Detecting Traffic Crash Patterns and Identifying the most Risky Hotspots by Street Section for Vision Zero Boston using Spatial Statistical Methods

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VISION ZERO BOSTON

- Vision Zero is an international road traffic safety initiative that aims to achieve a road traffic system with no fatalities or serious injuries. It started in Sweden and was approved by their parliament in October 1997.

- The City of Boston joined New York, Washington DC and other cities worldwide in adopting Vision Zero and issuing similar plans to prioritize transportation safety in March 2015.

- Vision Zero Boston is our commitment to focus the city's resources on proven strategies to eliminate fatal and serious traffic crashes.

- See http://www.visionzeroboston.org for more details.

VISION ZERO BOSTON –
THE MOST RISKY HOTSPOTS BY STREET SECTION

- Objectives:

  To detect traffic crash patterns and identify the most risky clusters / hotspots by street section and to help to prioritize engineering projects for improving traffic conditions.

- Methodologies:

  Two spatial statistical methods:

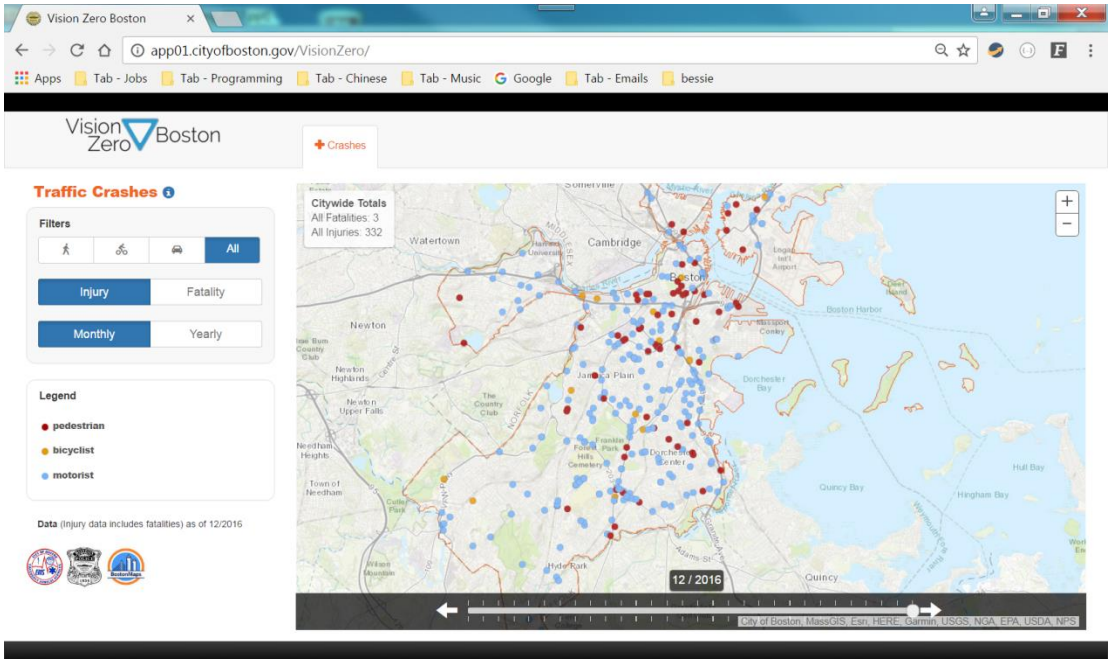
  1, Kernel Density Estimation (Planar and Network KDE).

  2, Local Indicator (Getis-Ord Gi*) of Network-Constrained Clusters (GLINCS).

- Website: http://app01.cityofboston.gov/proxy/vzanalysispart2

TRAFFIC CRASH DATA

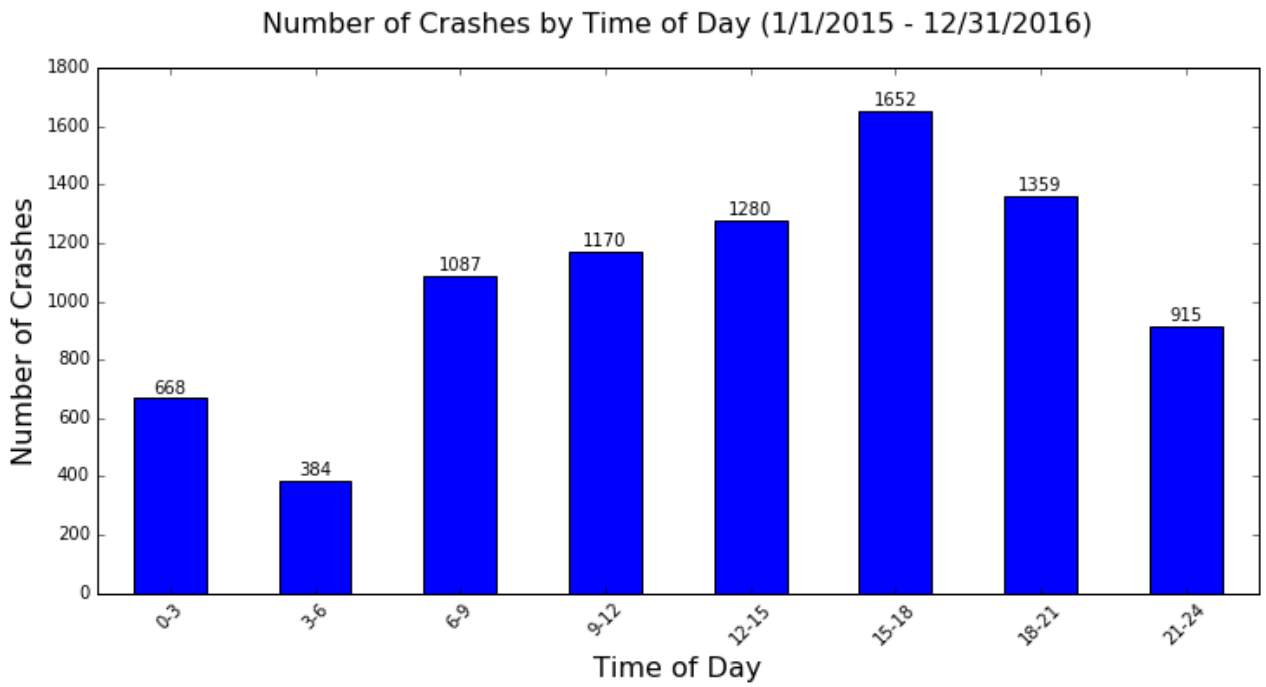
- http://app01.cityofboston.gov/VisionZero



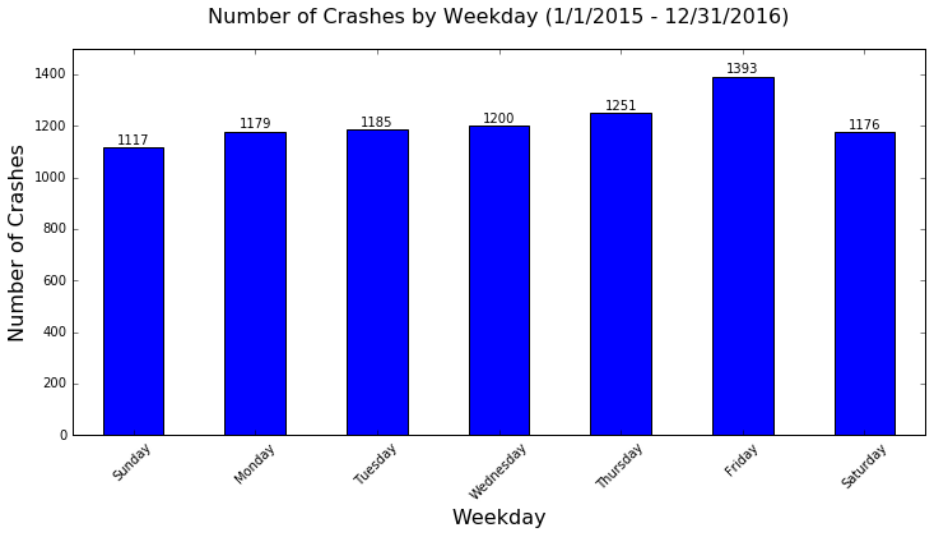
- Traffic Crash Data Used in Analysis

  Totaled 10,752 Crashes from 7/1/2014 - 12/31/2016.

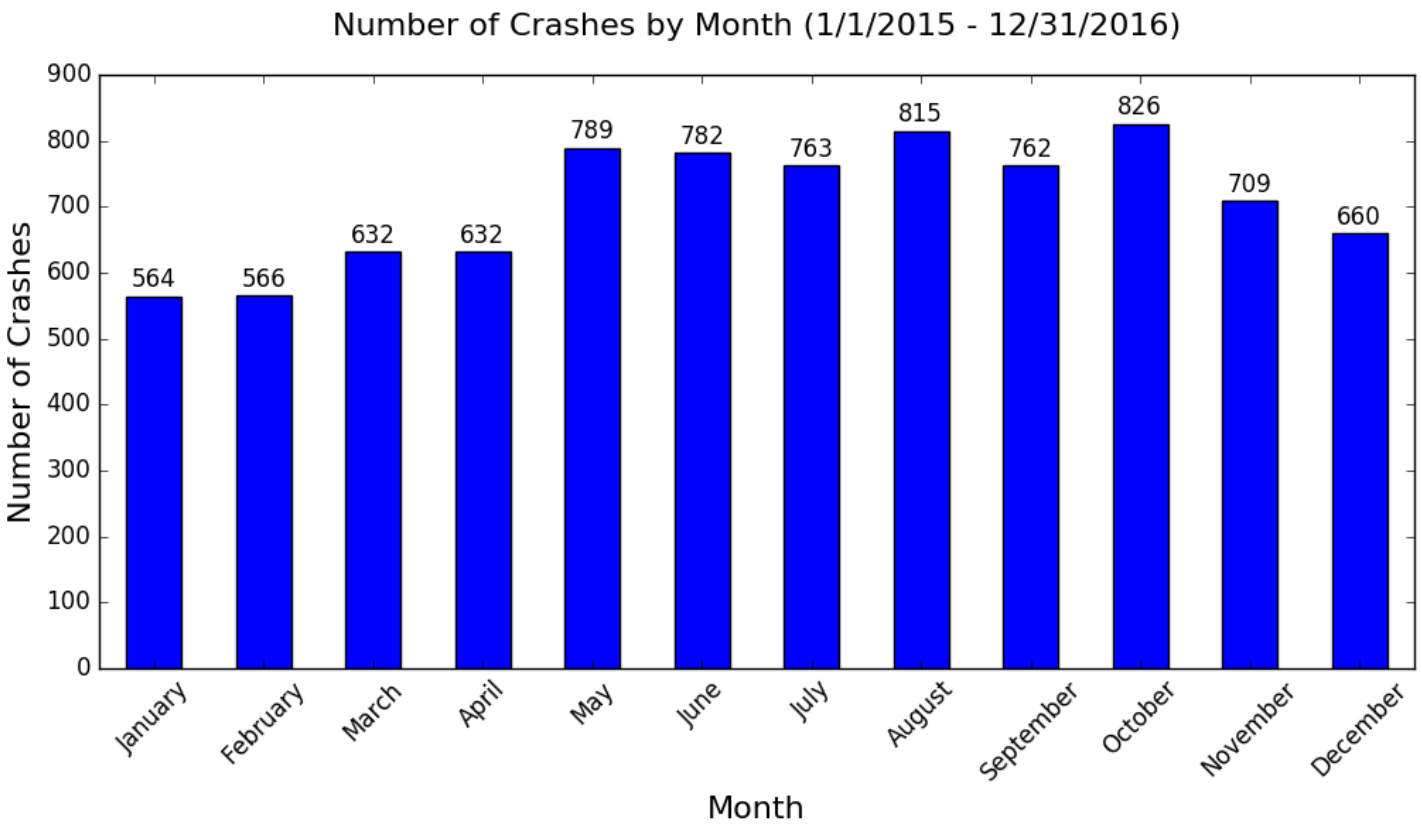
TRAFFIC CRASH DATA



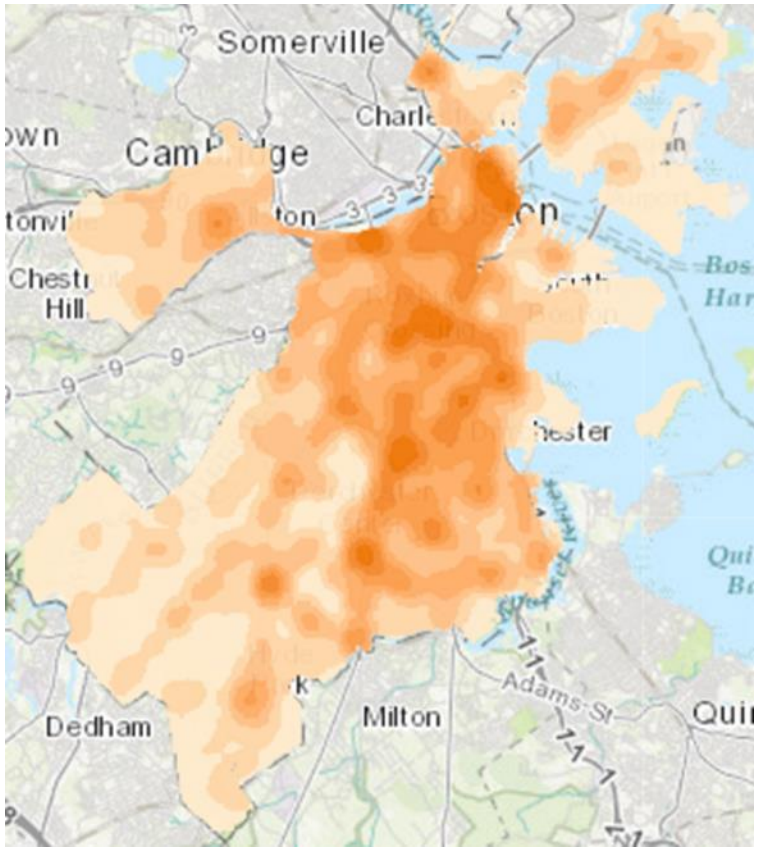
TRAFFIC CRASH DATA

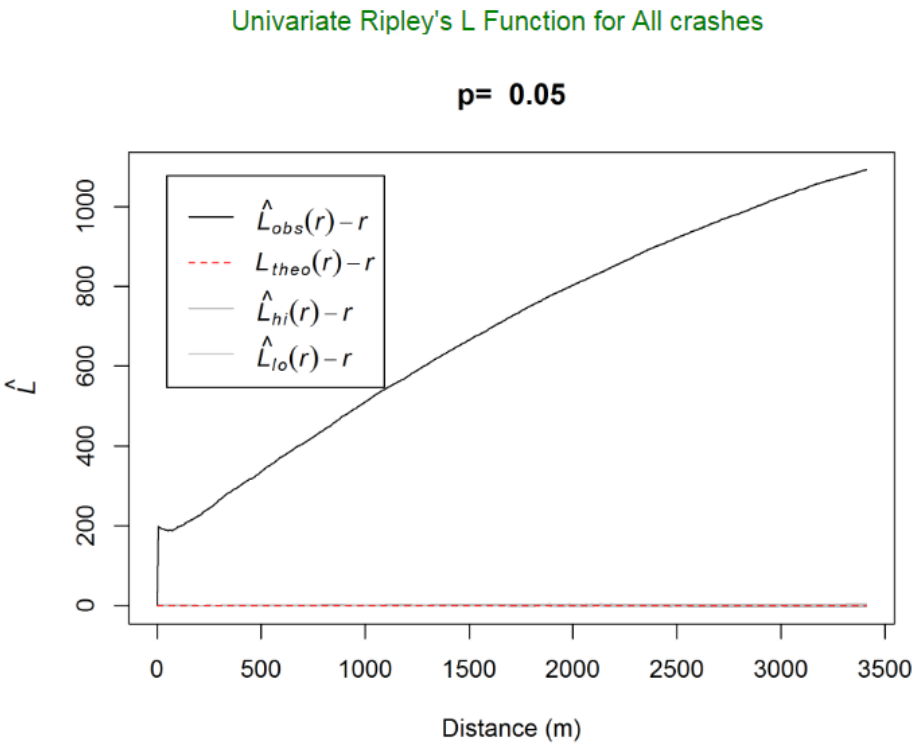


TRAFFIC CRASH DATA

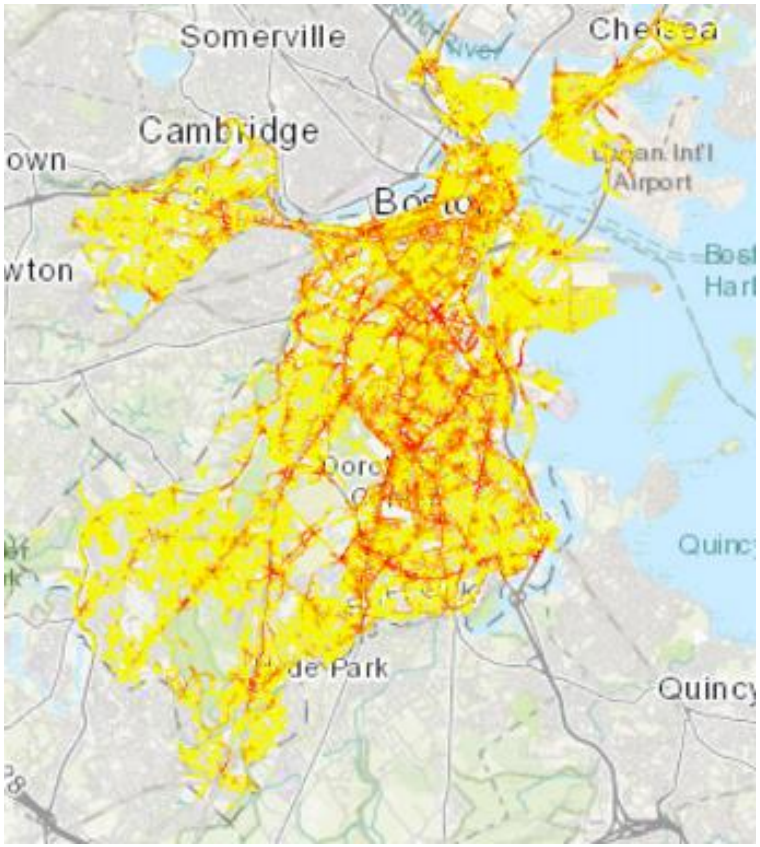


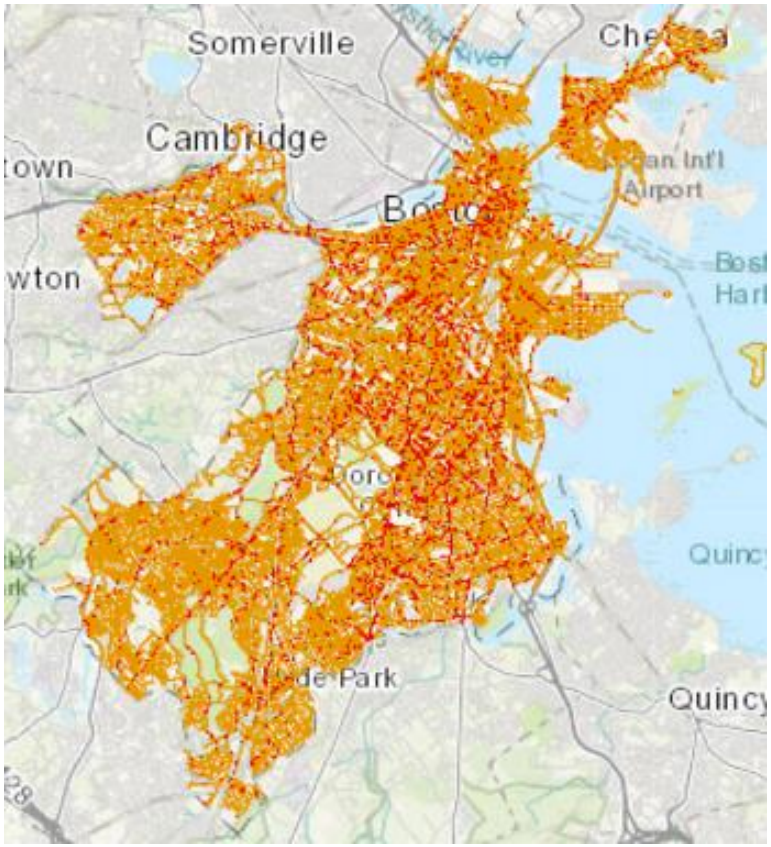
SPATIAL PATTERN OF TRAFFIC CRASHES BY PLANAR DISTANCE





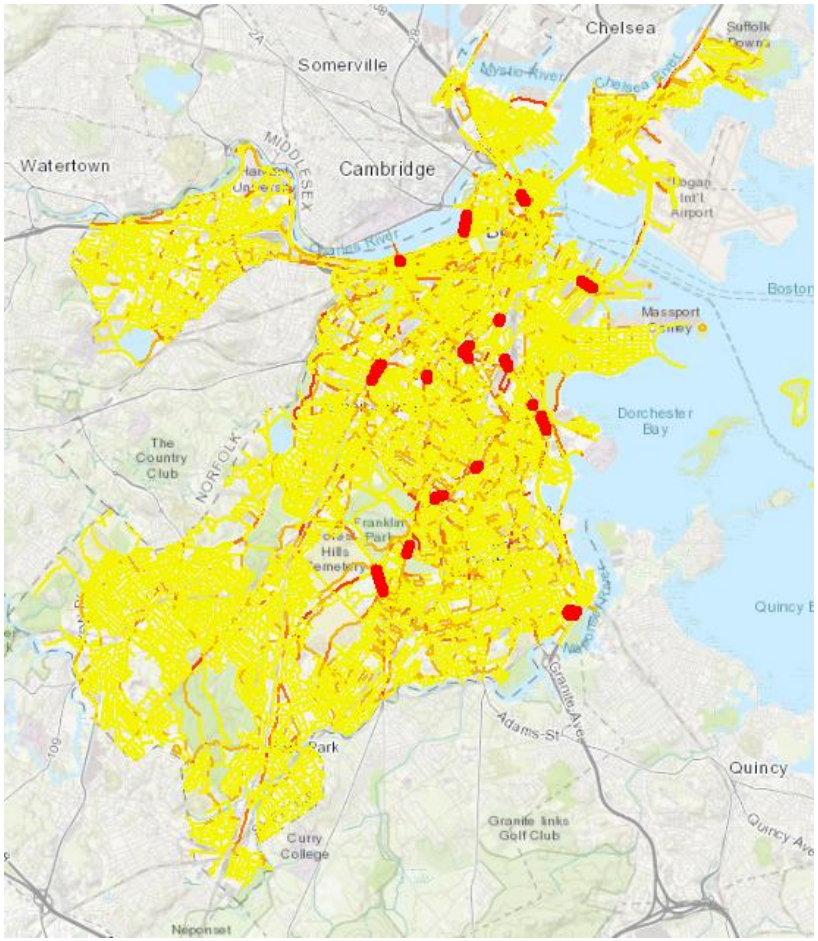
SPATIAL PATTERN OF TRAFFIC CRASHES BY NETWORK DISTANCE

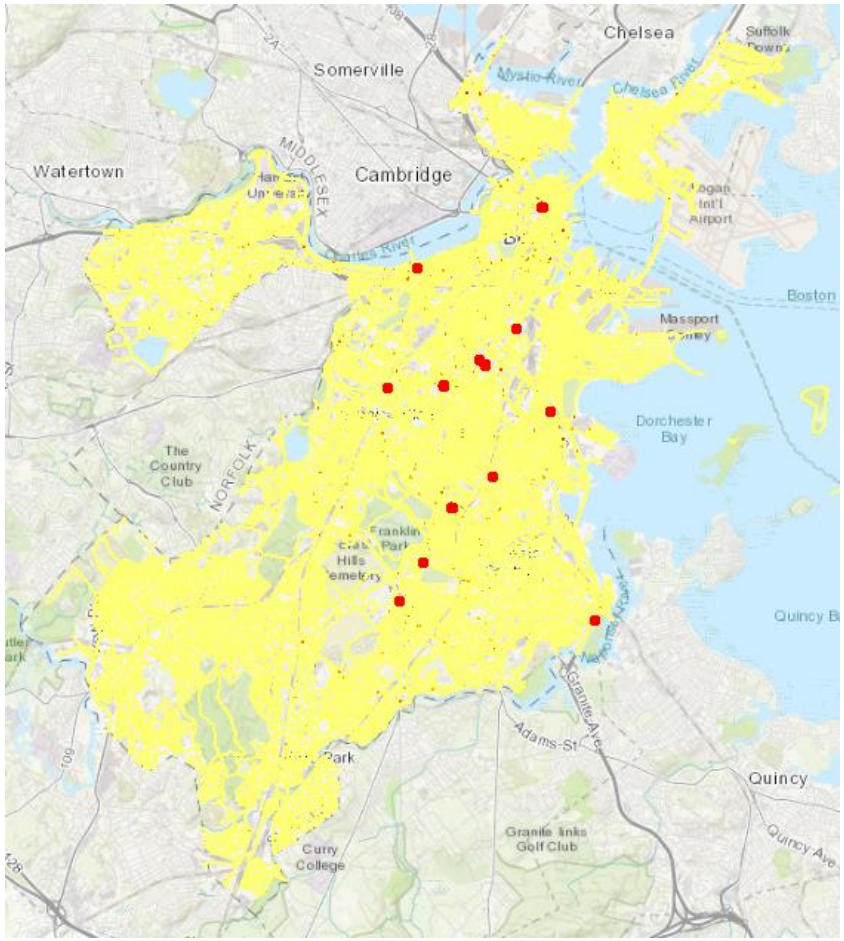




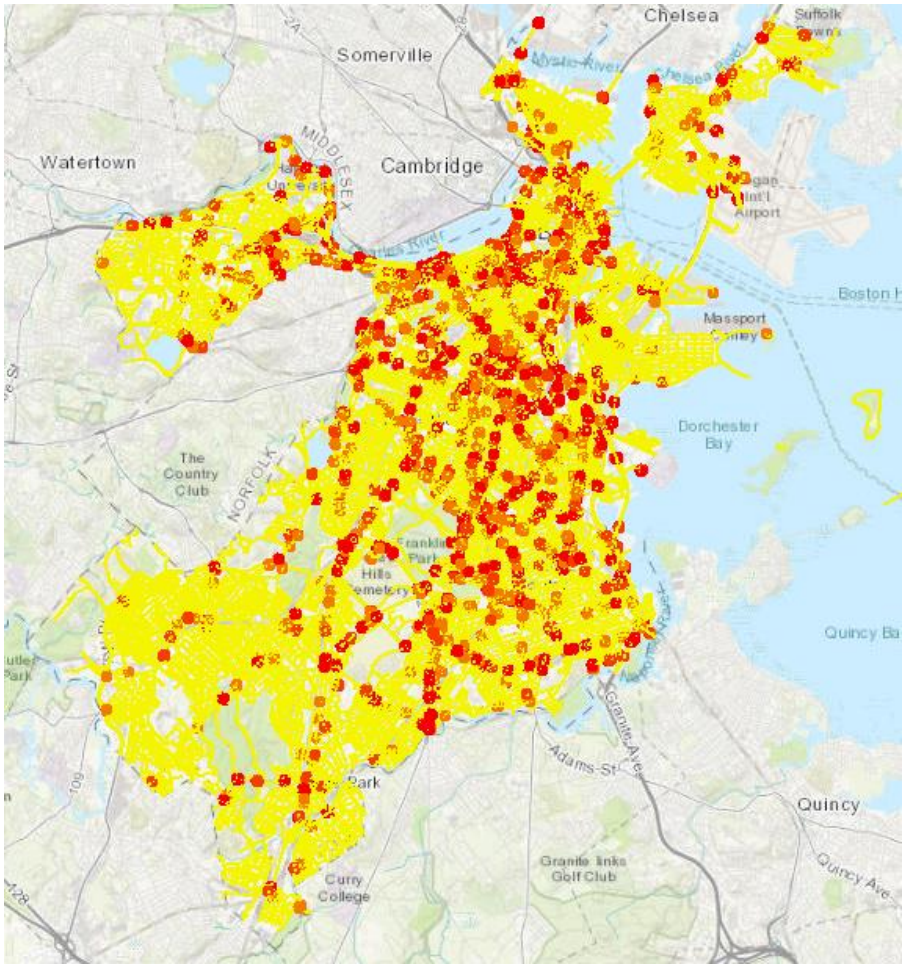
STREET SEGMENT VS STREET SECTION

THE MOST RISKY STREET SEGMENTS AND SECTIONS (> 20 Crashes)



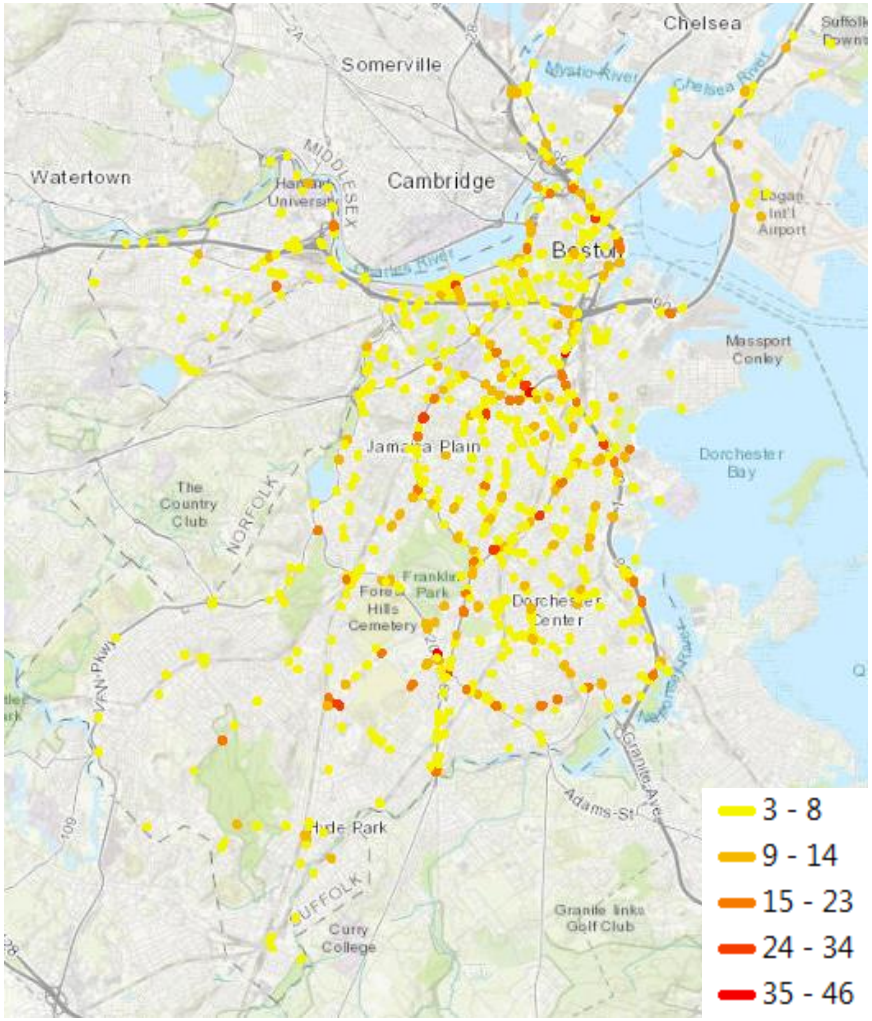


THE RISKY HOTSPOTS BY STREET SECTION



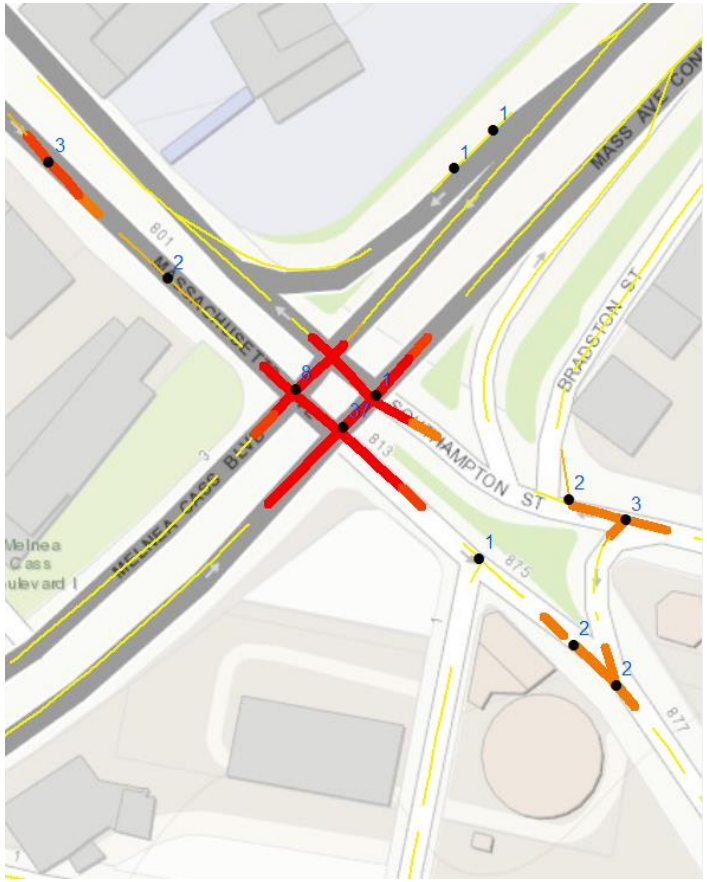
- Create a density map using Network Kernel Density Estimation (NKDE).
- Identify hotspots from the density map using Local Indicator (Getis-Ord Gi*) of Network-Constrained Clusters (GLINCS).
- GeoDaNET: A free and open source software.

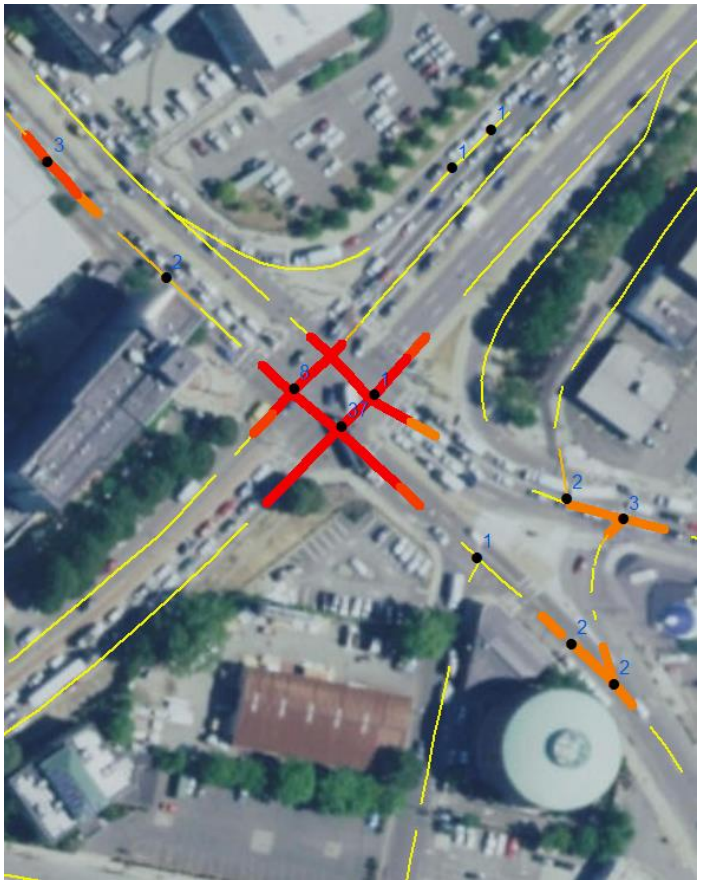
THE RISKY HOTSPOTS BY STREET SECTION



- 729 hotspots identified (Each hotspot has 3 or more crashes).
- The hotspots sorted by total number of crashes for each hotspot in descending order.
- Screenshots taken for top 17 most risky hotspots.

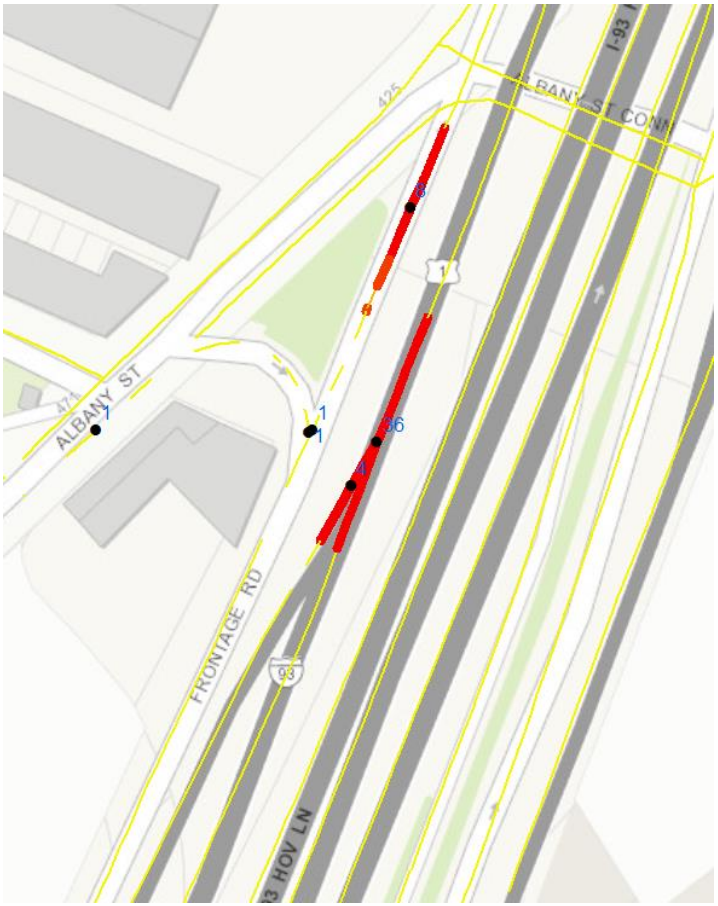
The Most Risky Hotspots (#1)





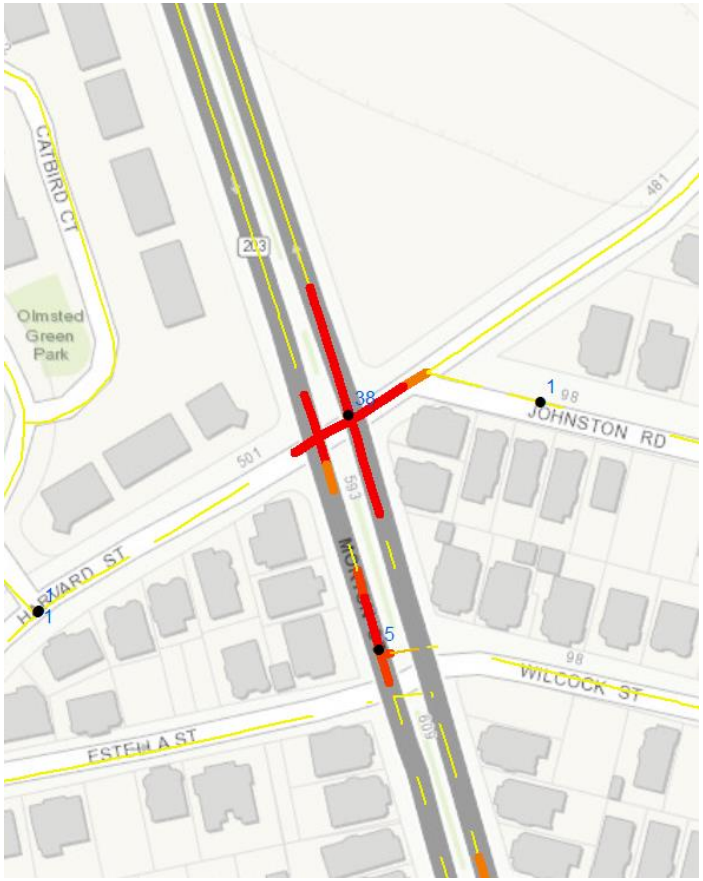
An intersection between Massachusetts Ave, Mass Ave Conn and Melnea Cass Blvd with 46 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#2)



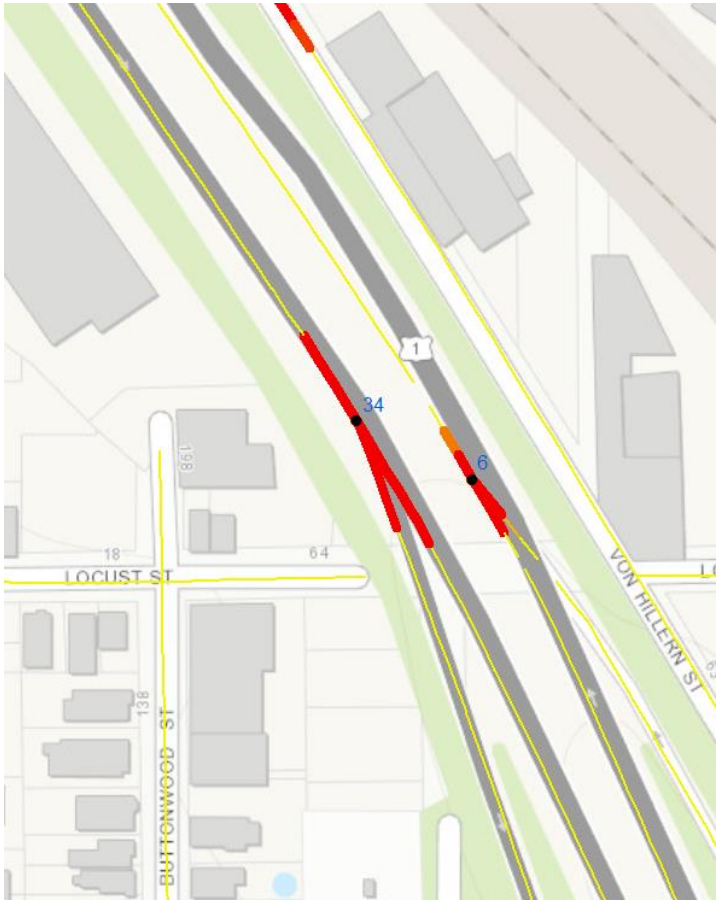
An Interstate 93 Exit towards Mass Ave Conn with 40 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#3)



An intersection between Morton St and Harvard St with 38 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#4)

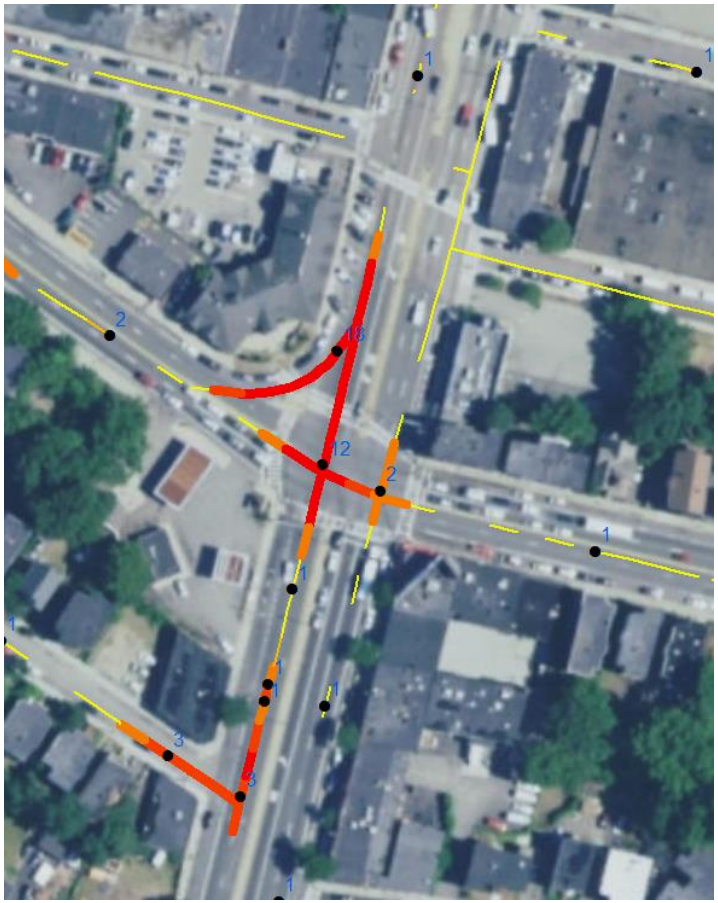


An Interstate 93 Exit towards Columbia Rd with 34 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#5)

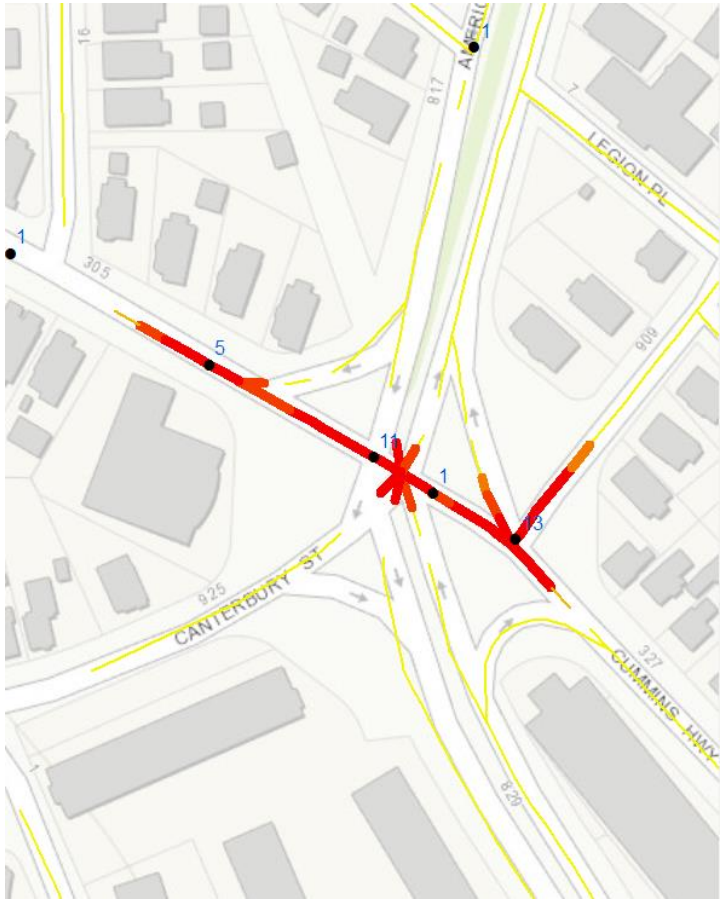
An Intersection between Massachusetts Ave and Albany St with 33 Traffic crashes during 7/1/2014 – 12/31/2016.

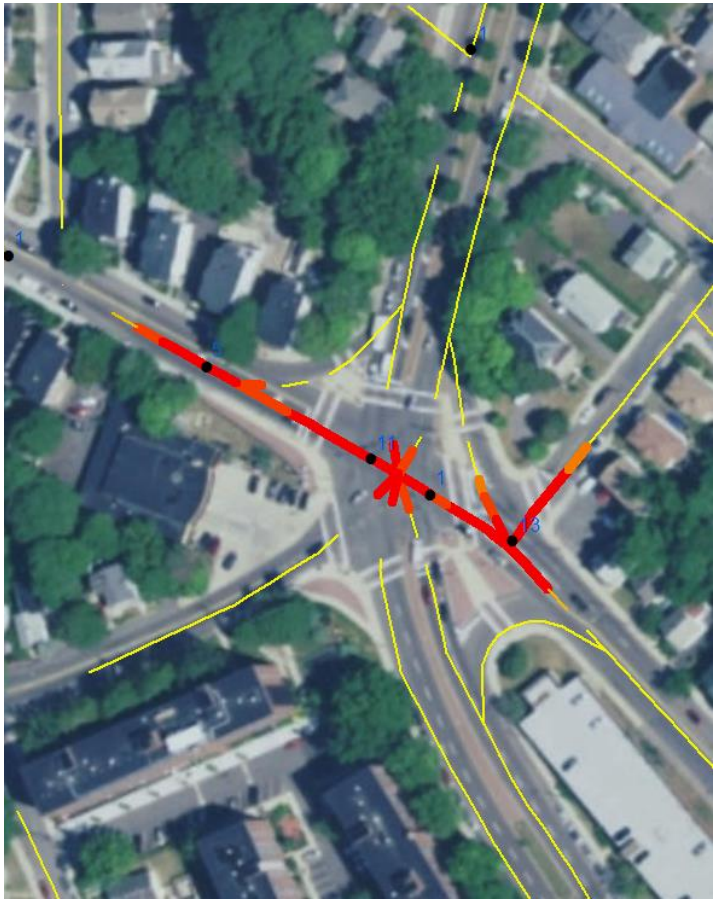
The Most Risky Hotspots (#6)



An Intersection between Blue Hill Ave Ave and Morton St with 32 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#7)



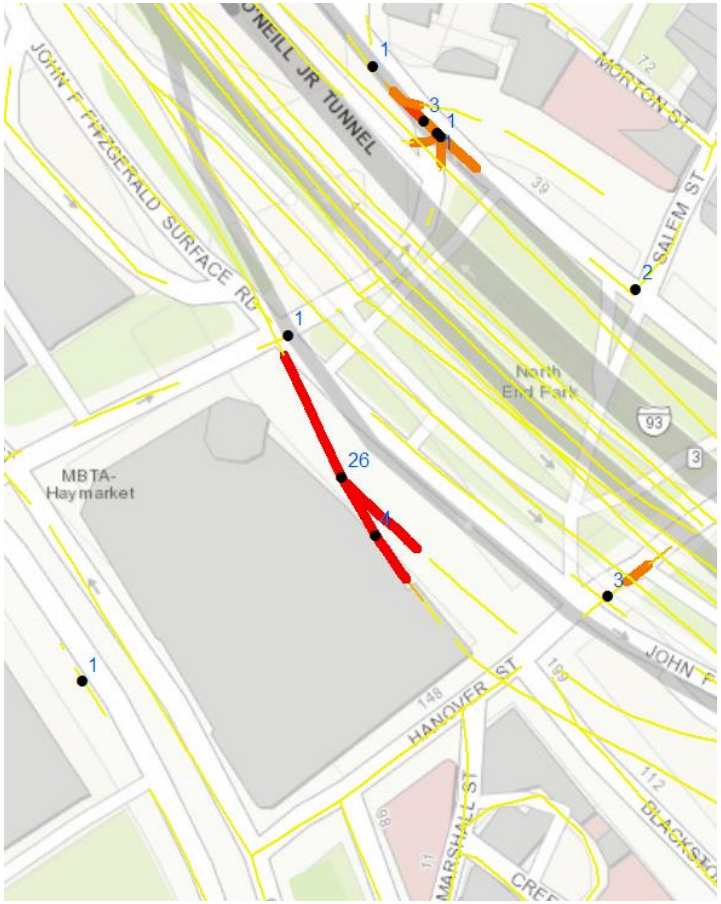


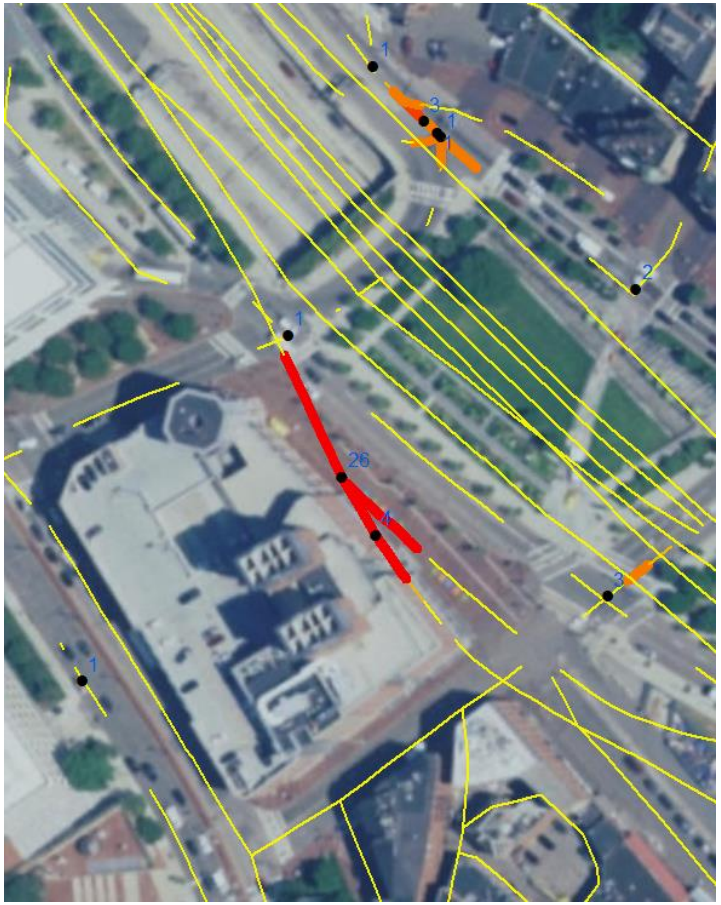
An Intersection between American Legion Hwy, Cummins Hwy and Canterbury St with 30 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#8)

An Intersection between Massachusetts Ave and Beacon St with 30 Traffic crashes during 7/1/2014 – 12/31/2016.

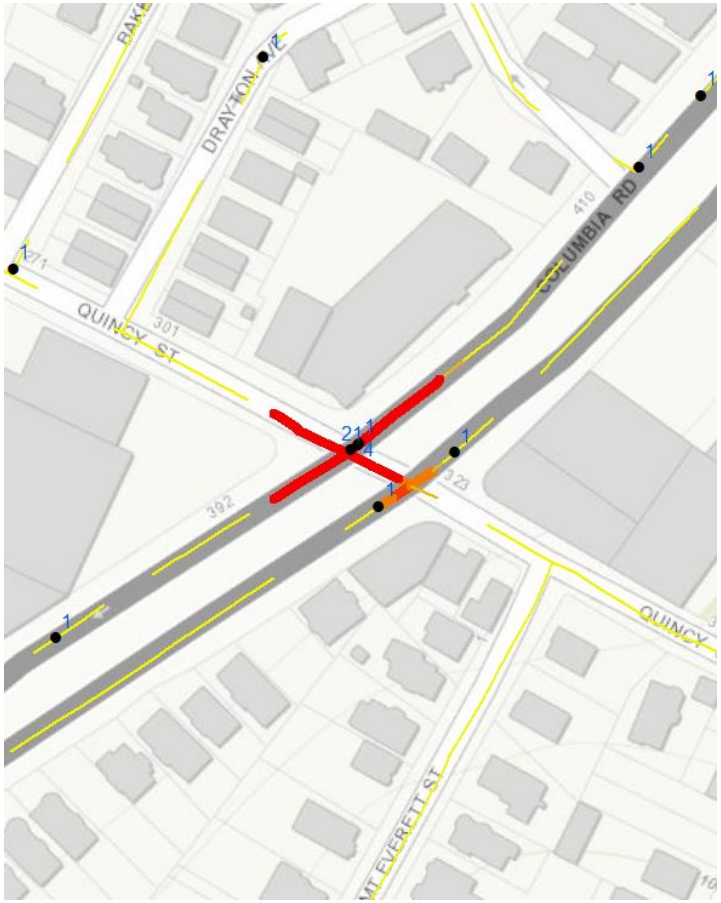
The Most Risky Hotspots (#9)





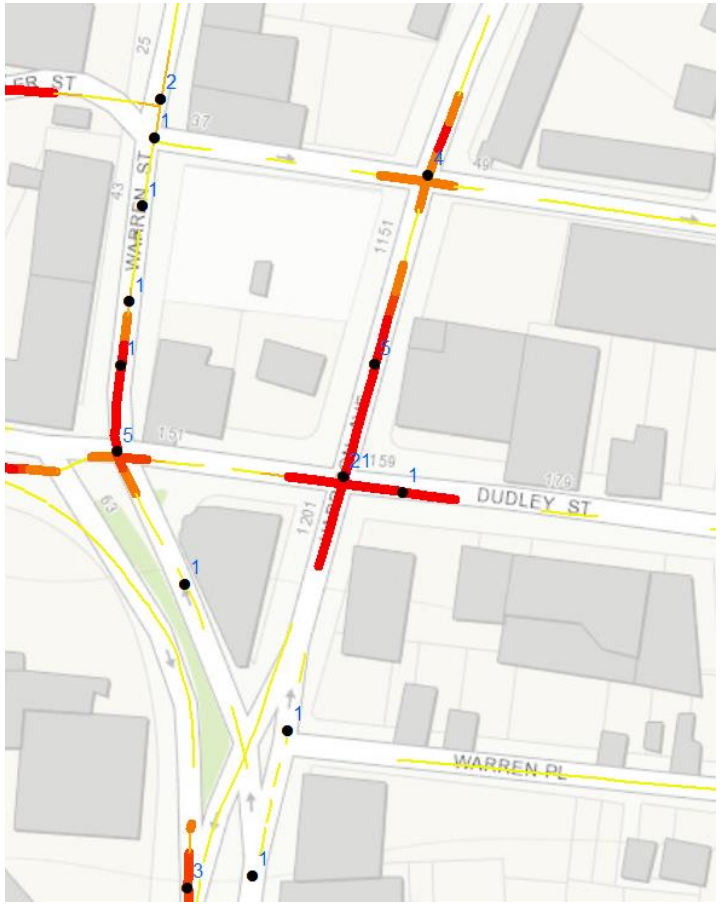
An Interstate 93 Ramp towards Clinton St with 30 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#10)



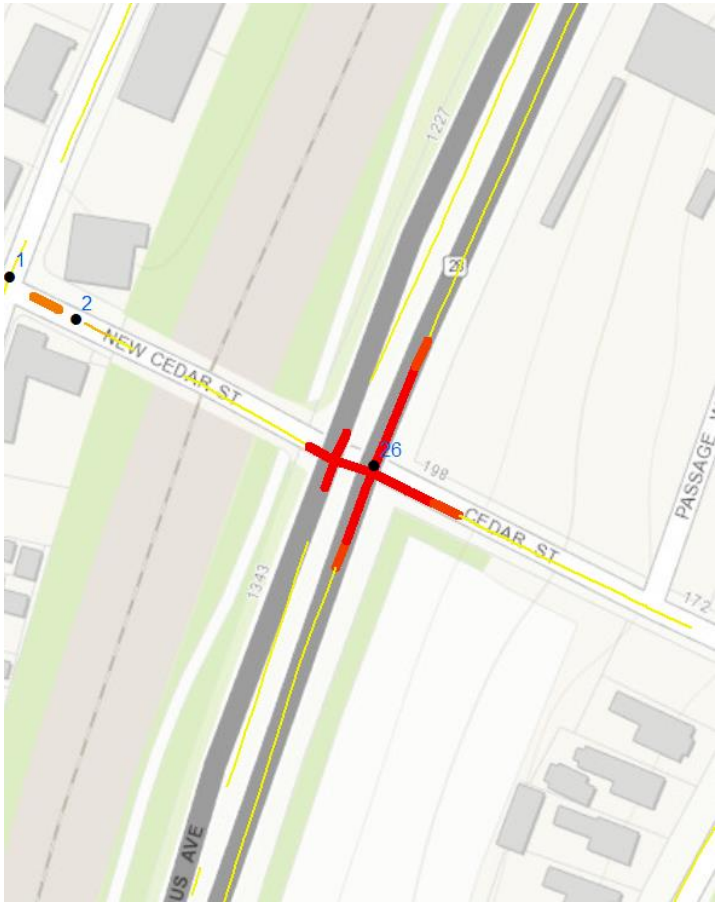
An Intersection between Columbia Rd and Quincy St with 27 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#11)



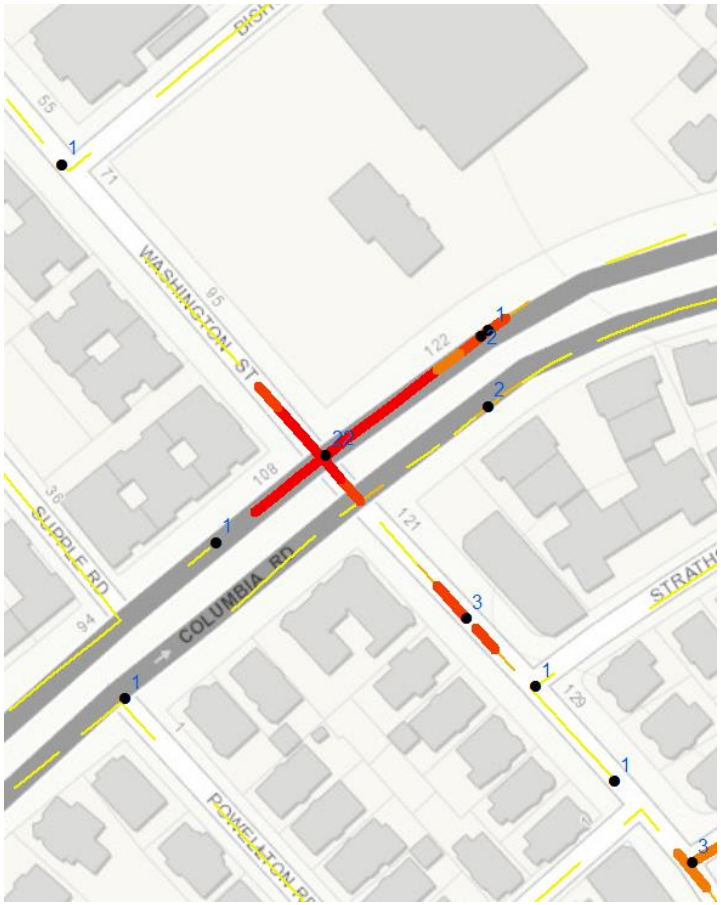
An Intersection between Harrison Ave and Dudley St with 27 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#12)



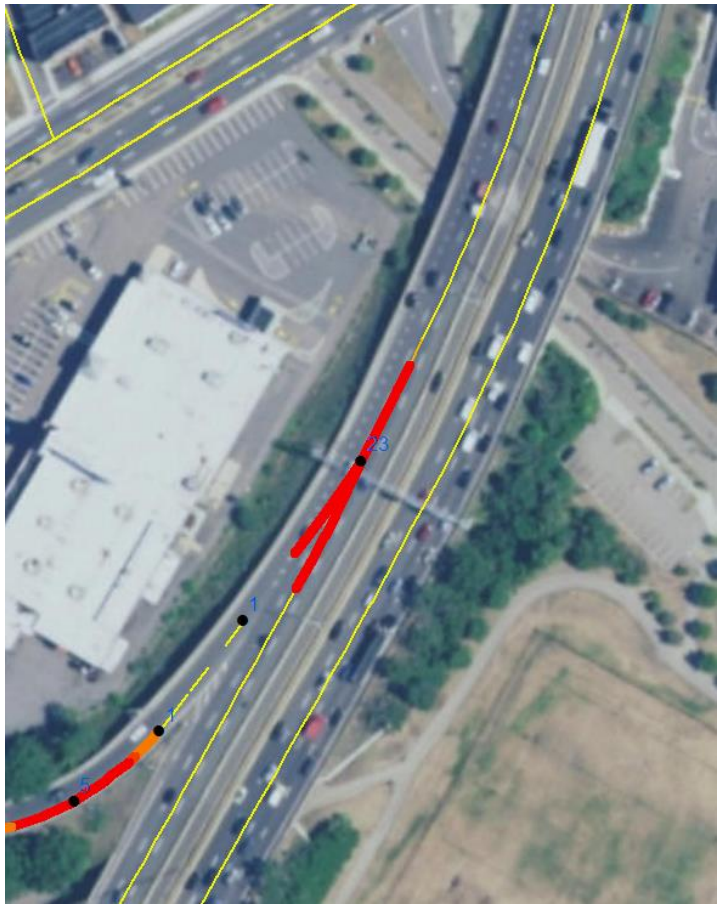
An Intersection between Columbus Ave, Cedar St and New Cedar St with 26 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#13)



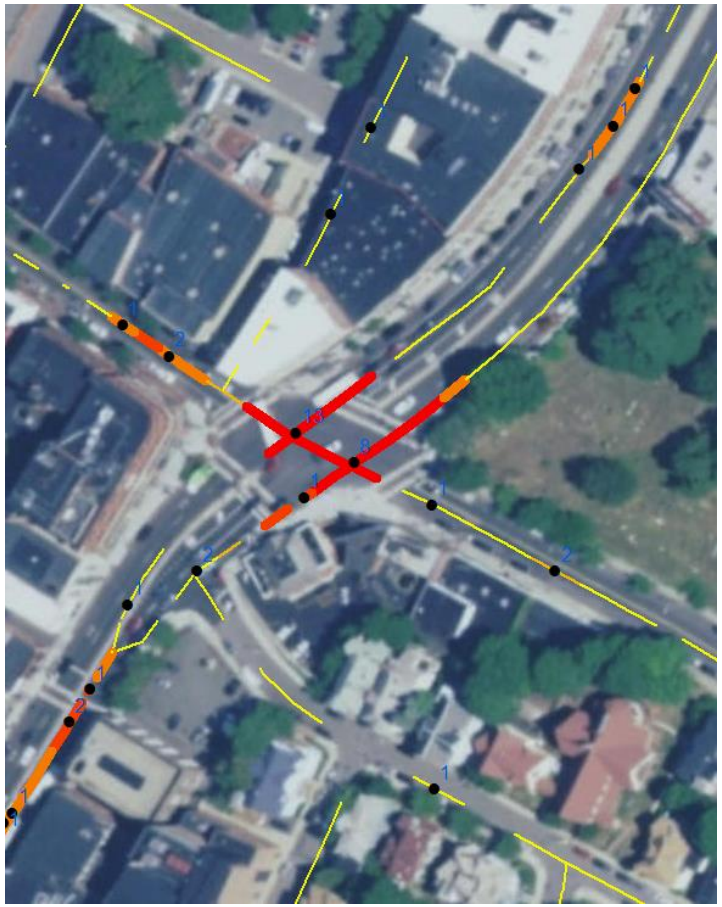
An Intersection between Columbia Rd and Washington St with 25 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#14)



An Interstate 93 Exit towards Gallivan Blvd with 23 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#15)

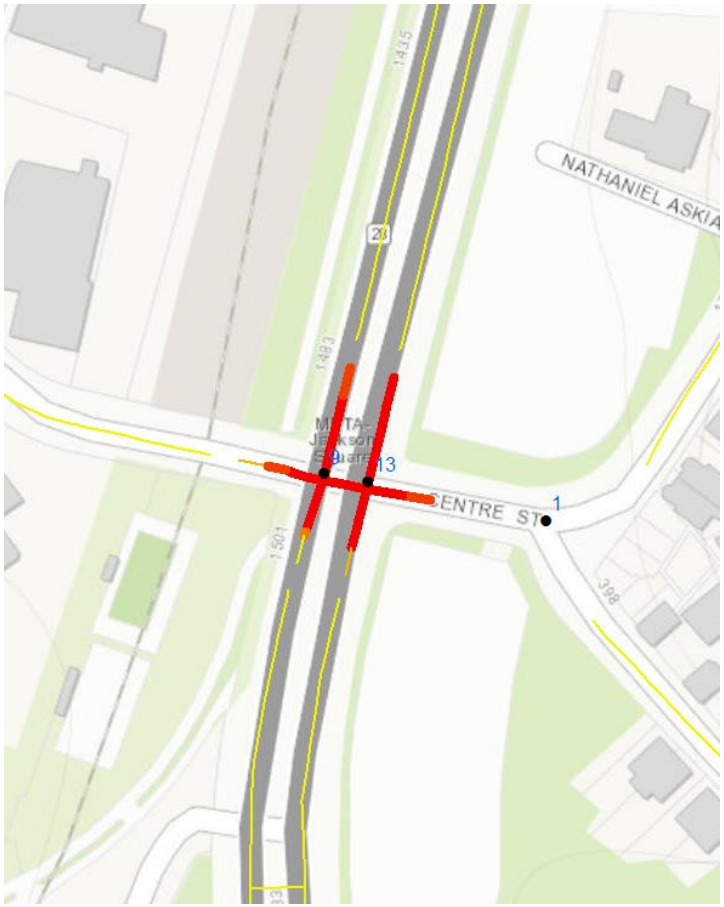


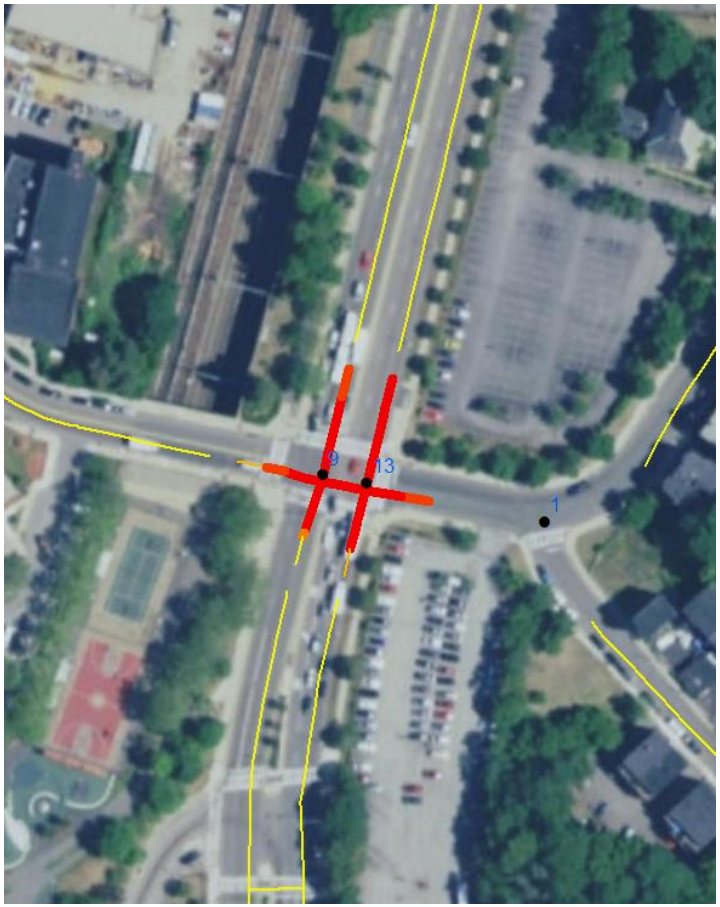
An Intersection between Columbia Rd and Dudley St with 22 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#16)

An Intersection between Harvard St, Walk Hill St and Hazelton St with 22 Traffic crashes during 7/1/2014 – 12/31/2016.

The Most Risky Hotspots (#17)

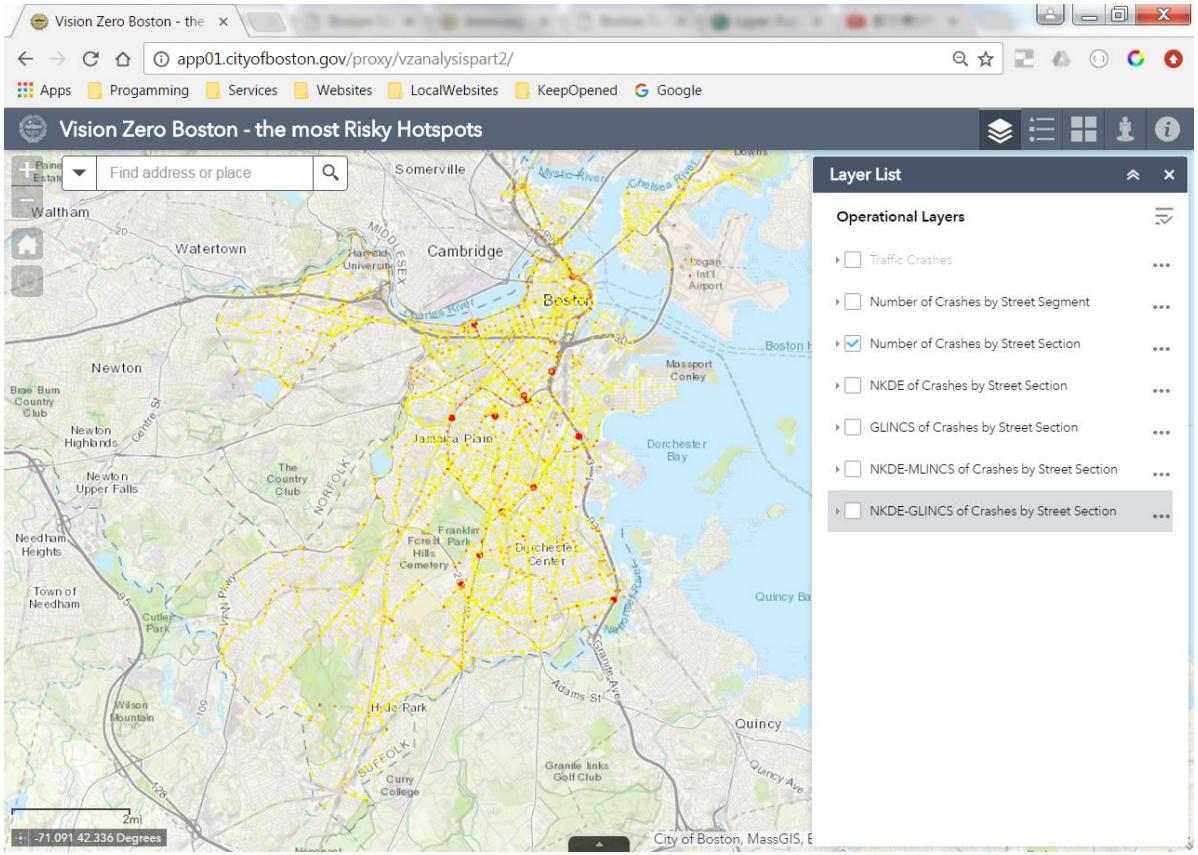




An Intersection between Columbus Ave, Heath St and Centre St with 22 Traffic crashes during 7/1/2014 – 12/31/2016.

WEBSITE FOR THIS ANALYSIS

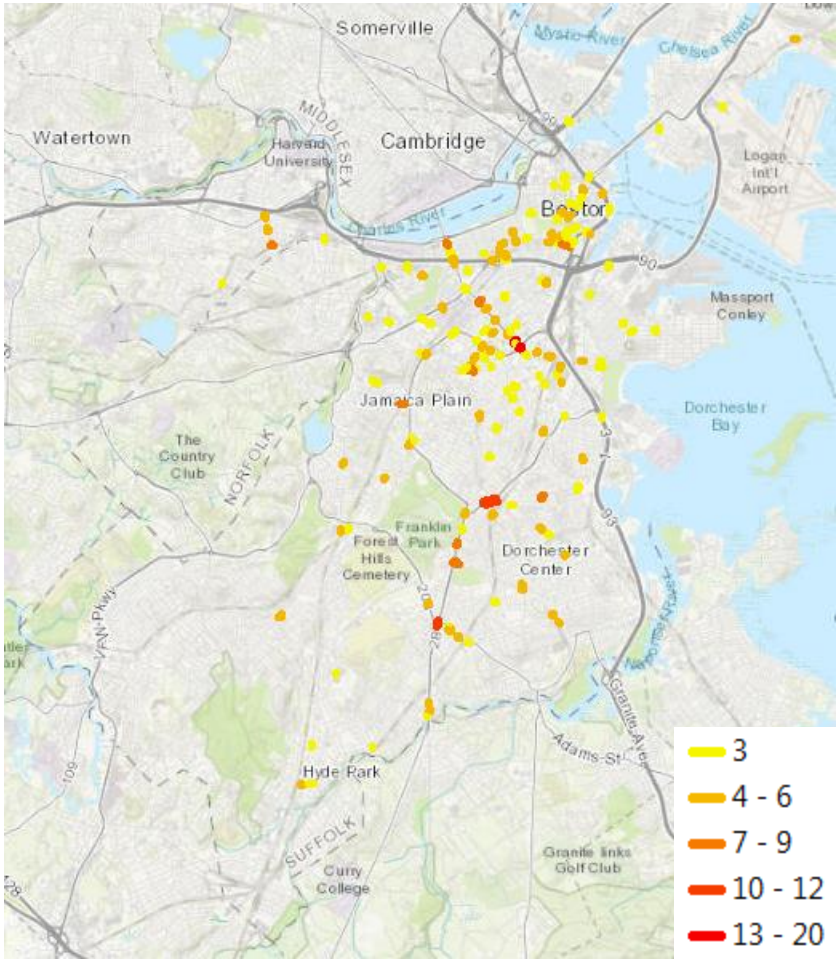
- http://app01.cityofboston.gov/proxy/vzanalysispart2



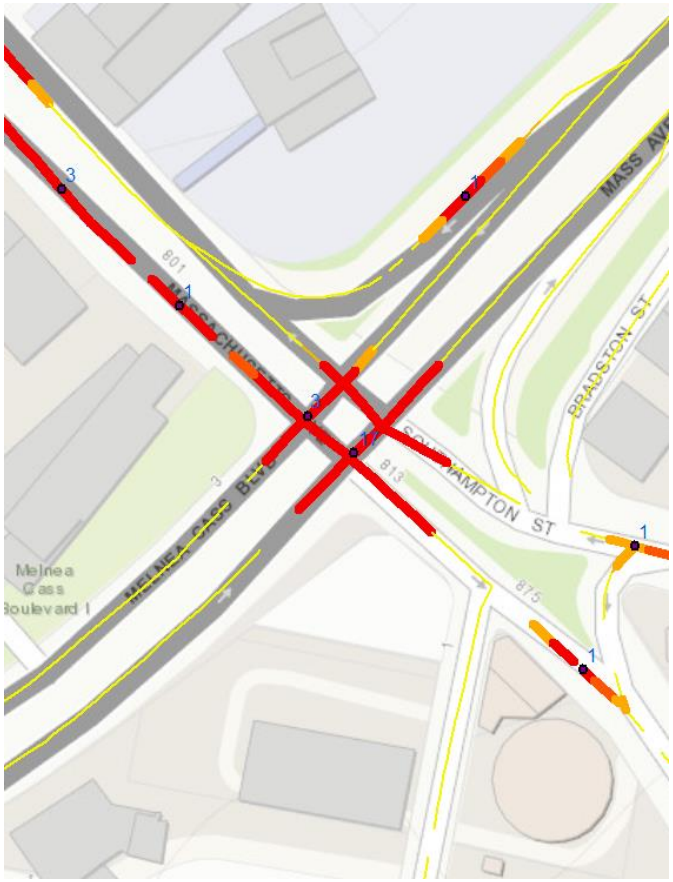
Crash Hotspots By Traffic Mode

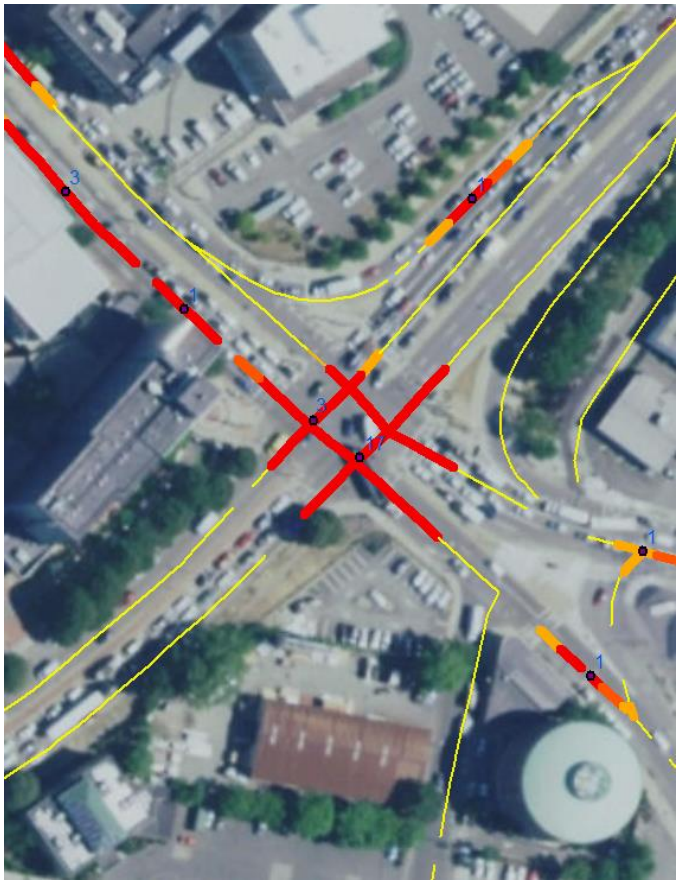
- Pedestrian Crashes
  - Totaled 2,047 Crashes from 7/1/2014 - 12/31/2016.
- Bicyclist Crashes
  - Totaled 1,307 Crashes from 7/1/2014 - 12/31/2016.
- Motorist Crashes
  - Totaled 7,398 Crashes from 7/1/2014 - 12/31/2016.

Hotspots for Pedestrian Crashes (156)
(Each hotspot has 3 or more crashes)



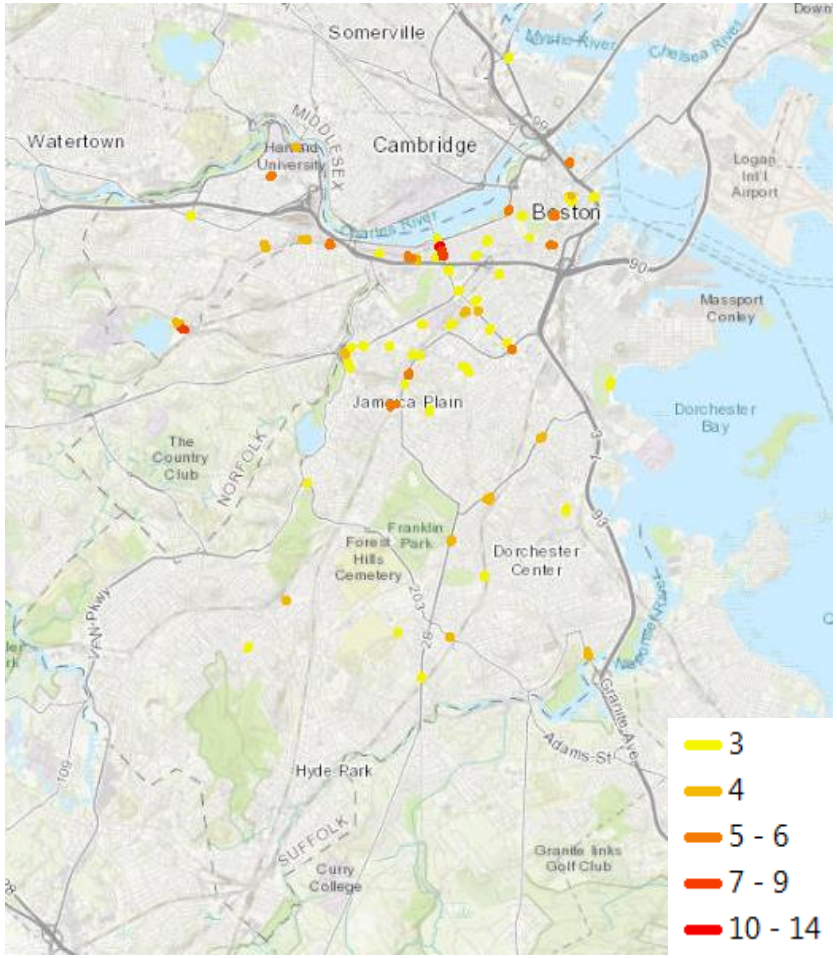
The Most Risky Hotspots (Pedestrian, #1)





An intersection between Massachusetts Ave, Mass Ave Conn and Melnea Cass Blvd with 20 Pedestrian crashes during 7/1/2014 – 12/31/2016.

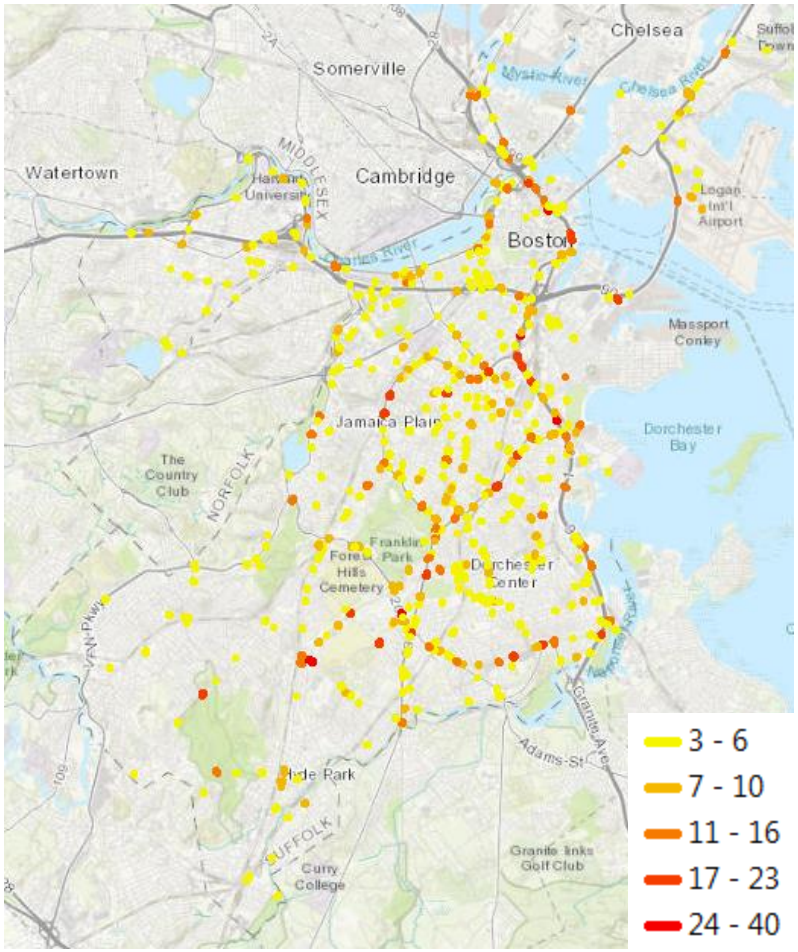
Hotspots for Bicyclist Crashes (67)
(Each hotspot has 3 or more crashes)



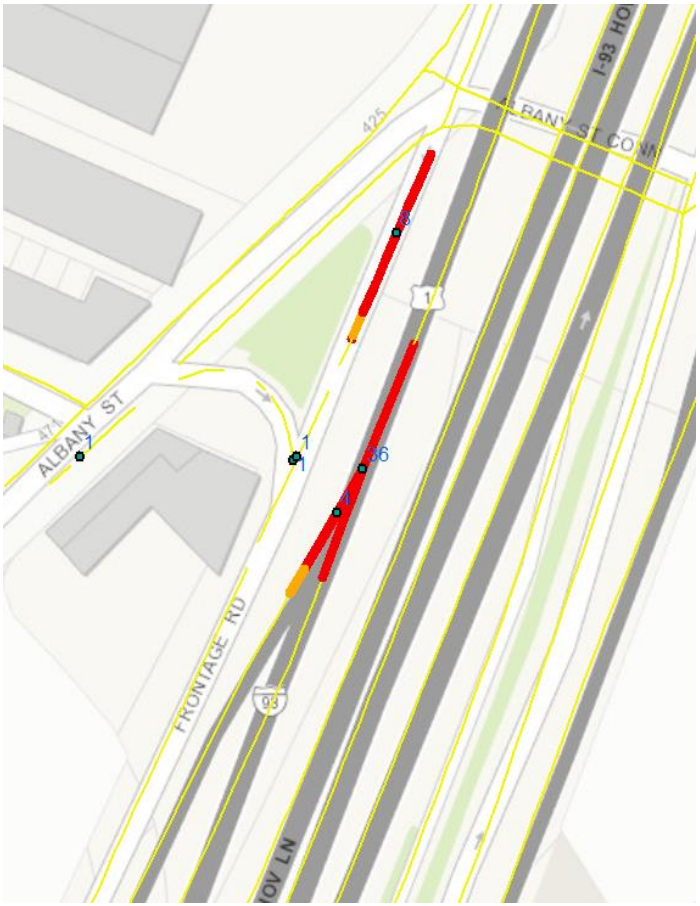
The Most Risky Hotspots (Bicyclist, #1)

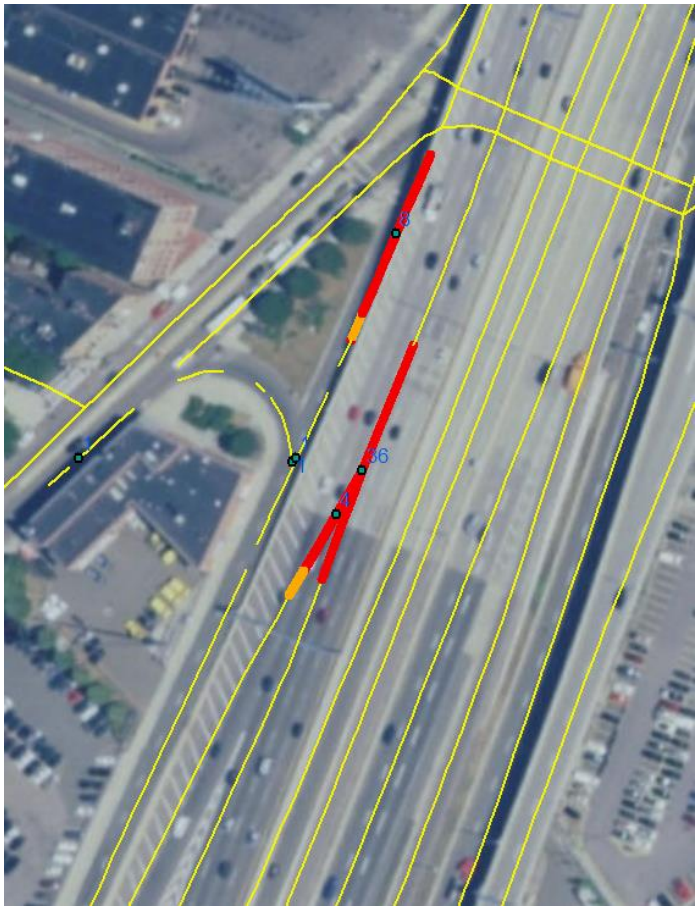
An Intersection between Massachusetts Ave and Beacon St with 14 Bicyclist crashes during 7/1/2014 – 12/31/2016.

Hotspots for Motorist Crashes (557)
(Each hotspot has 3 or more crashes)



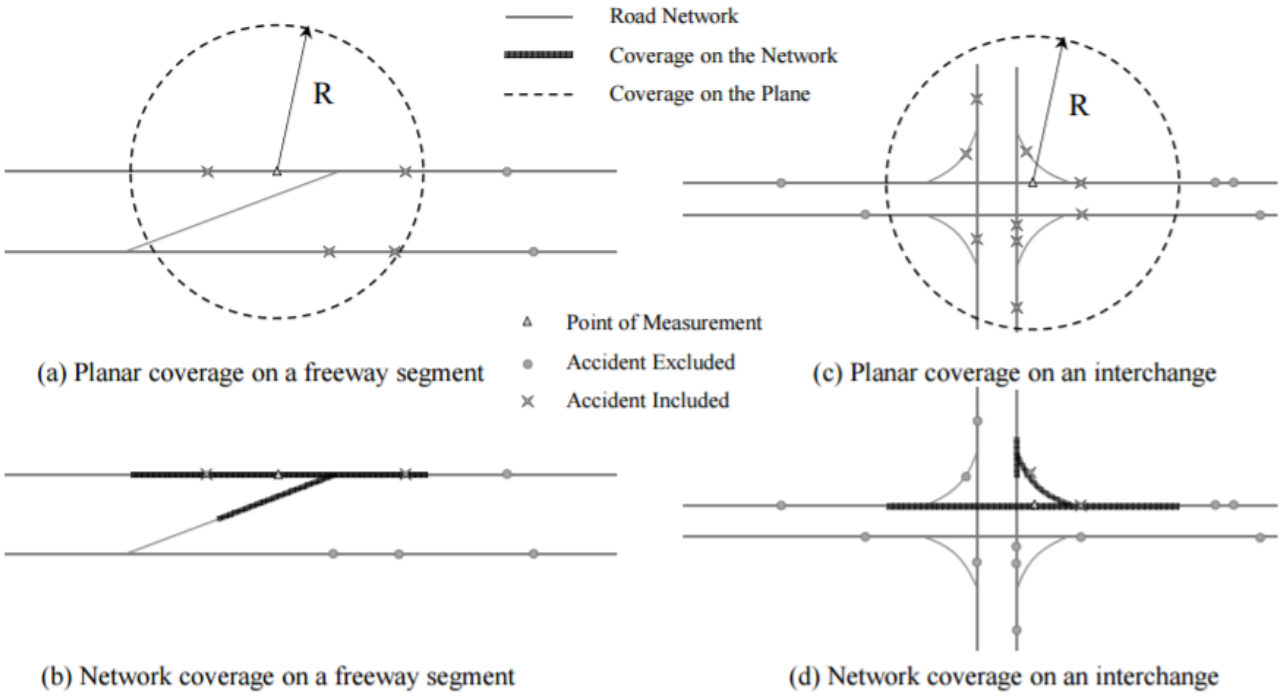
The Most Risky Hotspots (Motorist, #1)





An Interstate 93 Exit towards Mass Ave Conn with 40 Motorist crashes during 7/1/2014 – 12/31/2016.

Examples of Differences using Planar and Network Distance



Regional Pattern

Local Hotspots

KERNEL DENSITY ESTIMATION (PLANAR KDE)

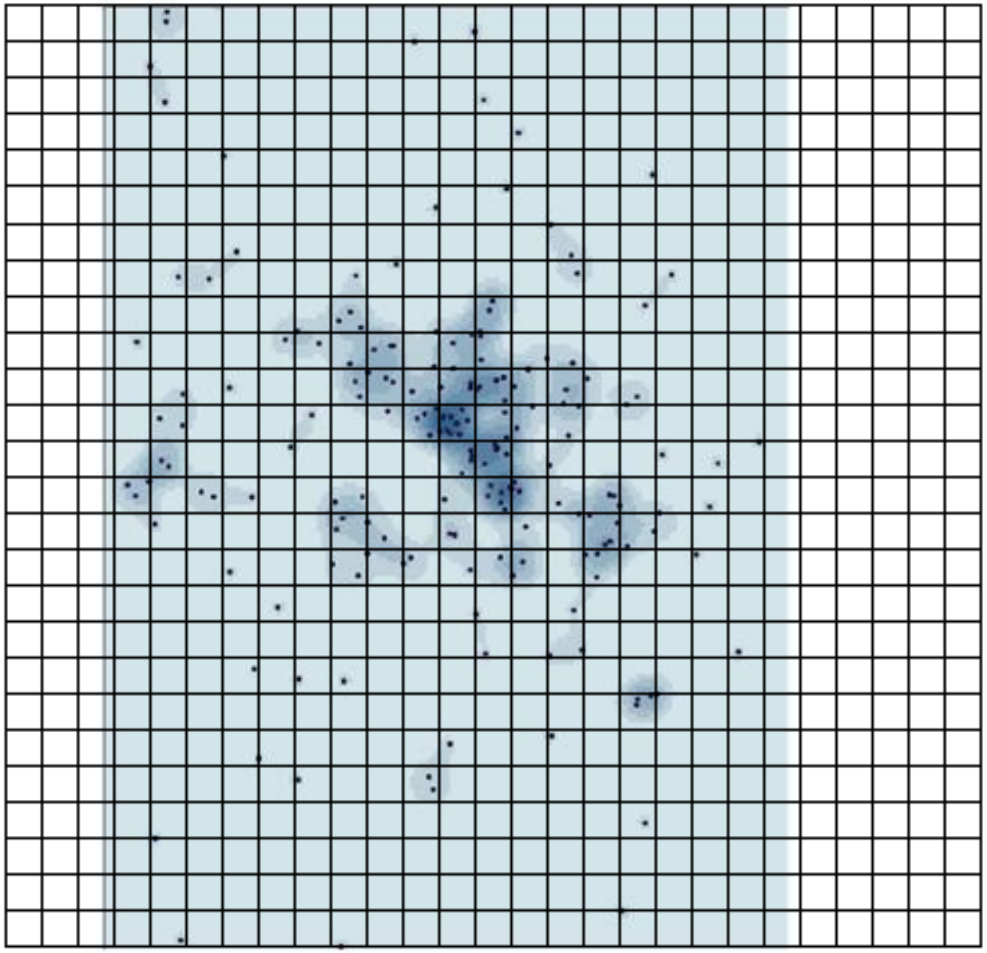
- In statistics, kernel density estimation (KDE) is a non-parametric way to estimate the probability density function of a random variable.

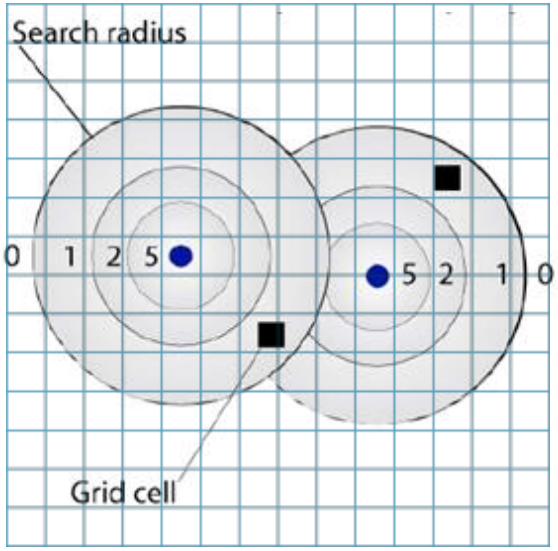
- Let (x1, x2, …, xn) be an independent and identically distributed sample drawn from some distribution with an unknown density ƒ. We are interested in estimating the shape of this function ƒ. Its kernel density estimator is

$$\hat{f}_h(x) = \frac{1}{n}\sum_{i=1}^{n} K_h(x - x_i) = \frac{1}{nh}\sum_{i=1}^{n} K\Big(\frac{x - x_i}{h}\Big),$$

  where K(•) is the kernel — a non-negative function that integrates to one and has mean zero — and h > 0 is a smoothing parameter called the bandwidth.

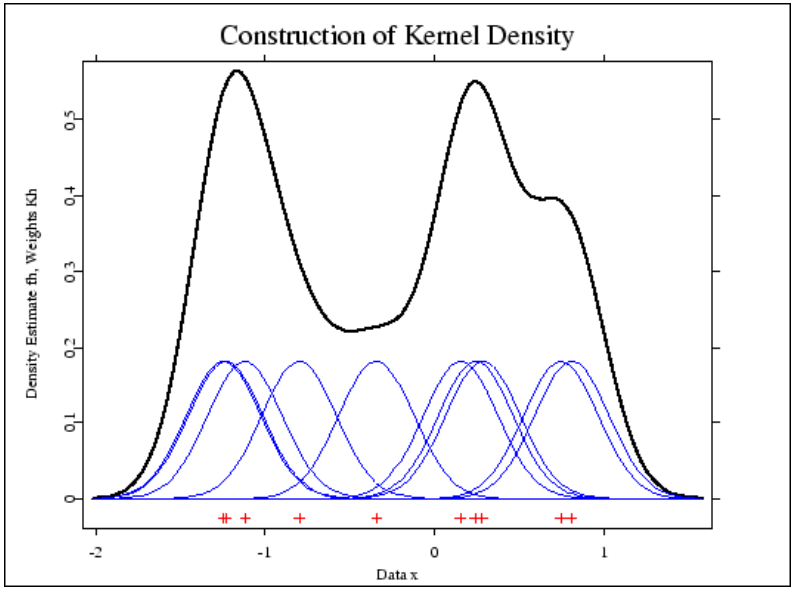
KERNEL DENSITY ESTIMATION (PLANAR KDE)

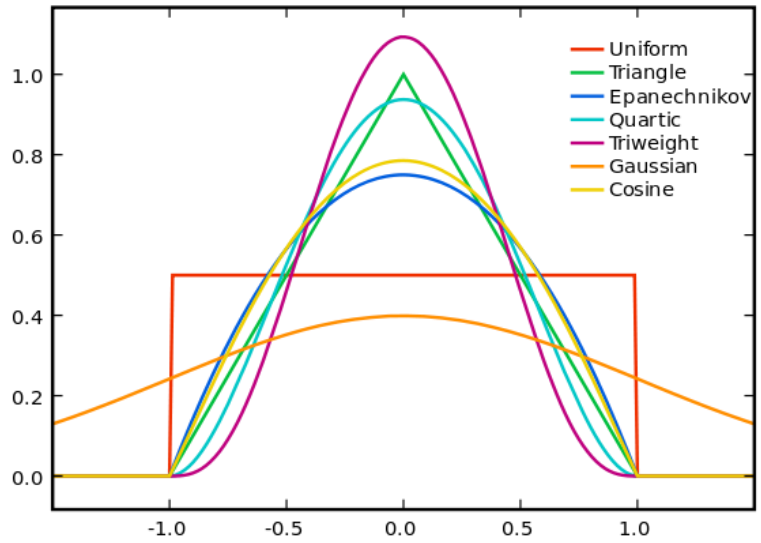




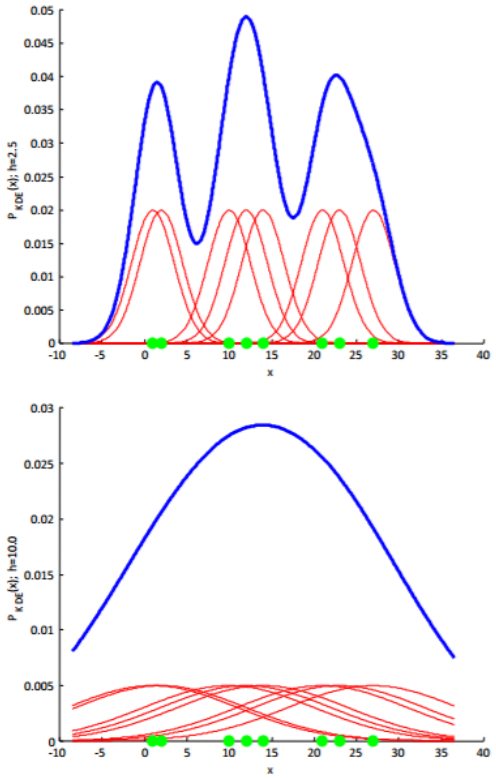
KERNEL DENSITY ESTIMATION

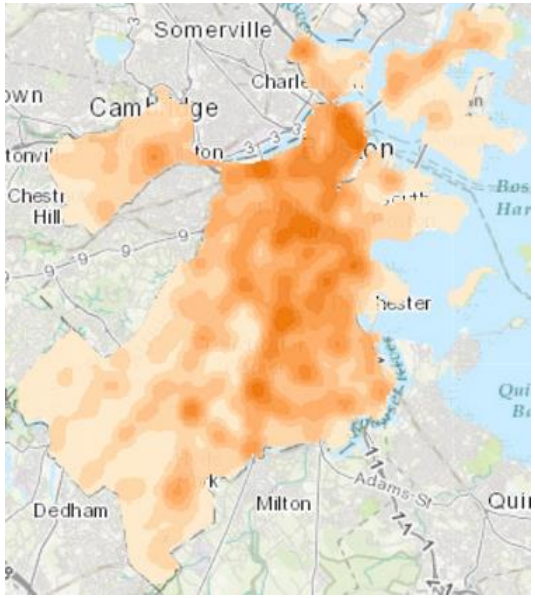
- Kernel Function
- Bandwidth



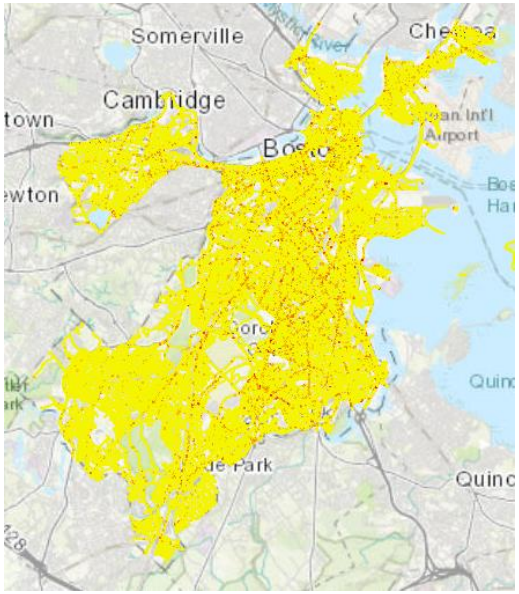


KERNEL DENSITY ESTIMATION





800 Meters
(Planar Distance)



30 Meters
(Network Distance)

GETIS-ORD GI* STATISTICS

- Gi* sums the values of the neighbors and divides by the sums of the values of all the features in the study area.

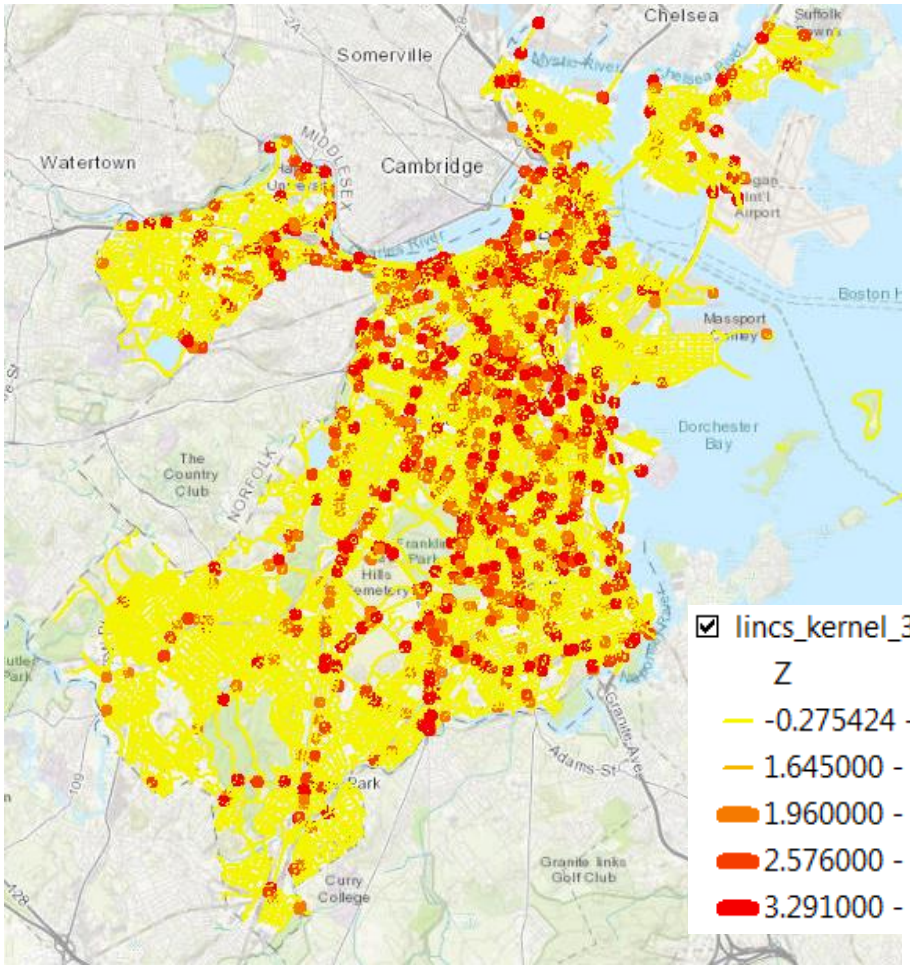
$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij} x_j}{\sum_{j=1}^{n} x_j}$$

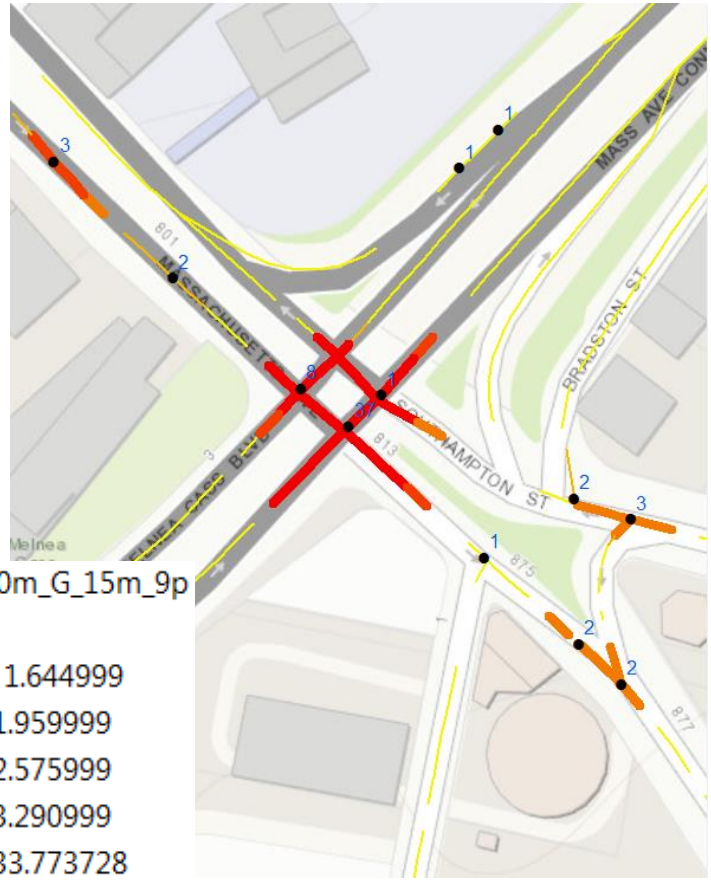
- The standardized Gi* is essentially a Z-value and can be associated with statistical significance.

$$Z(G_i^*) = \frac{\sum_{j=1}^{n} w_{ij} x_j - \bar{x} \sum_{j=1}^{n} w_{ij}^2}{s \sqrt{\frac{n \sum_{j=1}^{n} w_{ij}^2 - (\sum_{j=1}^{n} w_{ij})^2}{n-1}}}$$

- A group of features with high Z scores indicates a cluster or concentration of features with high attribute values. Conversely, a group of features with low Z scores indicates a cold spot. A Z score near 0 indicates there is no concentration of either high or low values surrounding the target feature.

LOCAL INDICATOR (GETIS-ORD GI*) OF NETWORK-CONSTRAINED CLUSTERS (GLINCS)





lincs_kernel_30m_G_15m_9p
Z
-0.275424 - 1.644999
1.645000 - 1.959999
1.960000 - 2.575999
2.576000 - 3.290999
3.291000 - 33.773728

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ABSTRACT

Detecting Traffic Crash Patterns and Identifying the most Risky hotspots by Street Section for Vision Zero Boston using Spatial Statistical Methods

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The purpose of Vision Zero Boston (http://www.visionzeroboston.org/) is to focus the City's resources on proven strategies to eliminate fatal and serious traffic crashes.

This study analyzed the traffic crashes data (http://app01.cityofboston.gov/VisionZero/) provided by Boston Emergency Medical Services (EMS) using two spatial statistical methods available from GeoDaNet: Network Kernel Density Estimation (NKDE) and Local Indicator (Getis-Ord Gi*) of Network-Constrained Clusters (GLINCS).

The spatial statistical methods revealed visually and statistically the traffic crash patterns and the most risky clusters / hot spots by street section (a segment is a part of a road between two closest intersections and every segment is split into 10 meter long sections). See http://app01.cityofboston.gov/proxy/vzanalysispart2 for more details.

This study would quantitatively provide helps to remedial engineering efforts of Vision Zero Boston and make efficient use of the City's resources. Further study would address the factors causing these crashes for crash modeling.

Thank you!

Questions?