Development of An Overall Experimental and Theoretical Methodology for Video-Based Safety Assessment

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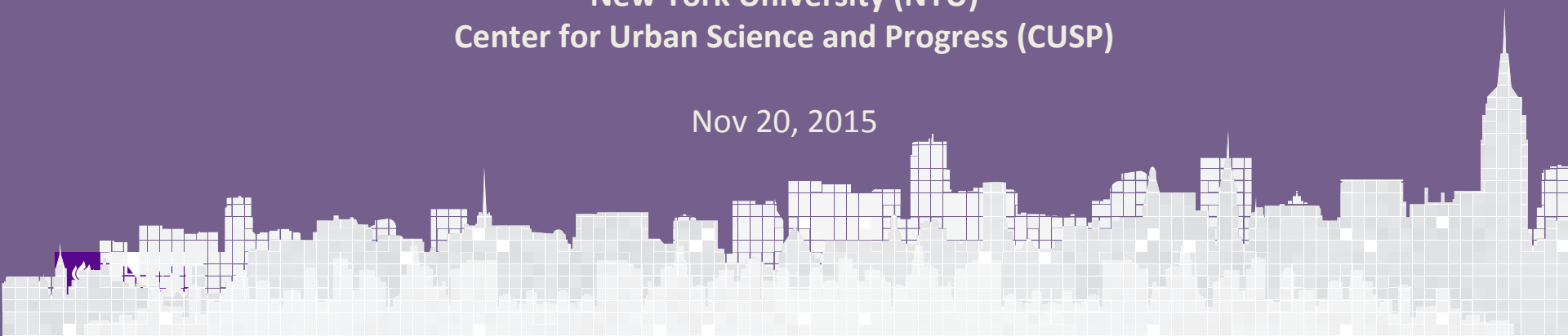
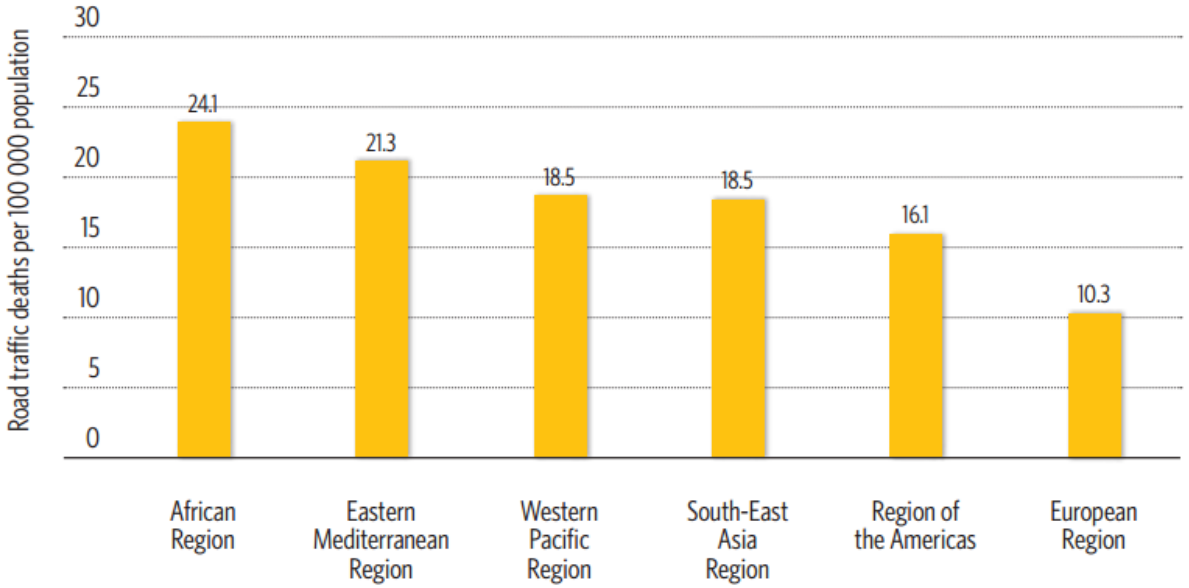
Nov 20, 2015



Addressing Global Safety Issues

- Each year, there are about 1.24 million road traffic deaths worldwide
- Road traffic injuries are the leading cause of death among young people, aged 15–29 years
- 91% fatalities occur in low-income & middle-income countries
- Half of those fatalities are "vulnerable road users": pedestrians, cyclists and motorcyclists
- Without action, the estimated road traffic crash deaths are about 1.9 million/year by 2020
- Only 28 countries, representing 416 million people (7% of the world's population), have adequate laws that address all five risk factors (speed, drink-driving, helmets, seat-belts and child restraints)



Source: Global Status Report on Road Safety 2013, WHO

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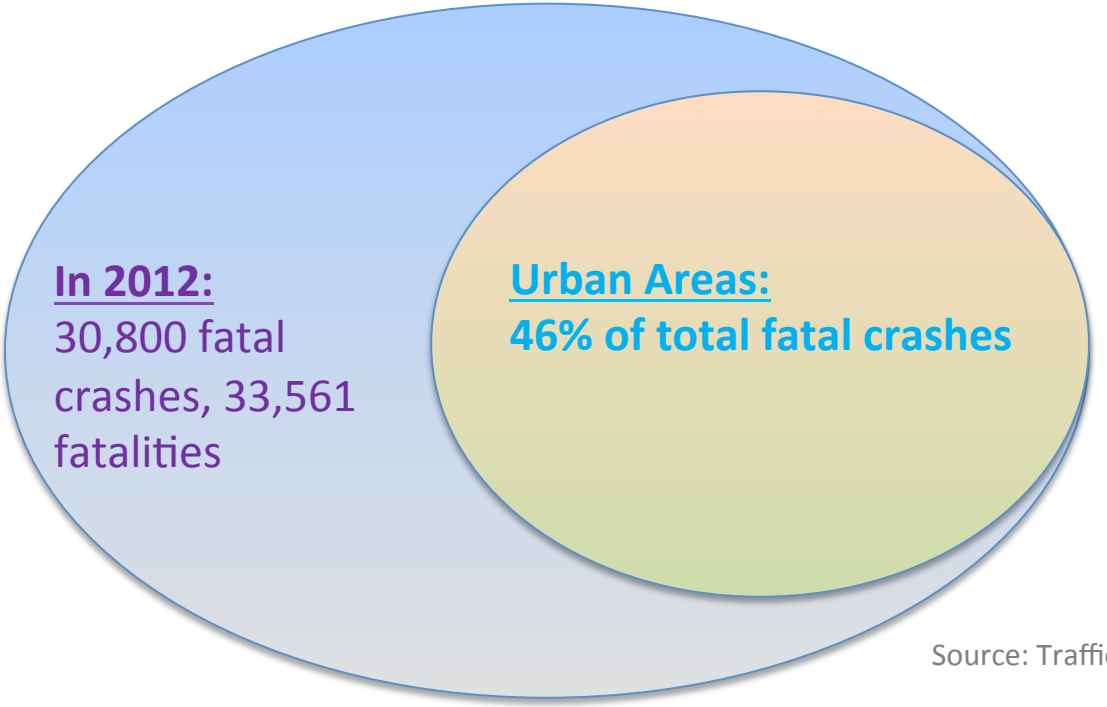
Traffic Safety Issues in US

- In 2012, there were 30,800 fatal crashes resulting in 33,561 fatalities



Source: Traffic Safety Fact 2012, NHTSA

- 43% of vehicle crashes occur at intersections or are "intersection-related" (12,449 fatal crashes and 1,505,000 injury crashes)

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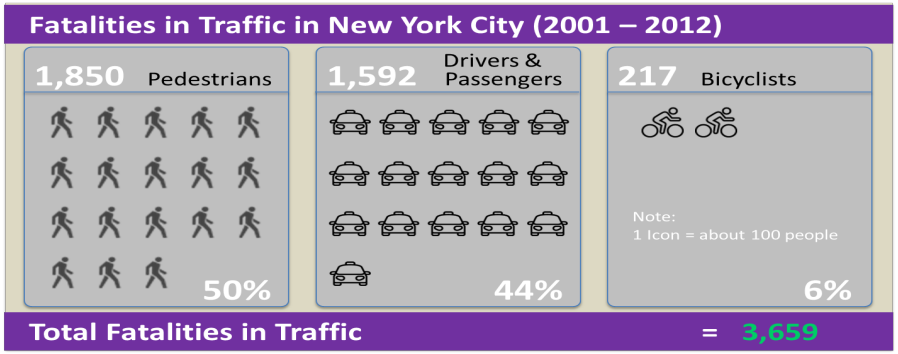
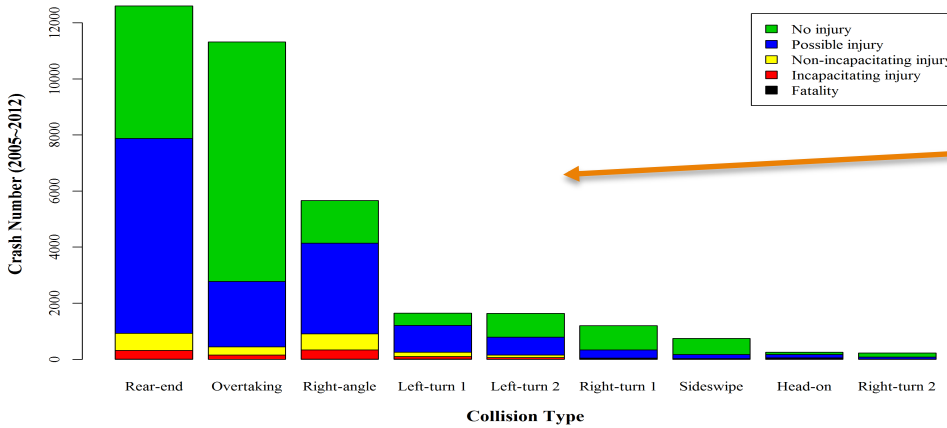
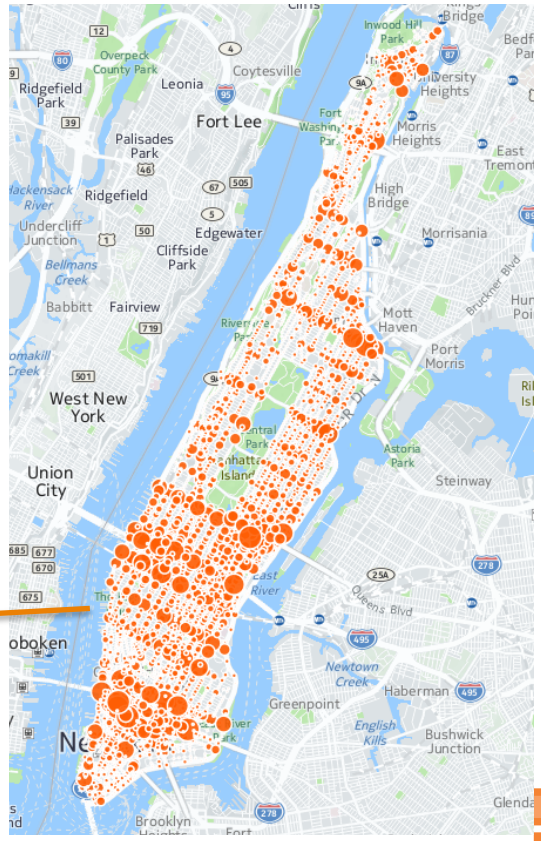
NYC Safety Issues and Vision Zero Plan

- The Vision Zero Action Plan: 63 initiatives to reduce death and serious injury on our streets
- Identification of high-risk intersections and highways; and the assessment of safety improvement solutions are needed



Note: US traffic fatalities (2001 – 2012) = 435,182
NY State fatalities (2001 – 2012) = 16,199





Start-of-the-Practice for Safety Improvements

- Improving intersection safety in a comprehensive and focused way is a highly complex task, which may include:
  - ✓ Alternative intersection design (geometric, sight distance)
  - ✓ Traffic control and operational improvements
  - ✓ Signal timing optimization
  - ✓ Red-light running enforcement
  - ✓ Human factors (improve awareness, compliance)
  - ✓ Pedestrian and bicyclist (infrastructure, access, control, etc.)

Limitations of Existing Approaches

- Heavily relying on multi-year historical crashes data
- Ethical issues: have to wait until the crash happen for assessment
- Before-After comparisons cannot control all factors; difficult to find reference groups, etc.

Evaluation is needed to assess whether the proposed solutions work!

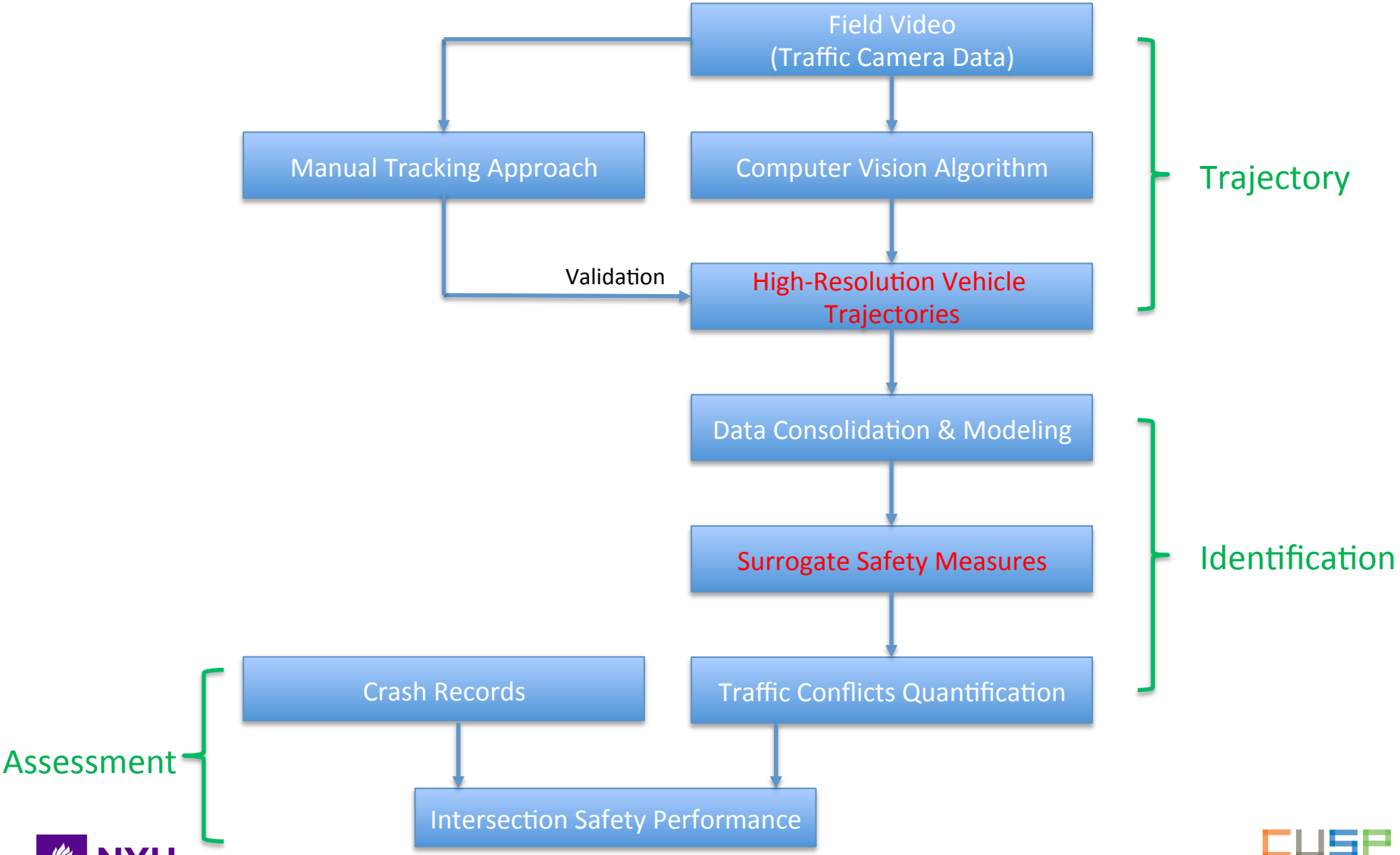
Alternative approaches that do not rely on crash data will be helpful.

Project Goals and Objectives

- **Goals**: Advance data-driven traffic analytics to enhance Global Resilience

- **Objectives**:
  - ✓ Propose a novel approach for examining traffic safety performance at intersections
  - ✓ Quantify traffic conflicts using developed "*surrogate*" safety measures
  - ✓ Develop automatic data acquisition, analysis and modeling approaches based on computer vision techniques

Overview of Proposed Approach



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Vehicle Tracking Process

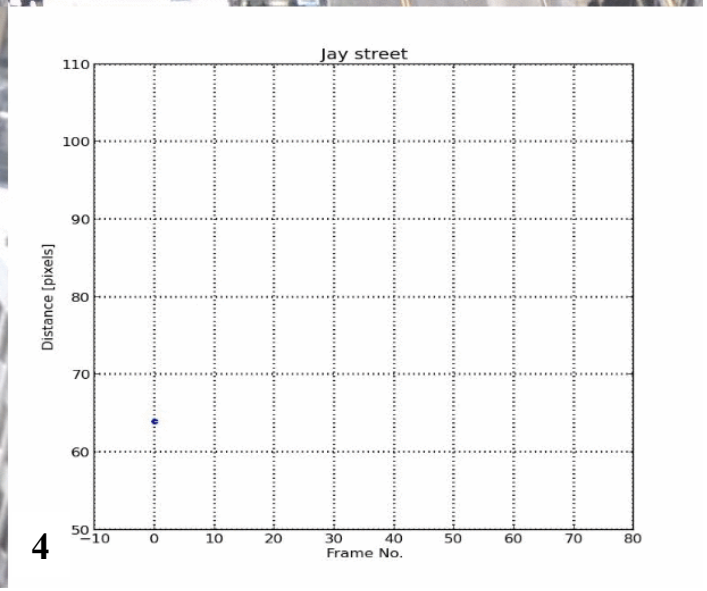
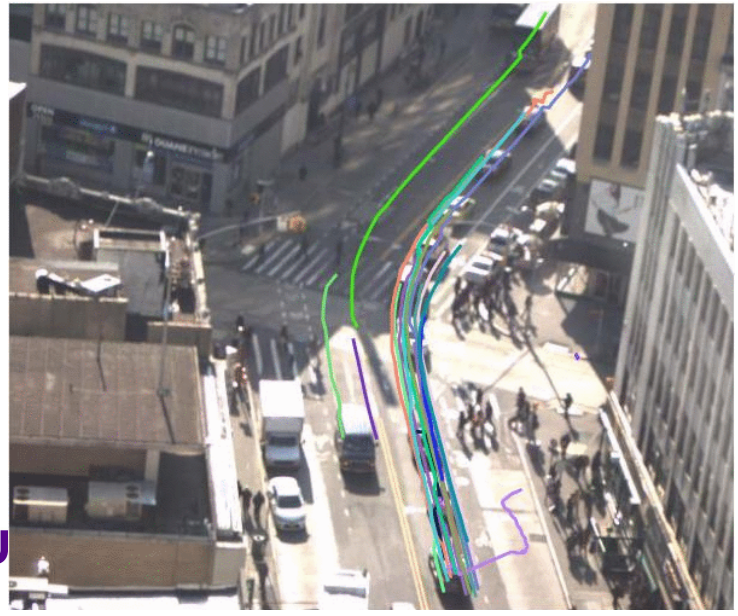
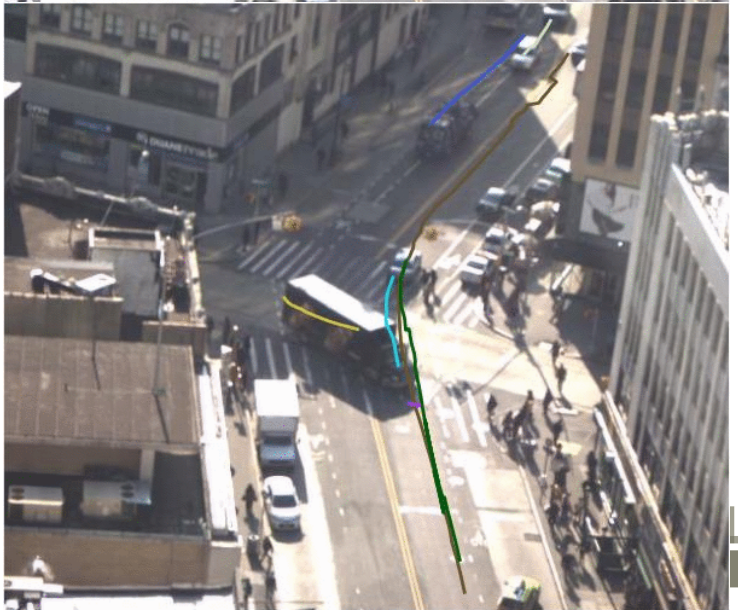


Fig. 1: Original video recording
Fig. 2: Extract feature points using Kanade-Lucas-Tomasi (KLT) Feature Tracker
Fig. 3: Group feature points using Dirchlet process mixture algorithm
Fig. 4: Convert coordinates to relative distances

More Tracking Results





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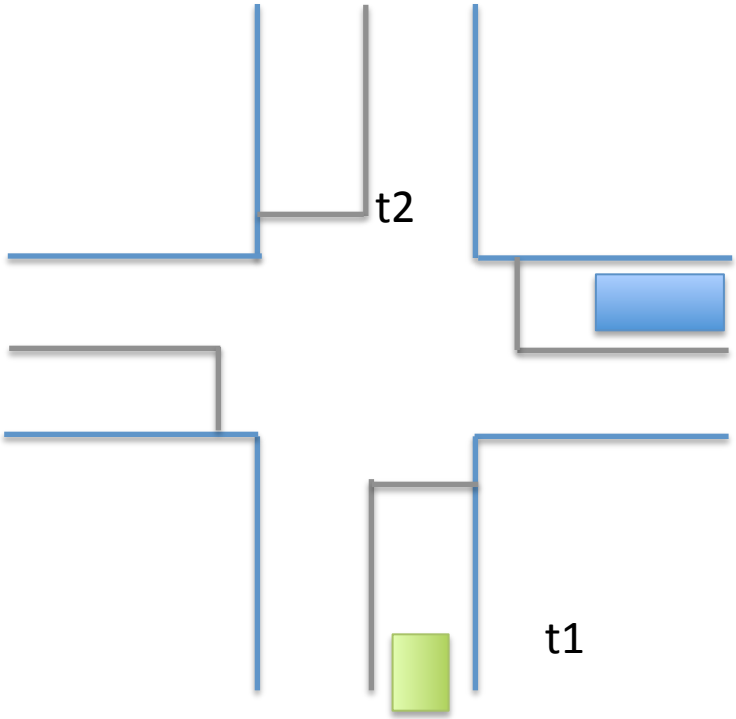
Identify Traffic Conflicts Using "*Surrogates*"

- "***Surrogate***" **Safety Measures:** Indicators that describe the scenarios in which a vehicle would collide with another vehicle if they did not change their current intentions.

Rear-end conflict



Right-angle conflict

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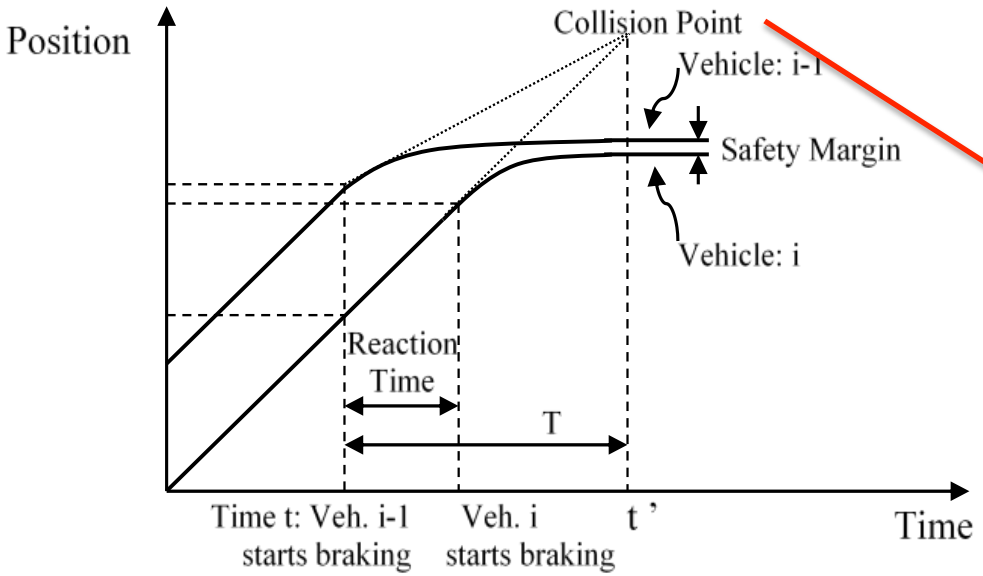
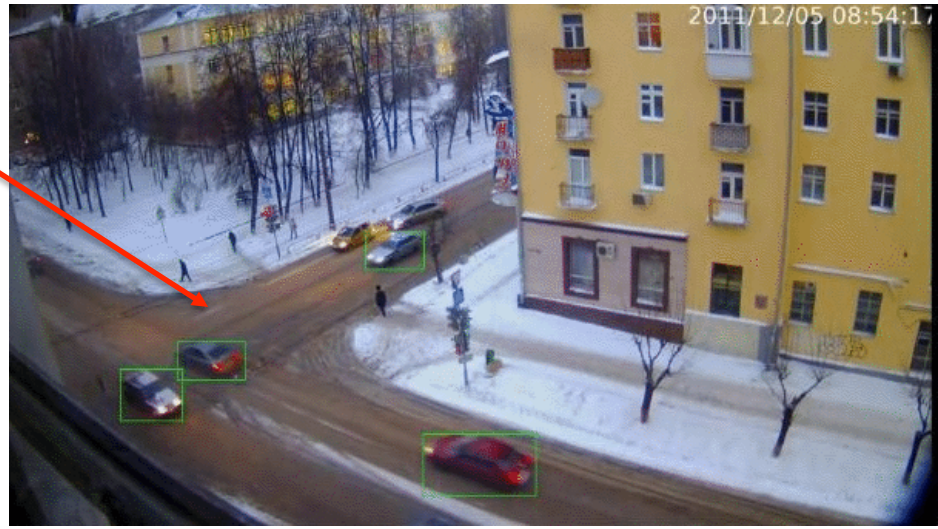
Development of Surrogate Safety Measures

- Time to collision (TTC)



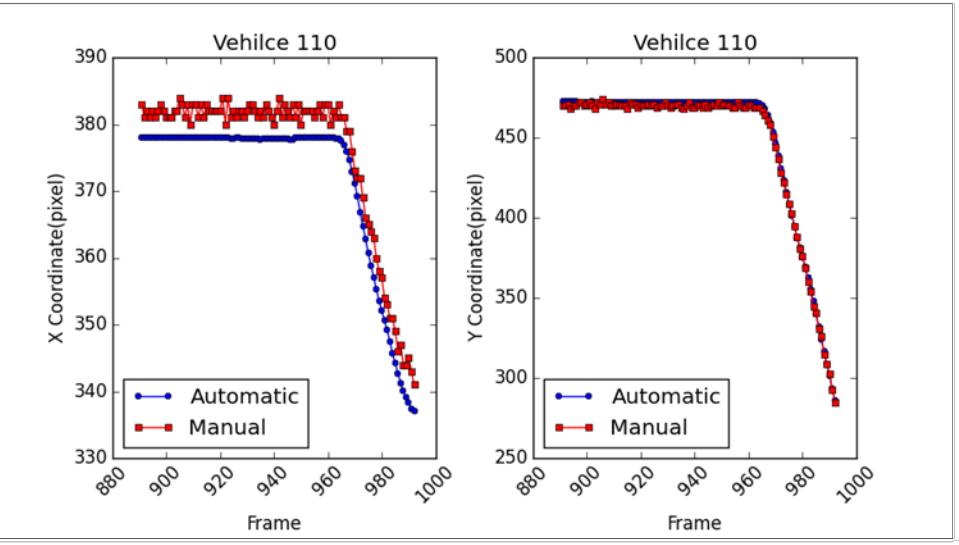


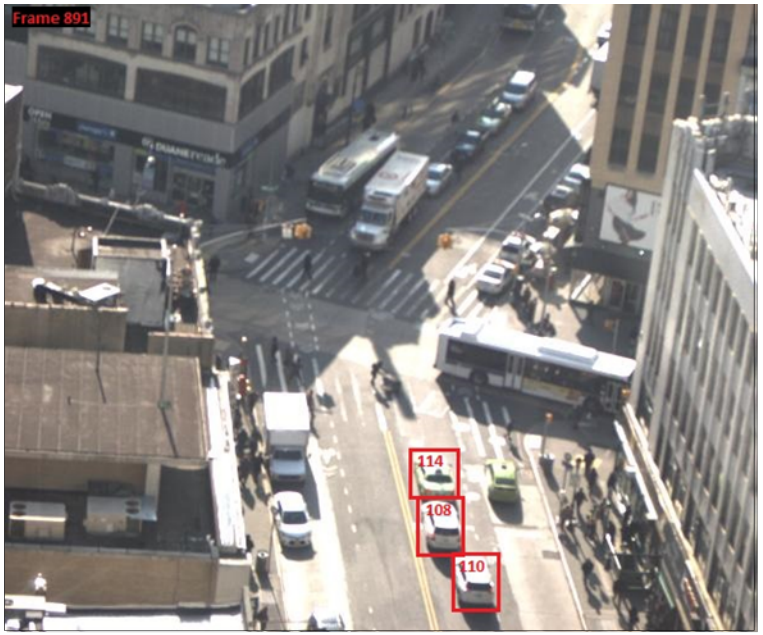
Our goal is to identify the conflict prior to the actual collision at t'.

$$TTC_i(t) = \frac{X_{i-1}(t) - X_i(t) - L_i}{V_i(t) - V_{i-1}(t)} \qquad \forall V_i(t) > V_{i-1}(t)$$

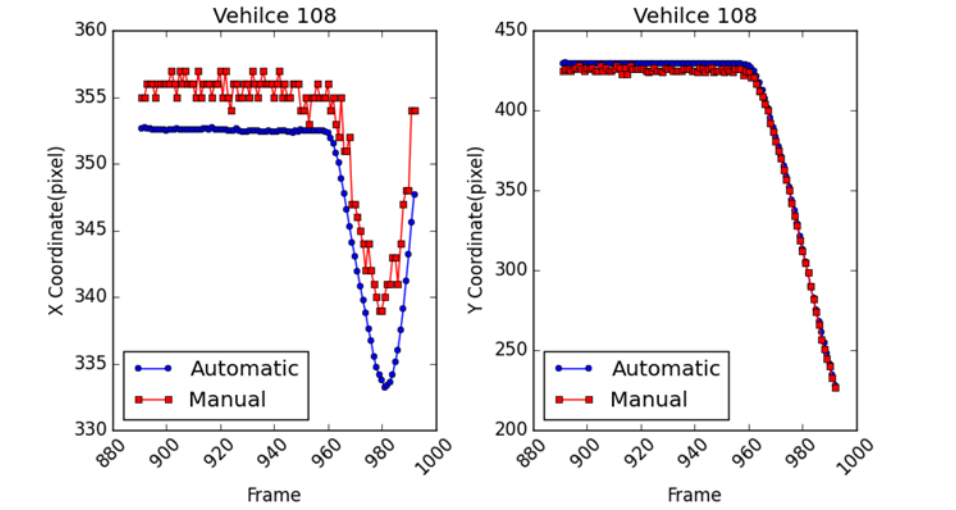
where X is the position of the vehicle at time t; V is the speed of the vehicle at time t; and L is the vehicle length

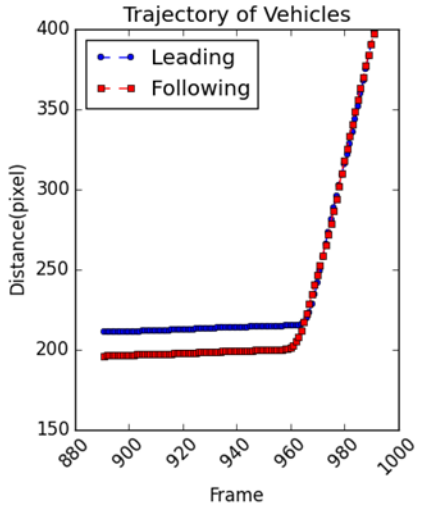
Jay St Demo: No Conflict

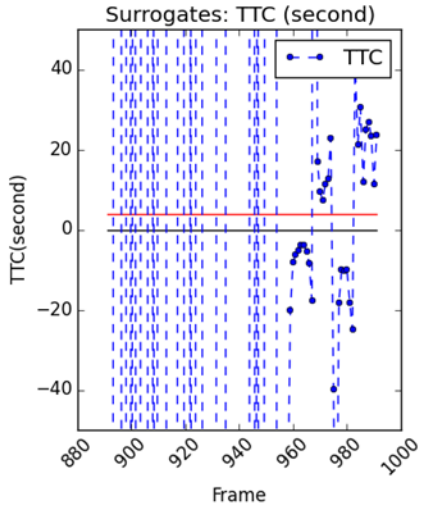




Estimated Surrogates based on Automatic Tracking Results







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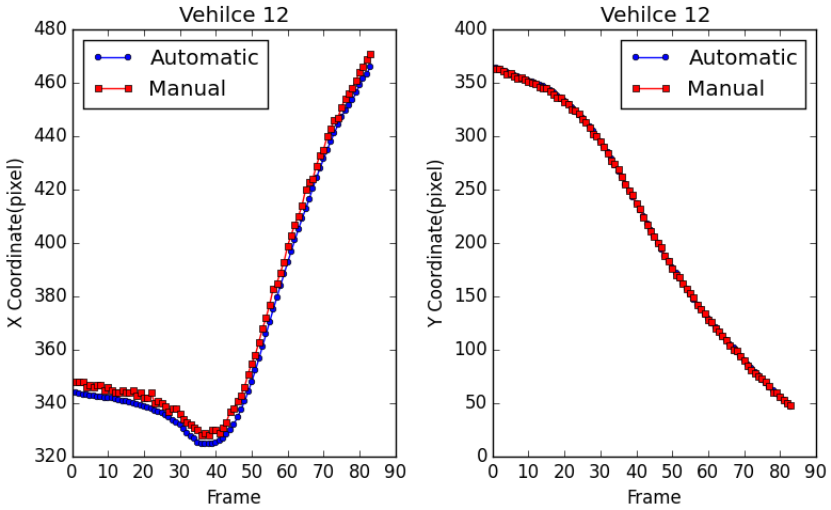
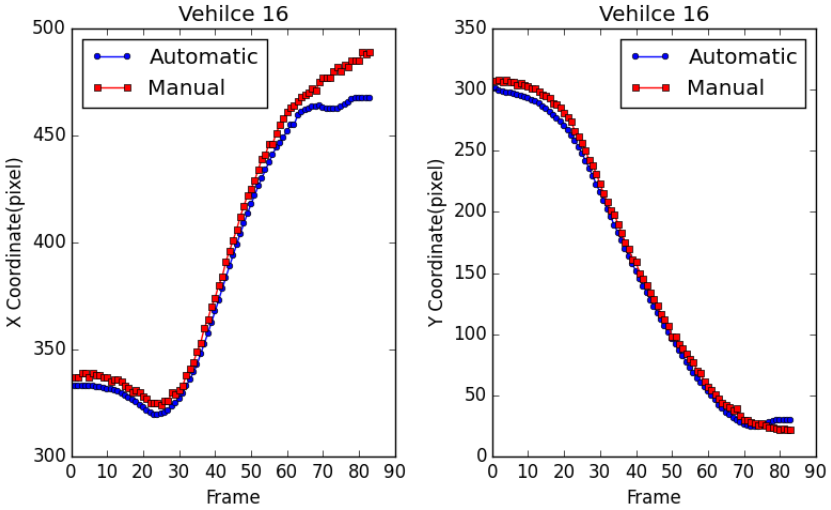
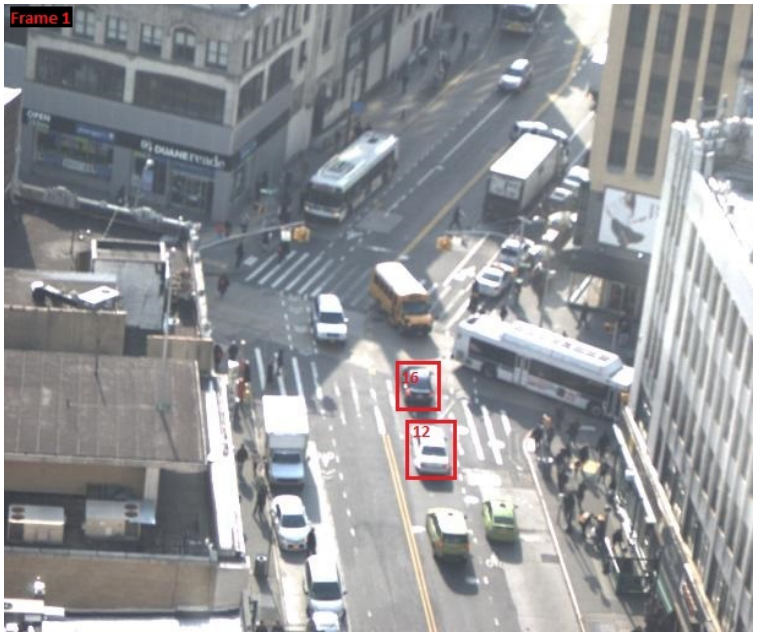
Manual tracking vs. automatic tracking

No conflicts

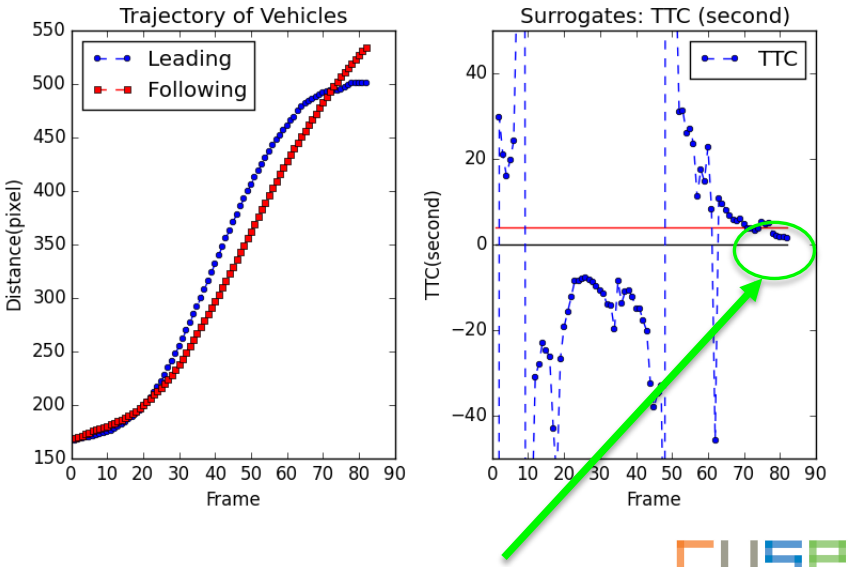
Jay St Demo: Conflicts







Estimated Surrogates based on Automatic Tracking Results



Conflicts: TTC<4.0 seconds

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Safety Analysis Using Automated Tracking Data

- Pair all the possible vehicles which can have chances to collisions.
- Identify the collision risk between each pair of vehicles.
- Obtain a comprehensive safety indices for the whole study period.
- Dataset used
  - 110 min video of Jay St & Fulton St
  - 4,340 vehicle trajectories generated

Filtering

- Any trajectories lasting less than 15 frames are eliminated, considering the average time an vehicle needed to pass through this intersection and the frame rate of this video.
- 1,079 out of original 4,340 trajectories are filtered out.

Direction Detection

- Detect driving direction of each vehicle (northbound or southbound), based on whether the y coordinates are monotonically decreasing or increasing.
- Vehicles whose driving direction changed are identified and screened out at this stage.

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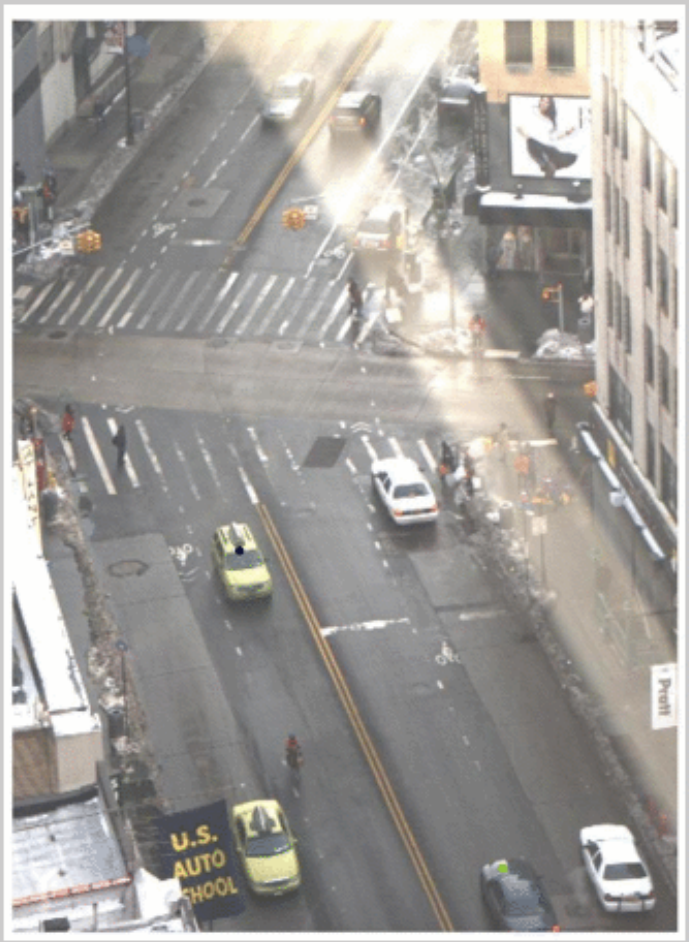
Pair Vehicles Automatically

- Find the start frame and end frame of each trajectory.
- Pair vehicles which coexist for at least 15 frames.
- Explore all the possible pairs.
- 4,757 pairs generated



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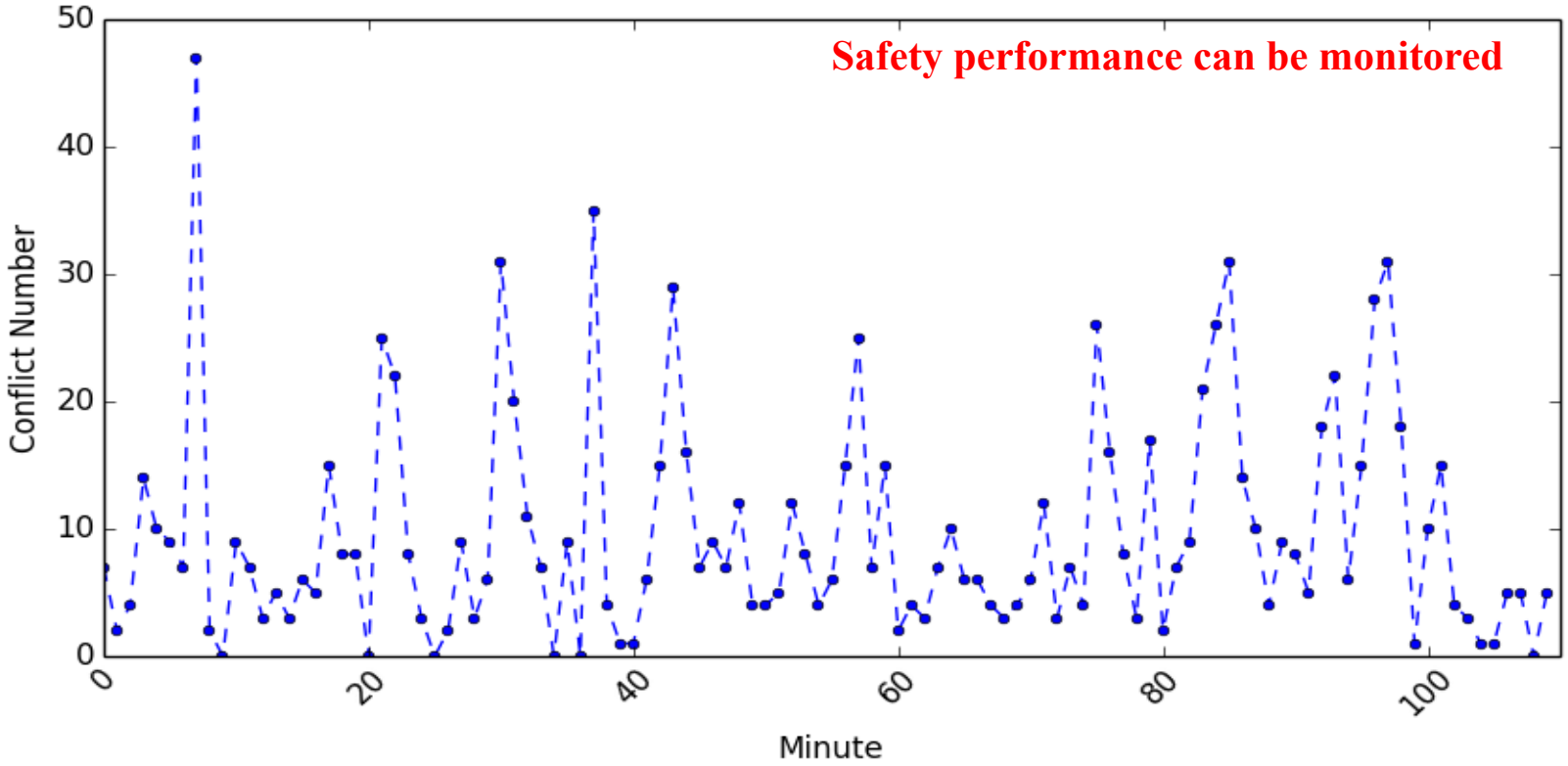
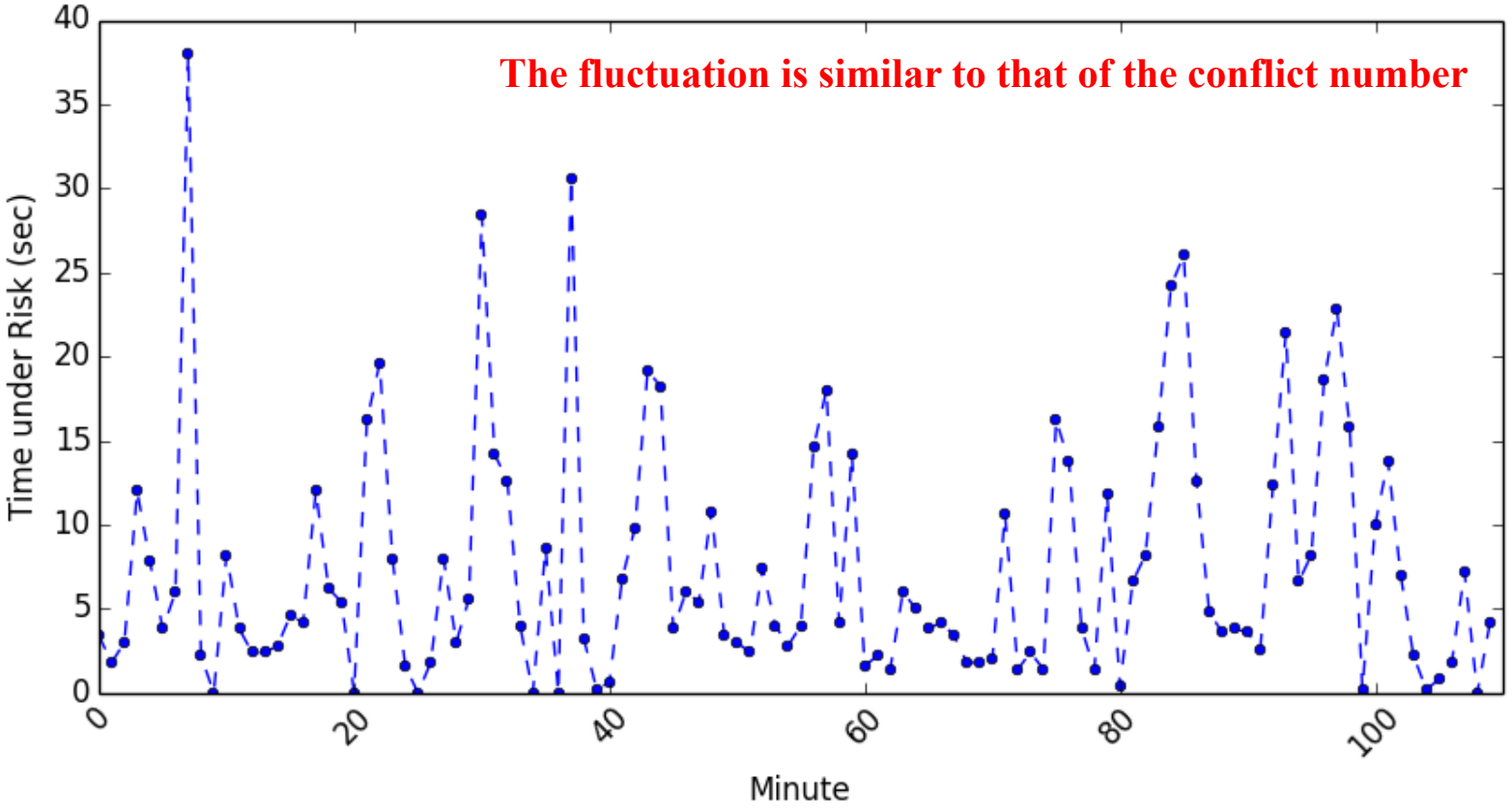
Comprehensive Safety Indices

- Conflict number: the number of vehicle pairs with 0< TTC <1.5 sec.
- The total conflict number for the whole study period (110 minutes) is **1059**.



Comprehensive Safety Indices

- Time under risk (sec): the cumulative time when 0< TTC <1.5 sec.
- The total time under risk for the whole study period (110 minutes) is **815.6 sec**.



Next Step

- Video Data from NYCDOT
  - Camera locations
    - ✓5 Ave @ 42 St (103 accidents)
    - ✓Canal St @ Baxter St (69 accidents)
  - Date
    - ✓06/16/2015-06/25/2015
  - Time
    - ✓6 AM-7 PM

Next Step

- Trajectory warping

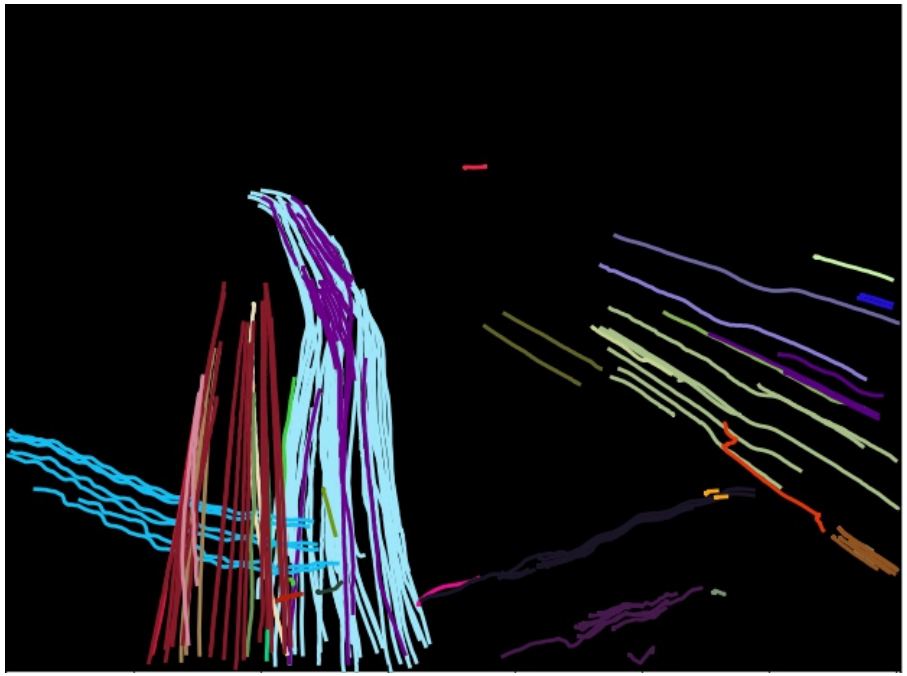


Fig 1. original trajectories directed generated from original video

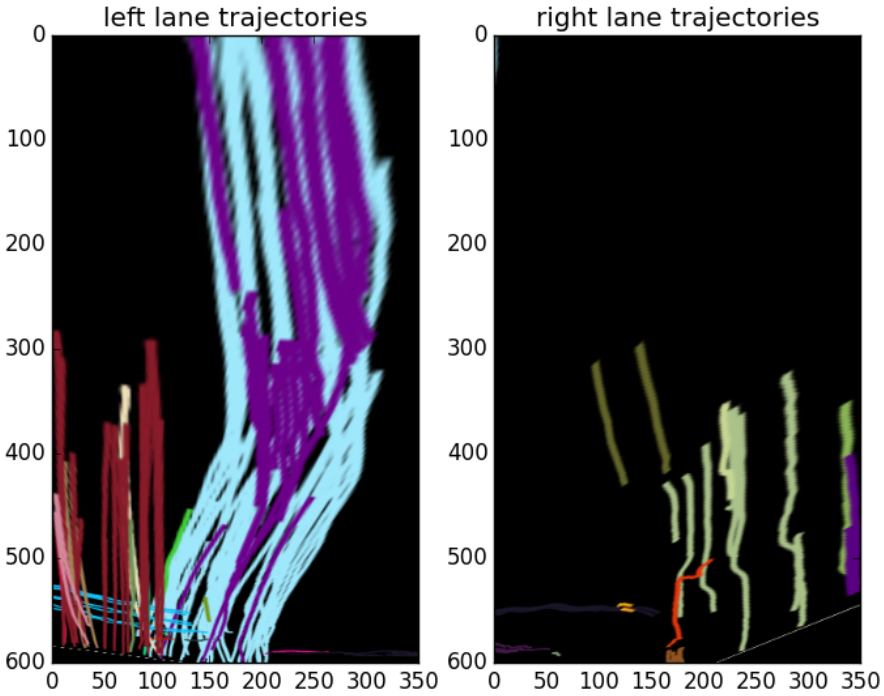


Fig 2. warped trajectories after perspective transformation

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Next Step

- Preliminary results from DOT camera

Baxter street & Canal street

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