Automated Road Safety Analysis Using Video Sensors

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Outline

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"Don't wait for accident to happen" (ICTCT's motto)

- Road safety is characterized by the occurrence of accidents.
- Traditionnal approaches rely on accident data.
- This requires large numbers, hence long collection time.
- One would even like to avoid waiting for accidents to actually happen.
- Need for complementary information, easily collectible, based on more frequent events and still related to safety (accidents).

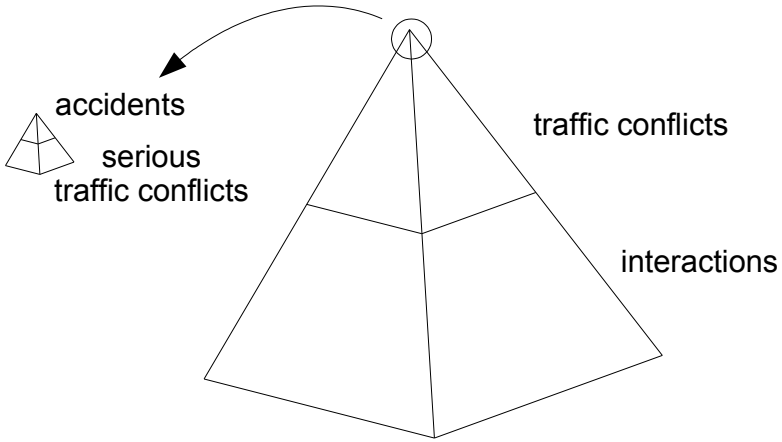
Traffic conflicts

Definition

"A 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." (1^{st} International Traffic Conflicts Workshop, 1977)

- A traffic conflict implies two components: a collision course and an emergency evasive action.
- A traffic conflicts is an interaction, defined as an observational situation in which two or more vehicles are close enough in space and time.

The safety hierarchy



Hypothesis

All interactions can be ranked in a safety hierarchy, with accidents at the top.

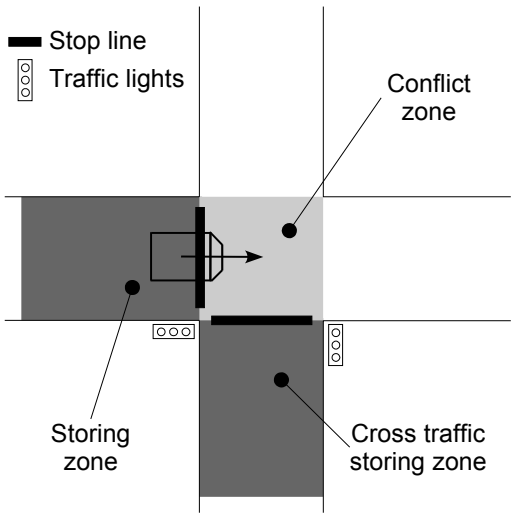
- The severity of an interaction measures the proximity to the potential occurrence of an accident.
- Development of Traffic Conflict Techniques (TCT).
  - Severity indicators, like the Time To Collision.
  - Need to assess the relationship between traffic conflicts and accidents: validity by construction and calibration conferences.
  - Interactions of all severity levels can help understand the traffic safety.

The need for automated methods

- TCTs provide a framework to investigate the safety of a location and provide detailed safety information.
- Main bottleneck of TCTs:
  - collection cost,
  - reliability and subjectivity of human observers.
- Few works on automated road safety analysis.

Outline

Categories of interaction



- Focus on the conflict zone
- Downstream category
- Cross traffic stationary category
- Cross traffic moving category

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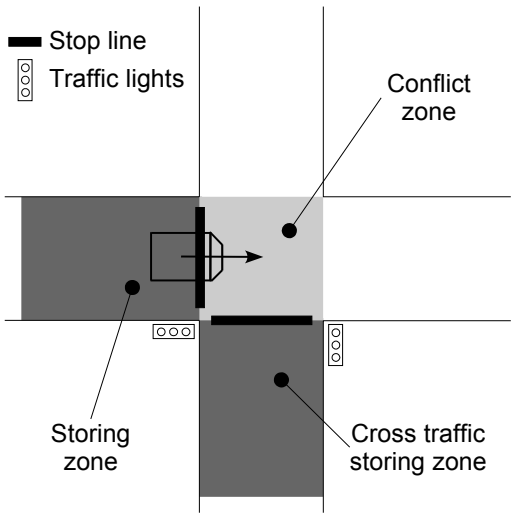

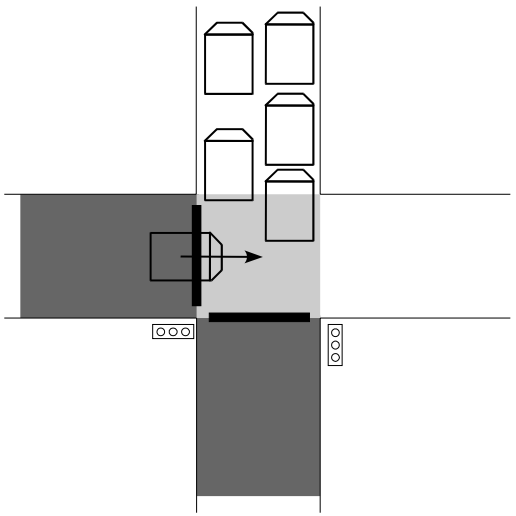

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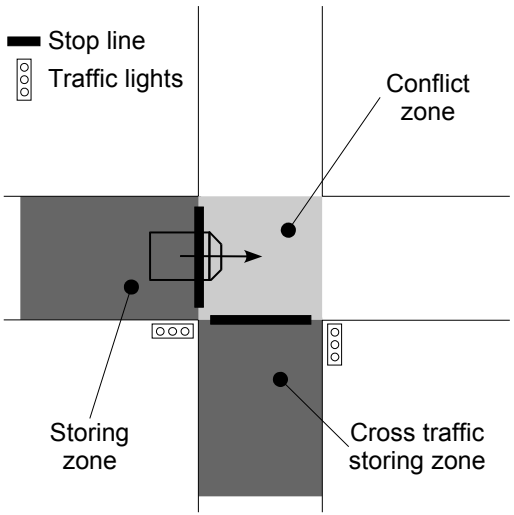

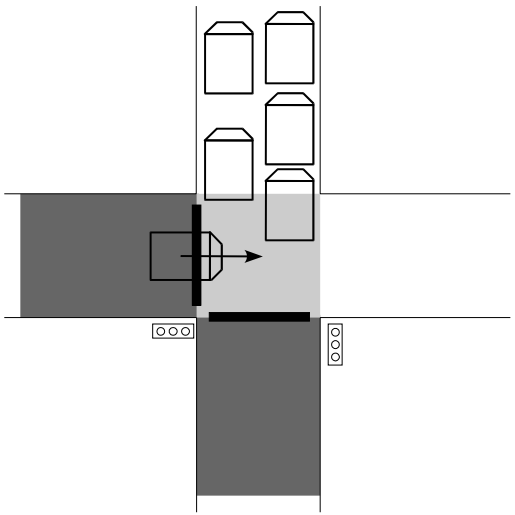

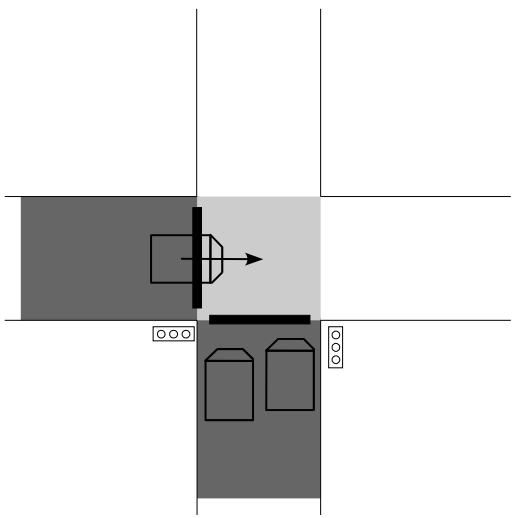

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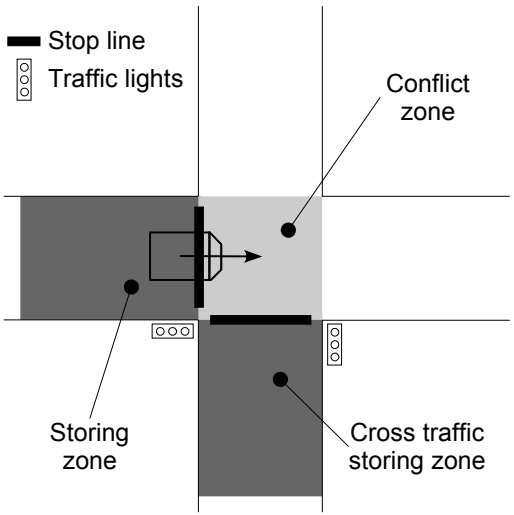

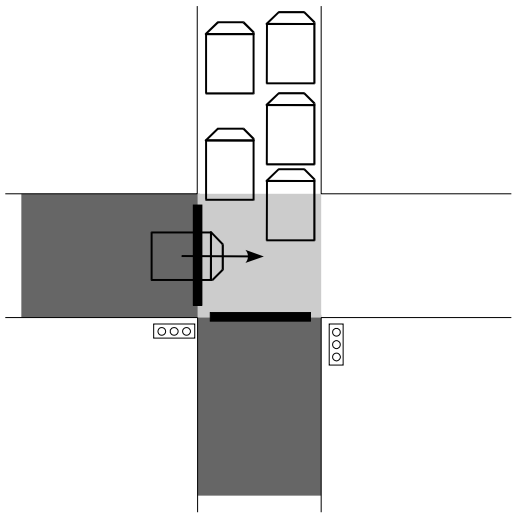

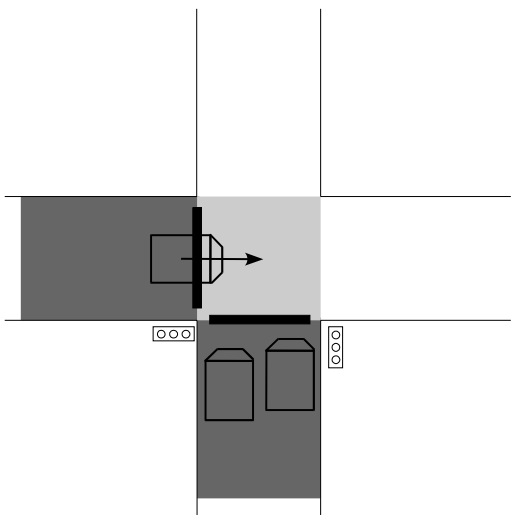

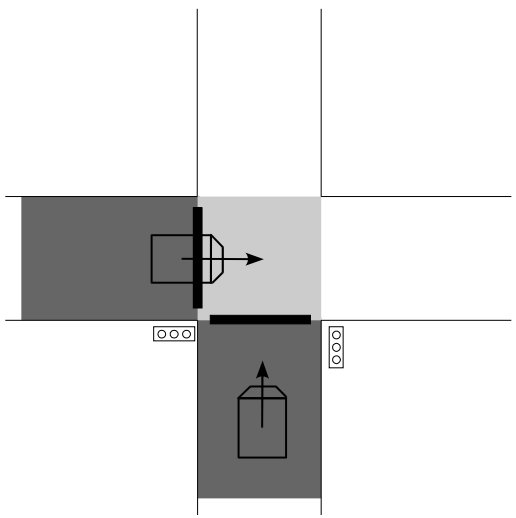

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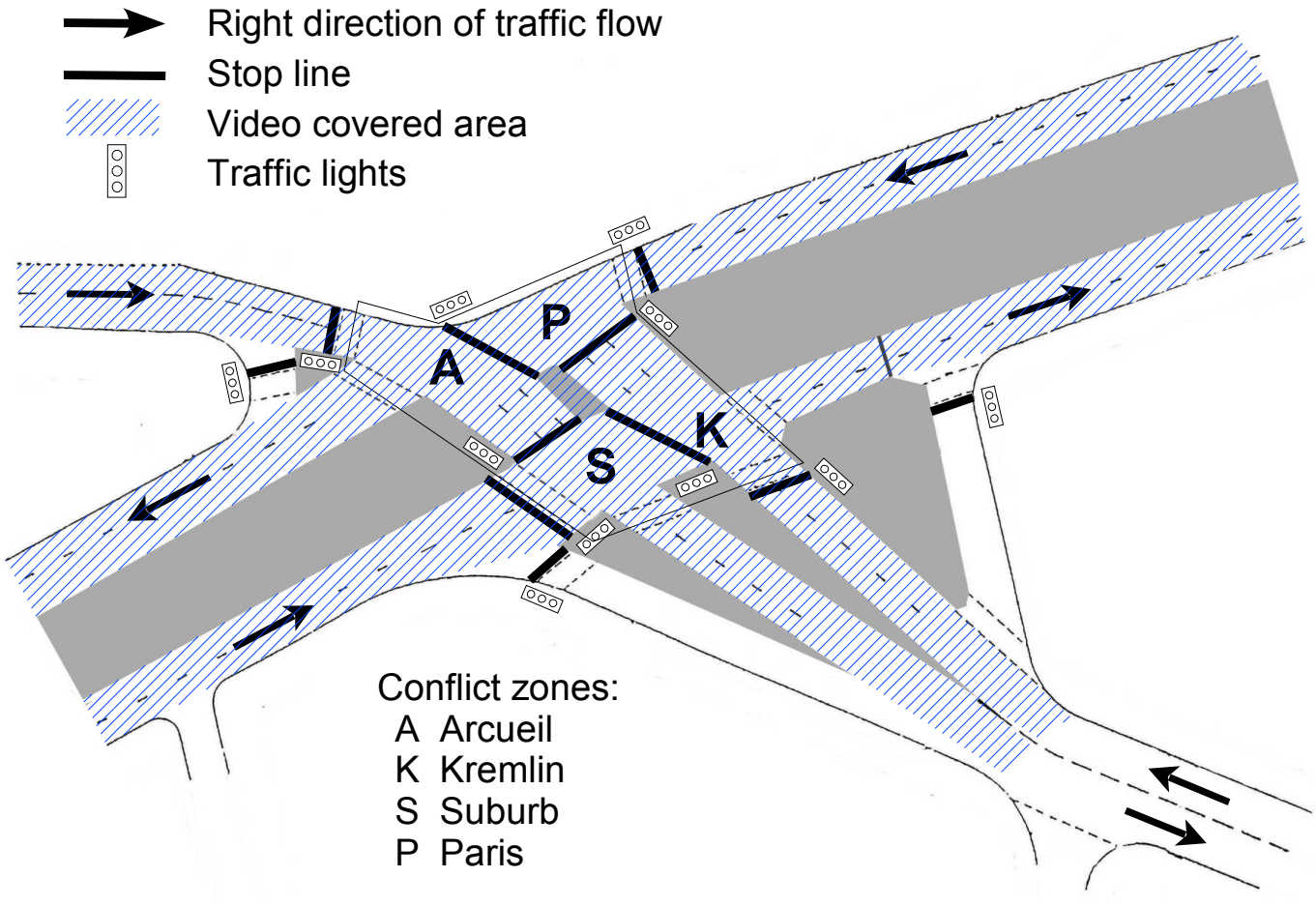
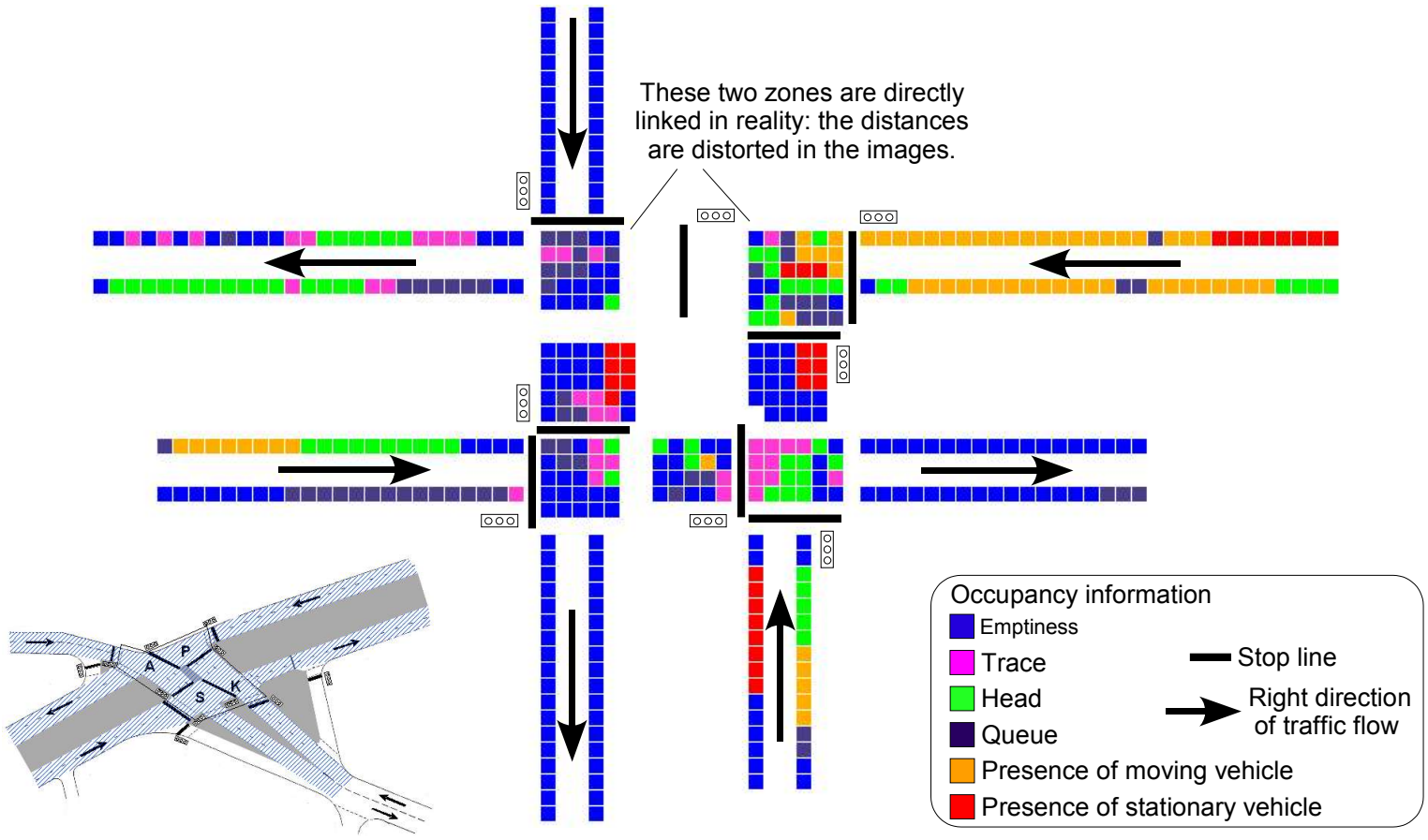
The experimental site



Isolated urban intersection, 8 month experiment with 4 traffic control strategies.

The data



Generic data, 1 frame/second, with information on the dynamics of vehicles.

The measurements

- Vehicles are not individually detected (nor recognized).
  - Interactions between groups of vehicles,
  - Interactions in different zones of the intersection.
- No tracking between frames.
  - The occurrence of interactions is detected at each instant, for a given conflict zone, origin, and category of interaction.

Definition

The exposure is a duration of interaction.

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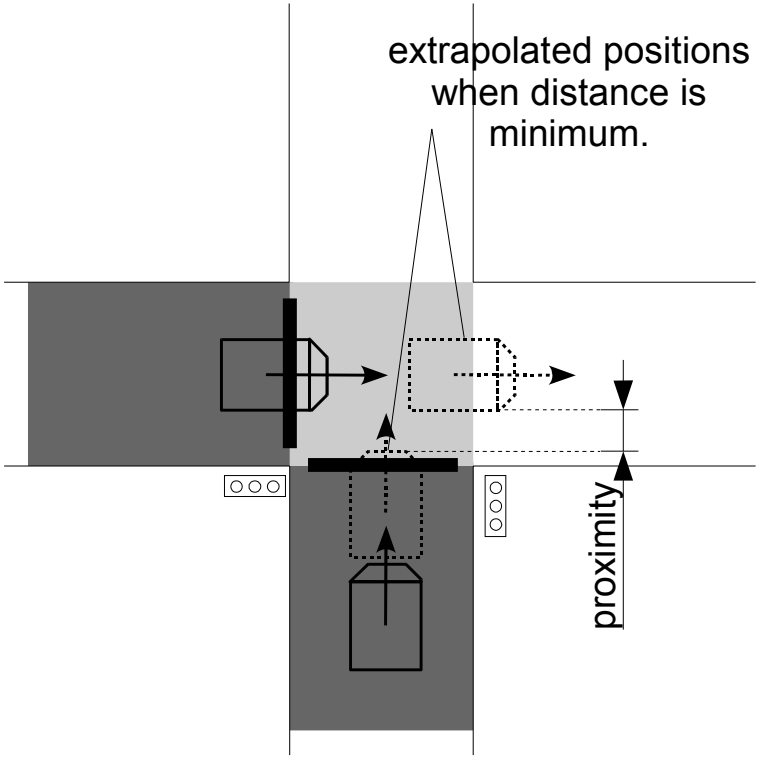
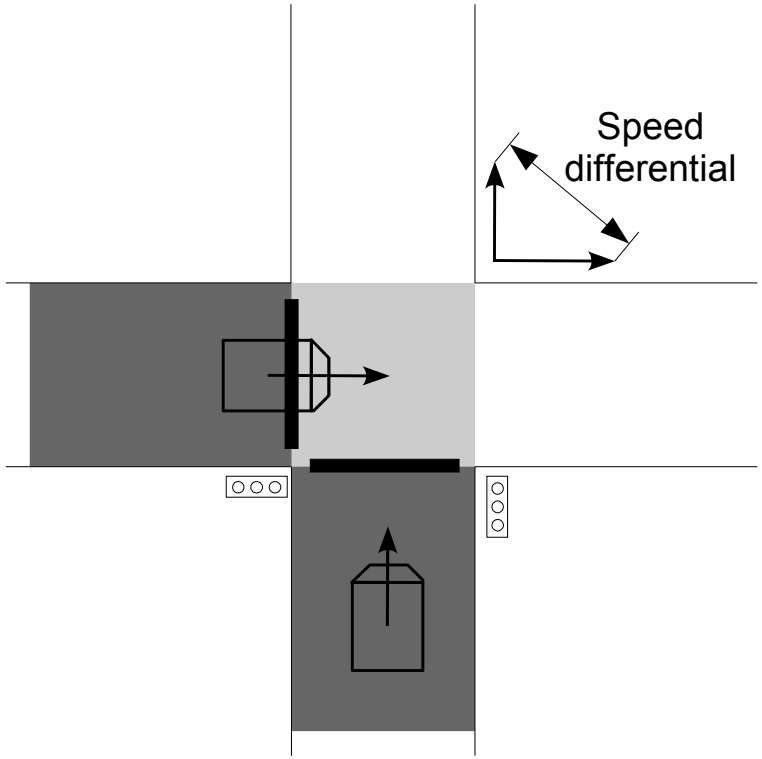
Severity indicators

Proximity indicator



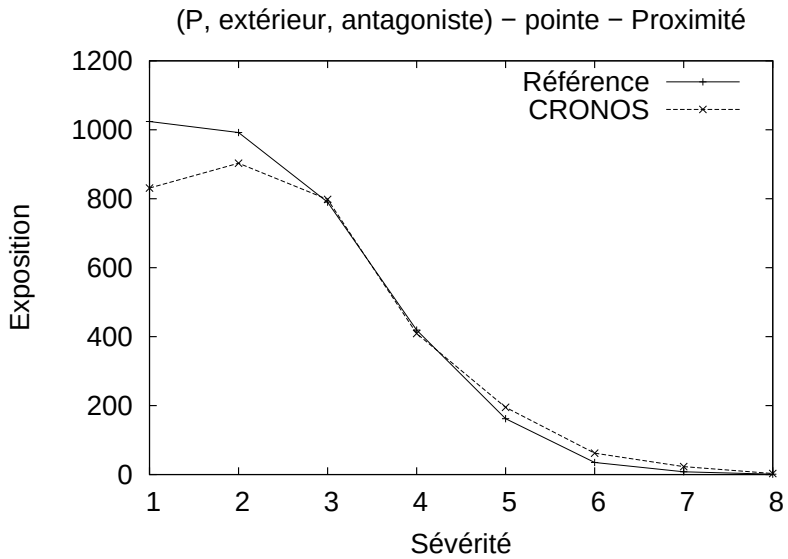
Speed indicator

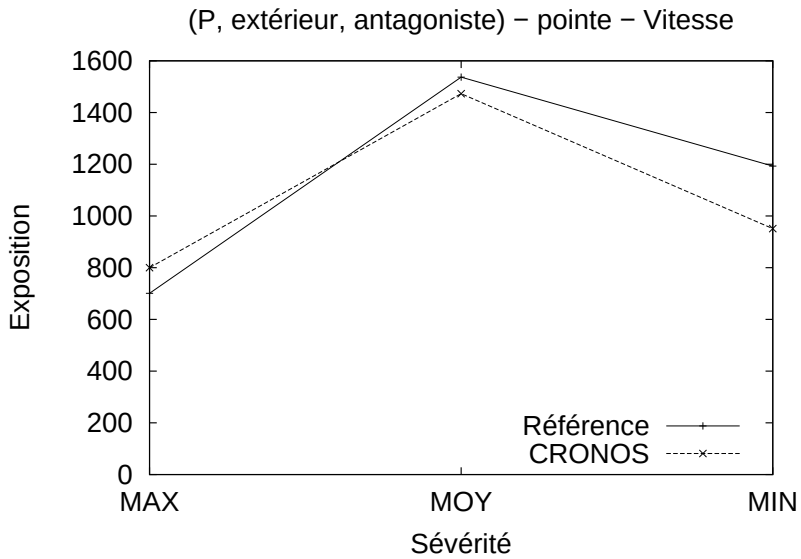


Method

- Study of exposure:
  - Total exposure over all severity levels,
  - Distribution of exposure according to the severity level.
- Comparison of a Reference strategy and a real-time adaptive strategy, CRONOS.
- Sample selection with close traffic demand for the 2 strategies: 5 hours per strategy and traffic condition (peak / fluid).

Results





- Differences:
  - The situation for total exposure is different in the studied conflict zones: P CRONOS / K Reference.
  - CRONOS implies a higher proportion of interactions with the maximum value of the speed indicator.

Summary

- Automatic system, integrated with other traffic management tools, to process complex real data.
- Precise task: compare the influence of traffic control strategies on traffic safety.
- Limitation of the severity range of detected interactions. The most severe interactions, e.g. traffic conflicts, cannot be identified as such. The link of the detected interactions to safety is not established.

Focus on more severe interactions, traffic conflicts.

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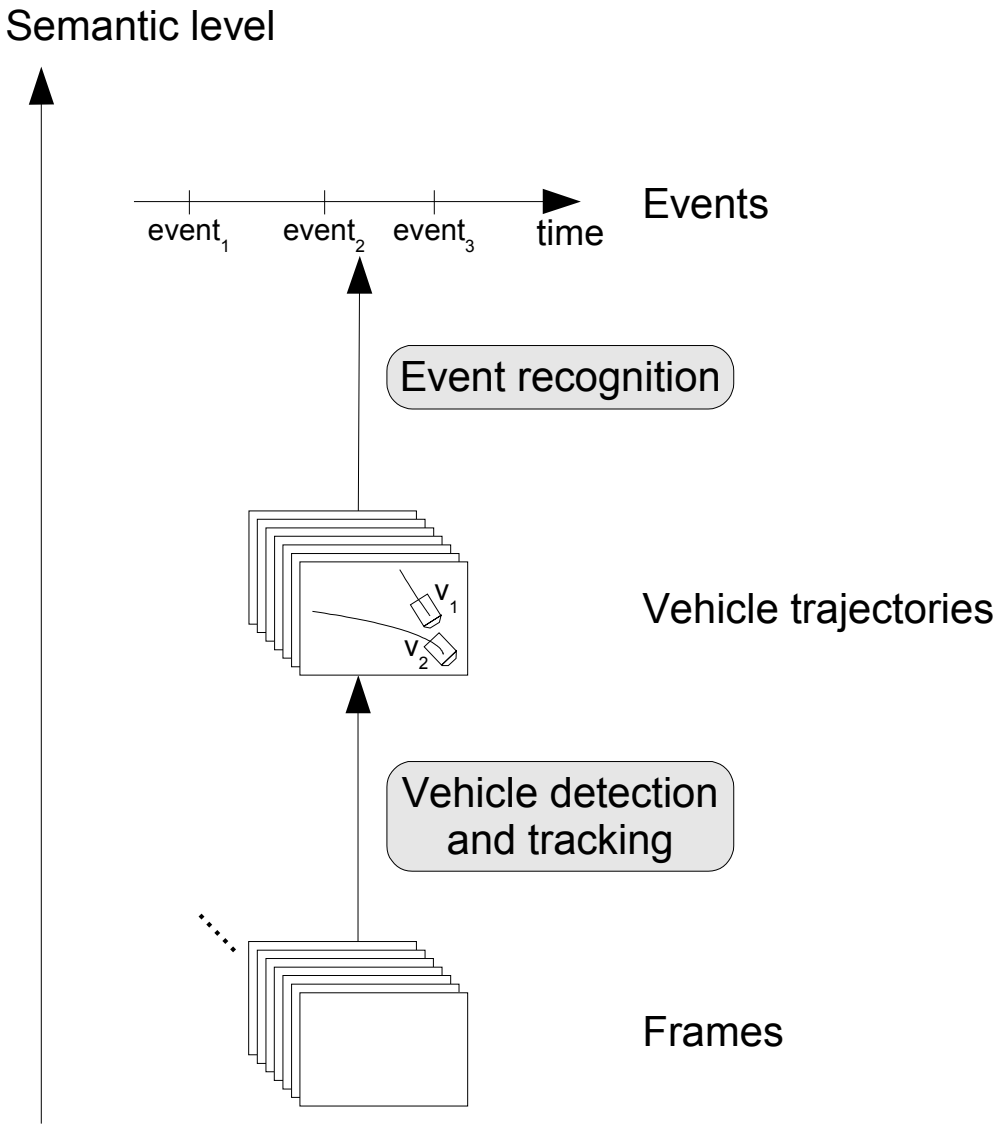
Video sensors

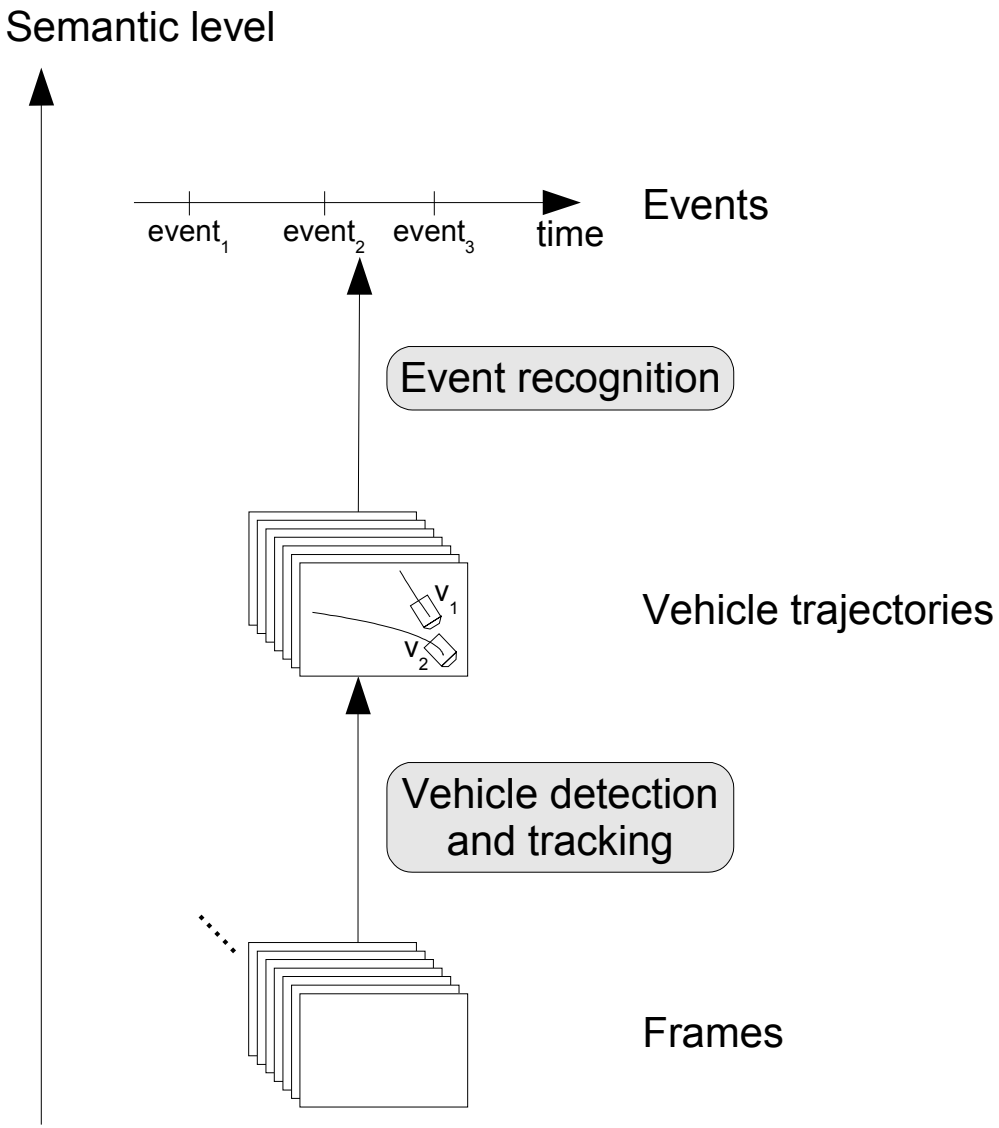
- Ease of use and installation.
- Possibility to get rich description of traffic parameters, even track vehicles.
- Large areas can be covered with a small number of video sensors.
- The main drawbacks are due to the complexity of the computer vision problems involved to interpret the data.
  - Existing open-source softwares: Intel OpenCV, KLT, matlab packages, Weka...

One stationary video camera to monitor intersections.
Task: detect traffic conflicts / filter hours of video sequences.

A generic scene analysis modular system

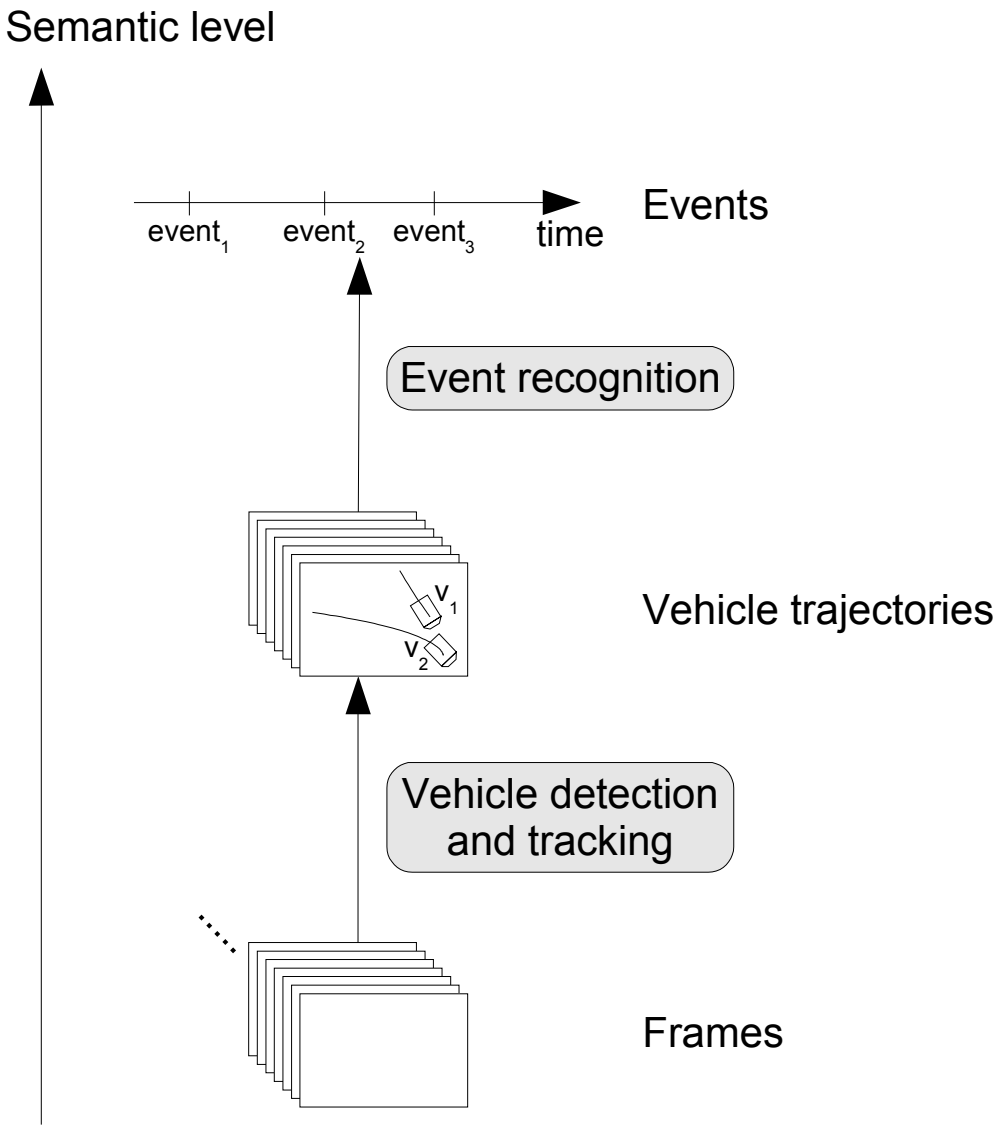


Vehicle detection



- Optical flow.
- Frame by frame differencing.
- Background subtraction.

Vehicle tracking



- Model-based.
- Blob-based.
- Contour-based.
- Feature-based.
  - robust to partial occlusions,
  - self-adapting to various lighting conditions,
  - problem of the grouping of features.

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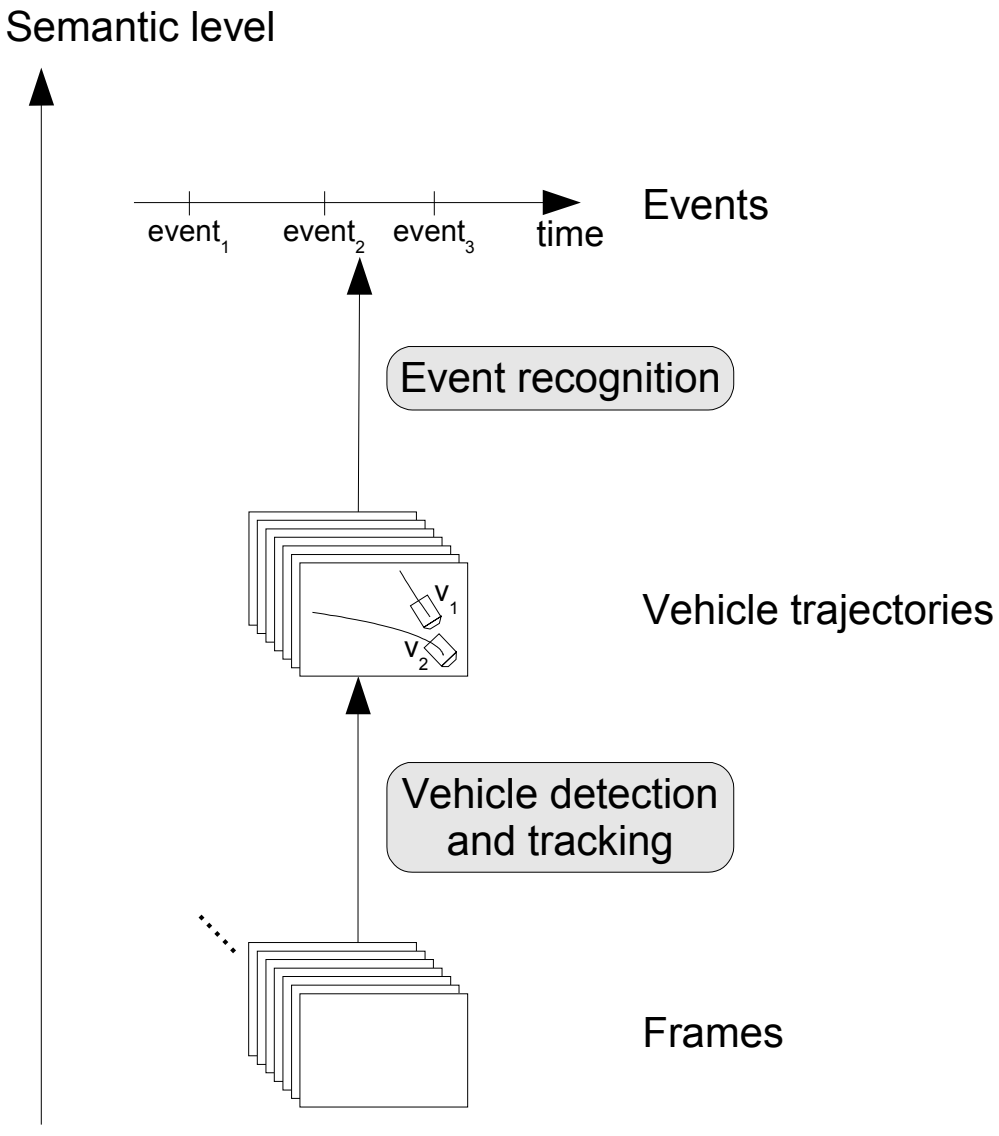

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Machine learning for scene understanding

"In general, it is not necessary to have perfect object reconstruction before we achieve the visual understanding required for real-world applications".

- Supervised learning for robustness (e.g. with respect to rule-based systems).
  - ex: Dynamic Bayesian Networks (Hidden Markov Models).
- Unsupervised learning: explore huge amount of unlabeled data to detect unusual events such as traffic conflicts.
  - ex: clustering techniques, hierarchical classification, SOM.

Semi-supervised learning

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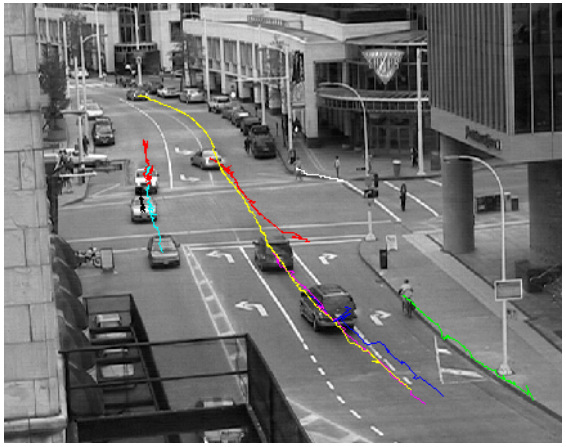
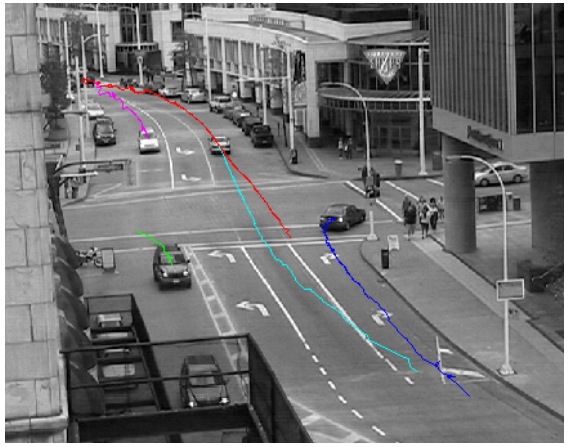
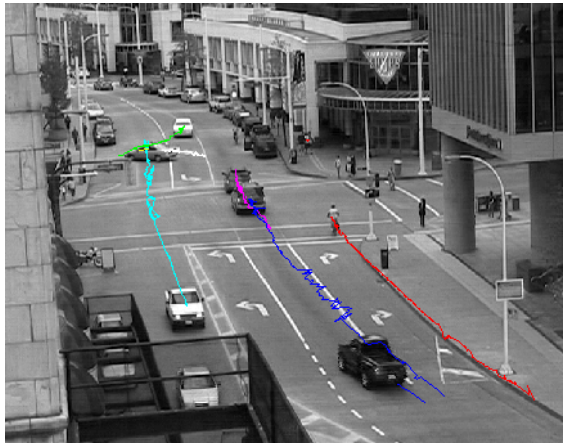
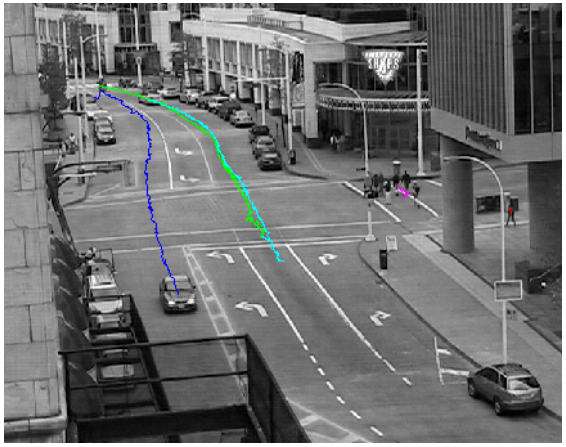
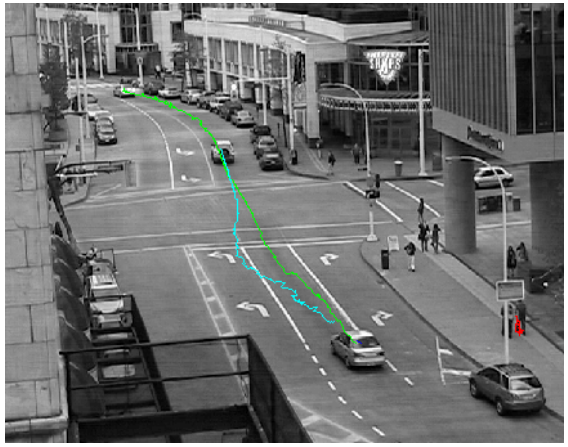
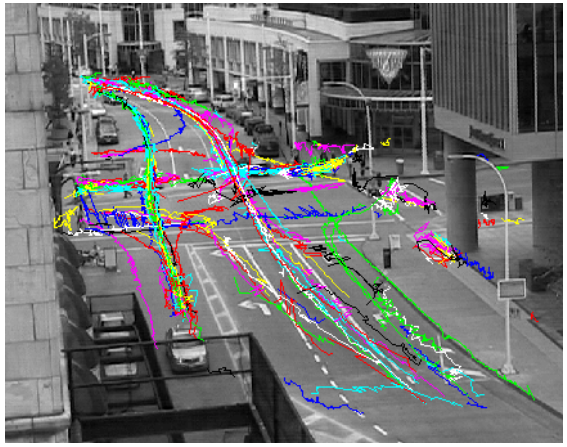
State of the tracking module

Work in progress

- Exciting point where computer science brings new capabilities to transportation science and road safety.
- Challenges to use the right models / data. Is vehicle tracking necessary ?
- Future developements,
  - camera calibration (real-world coordinates), vehicle classification, better occlusion handling, real-time functioning...

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