# Vision Based Automated Data Collection and Behavior Analysis of Active Modes of Transportation

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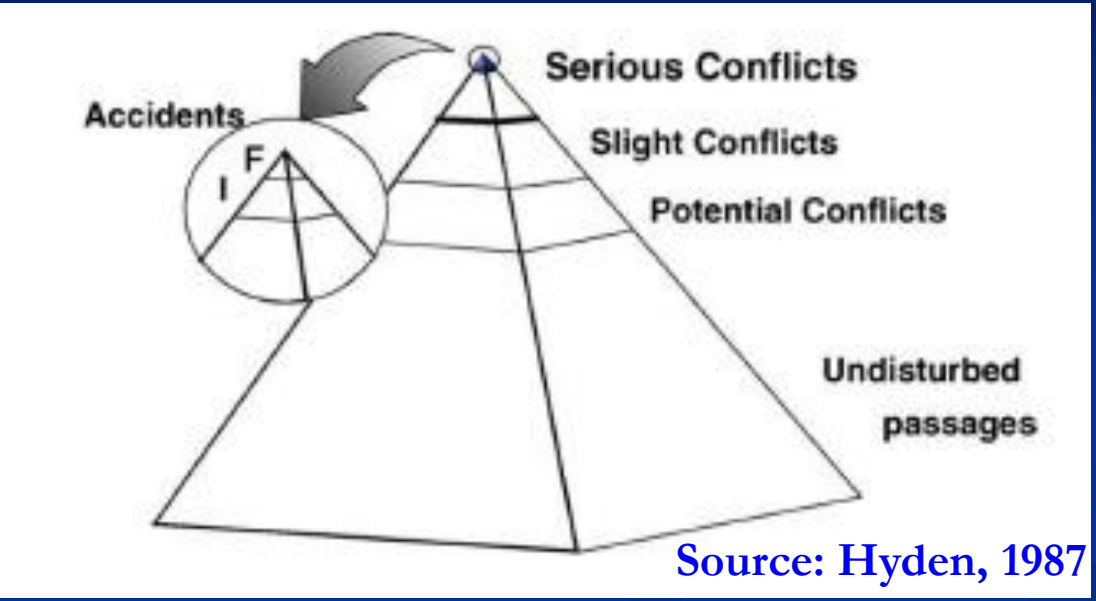
# Outline

- Motivation - Safety
  - Traffic Conflict Technique
- Motivation -Automated Data Collection
  - The need  for Microscopic Road User Behavior Data
- Case Studies
  - Automated Road User Classification and Data Collection
  - Automated Analysis of Traffic Conflicts
  - Automated Identification of Violations
  - Conducting Before/After Safety Evaluations
- Conclusions

# Motivation - Safety

- Traditional road safety analysis is a reactive approach, based on historical collision data
  - There are well-recognized availability and quality problems associated with collision data
  - Long observation periods
  - Less complete understanding of the complex interaction of collision factors and how safety measures work
- A more proactive approach is needed which provides a better understanding of collision occurrence

# Traffic Conflicts (near-misses)




- Shortcomings
  - Cost of data collection
  - Issues related to the reliability and accuracy of human observers
- Automation can enable the traffic conflict analysis in an accurate, objective, and cost-efficient way

# Motivation – Data Collection

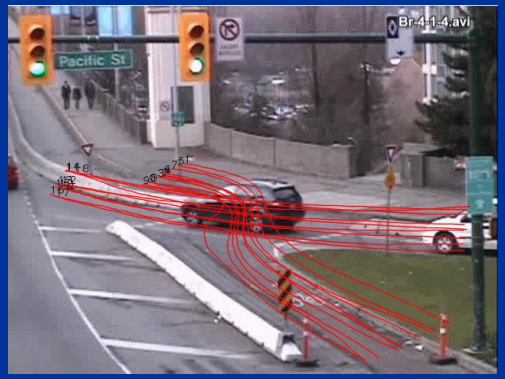
- Road-user movements and behavior are complex and difficult to capture manually
- A disparate mix of road users share the same road
- Manual data collection methods are more expensive, error-prone, and time consuming

# Automated Analysis Procedure

Features Tracking


Features Grouping


Objects Classification

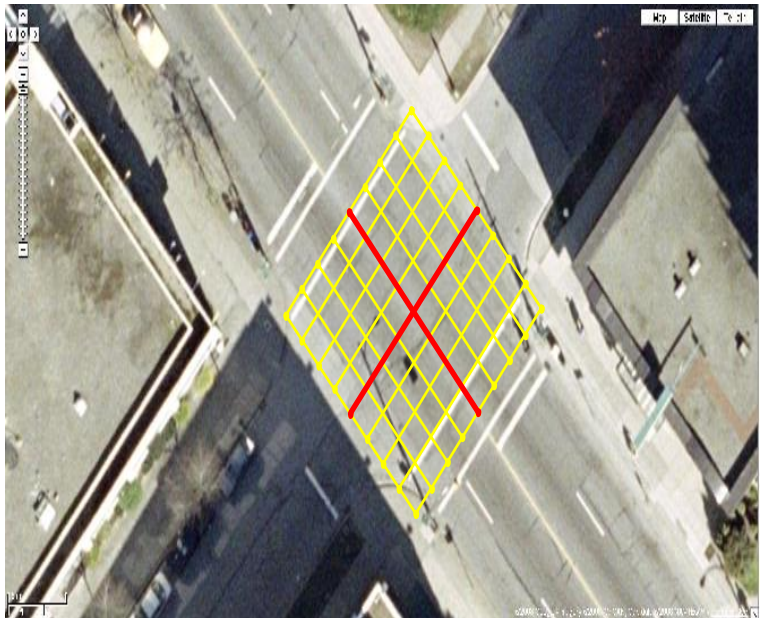

Prototypes Generation

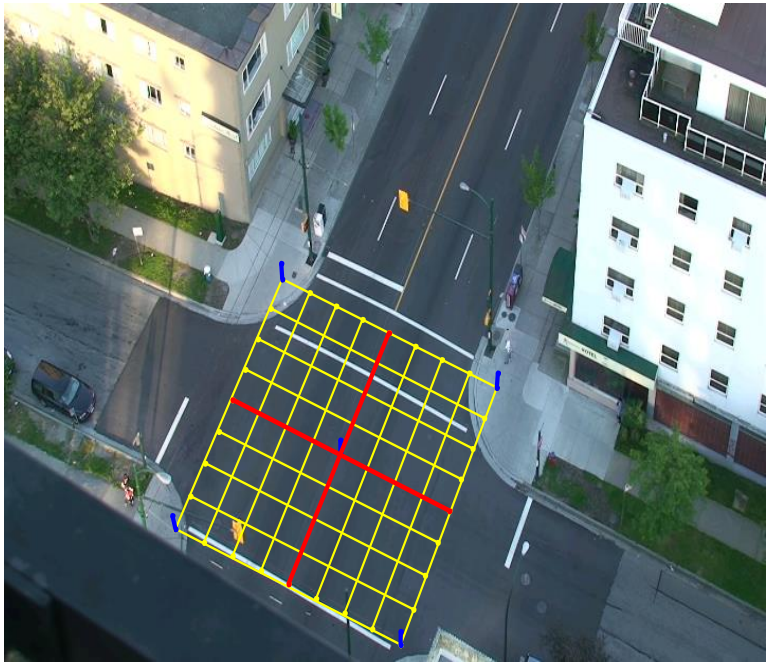

Events Detection


Violation Detection

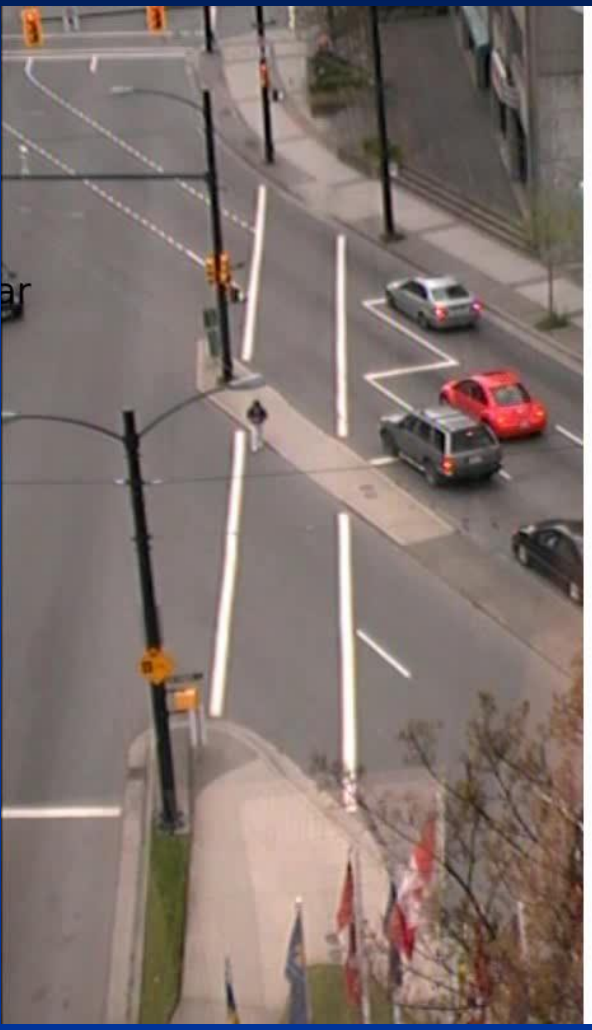
# Real-world Coordinates Recovery

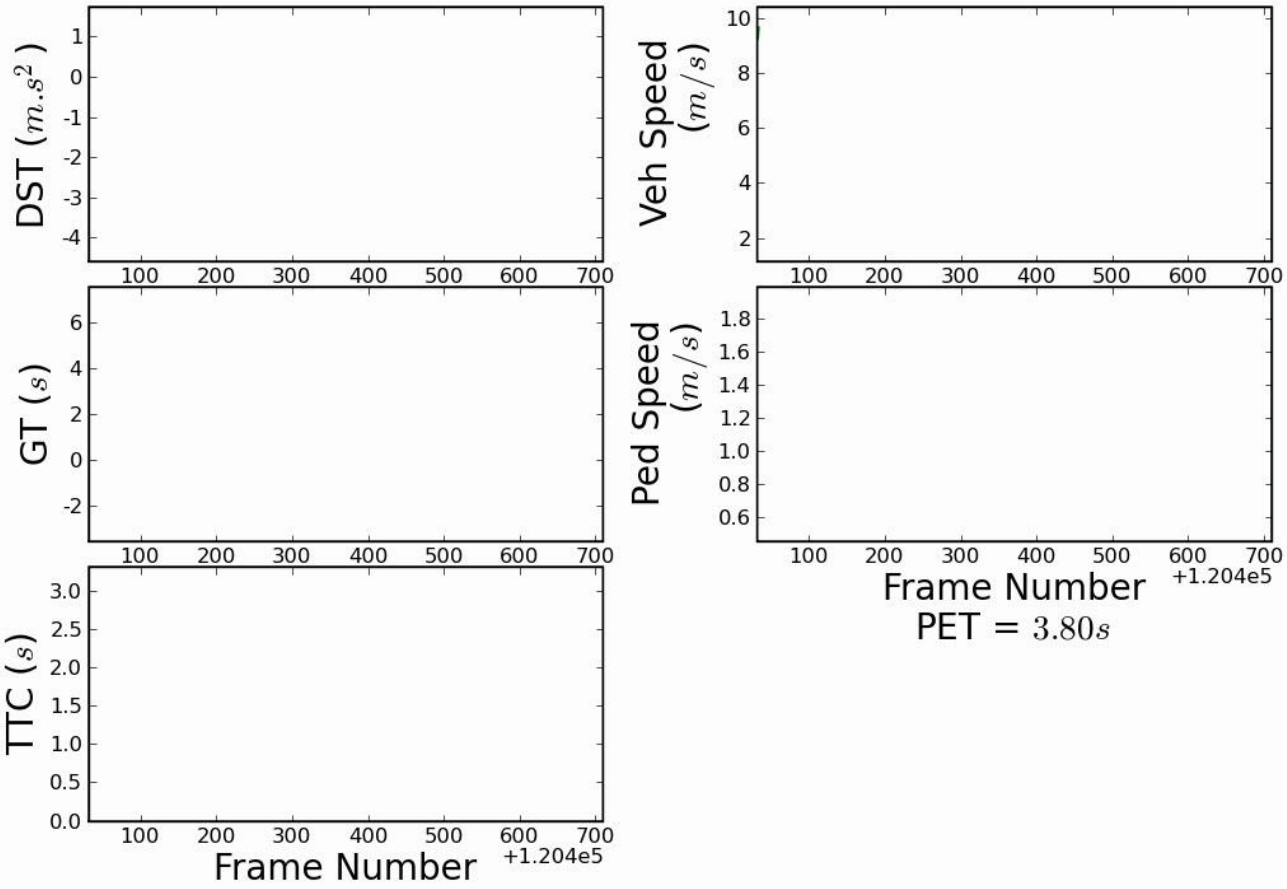
# Camera Calibration



# Automated Conflict Analysis





# Automated Conflict Analysis

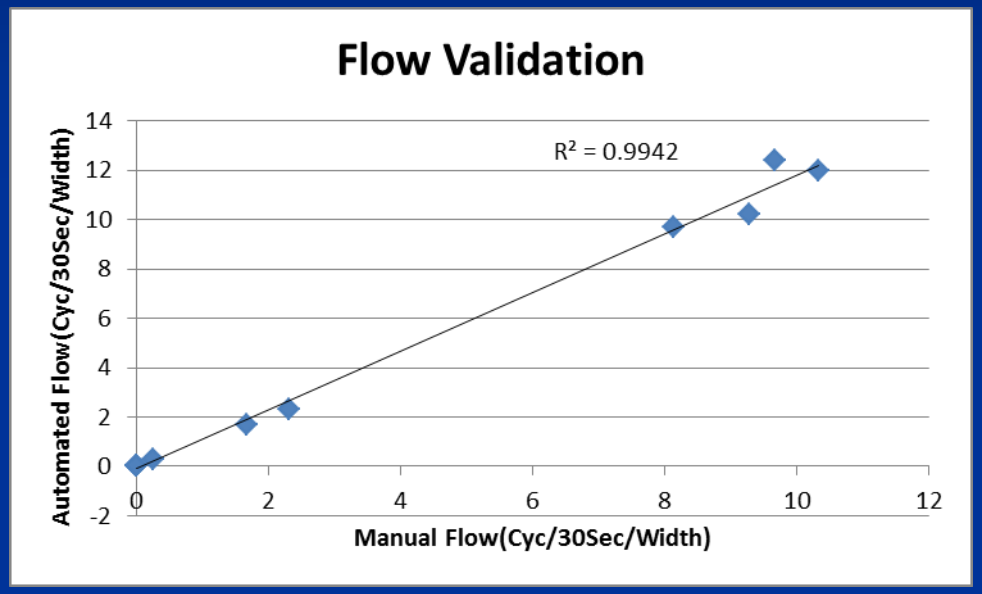
# APPLICATIONS

- Automated Data Collection
- Violations Detection
- Safety Diagnosis
- Before and After Safety Evaluations

# UBC Exposure Data For Cyclists

# Counts and Flow Validation

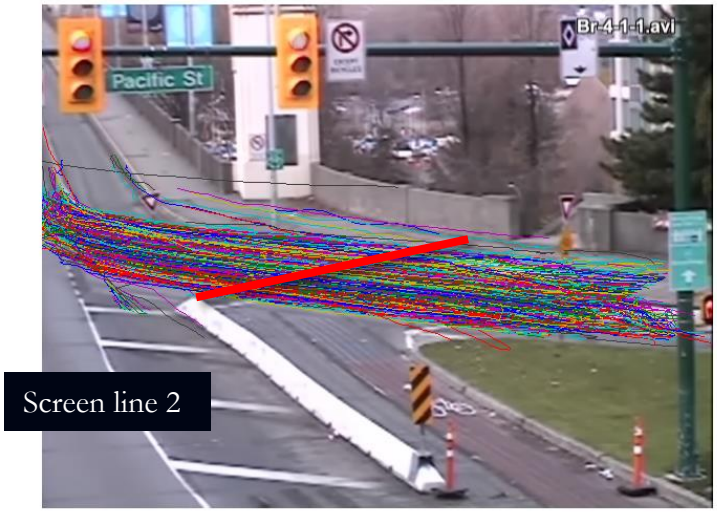
(RMSE = 1.382 cyclists/30Second /Width, $R^2 = 0.9942$).

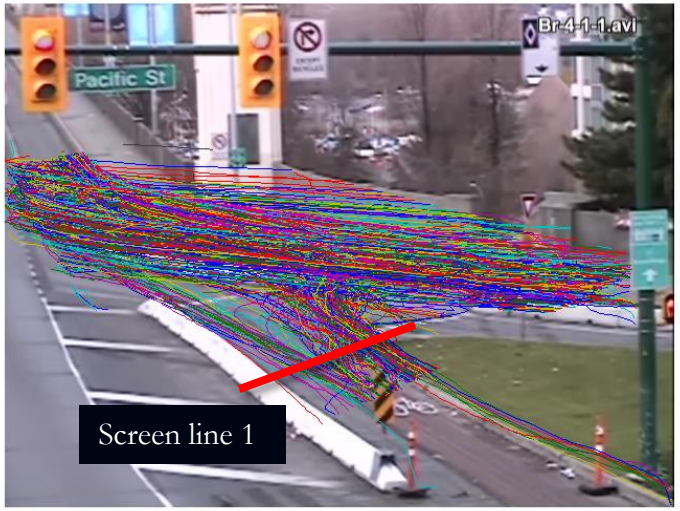




Count Screens

# Burrard and Pacific Intersection
## Counting Road-Users




Right-Turn Vehicles

Southbound Cyclists

| | Manual Counts | Automated Counts | Accuracy |
|---|---|---|---|
| Screen line 1 | 229 | 255 | 88.6% |
| Screen line 2 | 4880 | 4441 | 91 % |

# Behavior Based Pedestrian Conflict Indicators

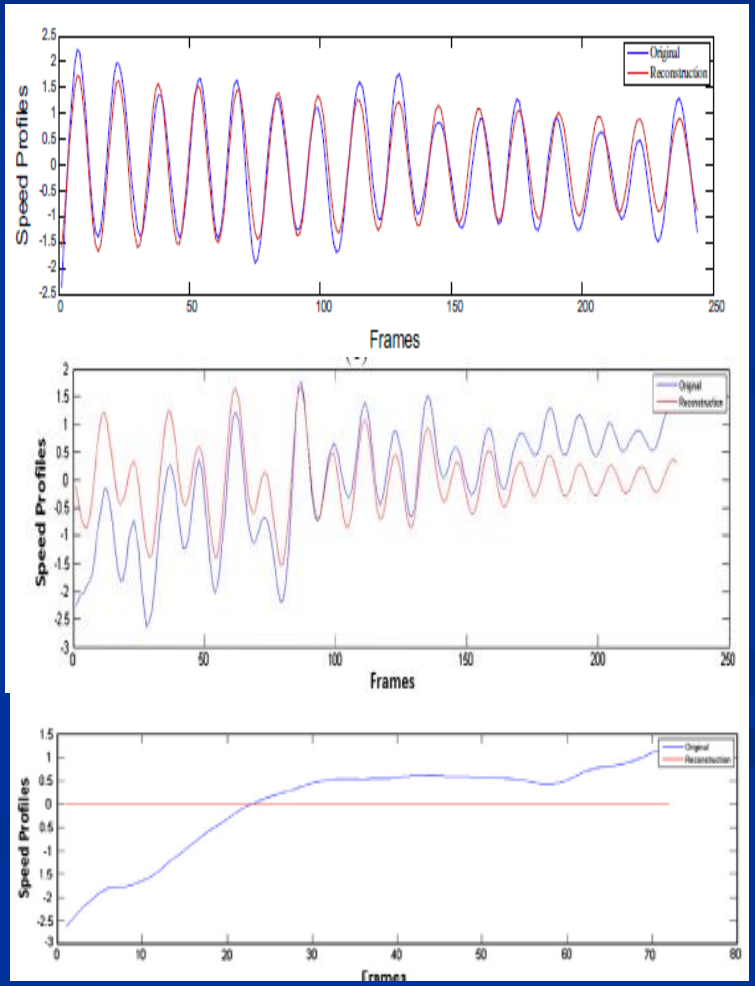
- Change in Step Frequency

# Classification

**Classify Road-Users based on their Speed Profiles using computer vision**

## Movement Mechanisms

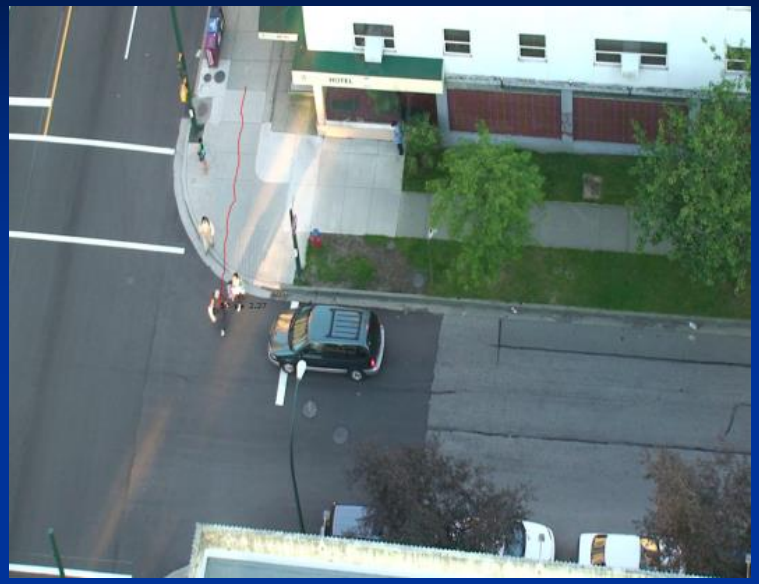
- Pedestrians: Ambulation
- Cyclists: Pedaling
- Vehicle: Mostly-Linear Movements



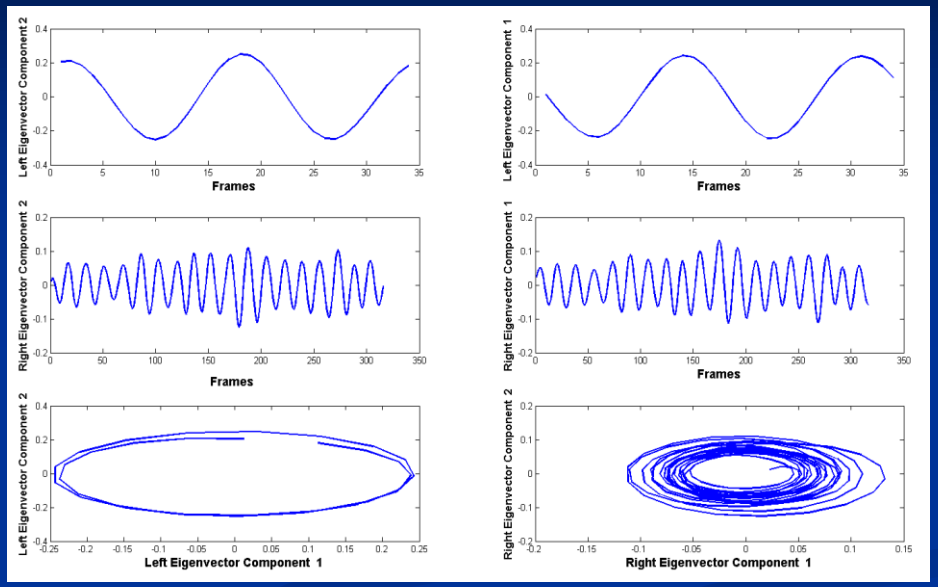
## Classification

- Decomposition gives insight into the underlying dynamics of movement that generated the speed profile.
- Singular Spectrum Analysis identify constituent components: trend, harmonics and noise.
- Decomposition and Reconstruction of a speed profile can provide clues on the Road-user behavior, deducing its class.

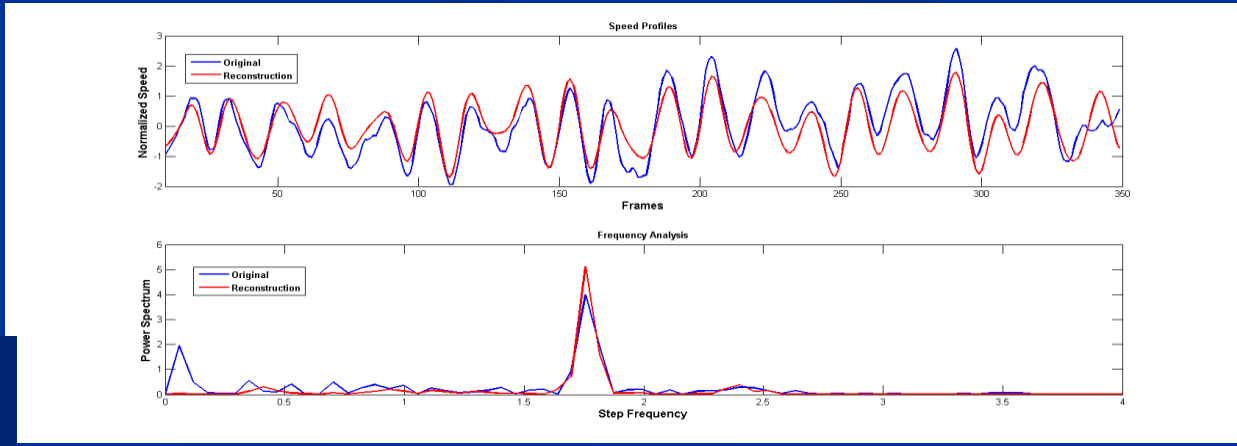
# Gait Analysis Extraction (Step Length and Frequency)



Eigen Components Pairing

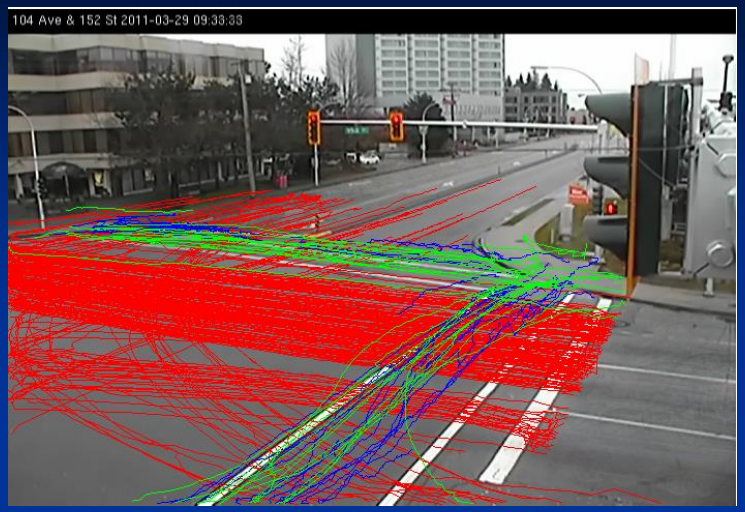



Reconstruction

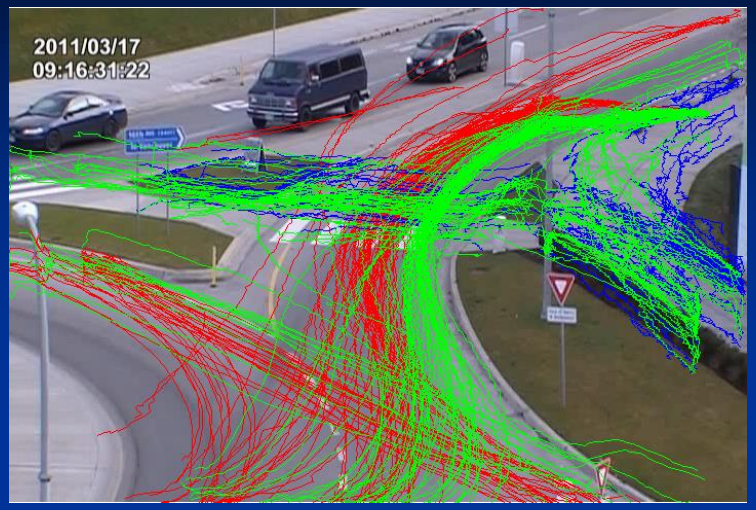



Walk Speed = Step Frequency X Step Length

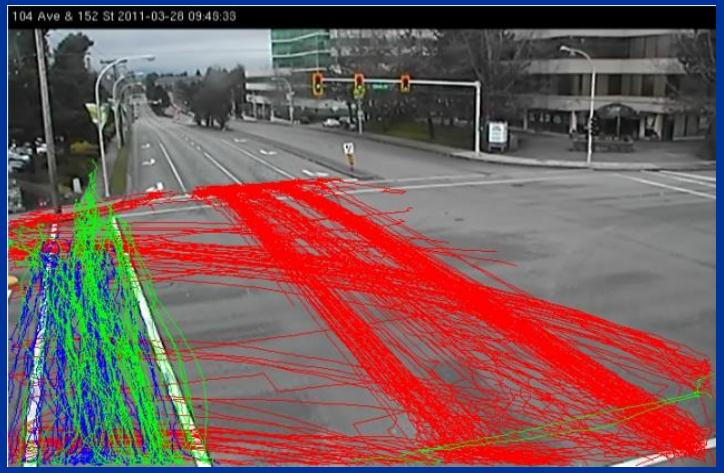
## Classification: Road-Users




Surrey Data Set 2



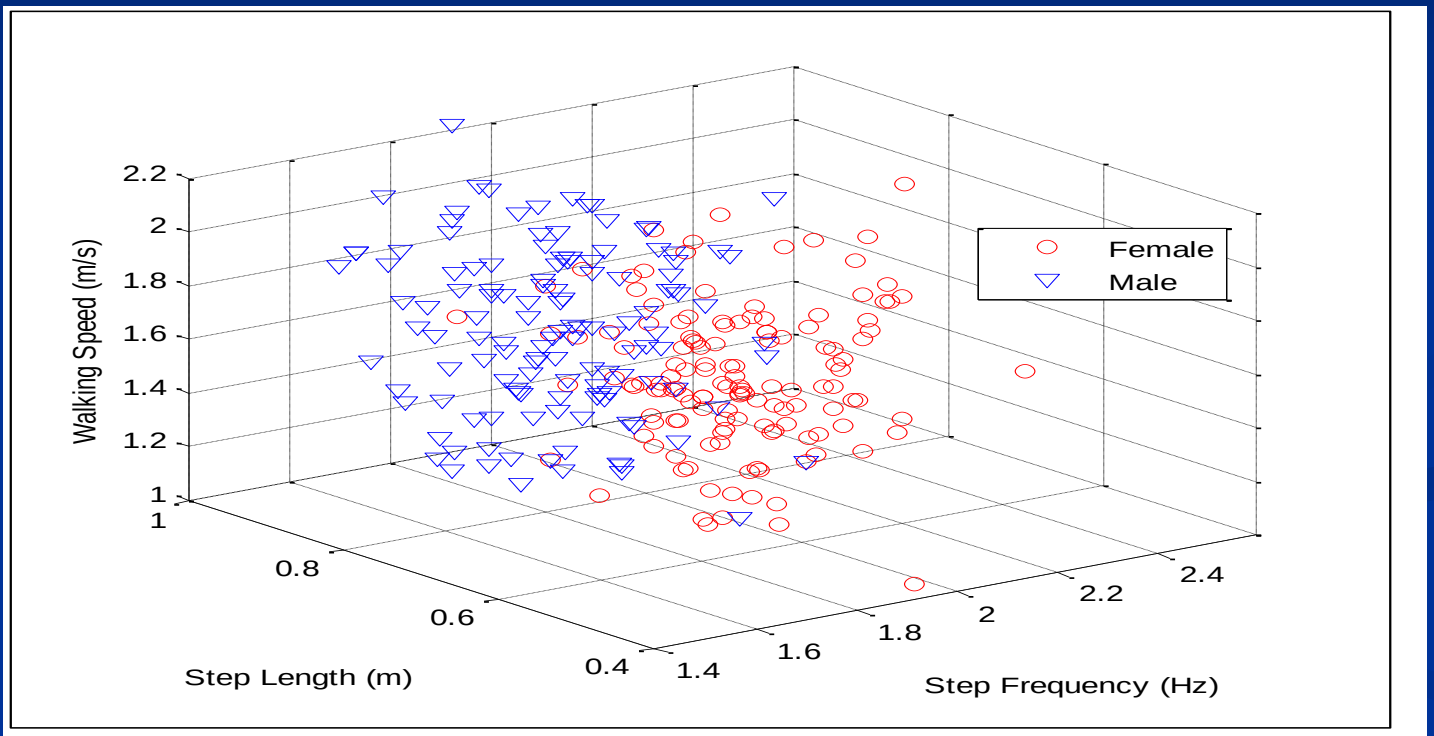

UBC Roundabout Data Set 3

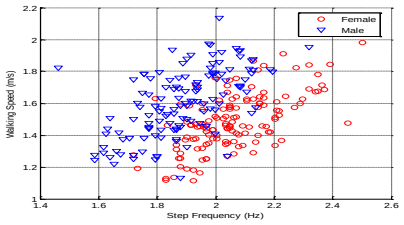


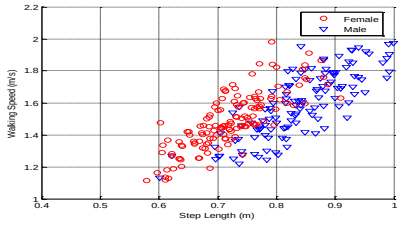

Surrey Data Set 1

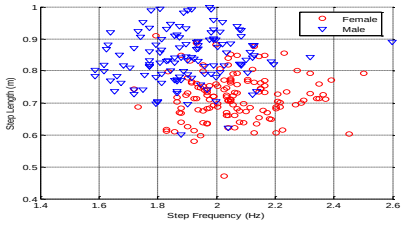
**85-96% Correct Classification rate**

# Automated Pedestrian Gender Classification

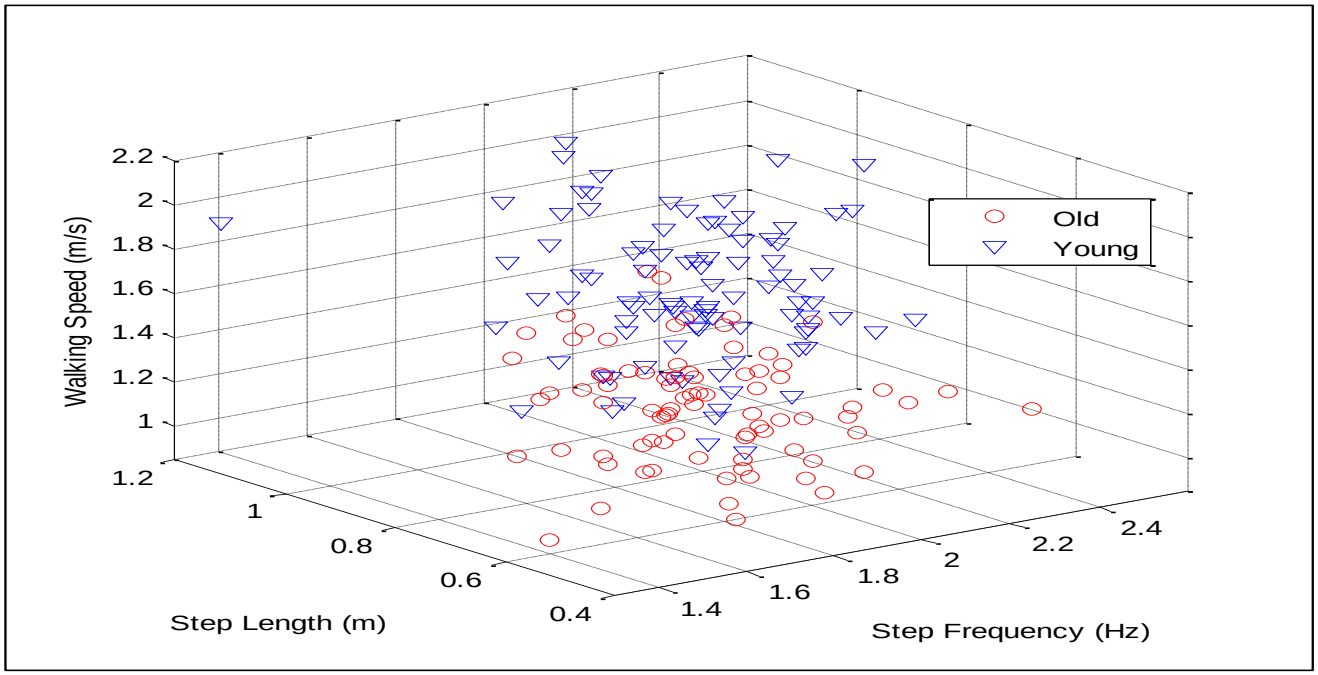


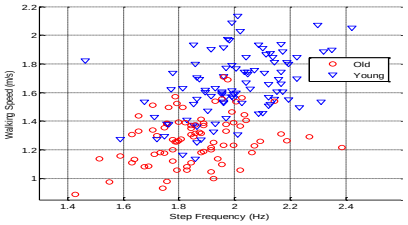



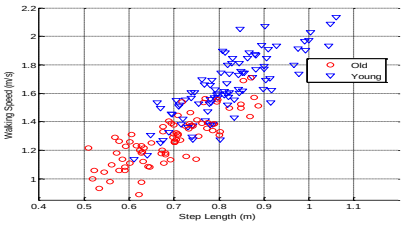



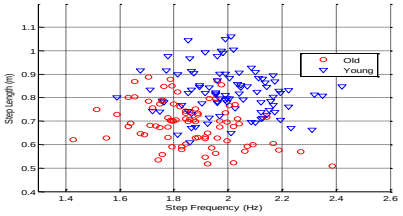



# Automated Pedestrian Age Group Classification



# Road User Classification/Behaviour

- 95% Correct pedestrian classification
- 85-90 % Correct bicycle classification
- 85 -90 % Correct pedestrian gender and age classification
- 85% identification of distracted Walking
- 85% Correct cyclist helmet wearing classification

# Is the cyclist wearing helmet or not?


Objective:

- Automatic Helmet Detection and Recognition
- Non-helmet Wearing Cyclist Retrieval System

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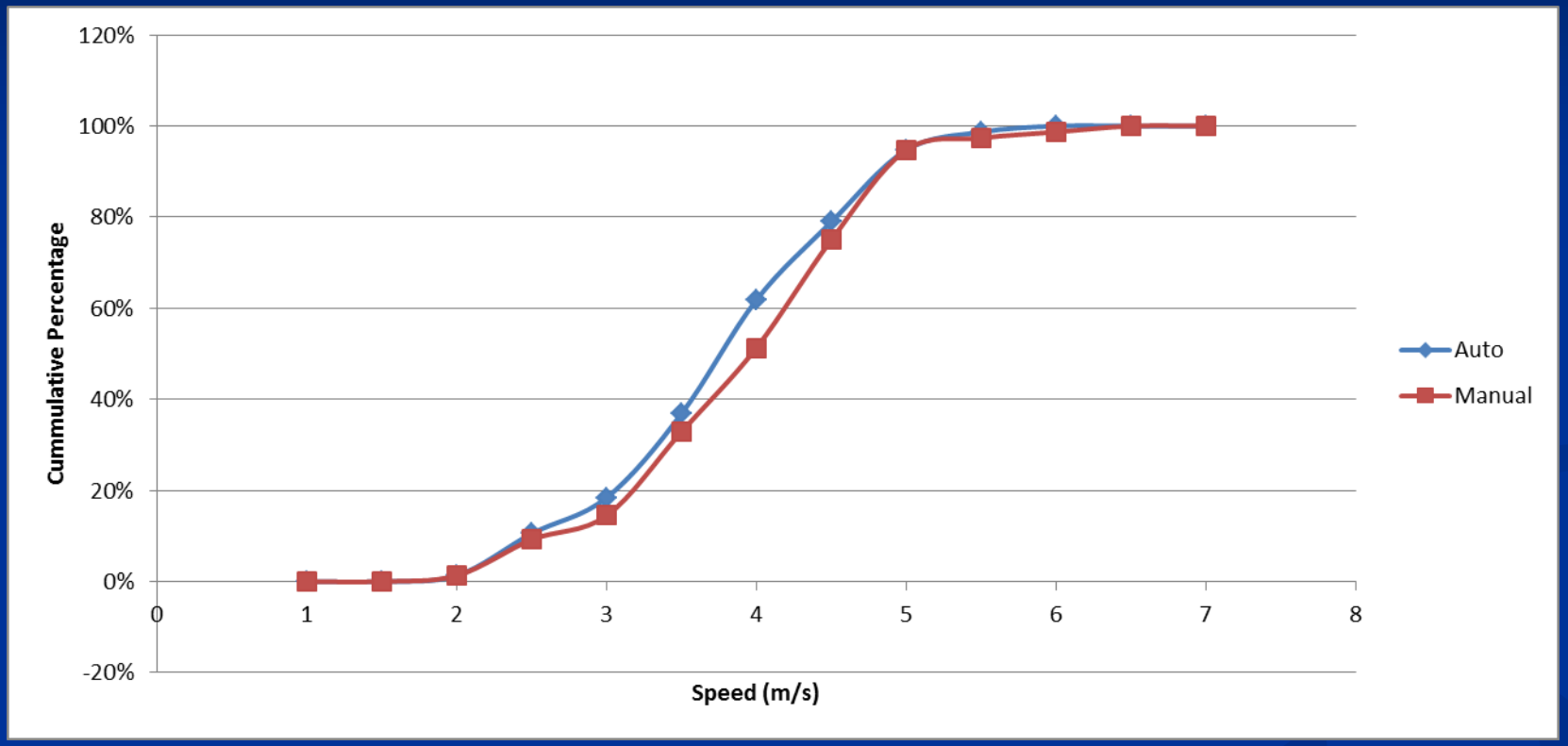
# Cyclists Speed


Average Speed Distribution throughout the Roundabout

# Automatic Speed Validation

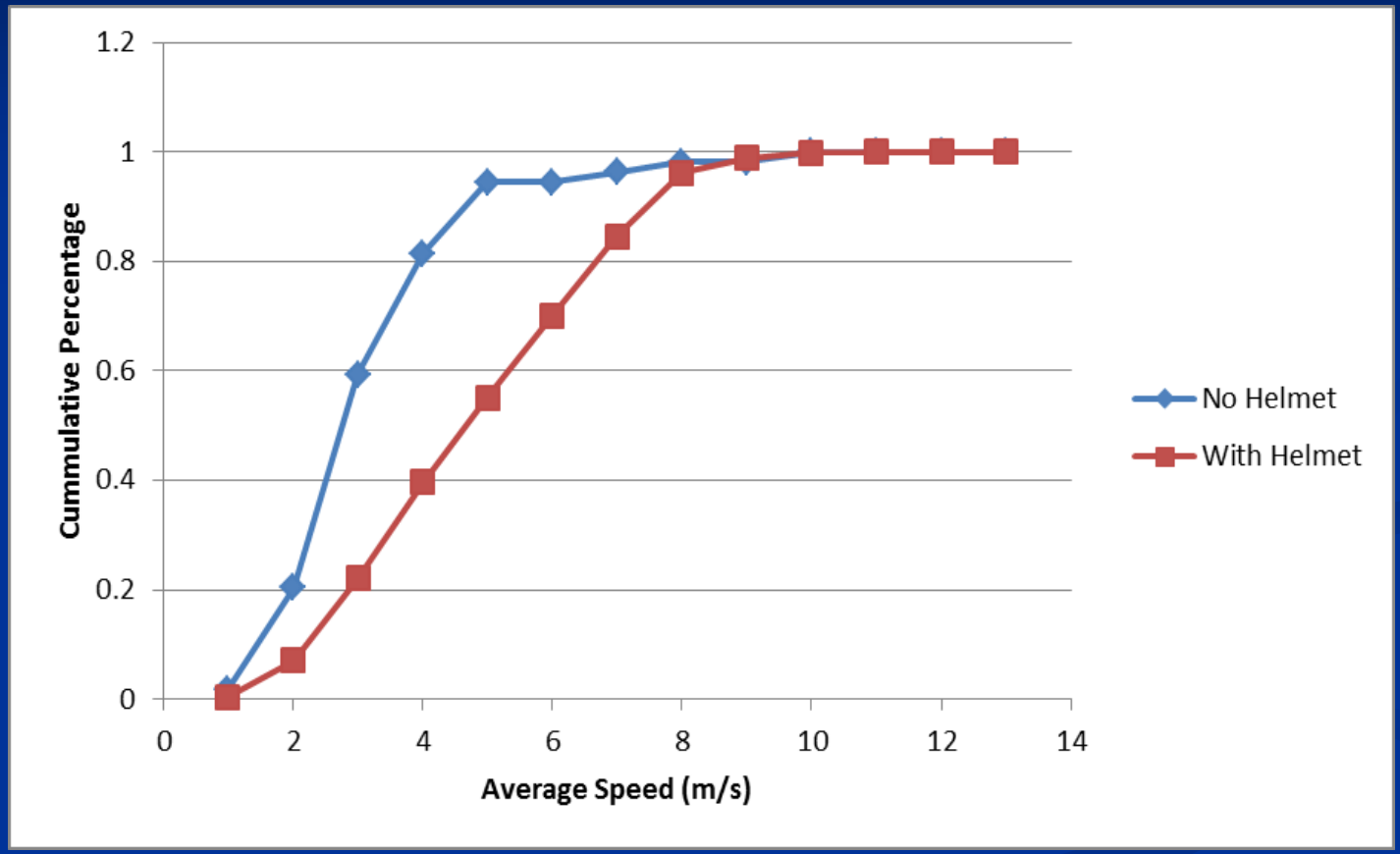


# Results Summary

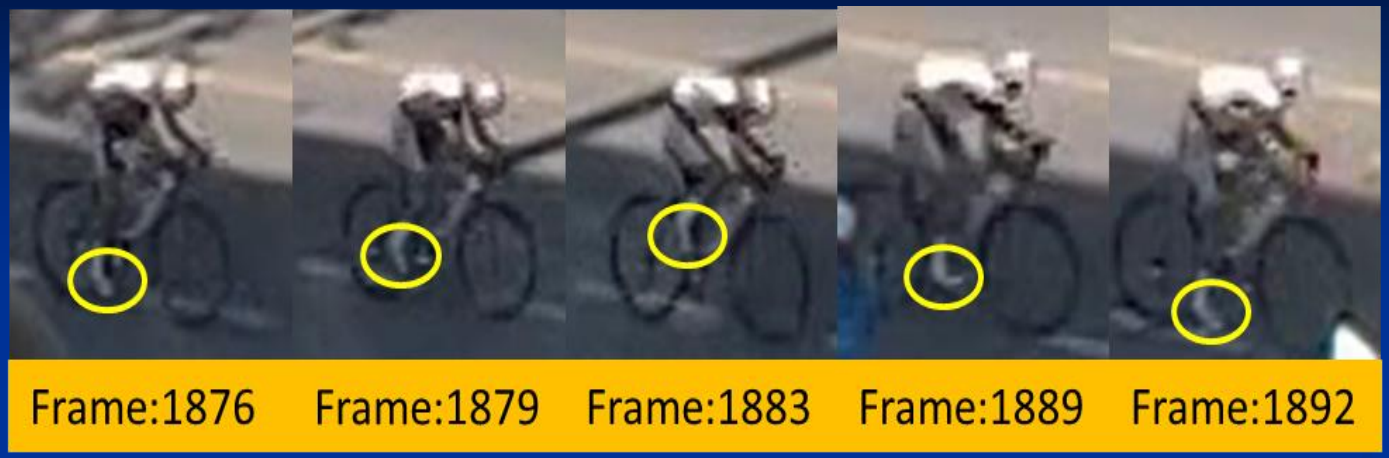
| Attribute | Category | Statistics | | ANOVA/ t-stat (P-Value) |
|---|---|---|---|---|
| | | Count | Mean Speed (SD) | |
| Group Size | 1 | 681 | 4.66(3.87) | 0.011 |
| | 2+ | 53 | 3.96(3.5) | |
| Lane Position | Left | 42 | 4.06(2.89) | 0.026 |
| | Middle | 372 | 4.5(4.67) | |
| | Right | 322 | 4.8(2.98) | |
| Helmet Use | With | 681 | 4.73(3.79) | <0.0001 |
| | Without | 53 | 3.06(2.29) | |
| Travel Path | Street | 395 | 5.91(2.45) | <0.0001 |
| | Sidewalk | 303 | 3.12(1.24) | |

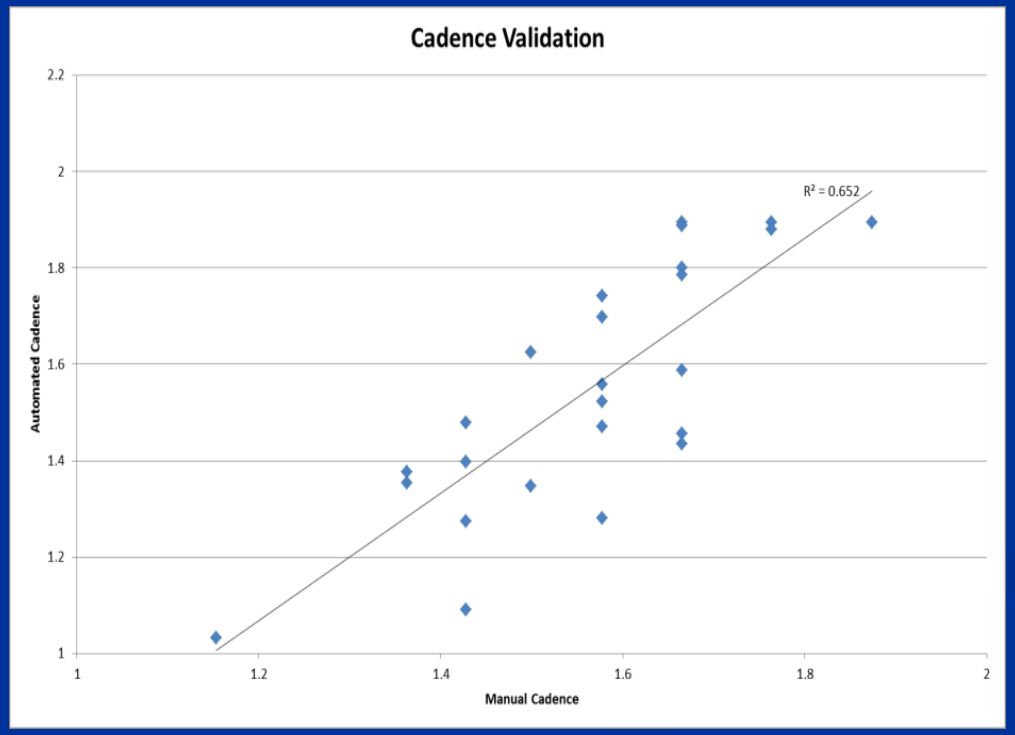
- As group size increases, cycling speed decrease
- Cyclists using helmets tend to travel at higher speed

# Results Summary



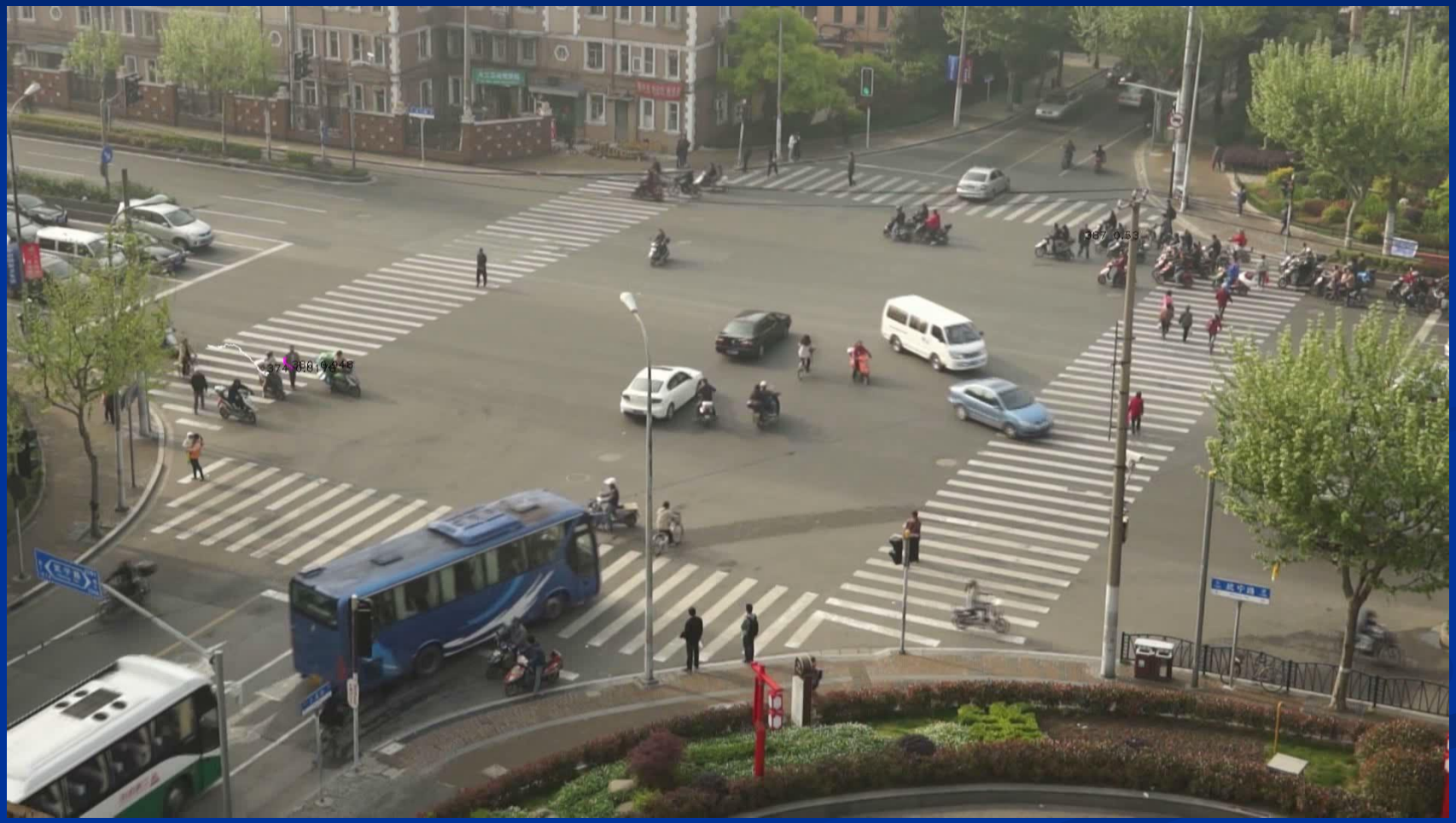
# Cadence Validation



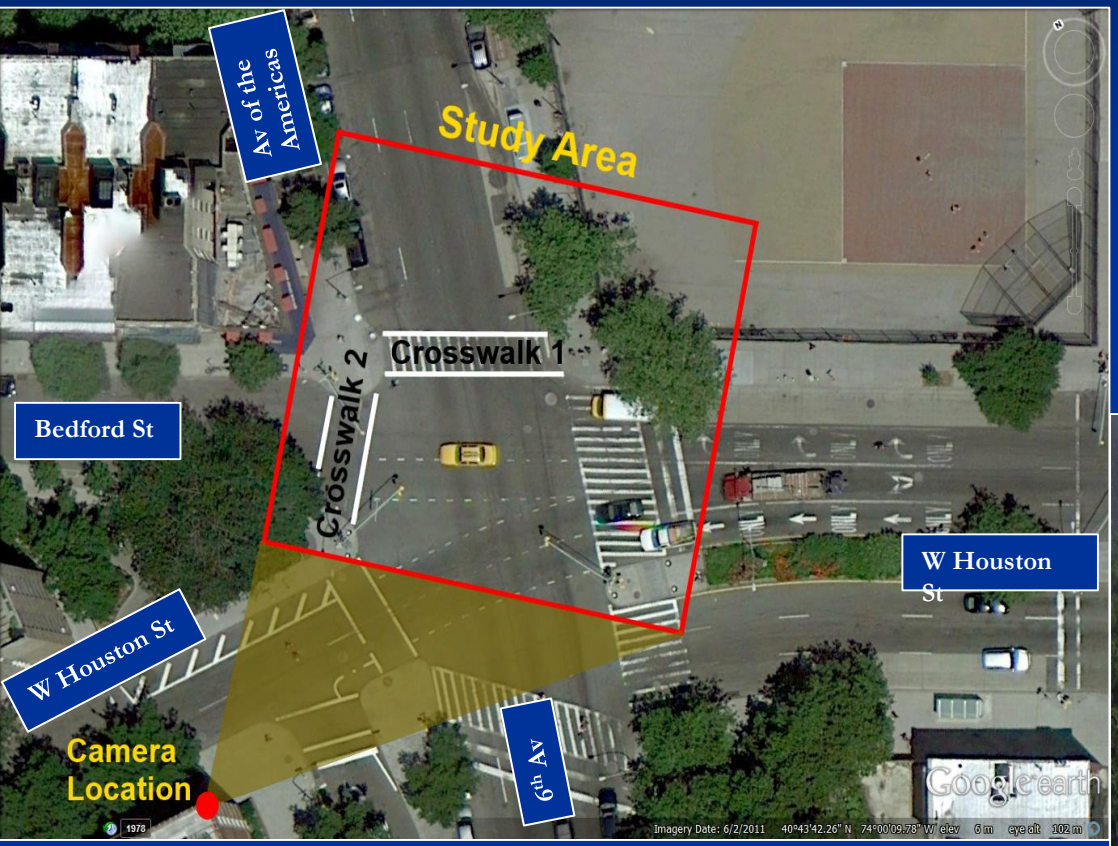

- RMSE = 0.1561 rotations/s, $R^2$ =0.65
- Manual calculated average cadence: 1.56 rotations per second
- Automated calculated cadence: 1.51 rotations per second.

# Analysis of Violations



# Analysis of Violations

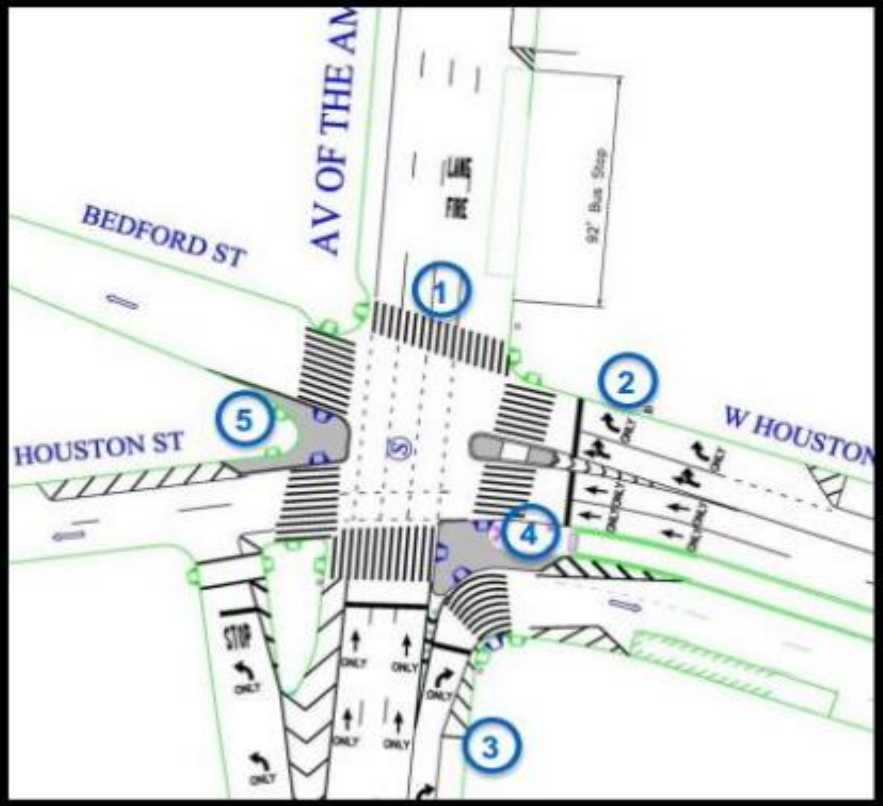
# Safety Diagnosis
# 6th Avenue and Houston Street




Twelve hours of video data were collected

# Proposed Improvements

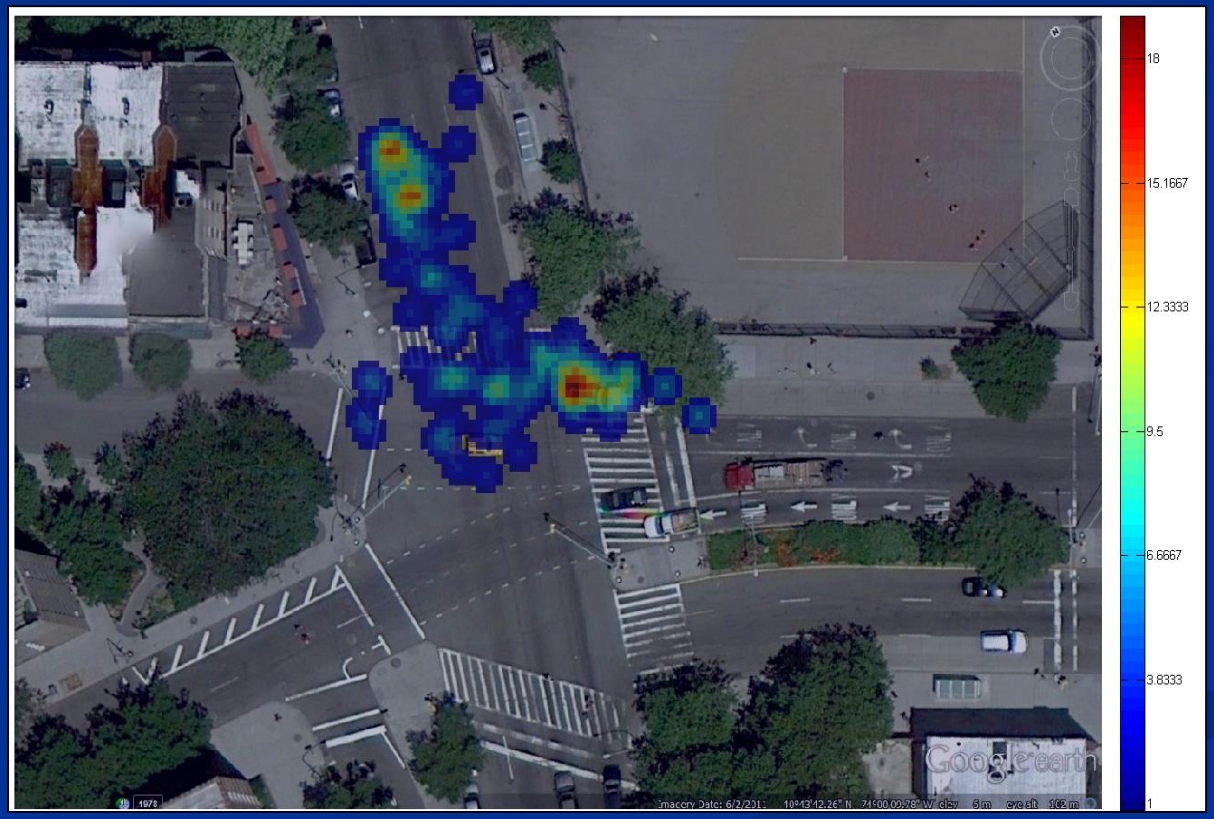
## Proposal Summary




1. Create conflict free pedestrian phase in north crosswalk
2. Formalize double right turns from w/b Houston St onto n/b 6th Ave
3. Create n/b 6th Ave right turn only lane
4. Extend Houston St/Bedford St sidewalk into west crosswalk
5. Construct sidewalk extension from Houston St median into east crosswalk

# Cyclist - Vehicle Conflicts

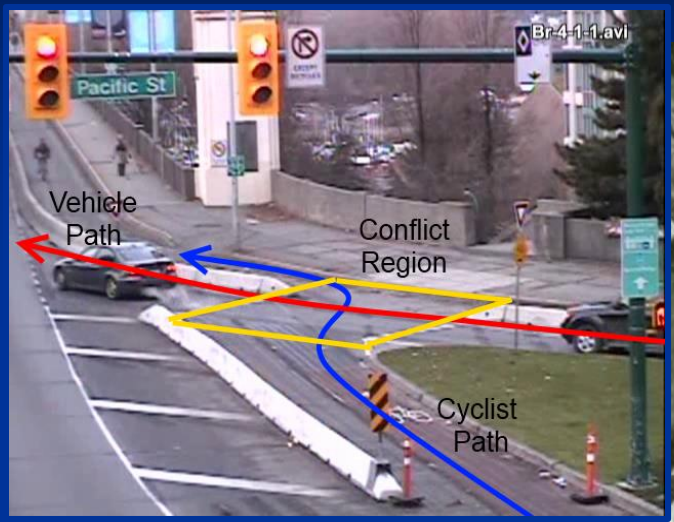
| TTC Range (Seconds) | Frequency |
|---|---|
| 0 < TTC ≤ 1 | 67 |
| 1 < TTC ≤ 2 | 30 |
| 2 < TTC ≤ 3 | 22 |
| **Total** | 119 |



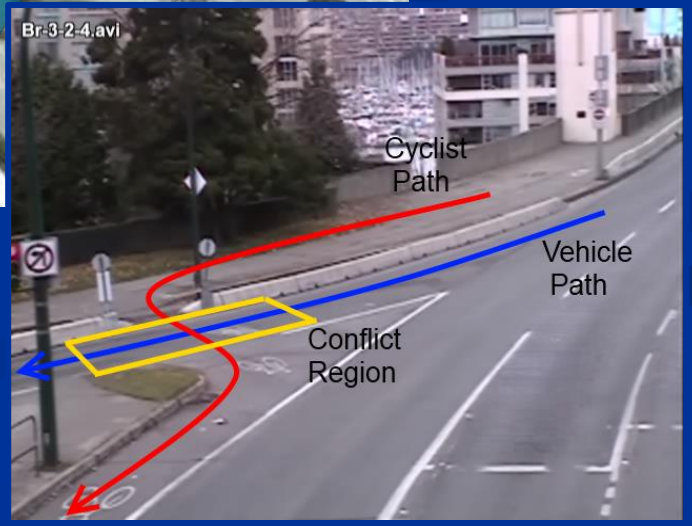
# Cyclist-Vehicle Conflict Examples

# Safety Diagnosis - Burrard and Pacific Intersection

## Cyclist Conflicts Zone







# ific Intersection
## ns Identification




| cation | Manual Detection per hour | Automated Detection per hour | Accuracy |
|---|---|---|---|
| Southbound | 64 | 73 | **86%** |
| Northbound | 92 | 99 | **92%** |

# Burrard and Pacific Intersection
## Conflicts Evaluation


# Burrard and Pacific Intersection
## Conflicts Analysis Summary


| Southbound Bikes and Right-turn Vehicles | |
|---|---|
| TTC range | # Events |
| 0-1 seconds | 34 |
| 1-2 seconds | 23 |
| 2-3 seconds | 15 |
| TOTAL | 72 |

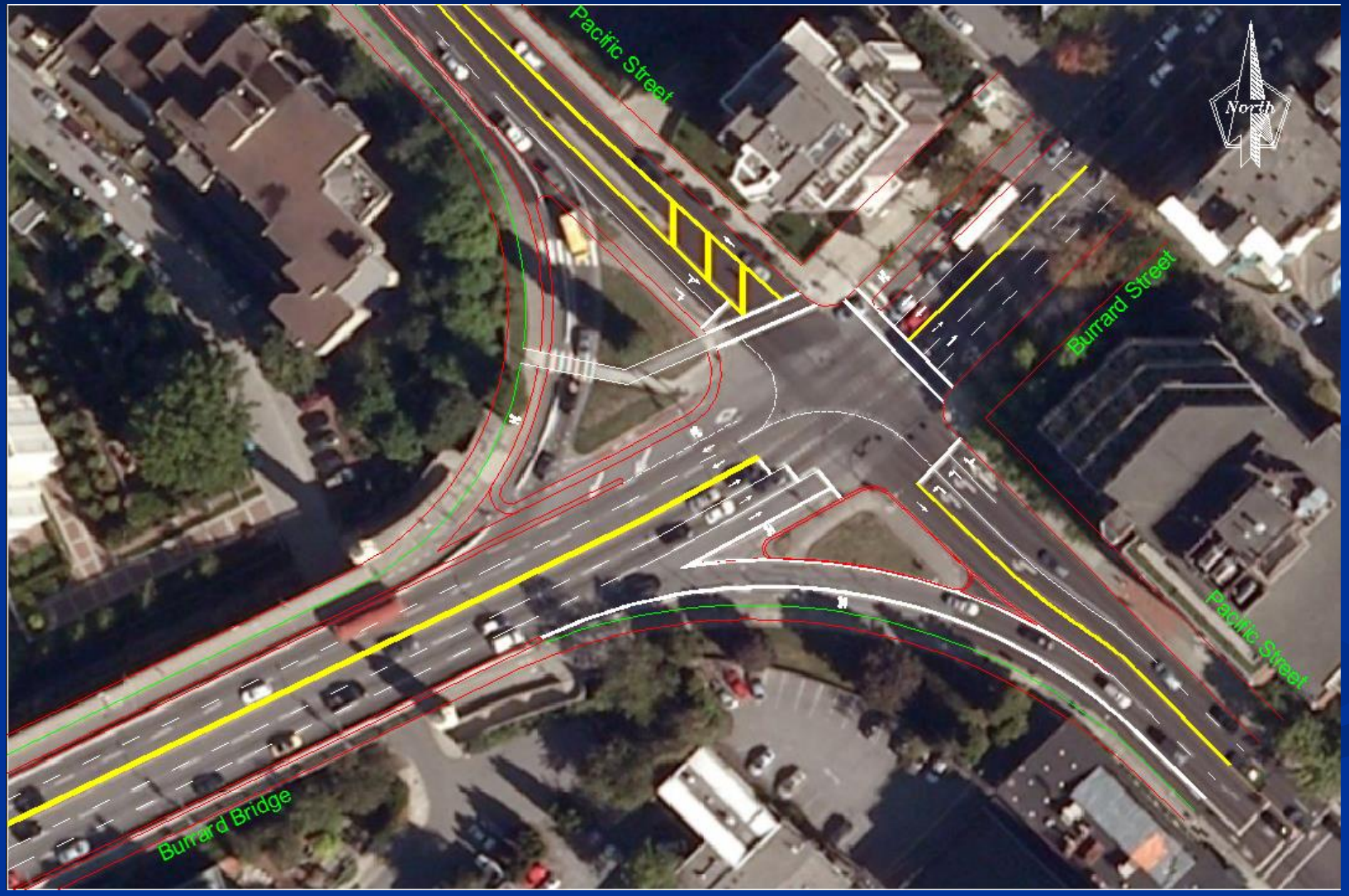
# Burrard and Pacific Intersection
## Conflicts Analysis Summary


| Northbound Cyclists and Right-turn Vehicles | |
|---|---|
| TTC range | # Events |
| 0-1 seconds | 19 |
| 1-2 seconds | 16 |
| 2-3 seconds | 0 |
| TOTAL | 35 |

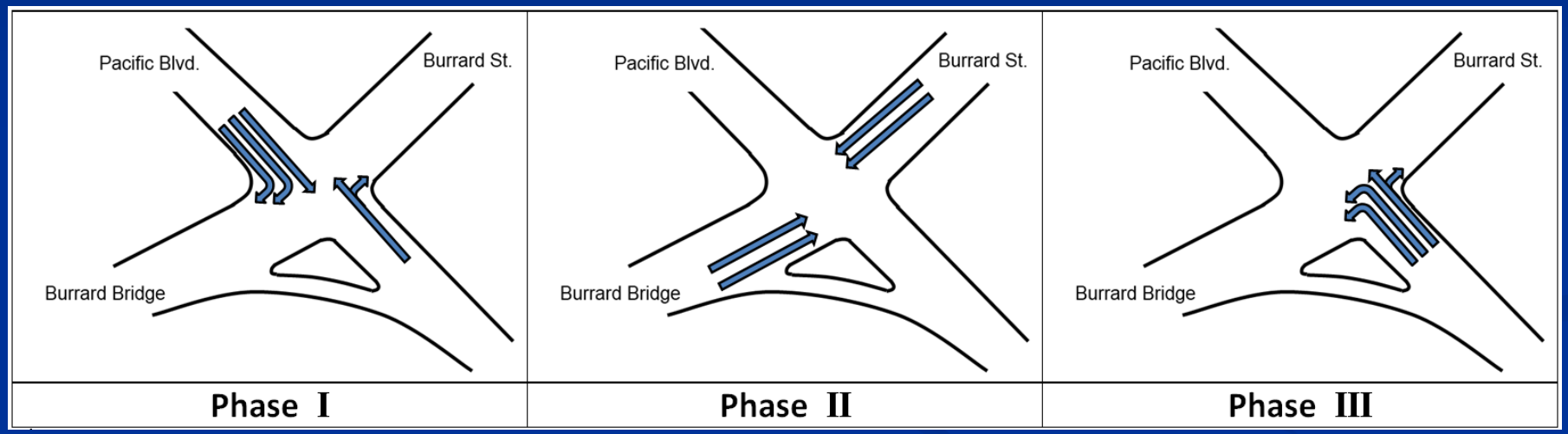
# Countermeasures

- Road Markings and Signage
- Close The Right Turn Ramp
- Urban Smart Channels

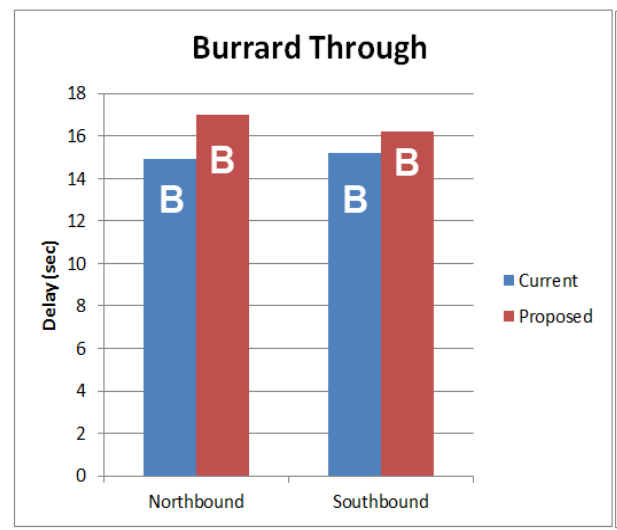
# Burrard and Pacific Intersection
## Proposed Geometric Modifications

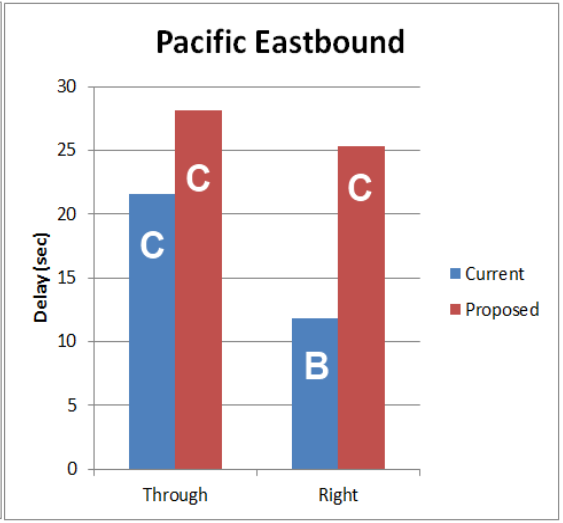


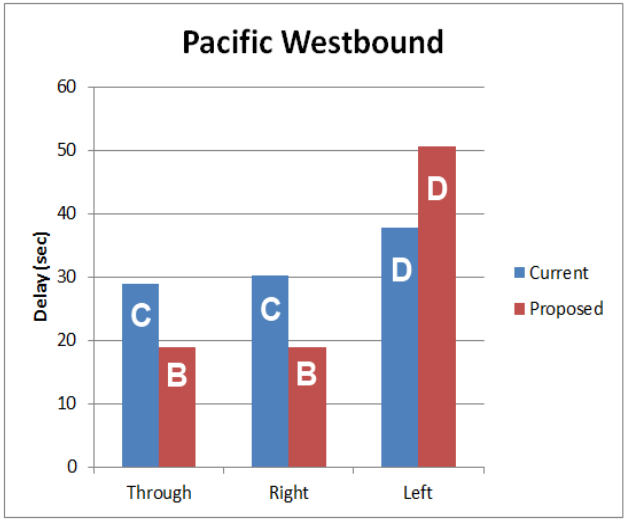
# Burrard and Pacific Intersection
## Signal Phasing for the Proposed Modifications



# Burrard and Pacific Intersection
## VISSIM Evaluation of the Proposed Modifications



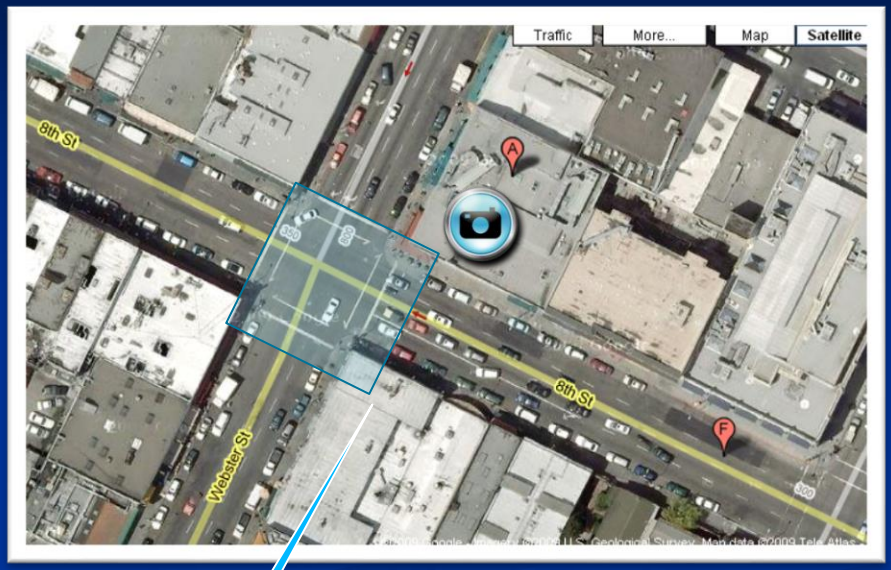



# Before-and-After Safety Studies

- Duration (1-3 years before as well as after treatment)
- Current statistical techniques have shortcomings
- Paradoxical situation !

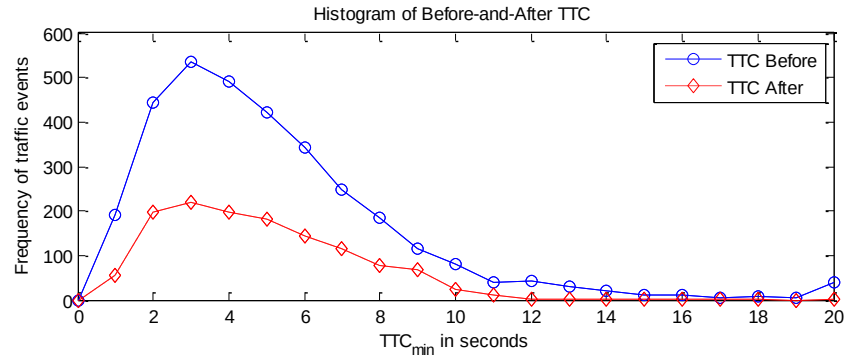
*The safety analyst, for the sake of methodological correctness, strives to observe events that ought to be prevented*

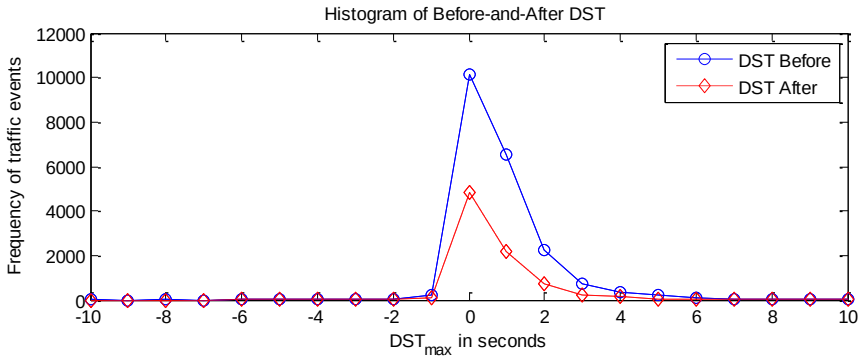
# Before/After Evaluation of Pedestrian Scramble

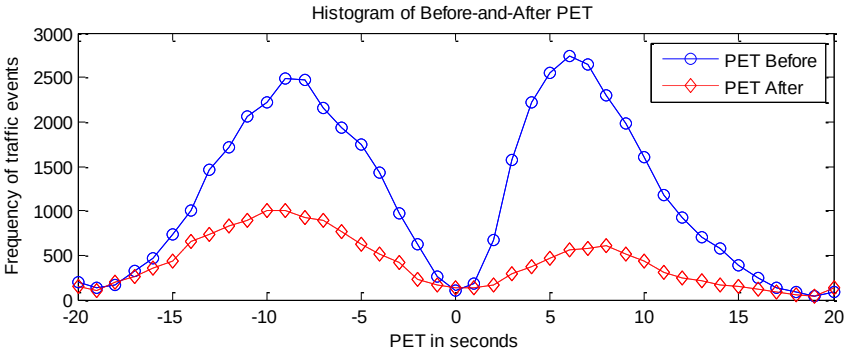


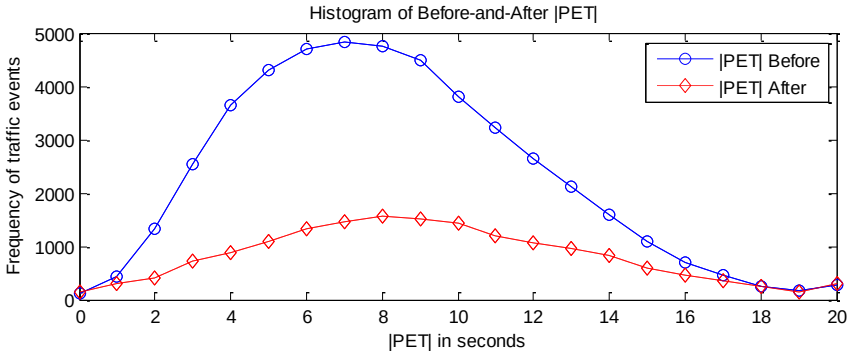

# Results

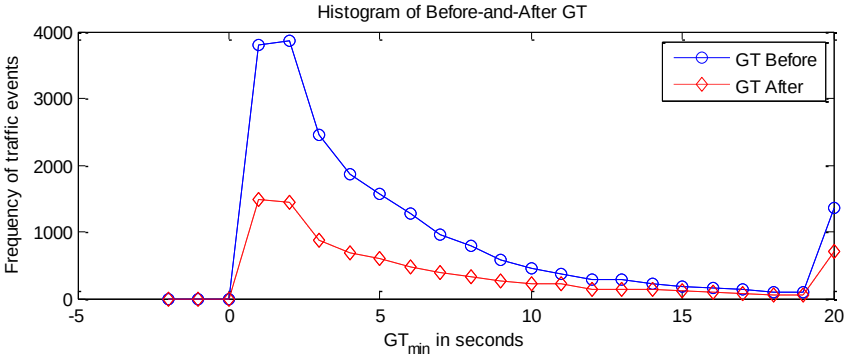
# Before-and-After Conflict Indicators

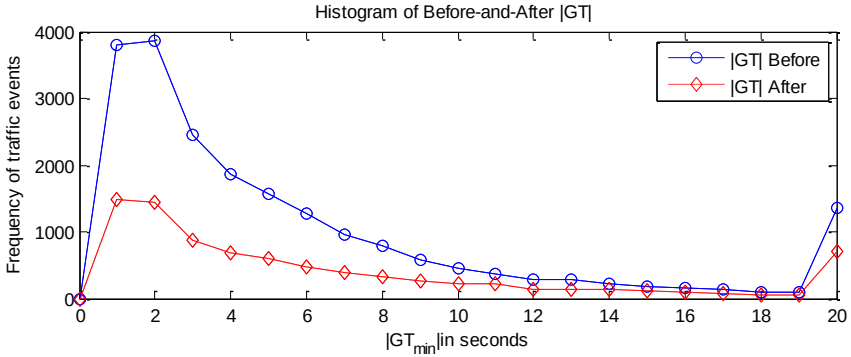


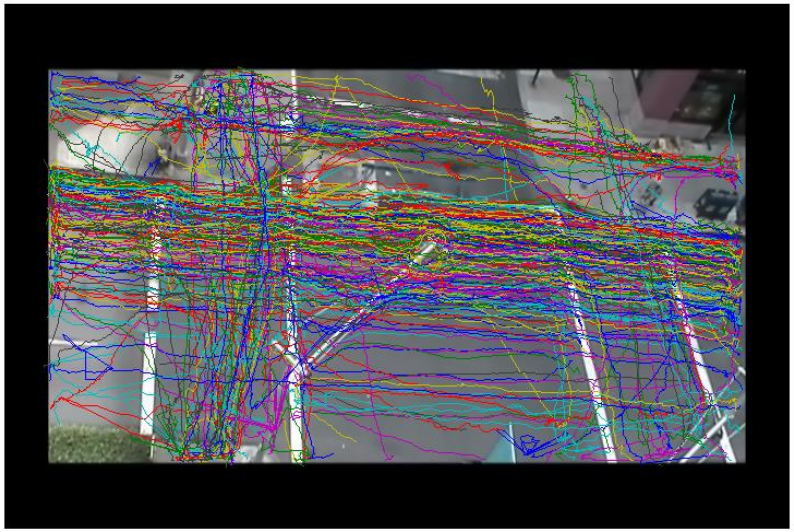



# Summer Streets

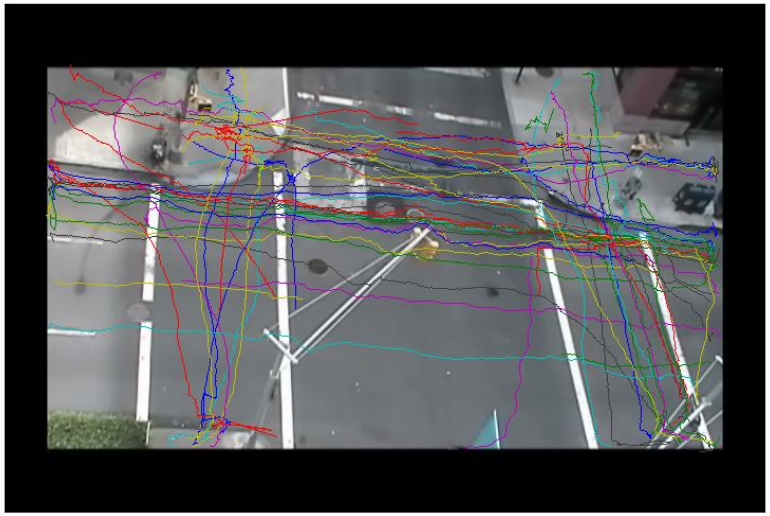
- Three consecutive Sundays in August, seven miles of New York City's streets are open to the public to play, run, walk and bike
- Annual program was initiated in 2008
- Events are free and are held between 7:00 am – 1:00 pm and extend from Brooklyn Bridge to Central Park along Park Avenue
- In 2013, over 300,000 people used the seven miles of streets closed to traffic during the festival

# Summer Streets

**Summer Streets**



**Transition**



After-Normal Operations

# Automated Safety and data Collection Analysis - Conclusion

- A **new** approach to road safety analysis and automated data collection
  - Proactive, generic and low cost approach
  - High accuracy and consistency
  - Provides microscopic road user behavior data
    - better understanding of road user behavior
  - BA safety evaluations can be undertaken in shorter time periods
- Applications: Safety, Planning, Simulation Calibration