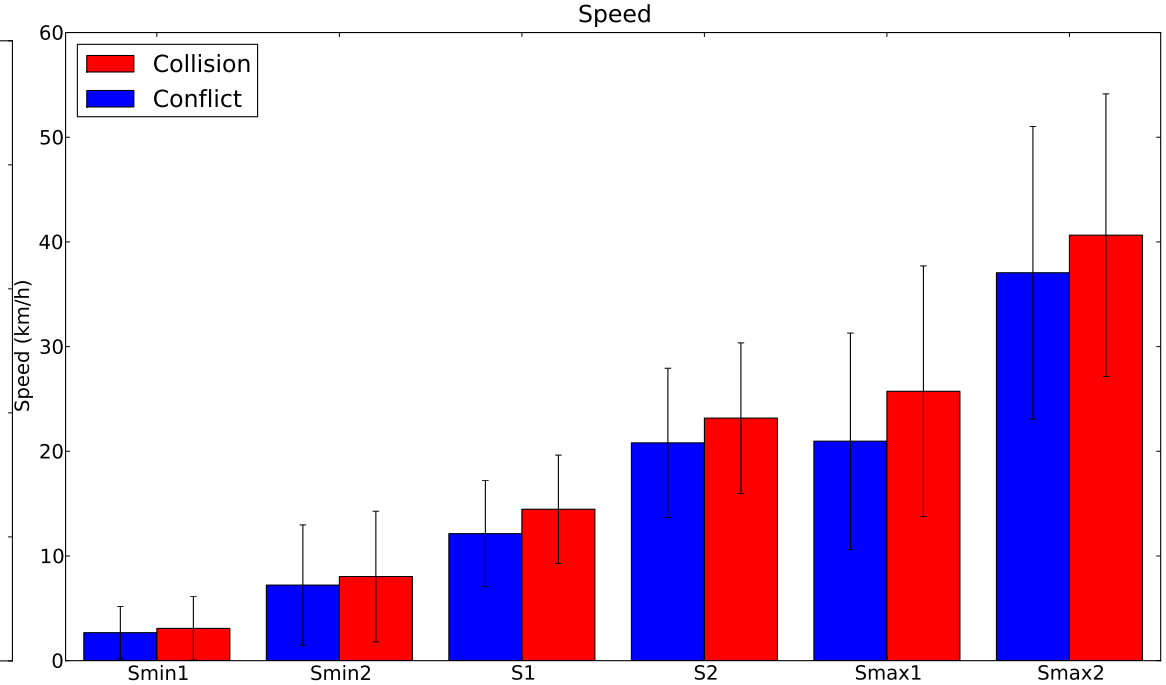
Categorical attributes	**Values**
Type of day	weekday, week end
Lighting condition	daytime, twilight, nighttime
Weather condition	normal, rain, snow
Interaction category	same direction, opposite direction, side
Interaction outcome	conflict, collision

Description of Interactions (continued)

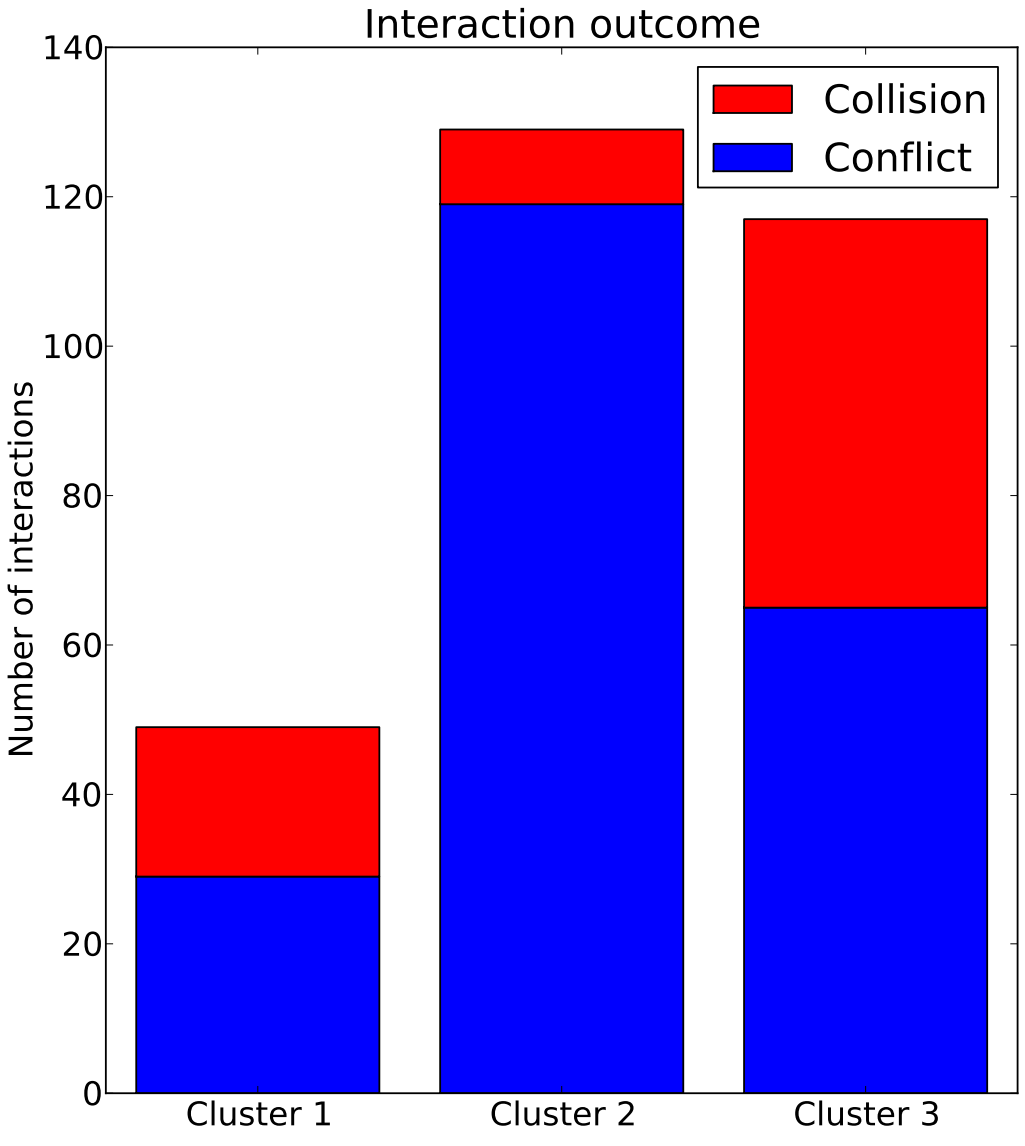
Numerical attributes	**Units**
Road user type	
passenger car	number of road users
van, 4x4, SUV	number of road users
bus	number of road users
truck (all sizes)	number of road users
motorcycle	number of road users
bike	number of road users
pedestrian	number of road users
Type of evasive action	
No evasive action	number of evasive actions
Braking	number of evasive actions
Swerving	number of evasive actions
Acceleration	number of evasive actions
3 attributes from Δv	km/h
6 values from s	km/h

Distribution of Speed Attributes

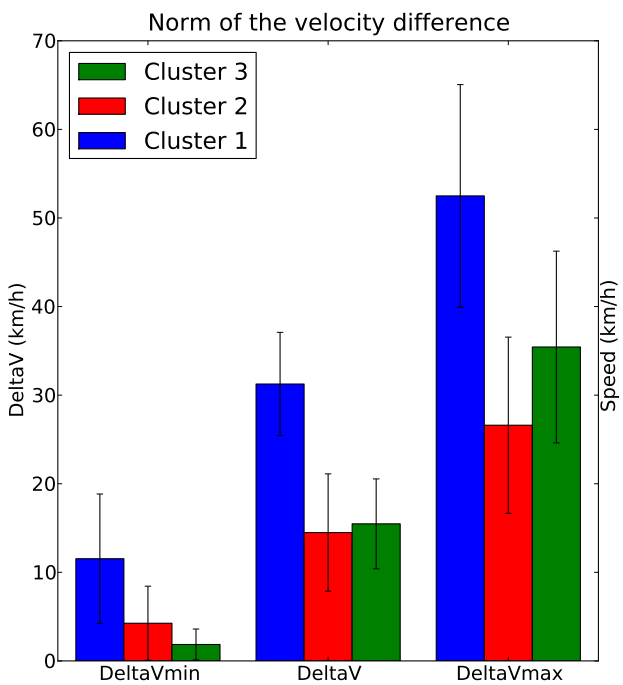


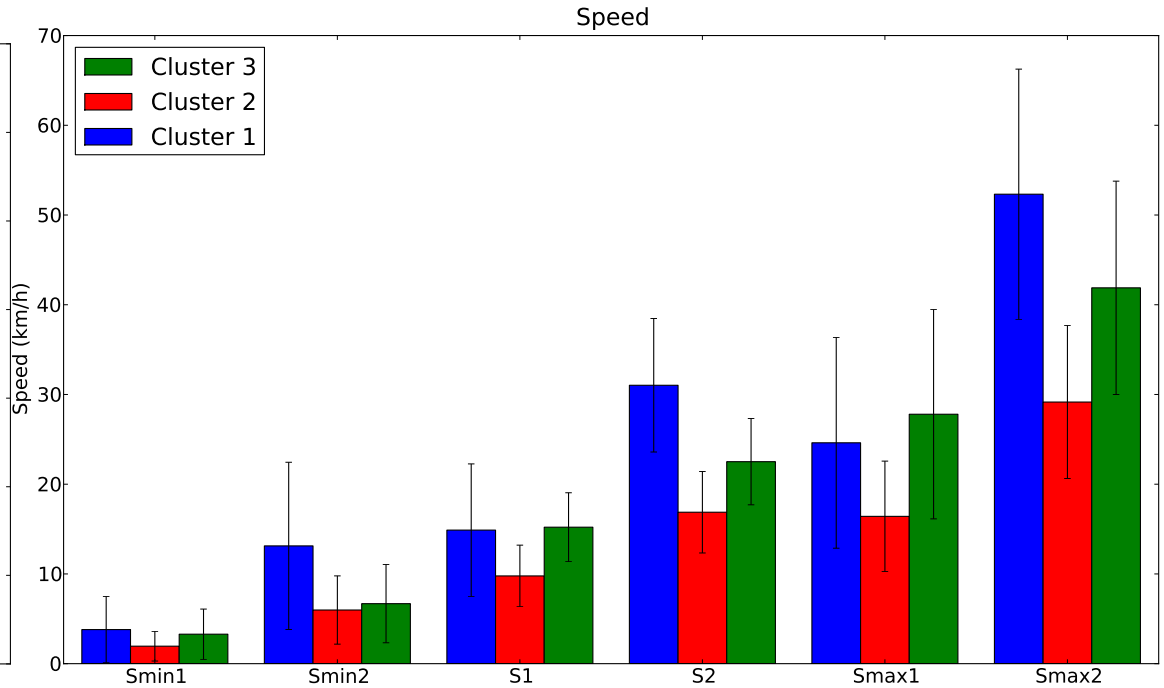


3 Clusters

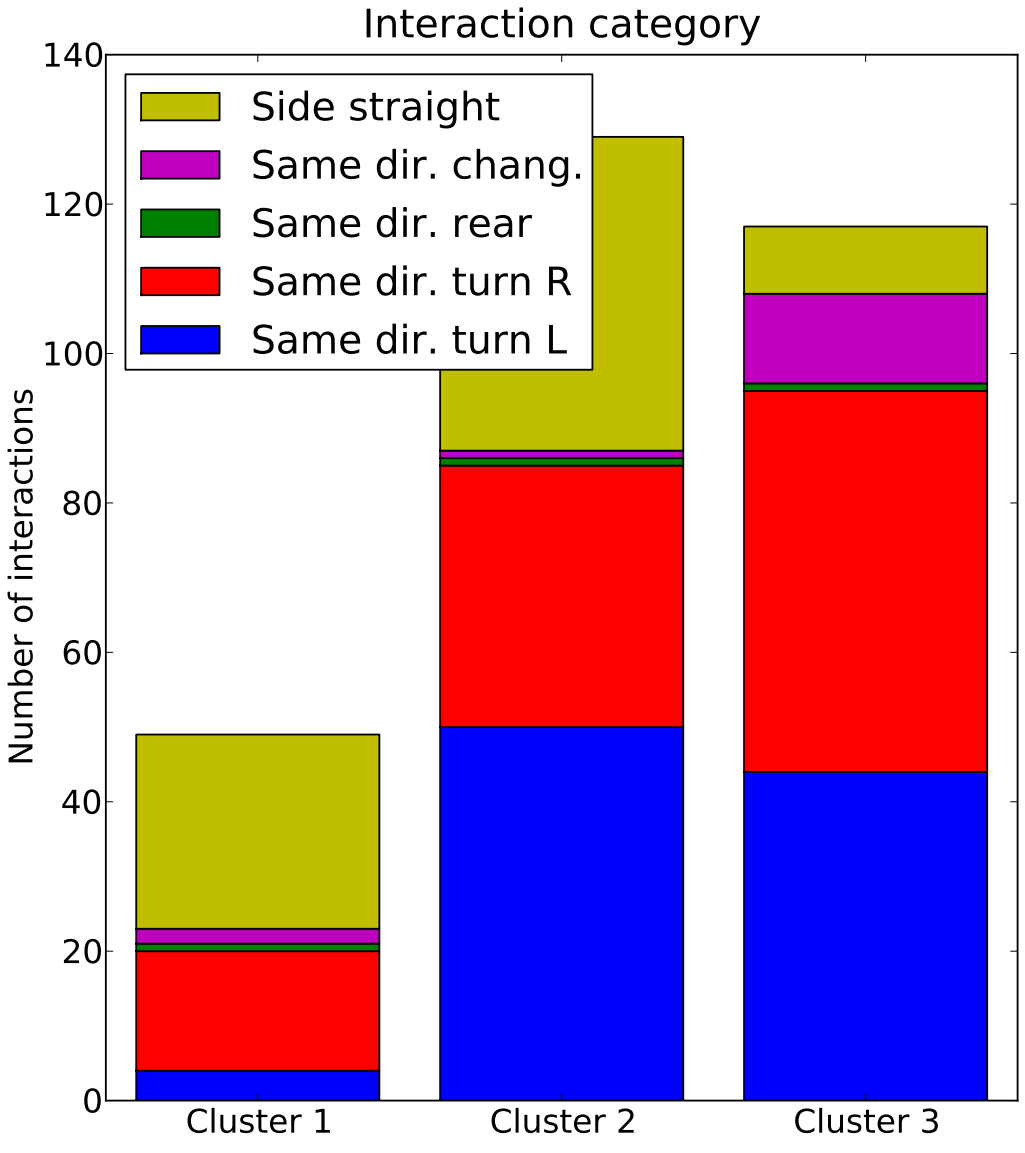

Interaction outcome
Collision
Conflict
Number of interactions
0
20
40
60
80
100
120
140
Cluster 1
Cluster 2
Cluster 3

3 Clusters: Speed Attributes





3 Clusters: Interaction Category



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  - Understanding and modelling of collision processes: collect more data
- Need for more open science: data and code sharing
  `http://nicolas.saunier.confins.net`

Collaboration with

- Clark Lim and Tarek Sayed (University of British Columbia)
- Karim Ismail (Carleton University)
- Nadia Mourji, Bruno Agard (École Polytechnique de Montréal)

Questions ?


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