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HOTSKETCH:
Drawing Police Patrol Routes Among Spatiotemporal Crime Hotspots

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information interfaces

Georgia Tech Visualization Lab

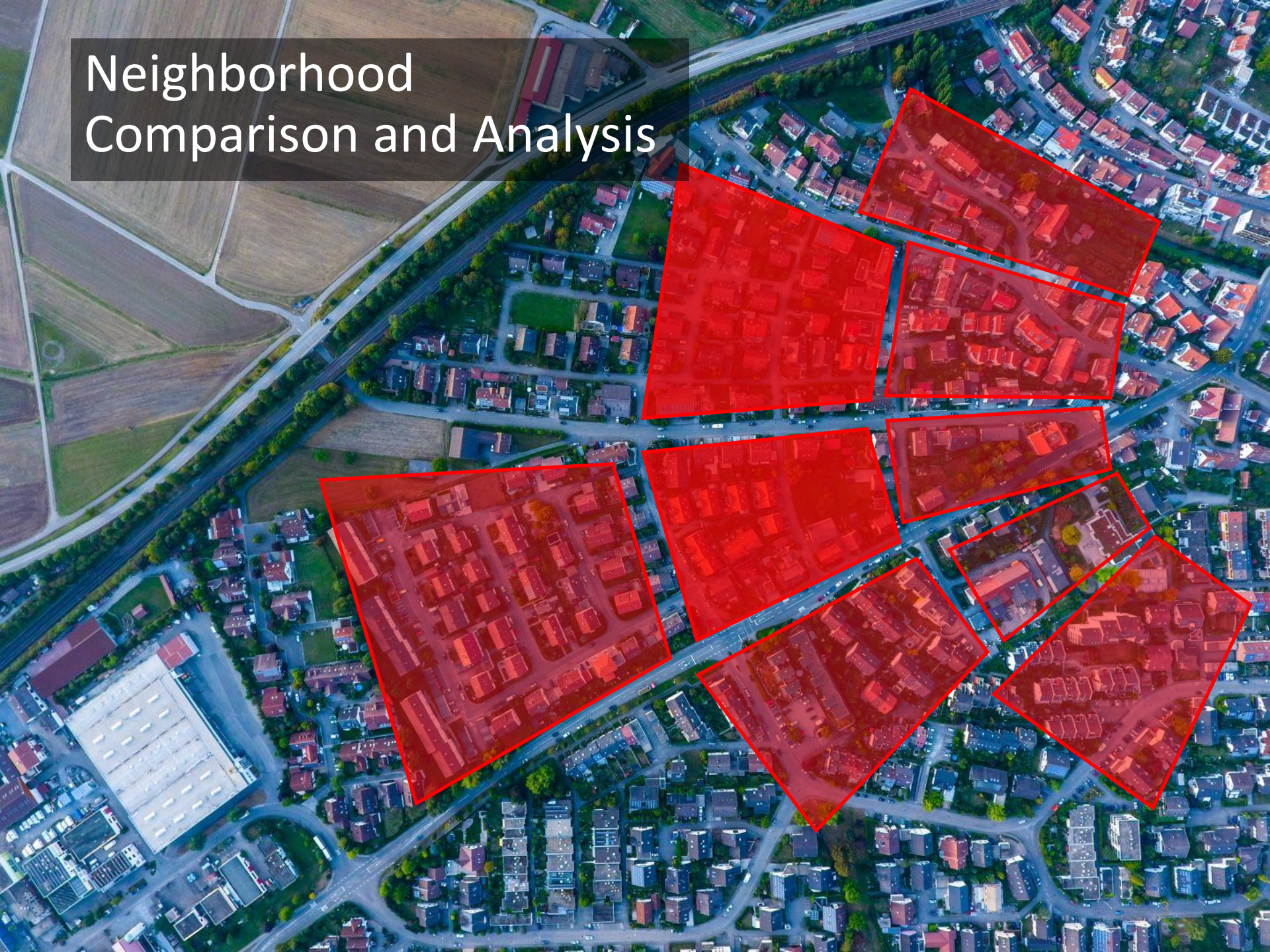
Proactive Policing

Show police presence

Engage with the community to learn their concerns

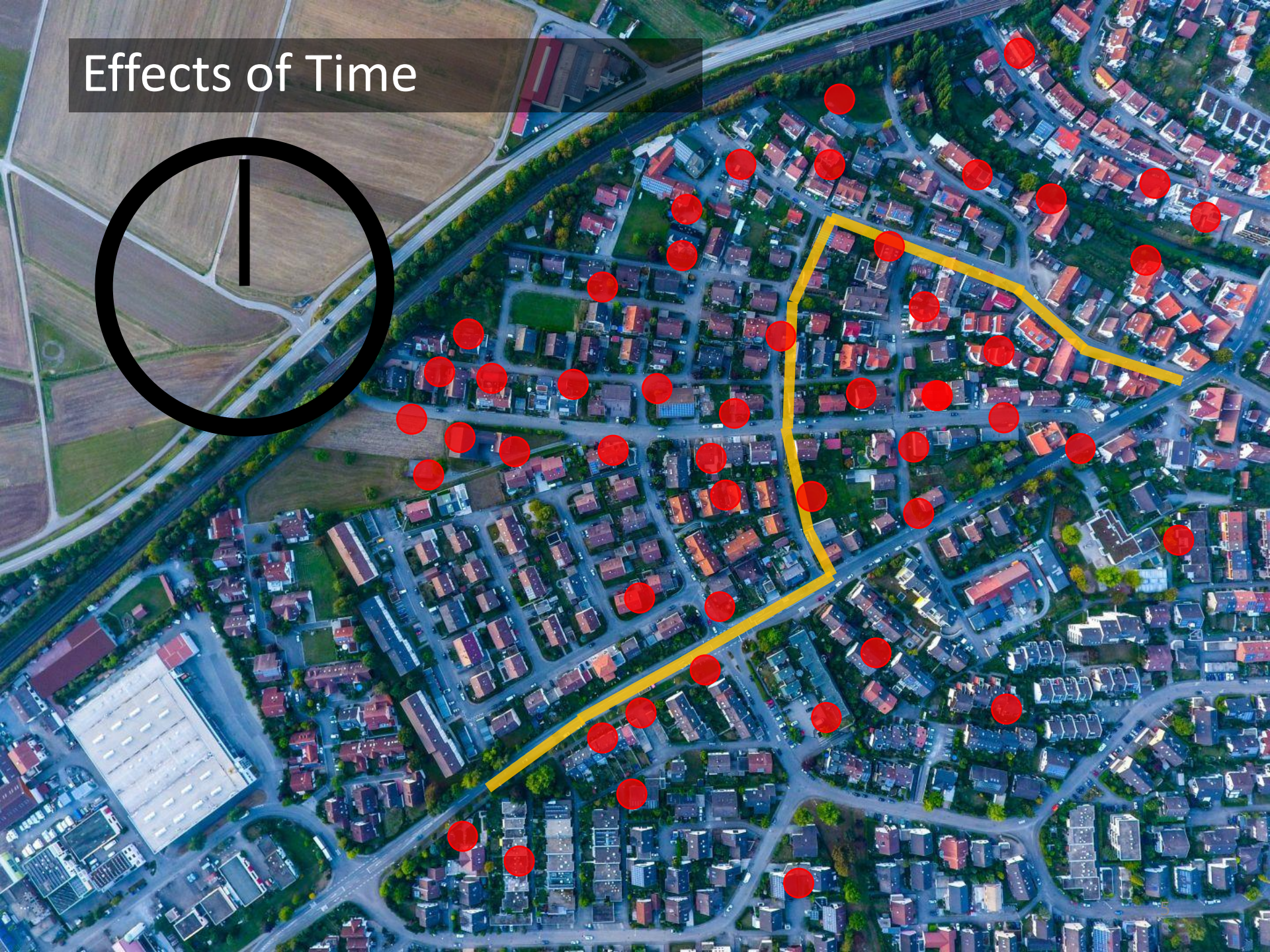
Analyze historical crime reports

Neighborhood Comparison and Analysis



Path Selection for Patrolling the Community

Effects of Time



HotSketch

Police units need a mobile system that allows them to view an updated analysis of crime hotspots based upon changing location and time

HotSketch

Sketch-based approach for dynamic route planning

HotSketch

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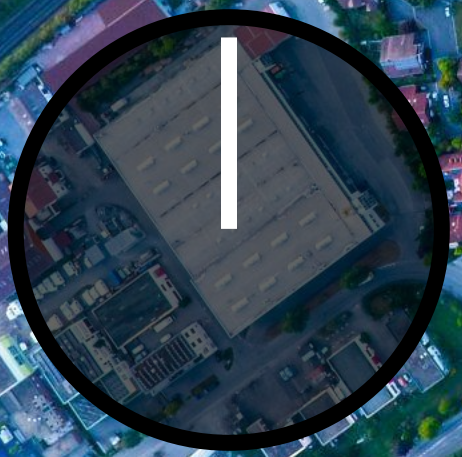
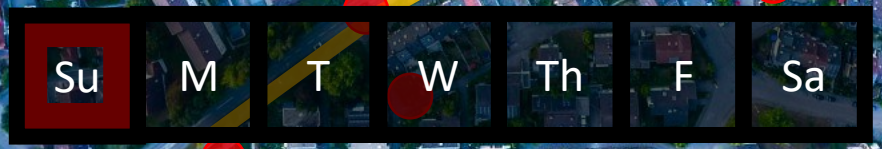
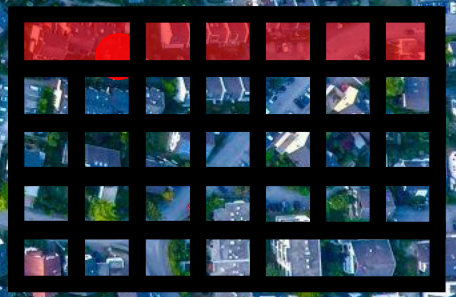
HotSketch

Dynamic hotspot approach that takes time into account







Related Work

- Predictive Policing
  - Chen et al., 2004
  - Chen et al., 2003
- Hotspots (Eck et al., 2005)
  - KDE (Chainey, Tompson, & Uhlig, 2008)
  - Variable spatial bandwidths (Maciejewski et al., 2010)
  - Linked views to help analyze temporal nature
    - Afzal, Maciejewski, & Ebert, 2011
    - Brunsdon, Corcoran, & Higgs 2007
  - Seasonal variation (Malik et al., 2014)
  - Mobile applications (Razip et al., 2014)
- Route analysis
  - Andrienko et al., 2008
  - Andrienko & Andrienko, 2011
  - Tominski et al., 2012
  - Sketching trajectories (Turkay et al., 2014; Blaser, 2000; Forbus, Usher, & Chapman, 2004)

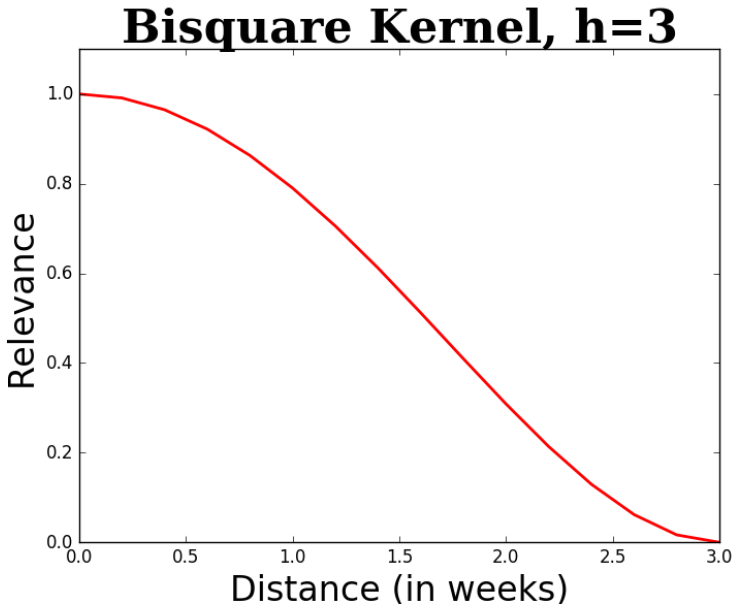
Hotspot Analysis

How to determine the relevance of an event that occurs at time x_i given the current time and date x_j?

1. We determine the difference between them, d, and a maximum allowable difference bandwidth h.
2. Given these parameters, we can use a kernel function *k(d,h)* to determine the relevance of all known events to the current time.
3. These relevance scores can then be used to create a heatmap of the spatial distribution of events on a map of an area.

Hotspot Analysis

$$k(d,h) = \begin{cases} \left(1 - \frac{d^2}{h^2}\right)^2, & d < h \\ 0, & d \geq h \end{cases}$$

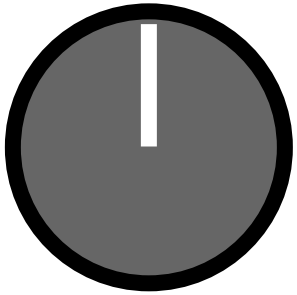


Hotspot Analysis

$$f(x_i, x_j) = \frac{2}{5}k(d_t, h_t) + \frac{2}{5}k(d_w, h_w) + \frac{1}{5}k(d_s, h_s)$$

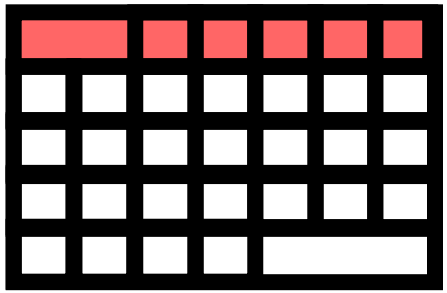
Weighted summation of kernels

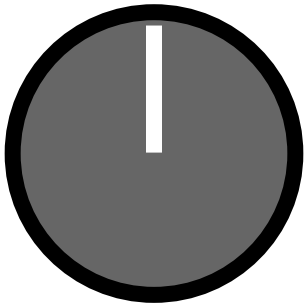
Time of Day kernel

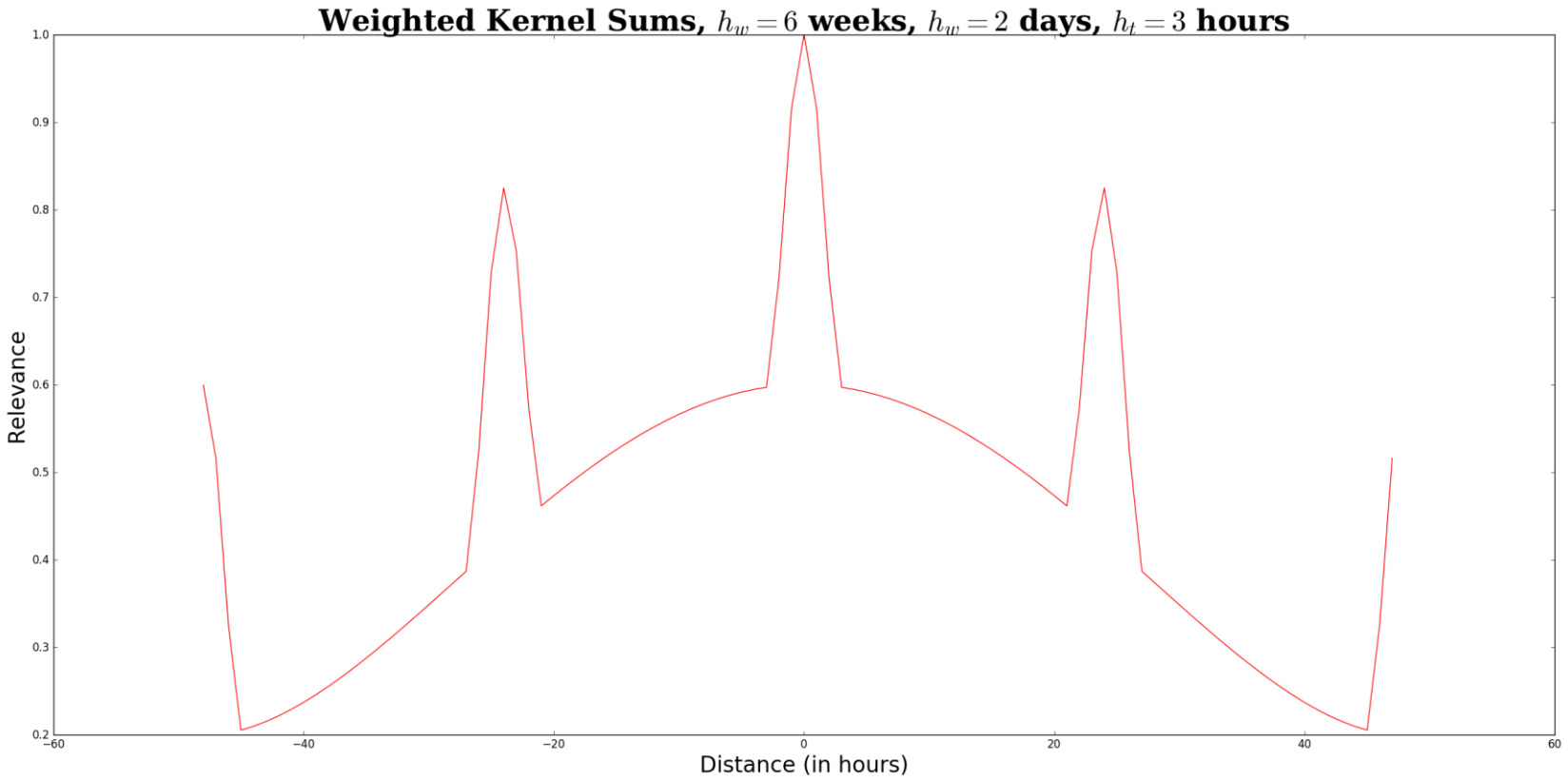


Day of Week kernel

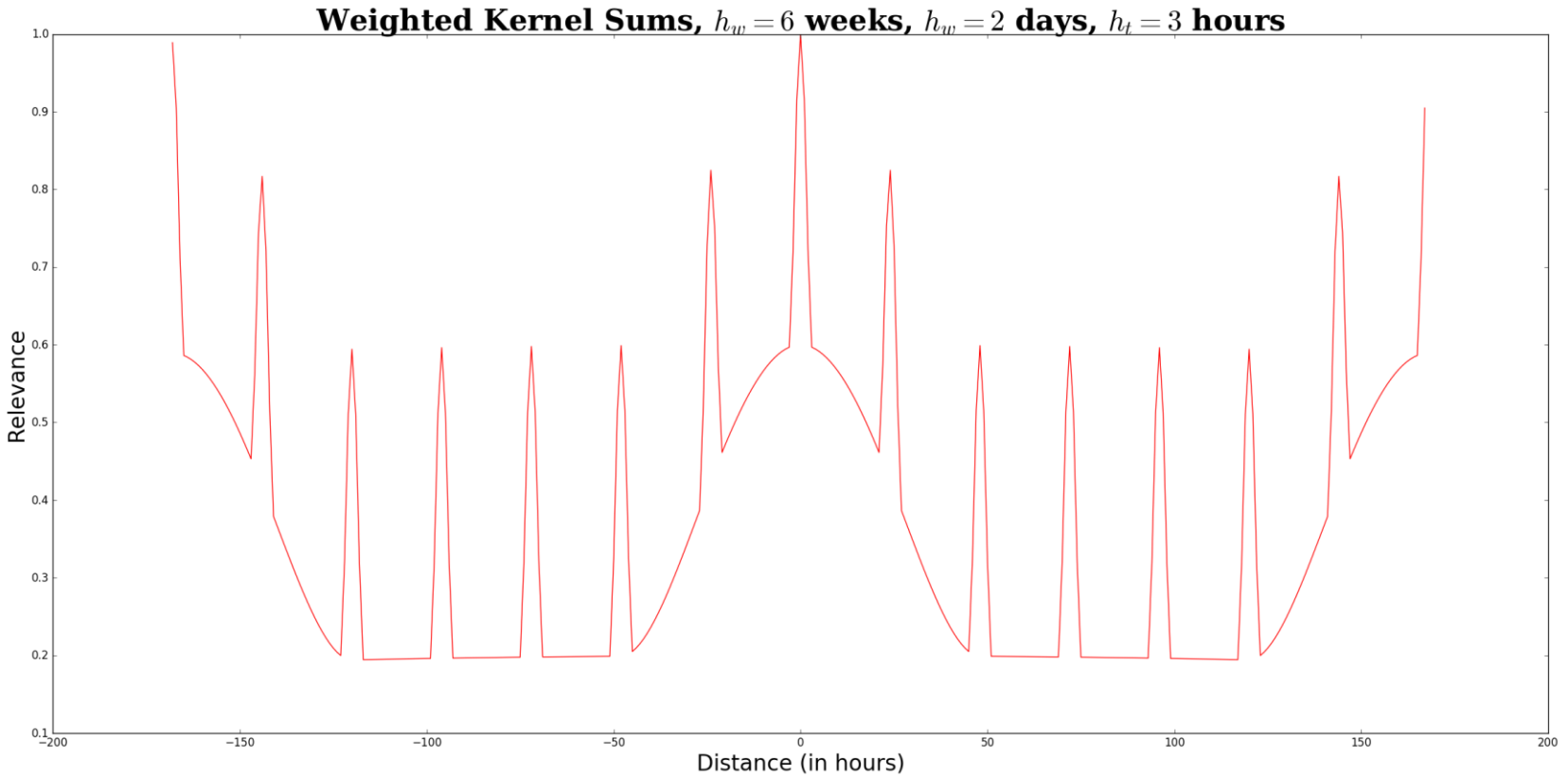
Season of Year kernel

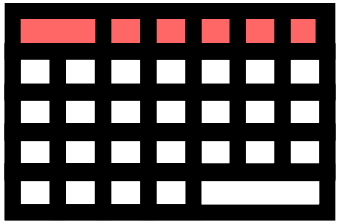


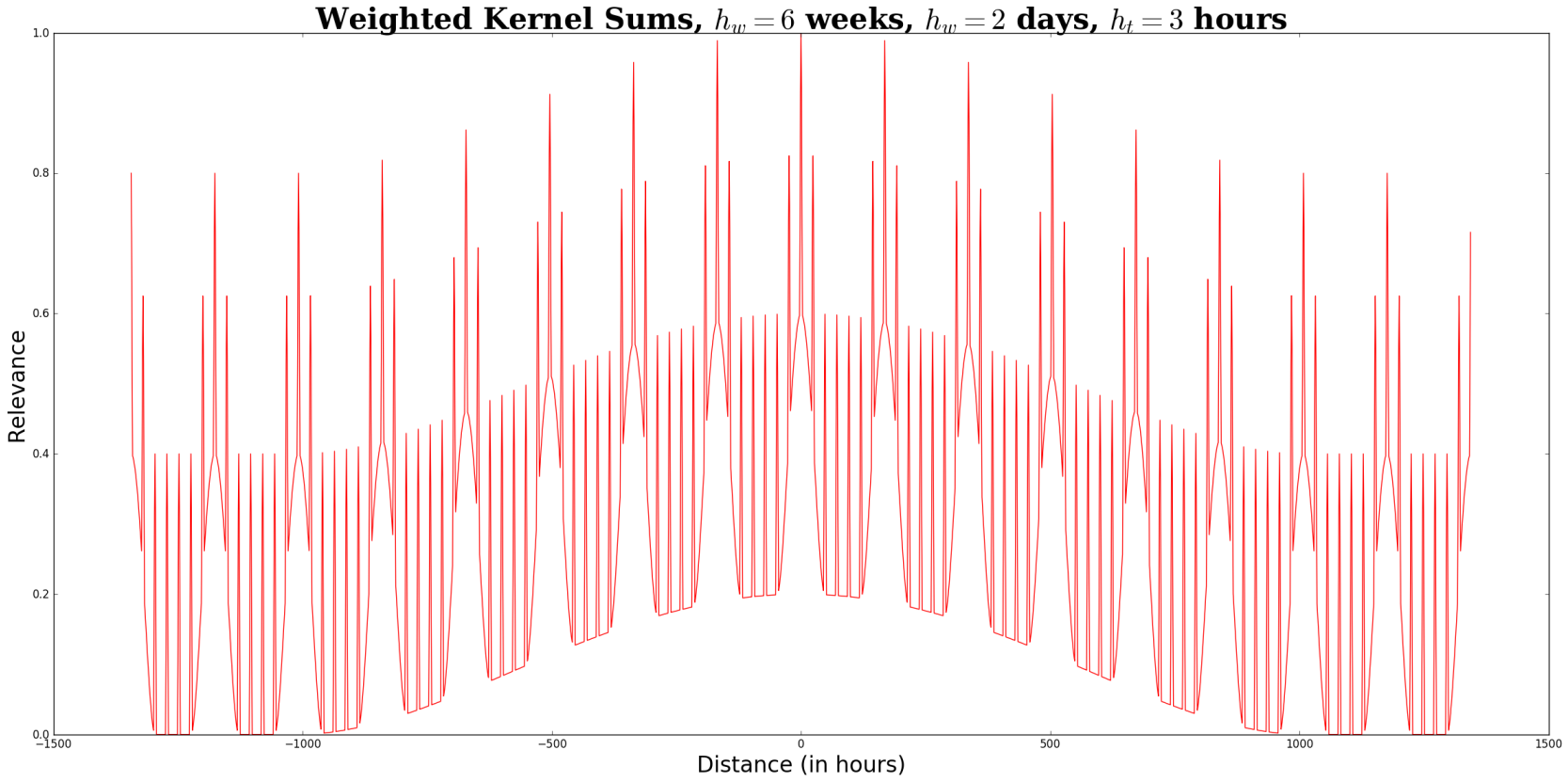



Weighted Kernel Sums, $h_w = 6$ weeks, $h_w = 2$ days, $h_t = 3$ hours
Relevance
Distance (in hours)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
−60
−40
−20
0
20
40
60

Su	M	T	W	Th	F	Sa


Weighted Kernel Sums, $h_w = 6$ weeks, $h_w = 2$ days, $h_t = 3$ hours
Relevance
Distance (in hours)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
−200
−150
−100
−50
0
50
100
150
200

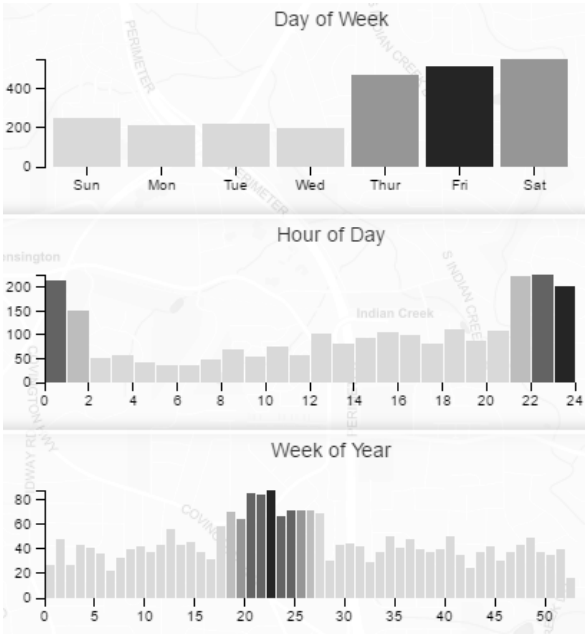


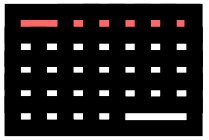

Weighted Kernel Sums, $h_w = 6$ weeks, $h_w = 2$ days, $h_t = 3$ hours
Relevance
Distance (in hours)
0.0
0.2
0.4
0.6
0.8
1.0
−1500
−1000
−500
0
500
1000
1500

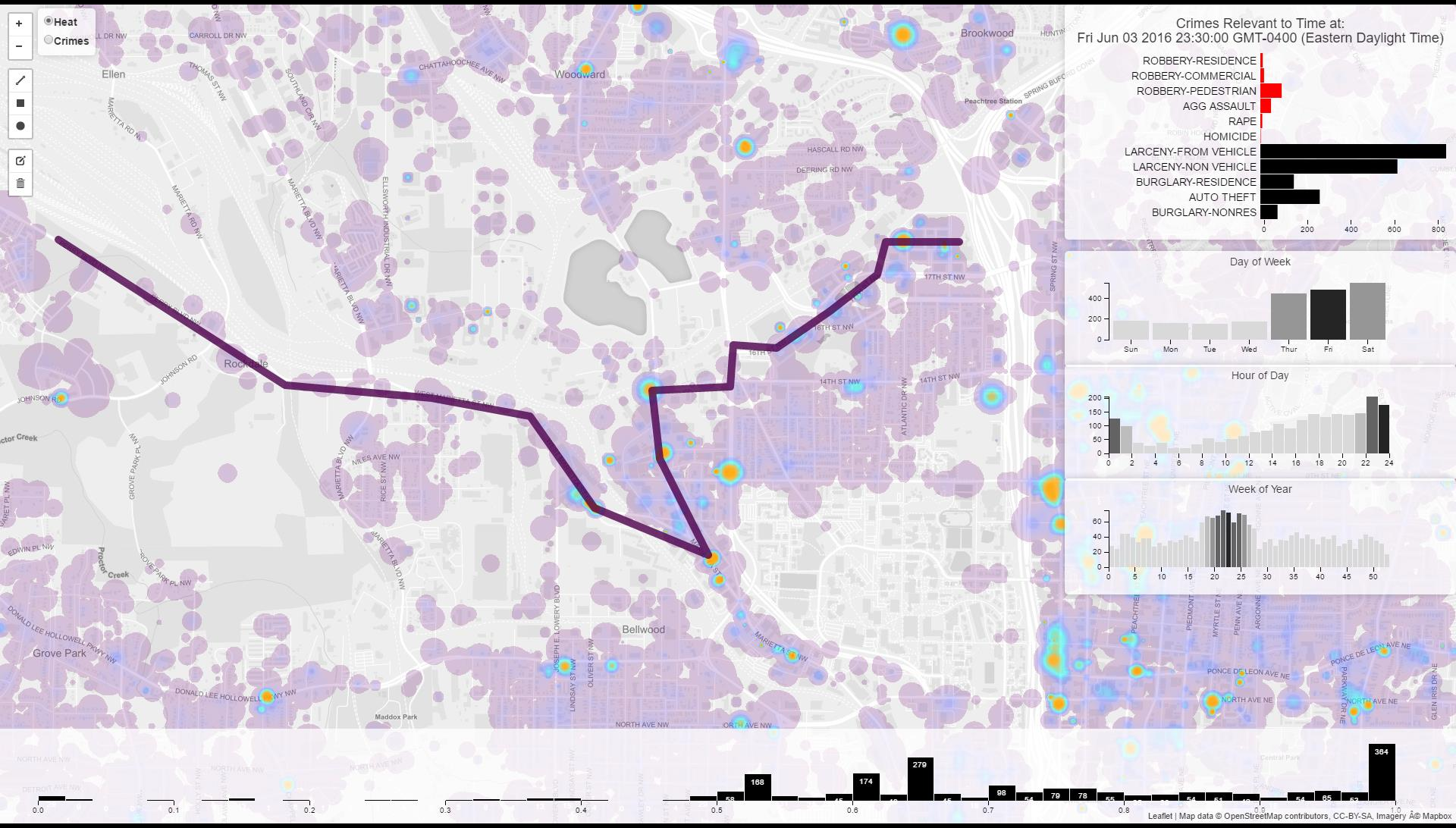
Panel: Relevance of Events by Kernel

Shows the distribution of events and the aggregated relevance of scores by kernel components

- Day of Week (x_i = *Friday*)
- Hour of Day (x_i = *11:30pm*)
- Season of Year (x_i = *Early June*)






Heat
Crimes
Crimes Relevant to Time at:
Fri Jun 03 2016 23:30:00 GMT-0400 (Eastern Daylight Time)
ROBBERY-RESIDENCE
ROBBERY-COMMERCIAL
ROBBERY-PEDESTRIAN
AGG ASSAULT
RAPE
HOMICIDE
LARCENY-FROM VEHICLE
LARCENY-NON VEHICLE
BURGLARY-RESIDENCE
AUTO THEFT
BURGLARY-NONRES
0
200
400
600
800
Day of Week
Sun
Mon
Tue
Wed
Thur
Fri
Sat
Hour of Day
Week of Year
Ellen
Woodward
Brookwood
Peachtree Station
Rockmele
Bellwood
Grove Park
Maddox Park
Proctor Creek
CARROLL DR NW
CHATTAHOOCHEE AVE NW
MARIETTA RD N
THOMAS ST NW
SOUTH AMO DR NW
MARIETTA RD NW
MARIETTA BLVD NW
ELLSWORTH INDUSTRIAL DR NW
HASCALL RD NW
DEERING RD NW
17TH ST NW
16TH ST NW
14TH ST NW
ATLANTIC DR NW
SPRING ST NW
JOHNSON RD
NILES AVE NW
RICE ST NW
GROVE PARK PL NW
EDWIN PL NW
DONALD LEE HOLLOWELL PKWY NW
JOSEPH E LOWERY BLVD
LINDSAY ST NW
OLIVER ST NW
NORTH AVE NW
PEACHTREE
PIEDMONT
MYRTLE ST
PENN AVE NE
ARGONNE
PONCE DE LEON AVE NE
NORTH AVE NE
PARKWAY DR NE
GLEN IRIS DR NE
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
58
188
15
174
15
279
15
98
54
79
78
55
54
54
54
65
53
384
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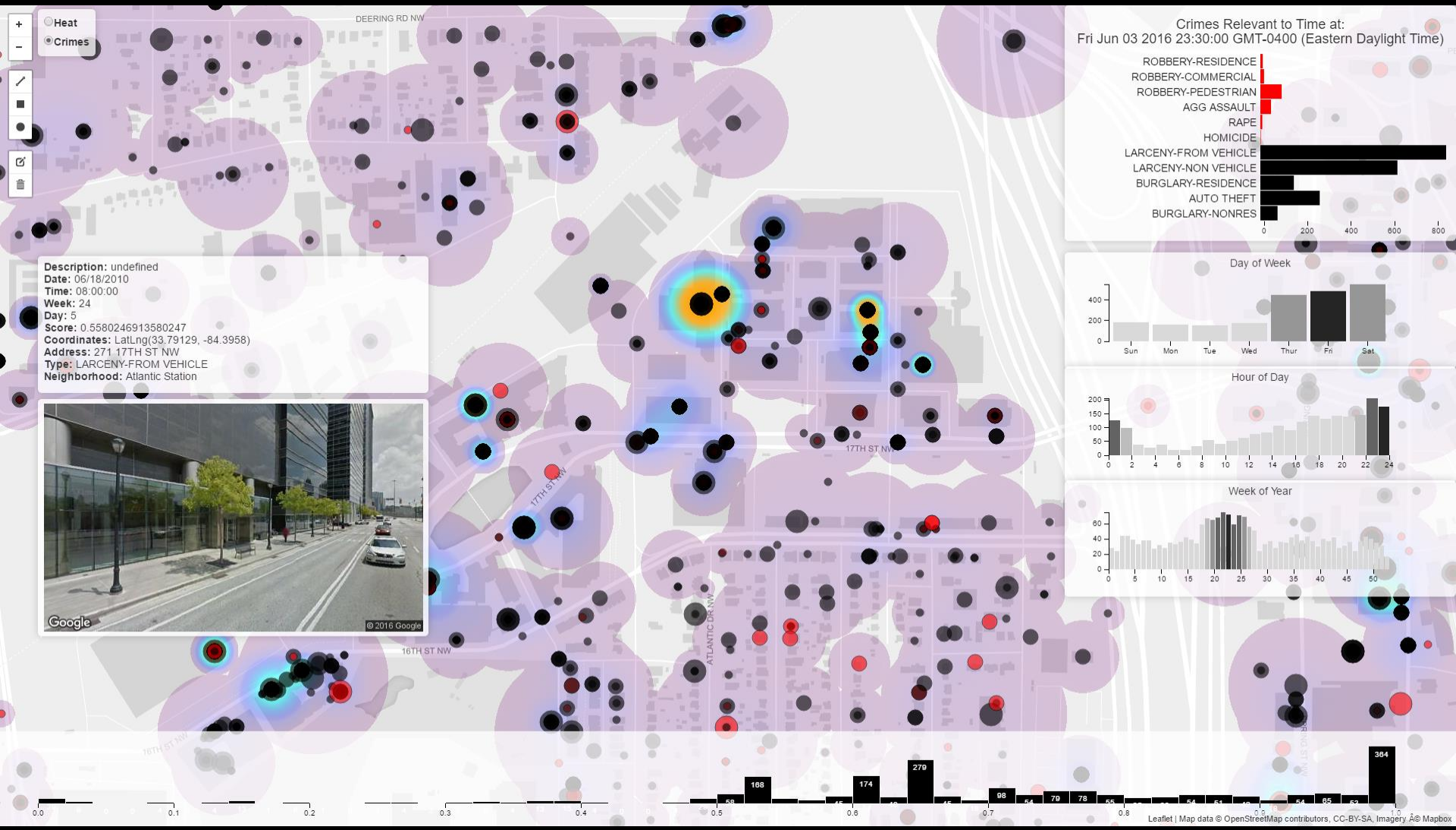
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Crimes
DEERING RD NW
Description: undefined
Date: 06/18/2010
Time: 08:00:00
Week: 24
Day: 5
Score: 0.5580246913580247
Coordinates: LatLng(33.79129, -84.3958)
Address: 271 17TH ST NW
Type: LARCENY-FROM VEHICLE
Neighborhood: Atlantic Station
Google
© 2016 Google
17TH ST NW
16TH ST NW
ATLANTIC DR NW
Crimes Relevant to Time at:
Fri Jun 03 2016 23:30:00 GMT-0400 (Eastern Daylight Time)
ROBBERY-RESIDENCE
ROBBERY-COMMERCIAL
ROBBERY-PEDESTRIAN
AGG ASSAULT
RAPE
HOMICIDE
LARCENY-FROM VEHICLE
LARCENY-NON VEHICLE
BURGLARY-RESIDENCE
AUTO THEFT
BURGLARY-NONRES
0
200
400
600
800
Day of Week
400
200
0
Sun
Mon
Tue
Wed
Thur
Fri
Sat
Hour of Day
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Week of Year
60
40
20
0
0
5
10
15
20
25
30
35
40
45
50
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
58
188
15
174
279
98
54
79
78
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51
54
65
53
364
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Demonstration

Evaluation

Exploration of an officer patrol route using crime data for Atlanta, GA

Atlanta (UCR) Crime Data

Violent	
Aggravated Assault	**17,500**
Robbery-Pedestrian	**13,364**
Robbery-Residential	**1,739**
Robbery-Commercial	**1,697**
Rape	**841**
Homicide	**519**
Non-violent	
Larceny-From Vehicle	69,611
Larceny-Non Vehicle	59,611
Burglary-Residence	40,400
Auto Theft	35,325
Burglary-Nonresidential	7,778

Heat
Crimes
Brookside Village
Queens Lake Estates
Castlewood Estates
Cardell
Hillcrest Valley
Fulton County Airport-Brown Field
Fairburn Heights
Normandy Forest
Boulder Park
Stratford
Simsville
Battle Hill Haven
Ellen
West End Park
Crimes Relevant to Time at:
Fri Jun 03 2016 23:30:00 GMT-0400 (Eastern Daylight Time)
ROBBERY-RESIDENCE
ROBBERY-COMMERCIAL
ROBBERY-PEDESTRIAN
AGG ASSAULT
RAPE
HOMICIDE
LARCENY-FROM VEHICLE
LARCENY-NON VEHICLE
BURGLARY-RESIDENCE
AUTO THEFT
BURGLARY-NONRES
0 50 100 150 200 250 300
Day of Week
300 200 100 0
Sun Mon Tue Wed Thur Fri Sat
Hour of Day
100 50 0
0 2 4 6 8 10 12 14 16 18 20 22 24
Week of Year
50 40 30 20 10 0
0 5 10 15 20 25 30 35 40 45 50
200 41 101 122
0.0 0.1 0.2 0.3
0.4 0.5 0.6 0.7
237 59 99 73 83 39
0.8 0.9 1.0
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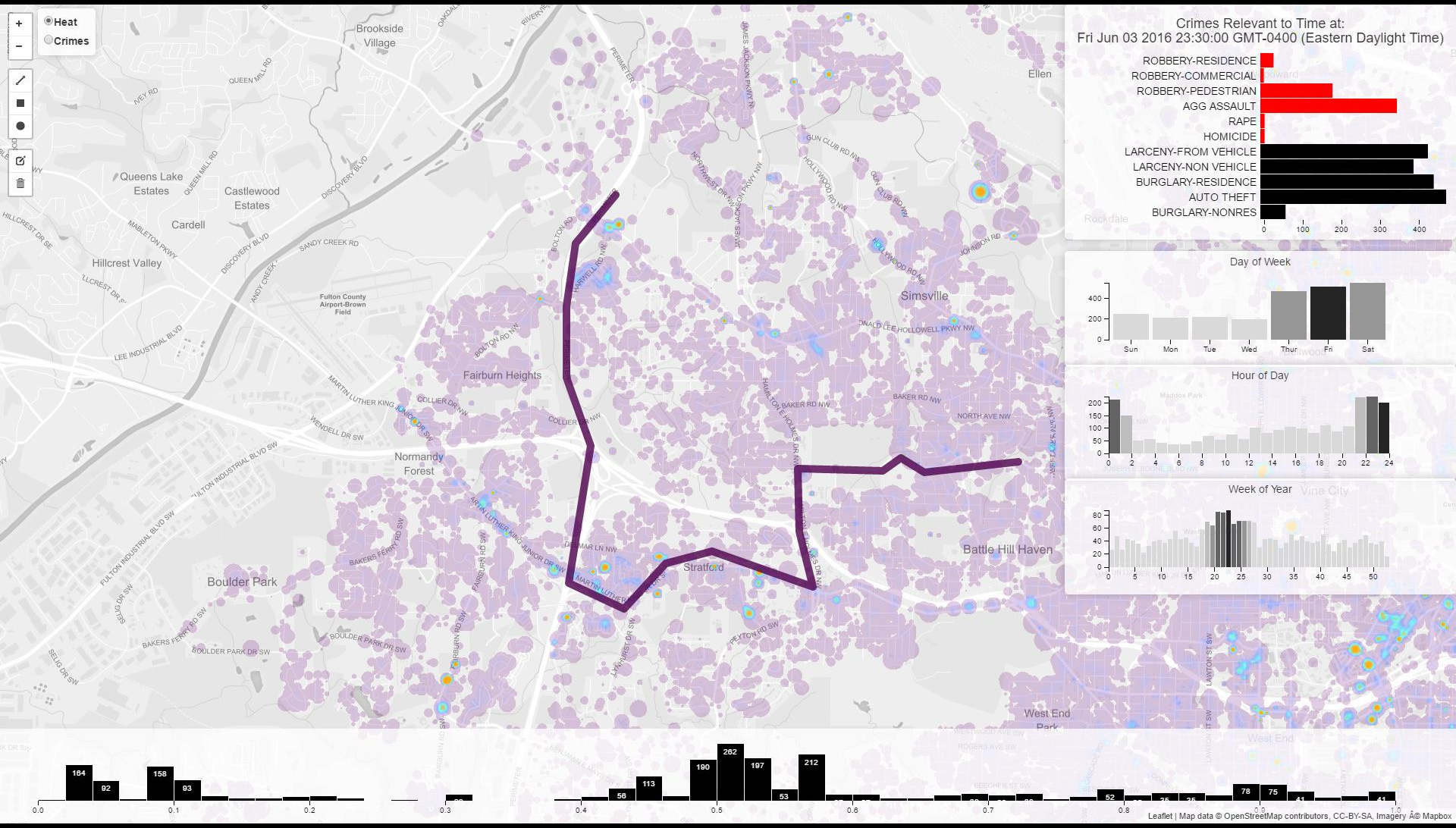
Heat
Crimes
Crimes Relevant to Time at:
Fri Jun 03 2016 23:30:00 GMT-0400 (Eastern Daylight Time)
ROBBERY-RESIDENCE
ROBBERY-COMMERCIAL
ROBBERY-PEDESTRIAN
AGG ASSAULT
RAPE
HOMICIDE
LARCENY-FROM VEHICLE
LARCENY-NON VEHICLE
BURGLARY-RESIDENCE
AUTO THEFT
BURGLARY-NONRES
0
100
200
300
400
Day of Week
Sun
Mon
Tue
Wed
Thur
Fri
Sat
Hour of Day
Week of Year
Brookside Village
Queens Lake Estates
Castlewood Estates
Cardell
Hillcrest Valley
Fulton County Airport-Brown Field
Fairburn Heights
Normandy Forest
Boulder Park
Stratford
Simsville
Battle Hill Haven
West End Park
Ellen
164
92
158
93
56
113
190
262
197
53
212
52
78
75
0.0
0.1
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0.6
0.7
0.8
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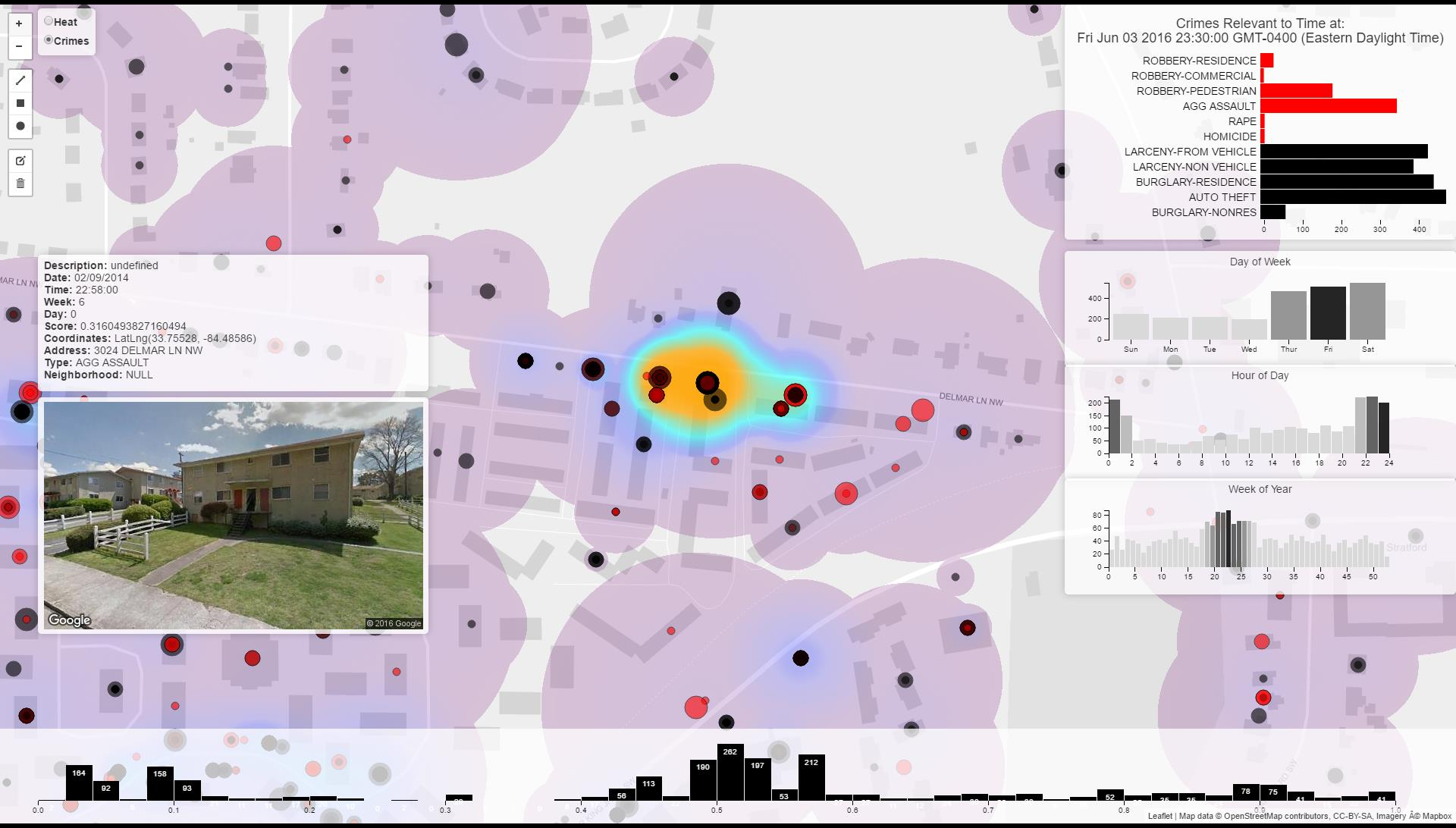
Heat
Crimes
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Date: 02/09/2014
Time: 22:58:00
Week: 6
Day: 0
Score: 0.3160493827160494
Coordinates: LatLng(33.75528, -84.48586)
Address: 3024 DELMAR LN NW
Type: AGG ASSAULT
Neighborhood: NULL
Google
© 2016 Google
DELMAR LN NW
Crimes Relevant to Time at:
Fri Jun 03 2016 23:30:00 GMT-0400 (Eastern Daylight Time)
ROBBERY-RESIDENCE
ROBBERY-COMMERCIAL
ROBBERY-PEDESTRIAN
AGG ASSAULT
RAPE
HOMICIDE
LARCENY-FROM VEHICLE
LARCENY-NON VEHICLE
BURGLARY-RESIDENCE
AUTO THEFT
BURGLARY-NONRES
0
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Day of Week
Sun
Mon
Tue
Wed
Thur
Fri
Sat
Hour of Day
Week of Year
Stratford
164
92
158
93
56
113
190
262
197
53
212
52
78
75
41
41
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Conclusions and Future Work

Initial work is promising, and evaluation in the field would provide ecological validation and allow us to identify future design requirements

Future work would include designing a version of HotSketch directed towards civilian needs for crime exploration within a community

Acknowledgments

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Questions?

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