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

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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

Credit: nypost.com
Traffic Safety Issues in US

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

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

Source: Traffic Safety Fact 2012, NHTSA
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

NY State fatalities (2001 – 2012) = 16,199

Total Fatalities in Traffic = 3,659

Table: Fatalities in Traffic in New York City (2001 – 2012)

- Pedestrians: 1,850 (50%)
- Drivers & Passengers: 1,592 (44%)
- Bicyclists: 217 (6%)

Map: Collision types and locations in New York City.
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.)

Evaluation is needed to assess whether the proposed solutions work!

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.

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

Field Video (Traffic Camera Data)

Manual Tracking Approach

Computer Vision Algorithm

High-Resolution Vehicle Trajectories

Data Consolidation & Modeling

Surrogate Safety Measures

Crash Records

Traffic Conflicts Quantification

Intersection Safety Performance

Intersecion Safety Performance

Assessment

Validation

Trajectory

Identification

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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
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.

![Diagram showing rear-end and right-angle conflicts]
Development of Surrogate Safety Measures

- Time to collision (TTC)

\[ \text{TTC}_i(t) = \frac{X_i(t) - X_{i-1}(t) - L_i}{V_i(t) - V_{i-1}(t)} \quad \forall V_i(t) > V_{i-1}(t) \]

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

Manual tracking vs. automatic tracking

No conflicts
Jay St Demo: Conflicts

Estimated Surrogates based on Automatic Tracking Results

Conflicts: TTC<4.0 seconds
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.
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
Comprehensive Safety Indices

- Conflict number: the number of vehicle pairs with $0 < \text{TTC} < 1.5$ 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 $0 < \text{TTC} < 1.5$ 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
Next Step

- Preliminary results from DOT camera
http://engineering.nyu.edu/urbanmits/

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