

# How to Evaluate all the Functions of Streets?

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**POLYTECHNIQUE  
MONTREAL**

WORLD-CLASS  
ENGINEERING

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Road User Behaviour and Safety Analysis

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**What are traditionally the functions of roads?**



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- Transit

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- Transit
- Access to land and buildings

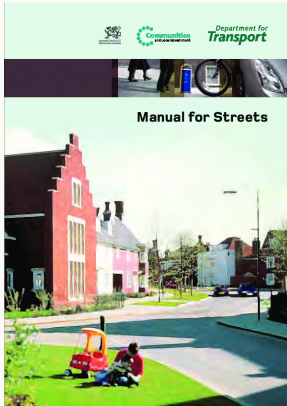
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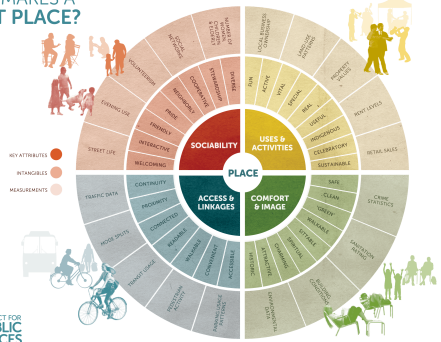
- Streets serve other functions and a larger variety of users with different abilities and needs

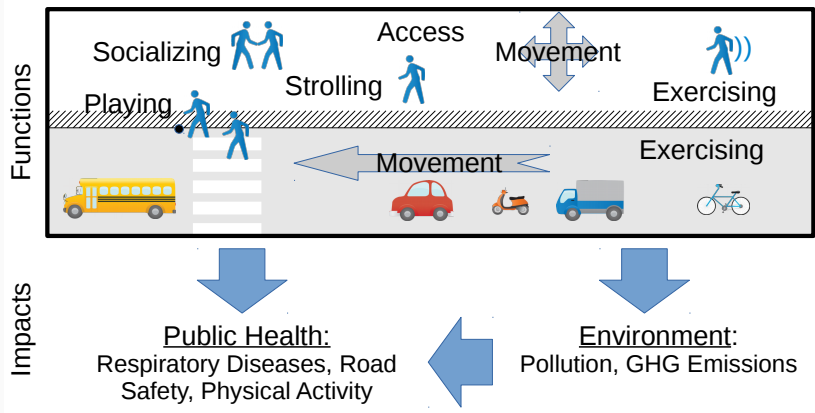
## **How are streets different?**

- Streets serve other functions and a larger variety of users with different abilities and needs
- A “place” for social activities



## WHAT MAKES A GREAT PLACE?





## **Long-term Objective**

To develop a framework and automated methods for the integrated evaluation of the functions of streets and the impacts of their use based on the naturalistic observation of all users



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# Processing Steps

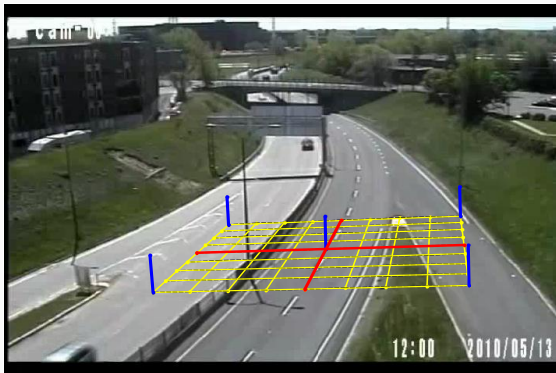
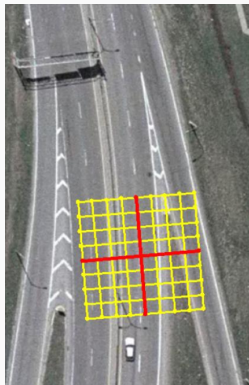
1. Video data collection
2. Data preparation
3. Moving road user detection, tracking and classification

# Step 1: Video Data Collection



## Step 2: Data Preparation

In particular, camera calibration: homography, distortion, etc.



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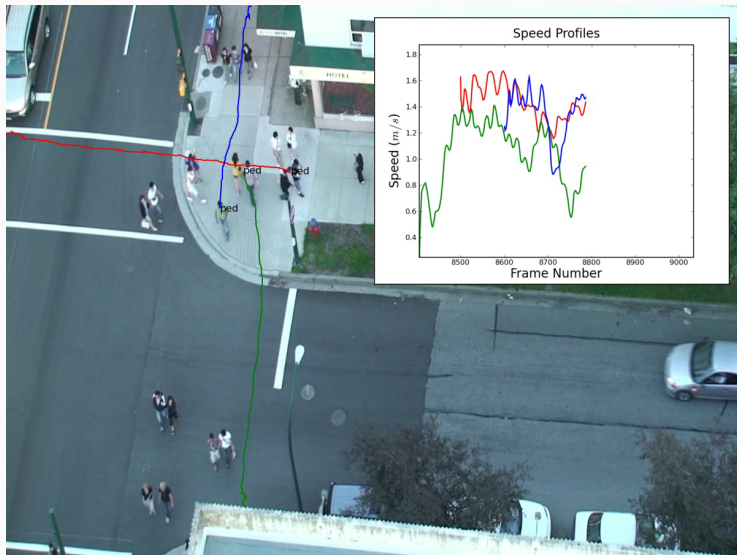
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## Step 3: Road User Detection, Tracking and Classification



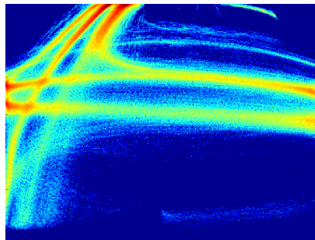
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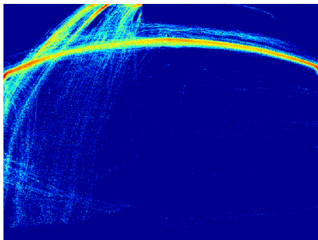
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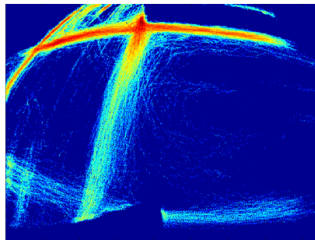
(a) Snapshot of video frame



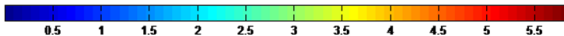
(b) Vehicle trajectory heat-map



(c) Cyclist trajectory heat-map



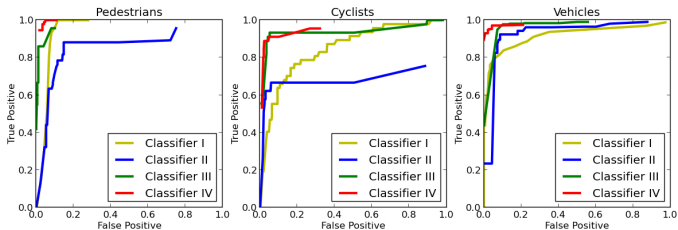
(d) Pedestrian trajectory heat-map



(e) Scale used for trajectory heat-maps (log-scale)

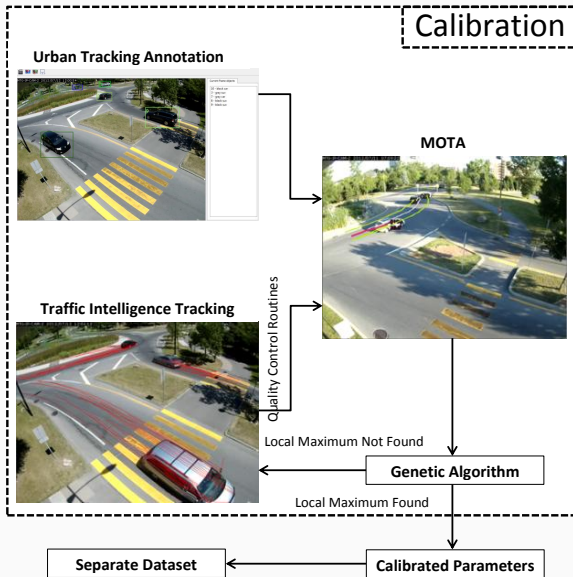


# Step 3: Road User Detection, Tracking and Classification



ROC Curves

# Step 3: Optimization of Tracking parameters



### Step 3: Optimization of Tracking parameters

		Parameters optimized for				
Site	Default	S1S	S1W	S2	S3V1	S3V2
S1S	0.719046	0.904502	0.820976	0.817581	0.841254	0.823145
S1W	0.041073	0.114581	0.709927	0.077883	0.044429	0.050852
S2	0.703178	0.74025	0.622532	0.766731	0.745787	0.718321
S3V1	0.759758	0.797088	0.778268	0.793216	0.817457	0.799231
S3V2	0.750416	0.704989	0.737339	0.776115	0.700151	0.788521
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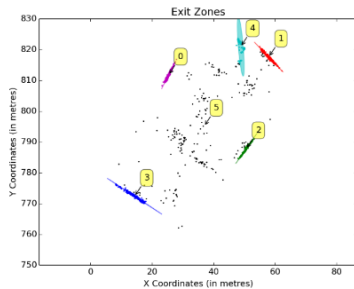
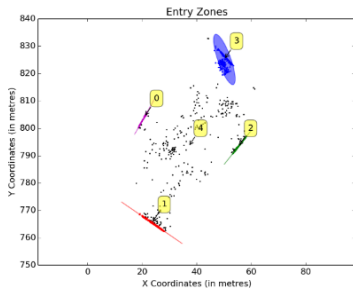
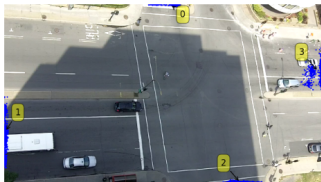
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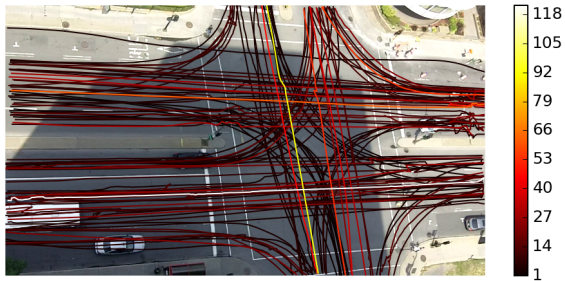
# Processing Steps

4. Motion pattern learning
5. Motion prediction
6. Safety indicators
7. Interpretation

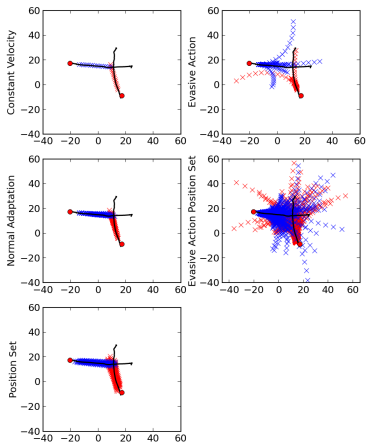
# Step 4: Motion Pattern Learning



## Step 4: Motion Pattern Learning



## Step 5: Motion Prediction



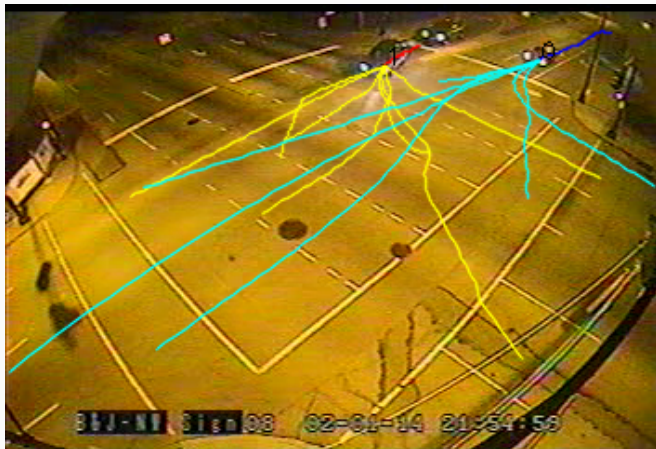
A traffic conflict is “an observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged”



## Step 5: Motion Prediction



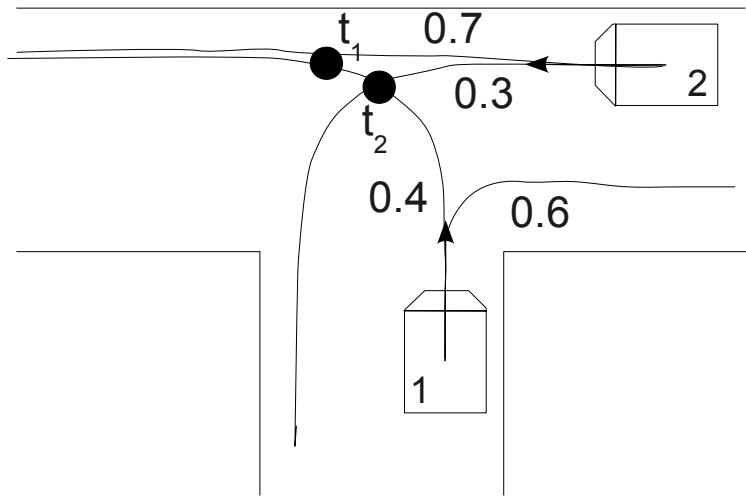
## Step 5: Motion Prediction



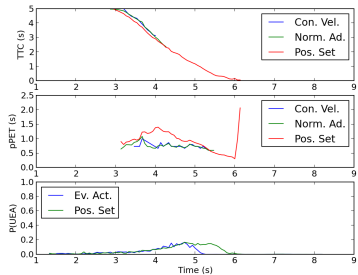
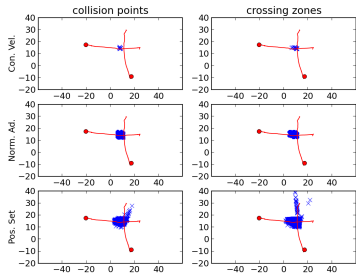
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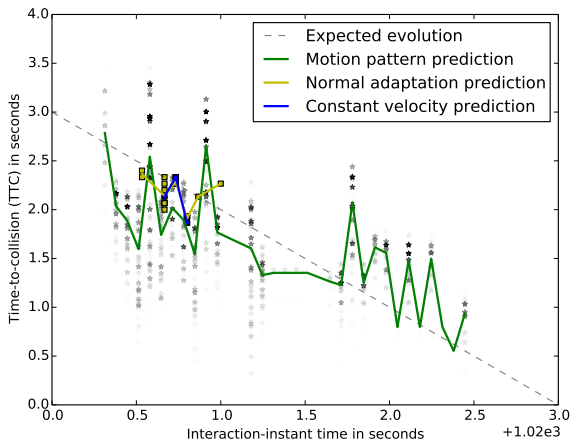
## Step 6: Safety Indicators



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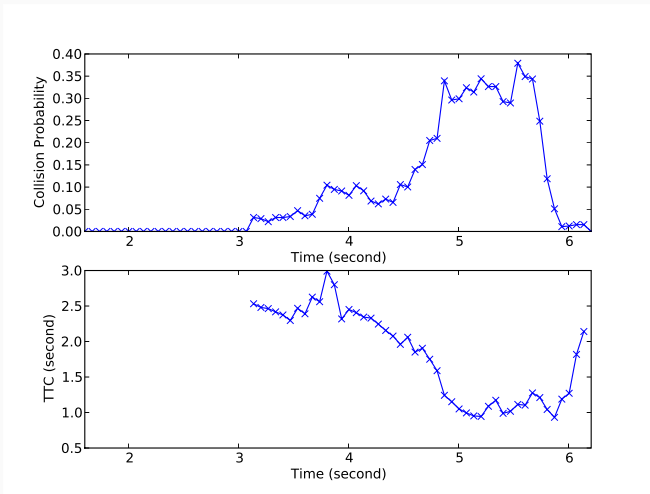


## Step 6: Safety Indicators



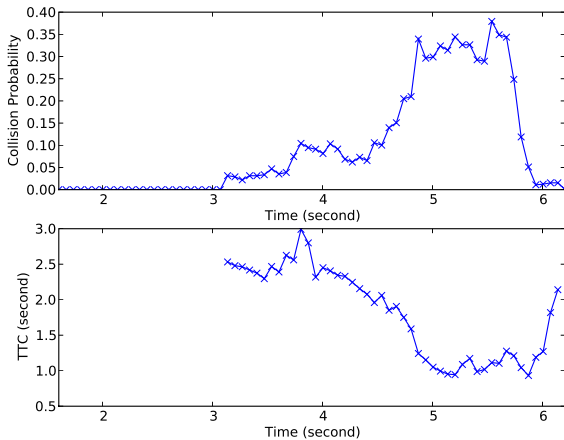
## Step 7: Interpretation

For each interaction, we have



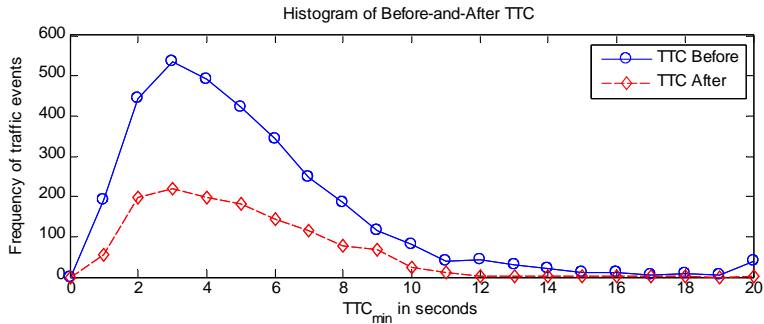
## Step 7: Interpretation

How should data be aggregated?



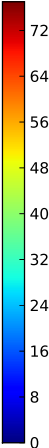
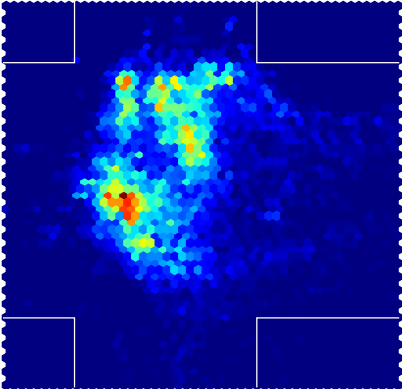


## Step 7: Interpretation

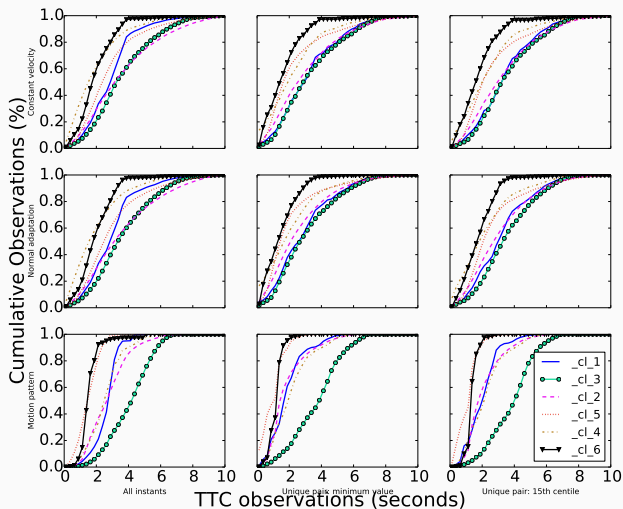


# Step 7: Interpretation

Traffic Conflicts



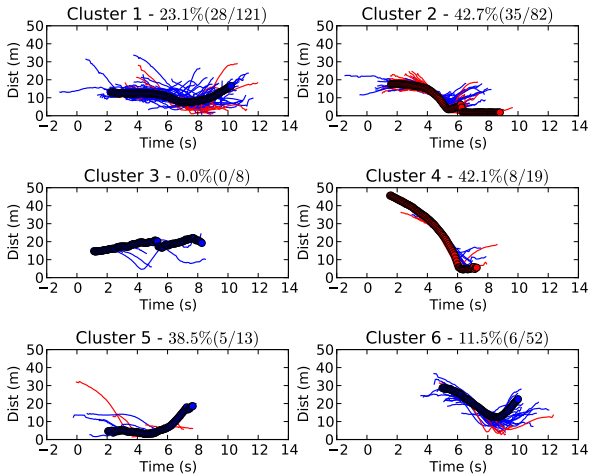
# Step 7: Interpretation



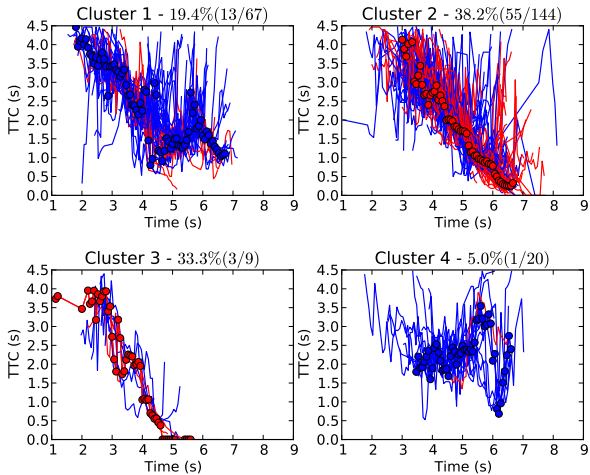
## Step 7: Interpretation

	<b>Model I. Cycle track on the right vs. no cycle track</b>			<b>Model II. Cycle track on the left vs. no cycle track</b>			<b>Model III. Cycle track on the right vs. cycle track on the left</b>		
	Coef.	Std. Err.	Sig.	Coef.	Std. Err.	Sig.	Coef.	Std. Err.	Sig.
Cycle Track on Right	0.395	0.181	0.03	-	-	-	-	-	-
Cycle Track on Left	-	-	-	Not Significant			-0.513	0.131	0.00
Bicycle Flow for 5s before to 5s after	Not Significant			0.088	0.038	0.02	0.066	0.034	0.05
Turning-Vehicle Flow for 5s before to 5s after	-2.771	0.132	0.00	-3.265	0.090	0.00	-3.131	0.080	0.00
Number of Lanes on the Main Road	-0.151	0.078	0.05	Not Significant			Not Significant		
Number of Lanes on the Turning Road	Not Significant			0.324	0.146	0.03	0.457	0.178	0.01
Cut-off 1	-6.599	0.353	0.00	-7.372	0.301	0.00	-7.621	0.323	0.00
Cut-off 2	-4.233	0.273	0.00	-3.807	0.223	0.00	-4.125	0.265	0.00
Cut-off 3	-3.150	0.256	0.00	-2.102	0.211	0.00	-2.479	0.258	0.00
Number of Observations	2880			4803			6567		
Log likelihood	-804			-1876			-2330		

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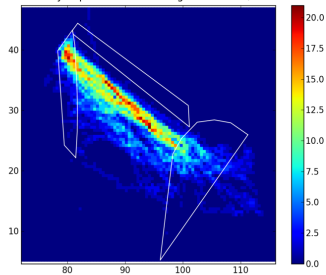
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# Dangerous Pedestrian Crossings and Violations at Signalized Intersections



Spatial density of pedestrians crossings at Amherst/Sherbrooke

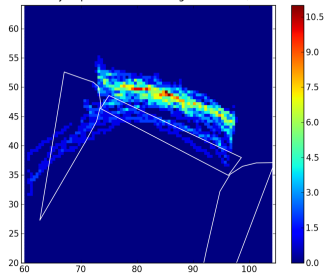




# Dangerous Pedestrian Crossings and Violations at Signalized Intersections



Spatial density of pedestrians crossings at Iberville/Sherbrooke



# Analysis of Bicycle Facilities in Montreal

- Bicycle boxes
  - video data collected at 2 sites, before and after the installation of a bicycle box, and 2 control sites without

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- Cycle tracks

	# intersections	Duration
Cycle track on the right	8 intersections	37 h
Cycle track on the left	7 intersections	22 h
No cycle track	8 intersections	31 h
Total	23 intersections	90 h

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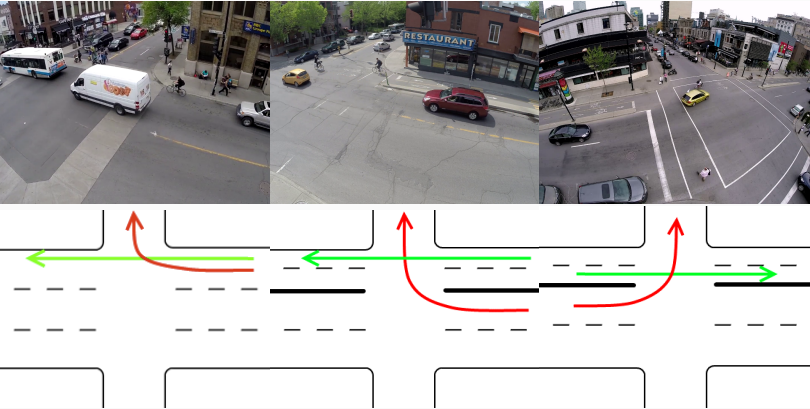
- Cycling discontinuities

# Model of Dangerous Interactions at Bicycle Boxes

Explanatory variables	Interaction Type 1						Interaction Type 2					
	Interaction (PET < 5s)			Dangerous Interaction (PET < 1.5s)			Interaction (PET < 5s)			Dangerous Interaction (PET < 1.5s)		
	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.
<b>Constant</b>	-0.559	0.00	-	-1.954	0.00	-	-2.994	0.00	-	-4.354	0.00	-
<b>Bicycle Flow during 30s before</b>	0.423	0.00	7.7 %	0.434	0.00	2.1 %	-	-	-	-	-	-
<b>Vehicle Flow 1 during 30s before</b>	0.091	0.00	1.6 %	0.040	0.04	0.2 %	0.063	0.00	0.4 %	-	-	-
<b>Vehicle Flow 2 during 30s before</b>	-0.086	0.00	-1.6 %	-0.082	0.01	-0.4 %	0.117	0.00	0.8 %	0.097	0.00	0.1 %
<b>Presence of Bicycle Box</b>	<b>-0.739</b>	<b>0.00</b>	<b>-14 %*</b>	<b>-1.226</b>	<b>0.00</b>	<b>-7 %*</b>	<b>-0.726</b>	<b>0.00</b>	<b>-5 %*</b>	<b>-2.050</b>	<b>0.00</b>	<b>-2 %*</b>
<b>Observations</b>	1054						1054					
<b>Percentage of positive obs.</b>	27.6 %			7.5 %			9.8 %			1.3 %		
<b>Log-likelihood</b>	-544.00			-251.48			-299.85			-66.44		
<b>Pseudo R<sup>2</sup></b>	0.133			0.109			0.117			0.110		

\* Elasticity for discrete change of dummy variable from 0 to 1

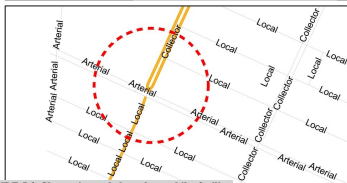
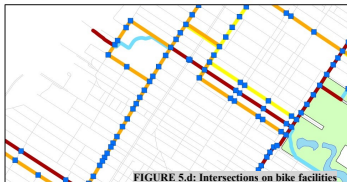
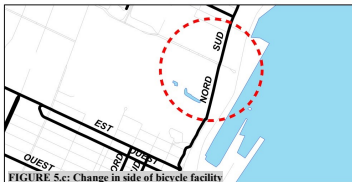
# Turning Vehicle Interactions with Cycle Tracks



# Three PET Ordered Logit Models

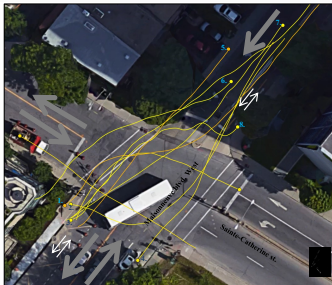
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# Cyclist Behaviour at Cycling Discontinuities

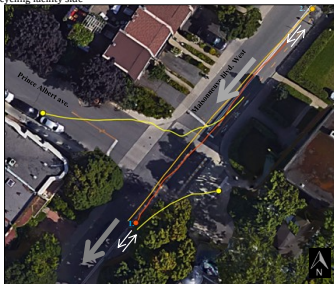




# Cyclist Behaviour at Cycling Discontinuities



Maisonneuve boulevard west and Sainte-Catherine street Discontinuity: change in cycling facility side

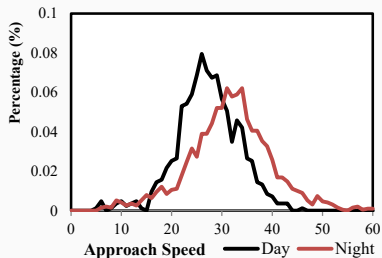


Maisonneuve boulevard west and Prince Albert avenue: control site

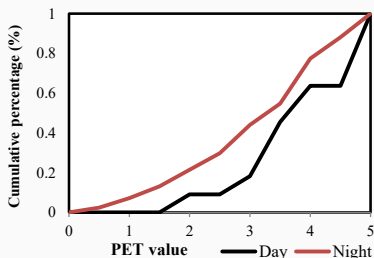
# Safety of Pedestrian Crossings at Night



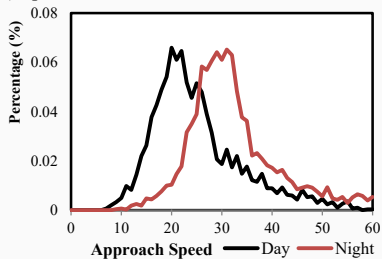
# Safety of Pedestrian Crossings at Night



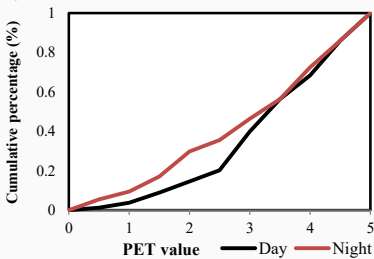
a) Speed distribution – du Fort



b) Accumulative conflict distribution – du Fort



c) Speed distribution – st-Laurent



d) Accumulative conflict distribution – st-Laurent

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# Conclusion

- Lots of work on safety, less on behaviour
- Video analysis can provide high quality trajectories, but analyzing automatically open urban traffic scenes in all conditions is still an open problem
- Video analysis for transportation applications is **big data**
  - many challenges: data organization, processing and interpretation

- Integrated framework of indicators to measure the different dimensions (functions and impacts) of streets
- Automated methods for activity recognition
- Systematic visualization of the dimensions of streets
- Case studies on shared spaces (official or informal)



- Collaboration with Tarek Sayed (UBC), Karim Ismail (Carleton), Mohamed Gomaa Mohamed, Paul St-Aubin, Martin Nabavi Niaki (Polytechnique Montréal), Luis Miranda-Moreno, Sohail Zangenehpour, Ting Fu (McGill), Aliaksei Laureshyn (Lund)
- Funded by the Natural Sciences and Engineering Research Council of Canada (NSERC), the Québec Research Fund for Nature and Technology (FRQNT) and the Québec Ministry of Transportation (MTQ), City of Montreal



Questions?