Visual Crime Analysis in Big Cities: A practical application for crime data in São Paulo

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Outline:

- Introduction/Motivation
- São Paulo Crime Data
- CrimAnalyzer
- Mirante
- HotspotVis
- Conclusions

Introduction/Motivation

Crime

Crime can be defined as breaking or breaching of criminal law (penal code) that governs a particular geographical area (jurisdiction) aimed at protecting the lives, property, and the right of citizens in that jurisdiction.

Crime is an offense against a person, or his/her property, violation of socially accepted rules of human ethical or moral behavior.

Robbery

Burglary

Larceny

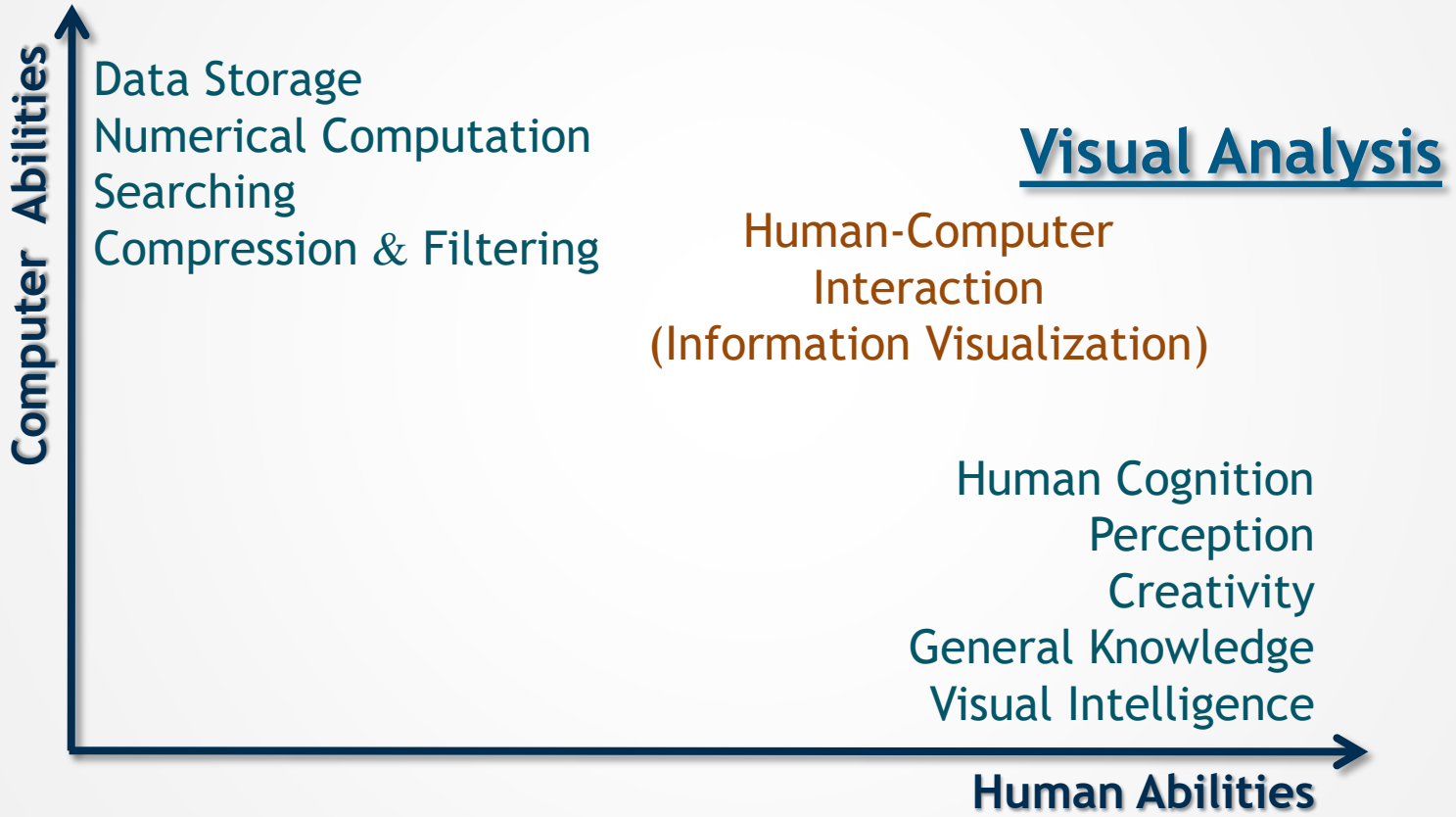
Law enforcement agencies deploy resources in a more effective manner to:

- Prevent
- Control
- Reduce

Crime activities

Introduction/Motivation

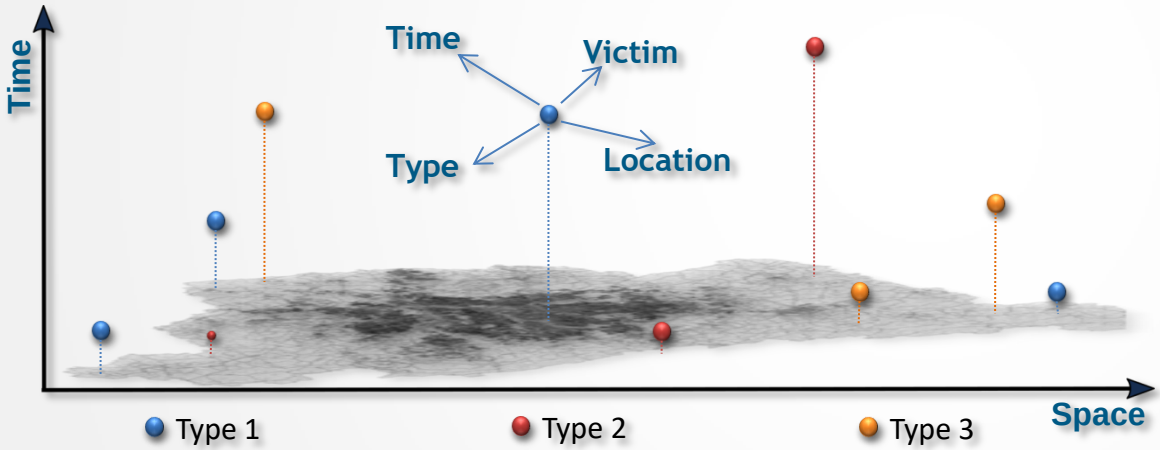
Search for patterns, trends, structure, irregularities, relationships among data



Introduction/Motivation

Crime Mapping

A branch of Geographic Information System (GIS) devoted to explain spatio-temporal behavior of criminal activities.



Allows

- *Demonstrate the importance of local geography for crime frequency and type.*
- *Identify and visualize hotspots.*
- *Identify the seasonality of crime types in certain locations.*

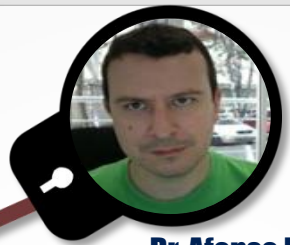
Introduction/Motivation

Brazil is a dangerous place, with a high murder rate and surprisingly high disparity when compared against other large countries.*

* http://metrocosm.com/homicides-brazil-vs-world/

Research Group

Dr. Luis Gustavo Nonato



Dr. Afonso Paiva

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Dr. Erick Gomez Nieto

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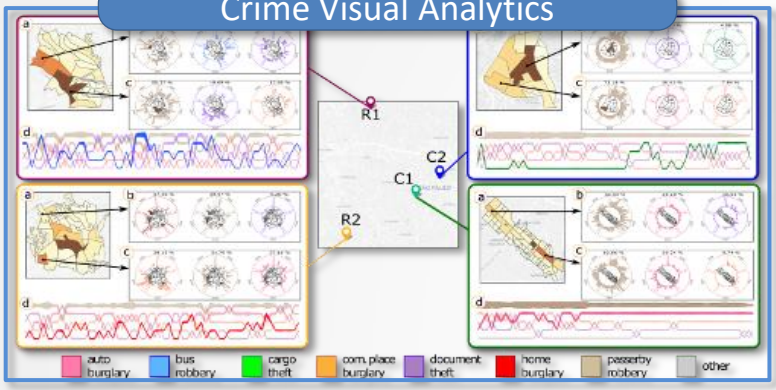
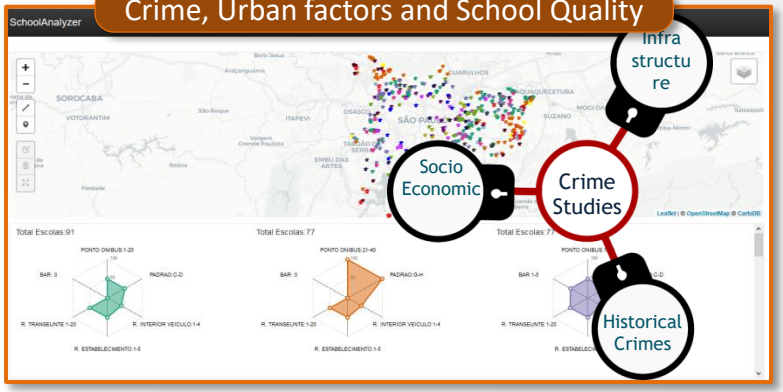
Research Group - Projects

Crime Visual Analytics

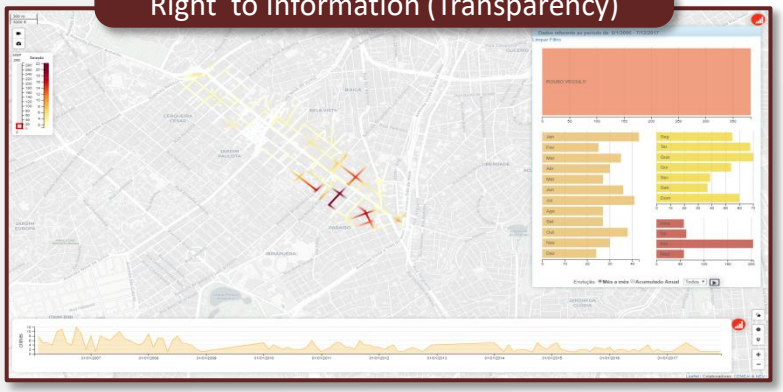


Crime, Urban factors and School Quality



NEV and Cemeai - USP

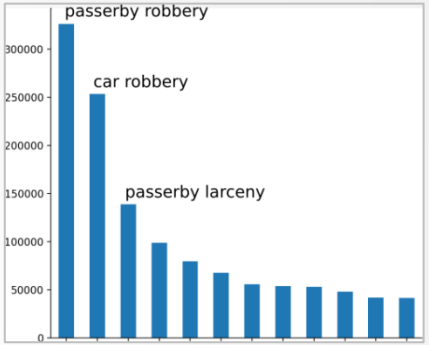
Right to Information (Transparency)



Crime Forecasting

Initial Data Set

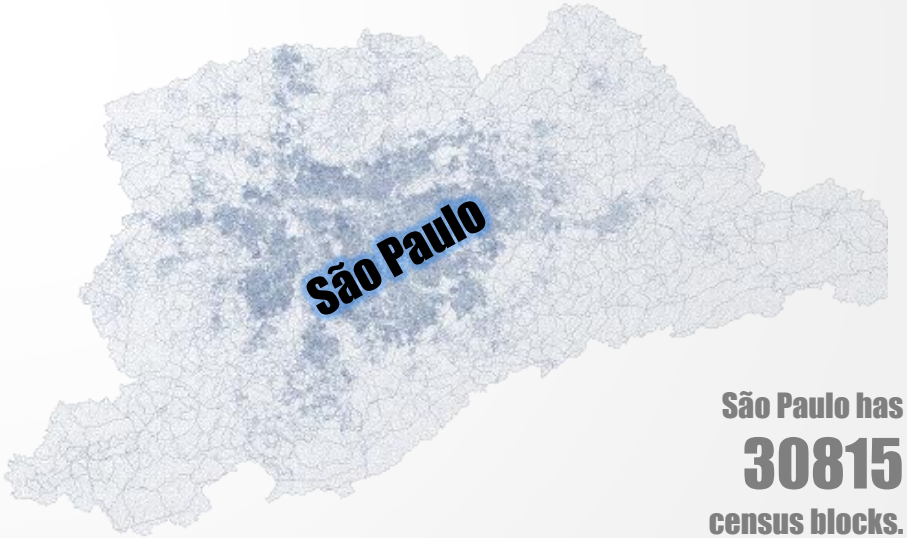
- From **2000** to **2006**



- The data set contains **3** **attributes**:
  - Census unit code where the crime happened.
  - Type of crime.
  - Date and time of the crime.

- **Crime types** range in **127**:
  - Passerby robbery
  - Auto theft
  - Larceny
  - …

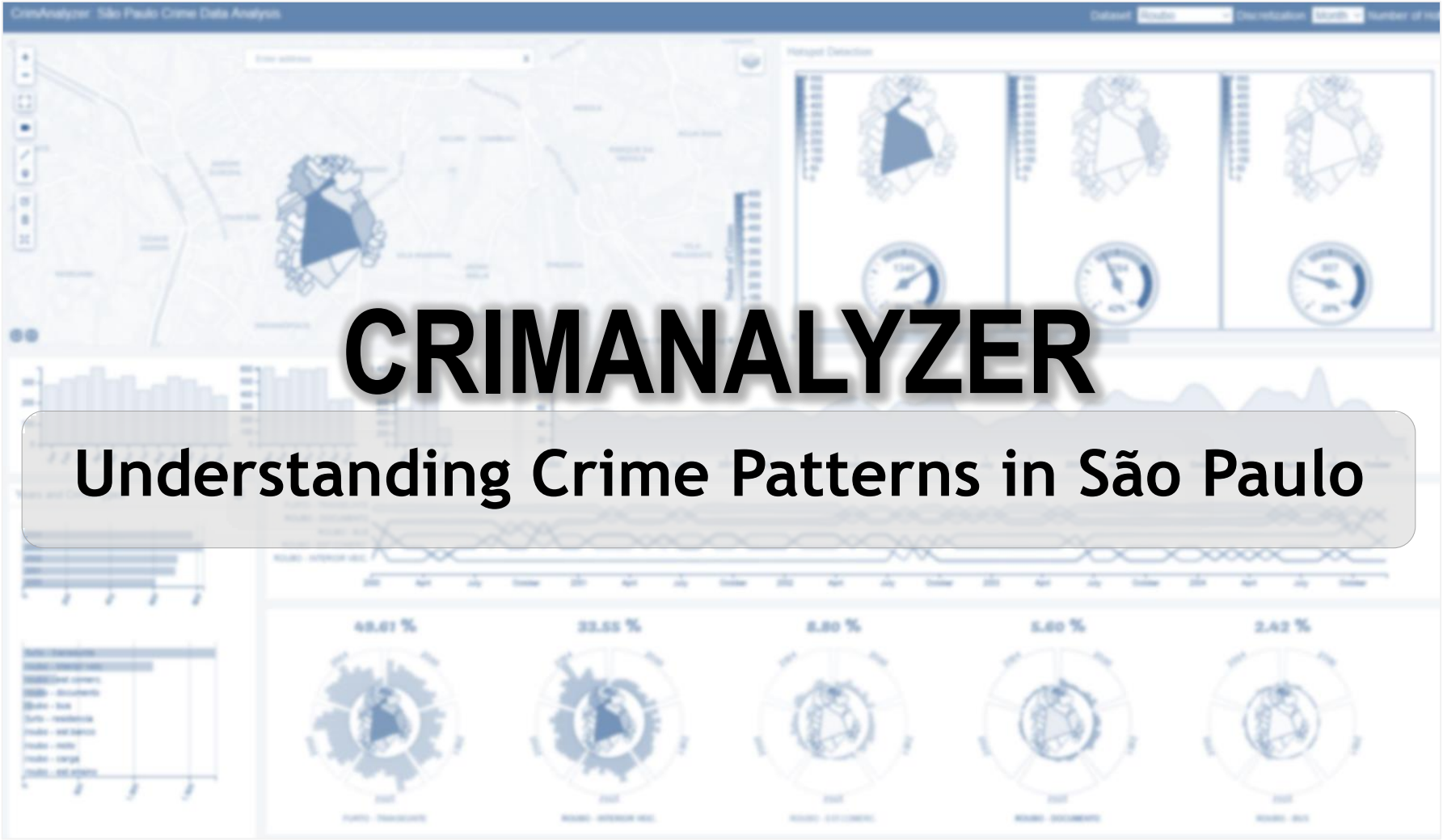
- **Categories** are:
  - Roubo - **691 954**
  - Furto - **587 885**
  - Roubo de veículo - **295 081**



São Paulo has
30815
census blocks.

Problem Analysis

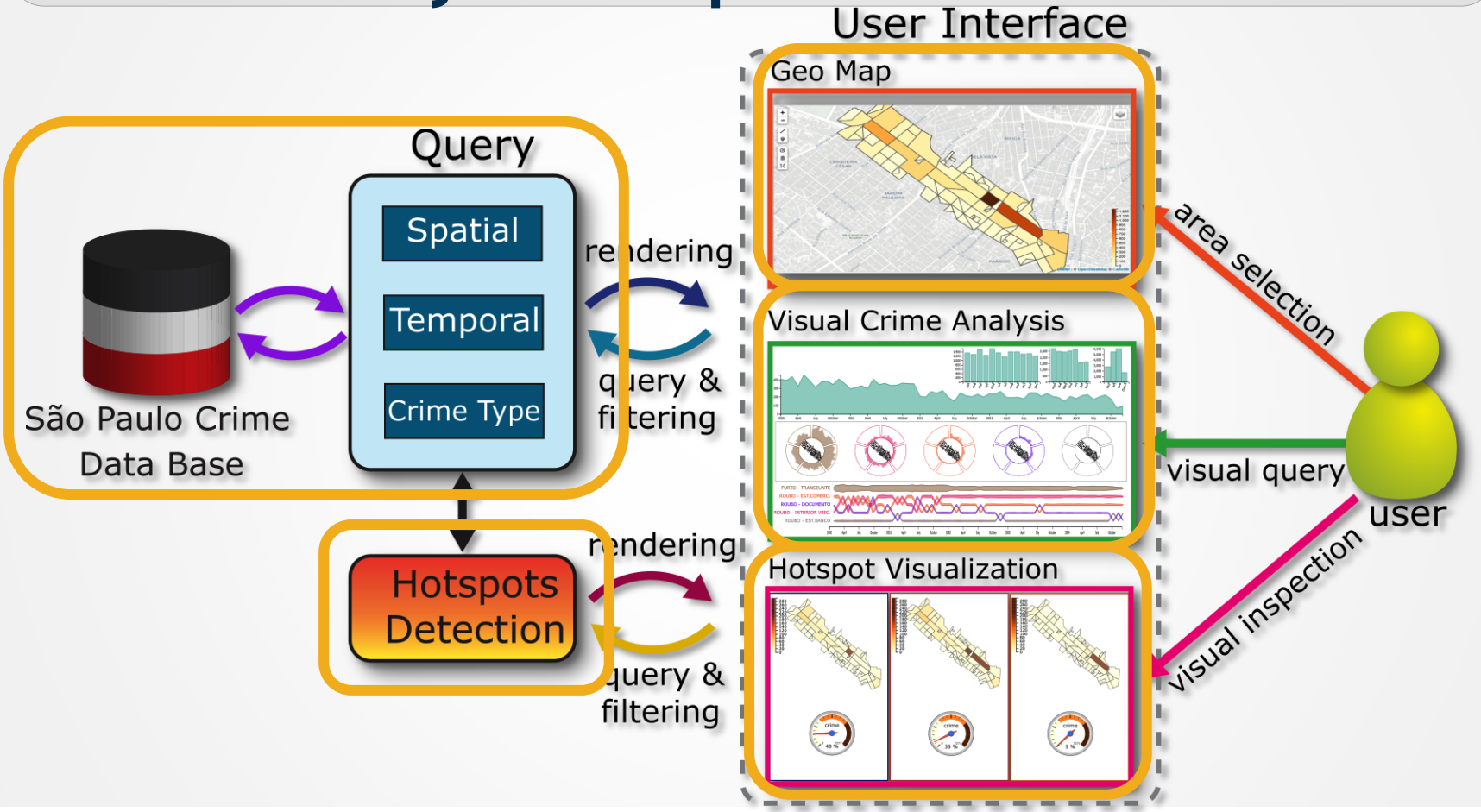
- **P1.** *Analyzing the characteristics and dynamics of crimes in particular regions of the city.*
- **P2.** *Identifying crime hotspots within a particular region.*
- **P3.** *Understanding and comparing crime patterns.*



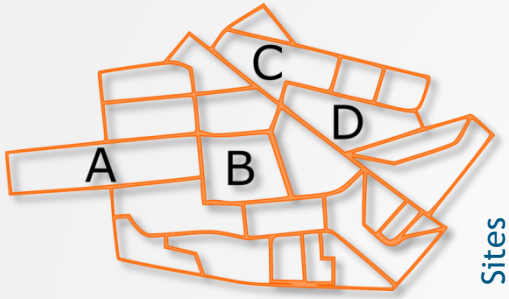
CRIMANALYZER

Understanding Crime Patterns in São Paulo

CrimAnalyzer - Pipeline



Data Modelling with NMF



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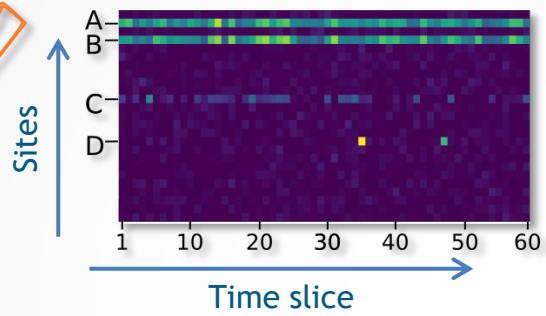

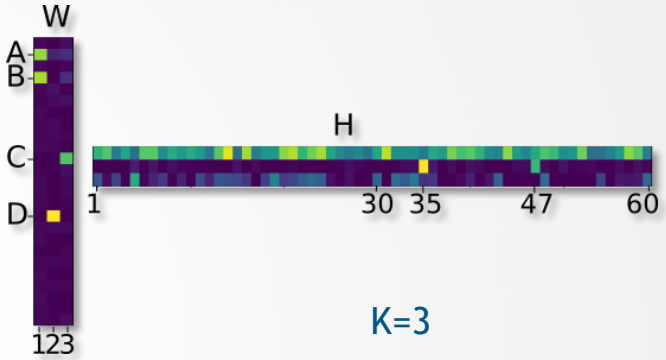

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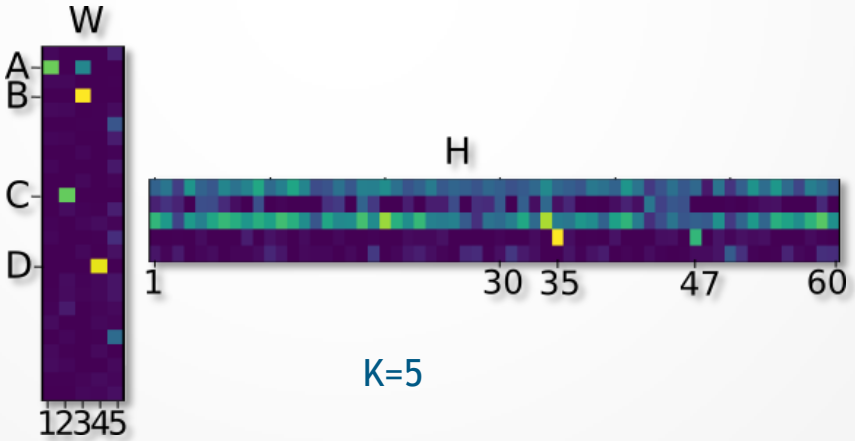

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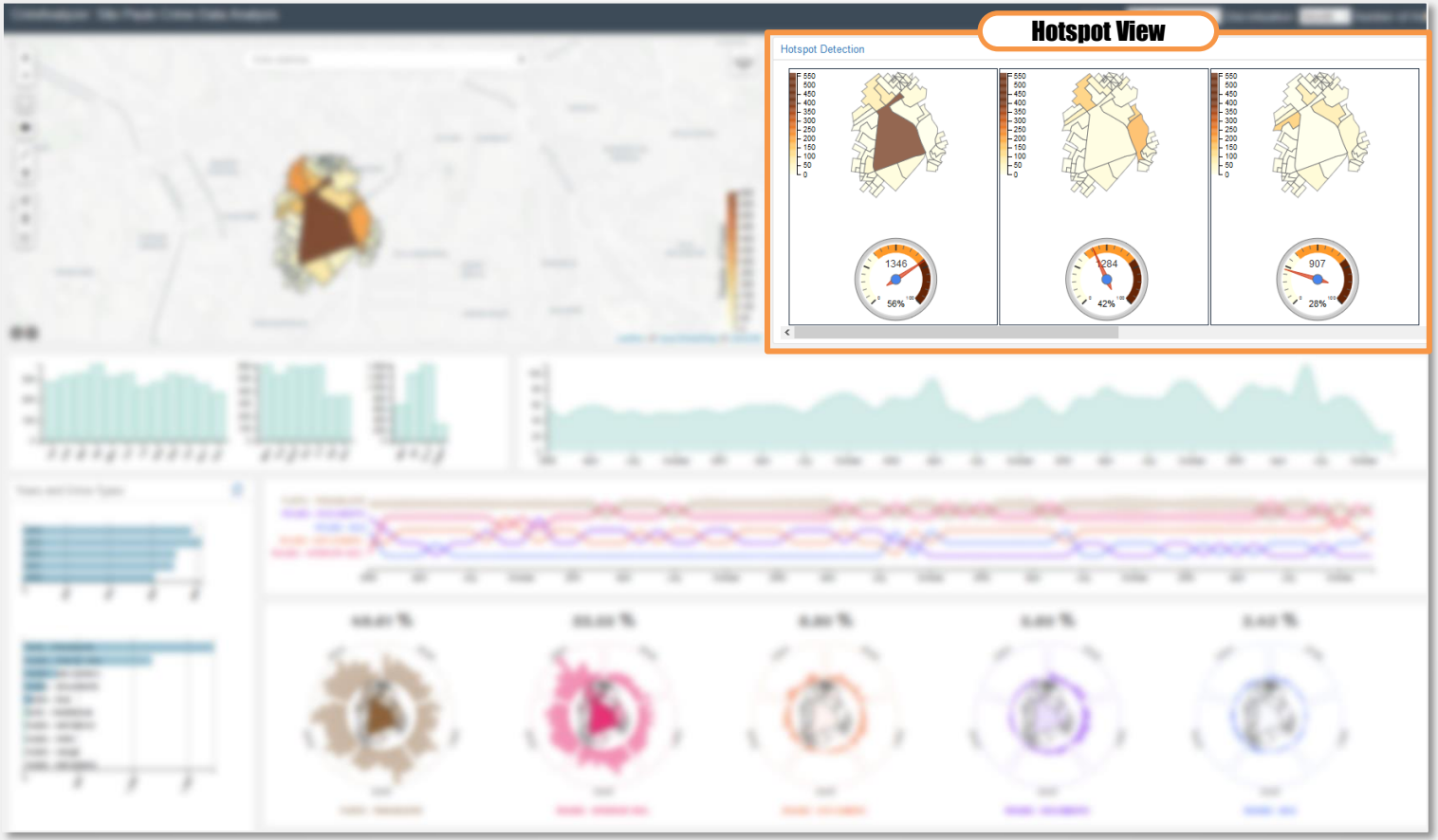
CrimAnalyzer - Framework

CrimAnalyzer - Framework

CrimAnalyzer - Framework



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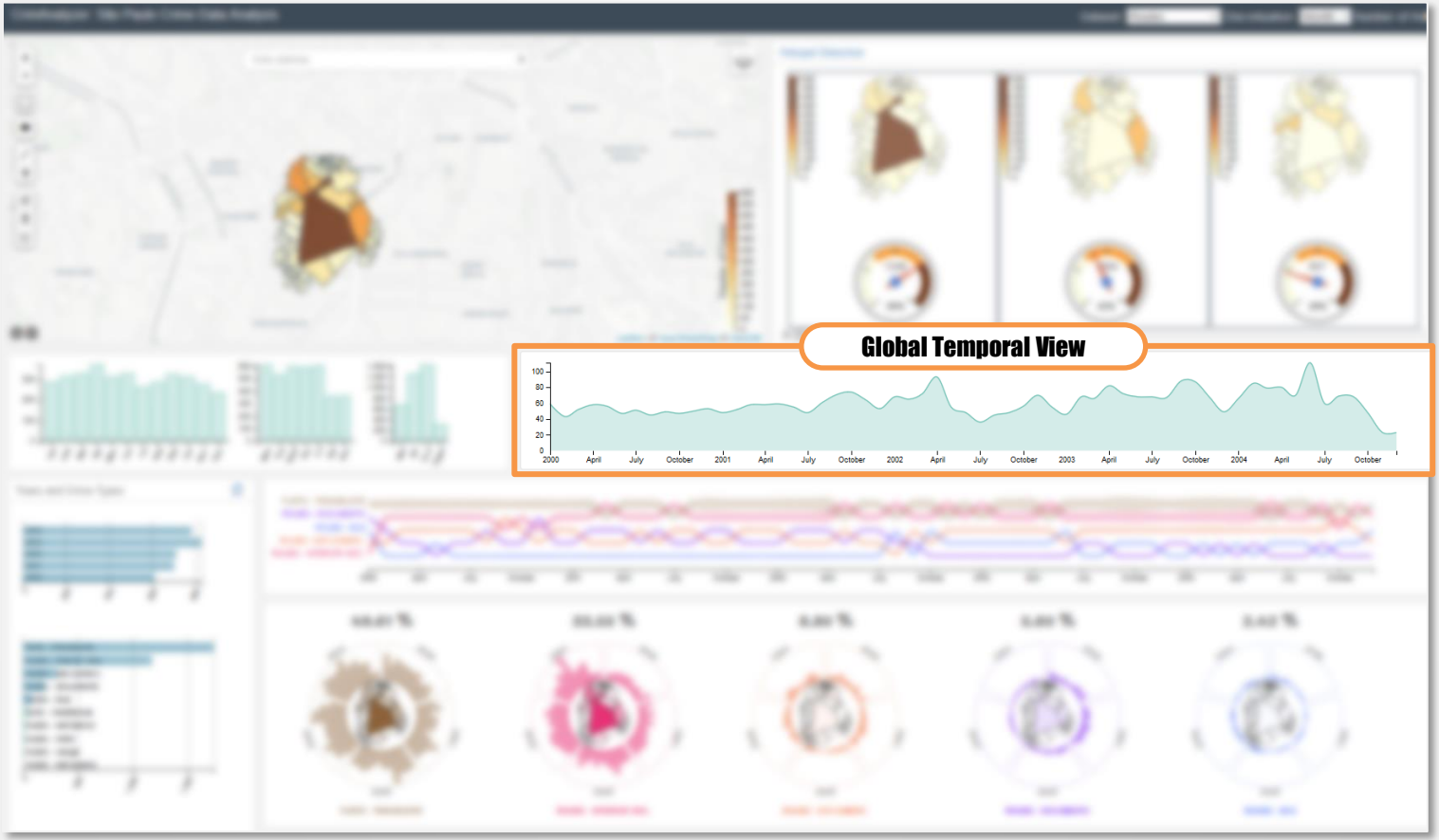

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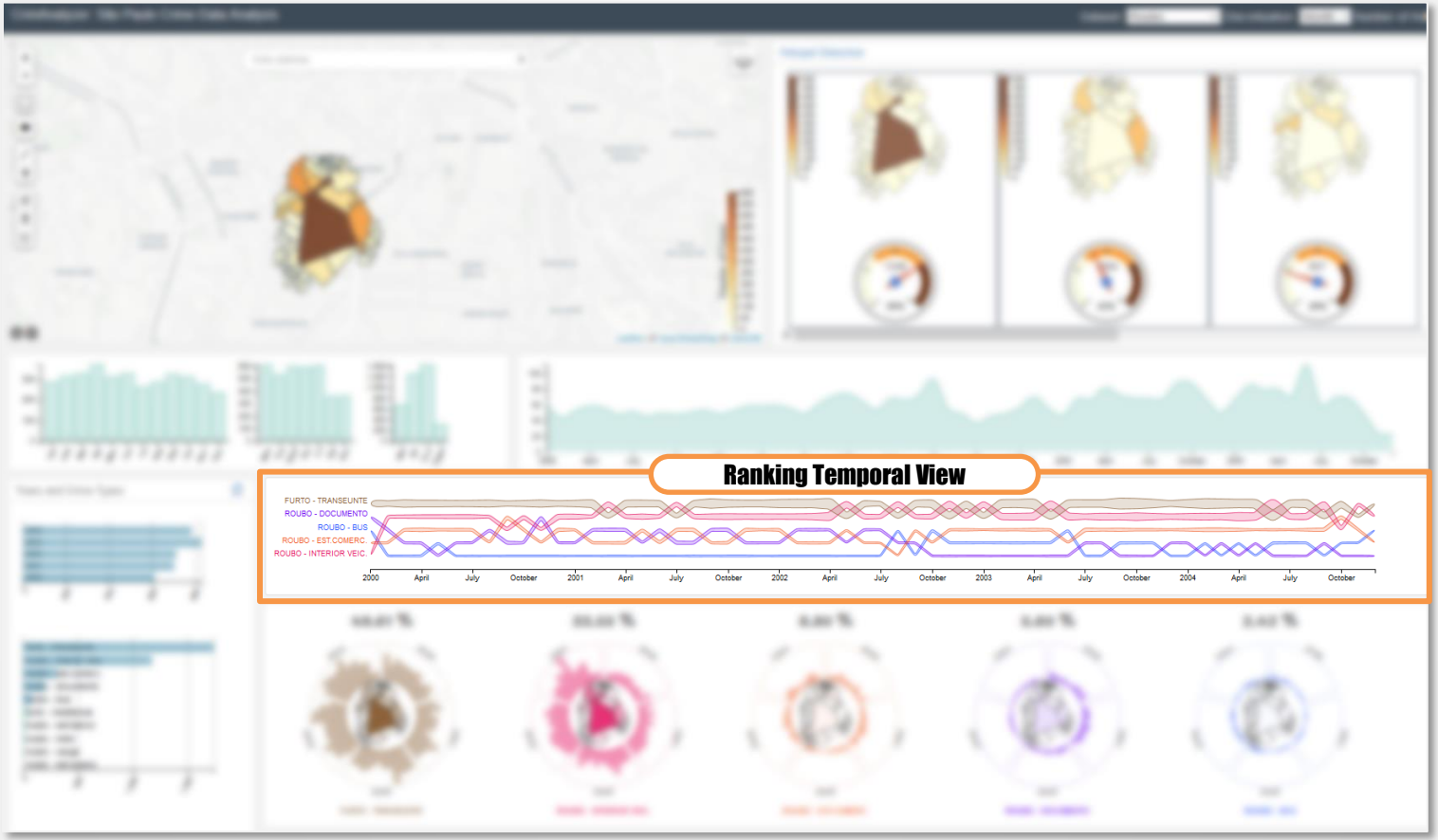


CrimAnalyzer - Framework

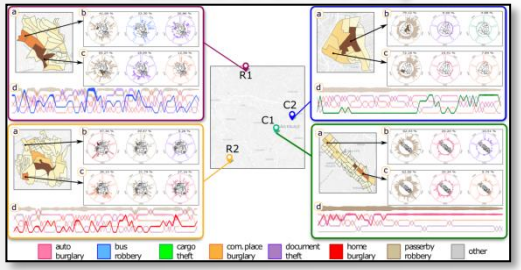
CrimAnalyzer - Paper

CrimAnalyzer: Understanding Crime Patterns in São Paulo

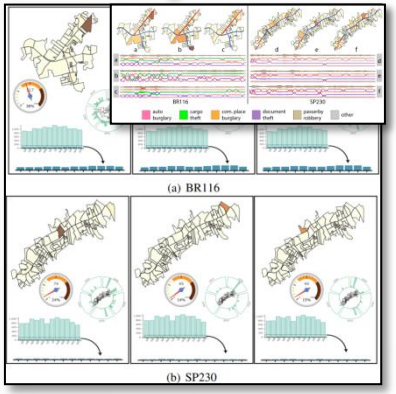
Published in: IEEE Transactions on Visualization and Computer Graphics

Case Studies

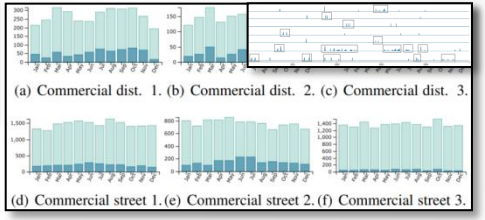
Comparing Crime Patterns over the City



Hotspot Analysis and Cargo Theft



Seasonality and the Temporal Element of Crime



https://ieeexplore.ieee.org/document/8869805

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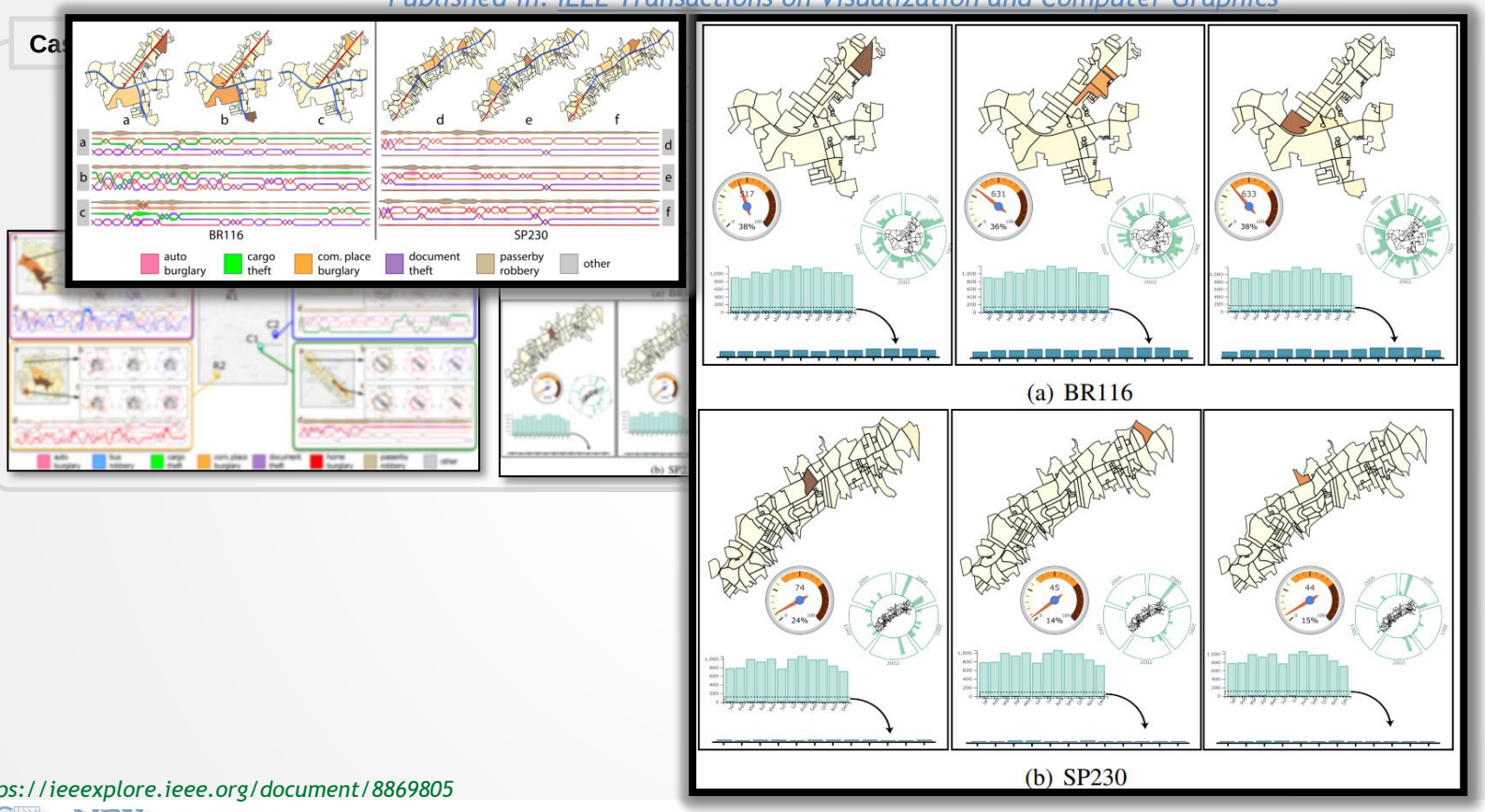

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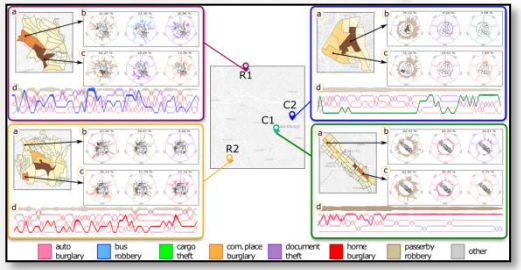

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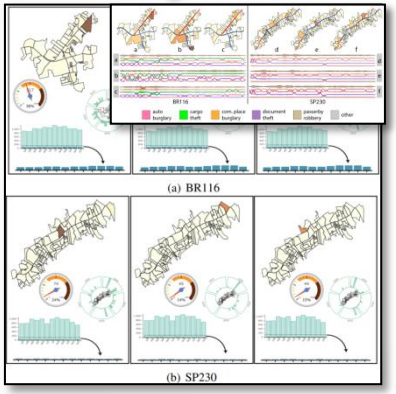

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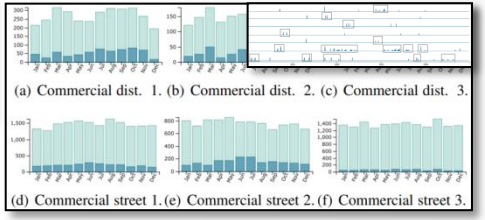
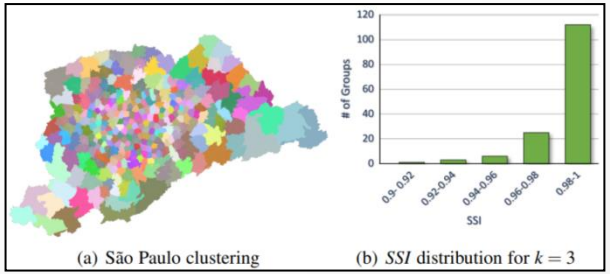


Statistics



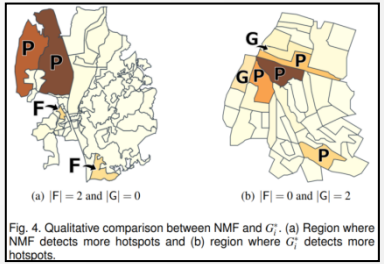


Fig. 4. Qualitative comparison between NMF and G_i^*. (a) Region where NMF detects more hotspots and (b) region where G_i^* detects more hotspots.

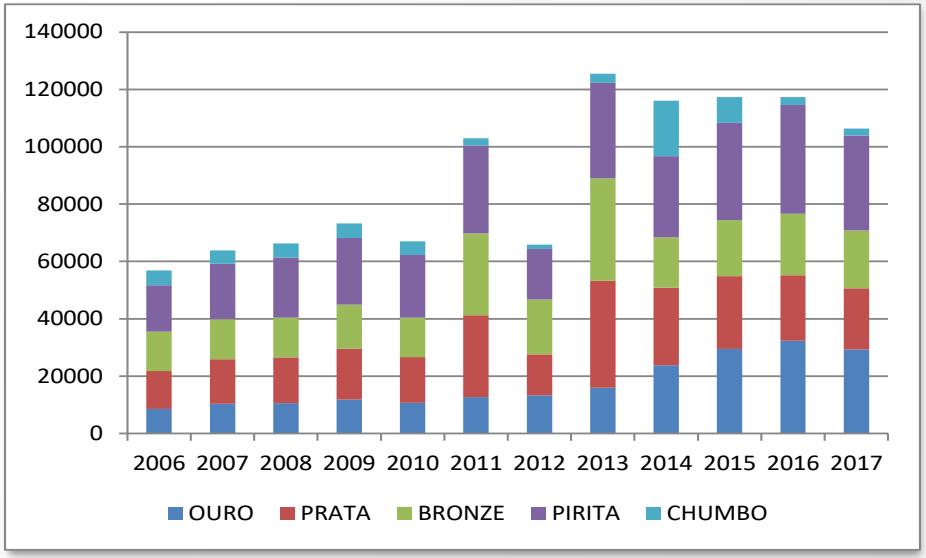
https://ieeexplore.ieee.org/document/8869805

Second Data Set

- From **2006** to **2017**

São Paulo has **30815** census blocks.

- **Attributes**:
  - **ANO_OCORR:** Year of occurrence.
  - **DATA_OCORRENCIA_BO:** Date of occurrence.
  - **HORA_OCORRENCIA_BO:** Hour of occurrence (many of them nominal: Madrugada, manhã, Noite).
  - **NOME_DELEGACIA_CIRC:** Station name
  - **RUBRICA:** Crime type (16 types)
  - **FLAG_STATUS:** Status (consumado).
  - **COD_SETOR:** Code of census block
  - **COORD_X:** lat
  - **COORD_Y:** lng

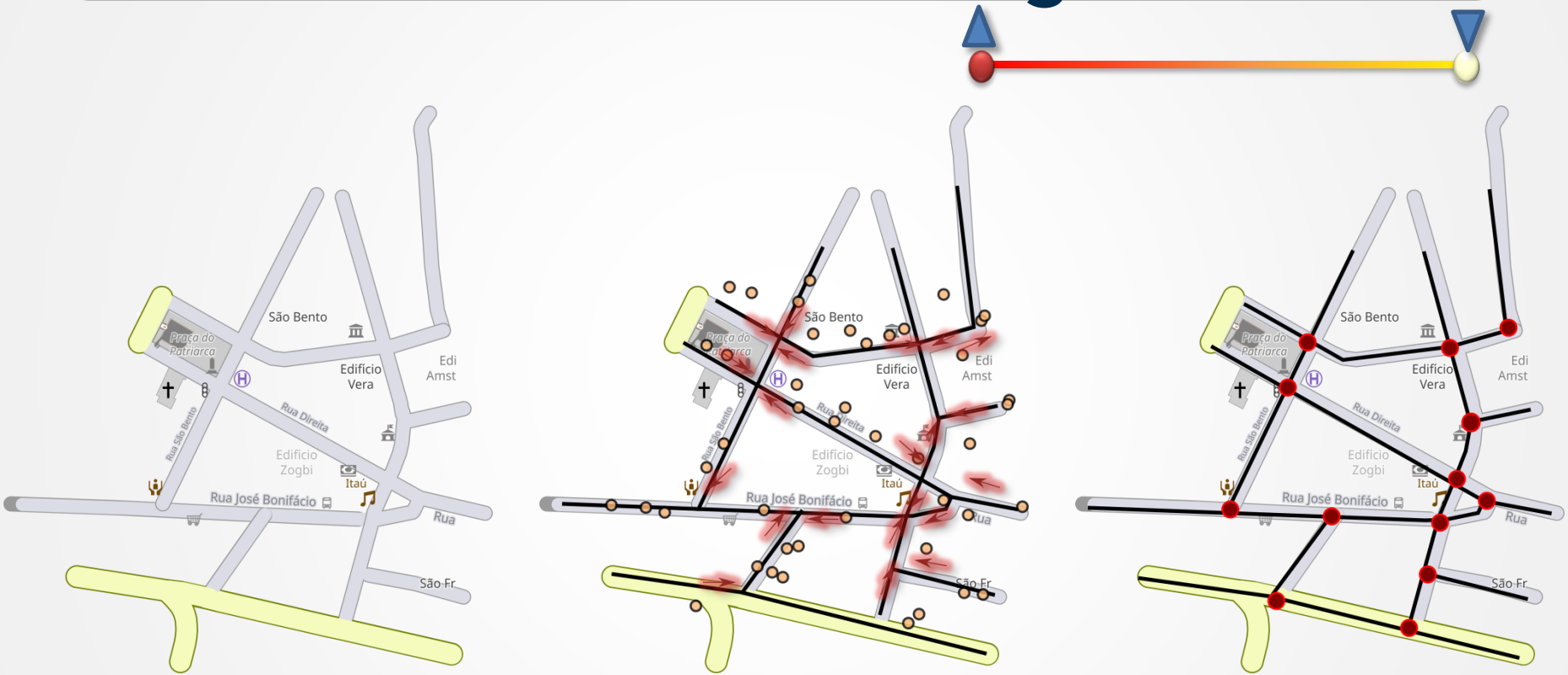


- **Categories** are:
  - Roubo, more than 1,000,000

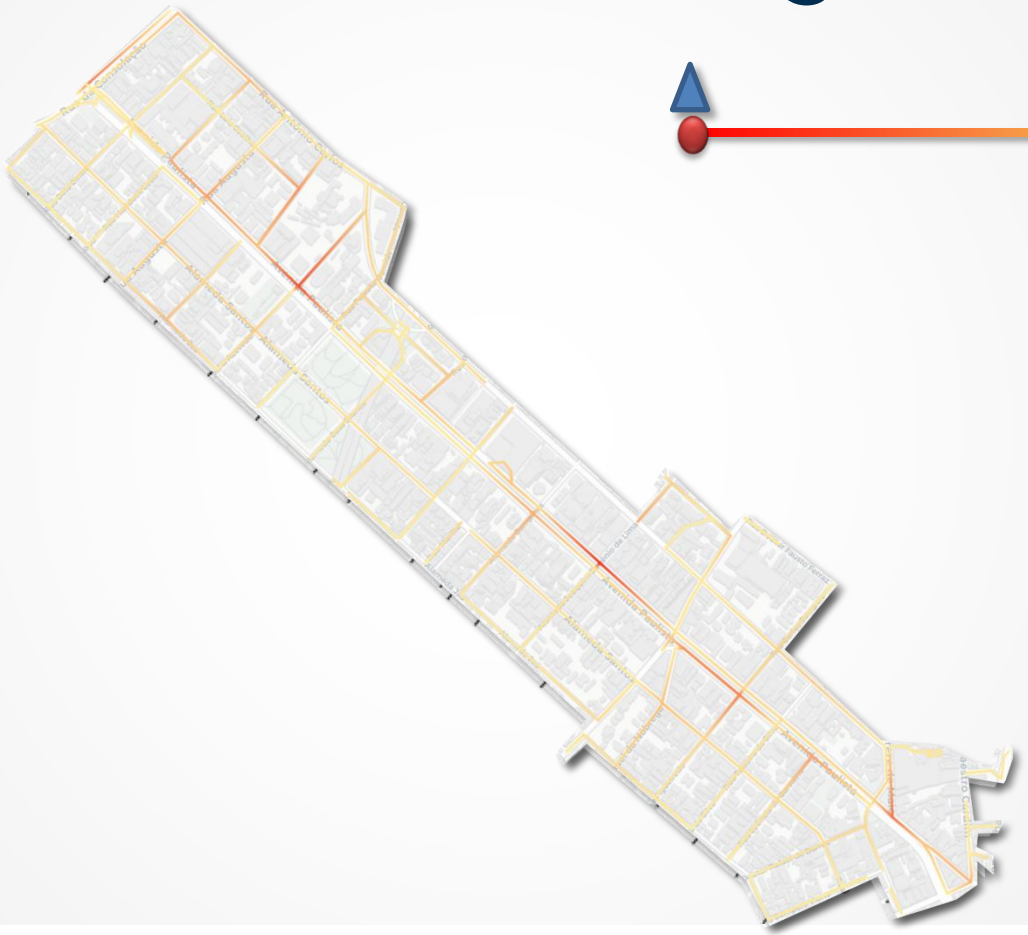
MIRANTE

Monitor Interativo de Reconhecimento e Análise de Notas de Transgressões e Eventos

MIRANTE - Data Modeling



MIRANTE - Data Modeling



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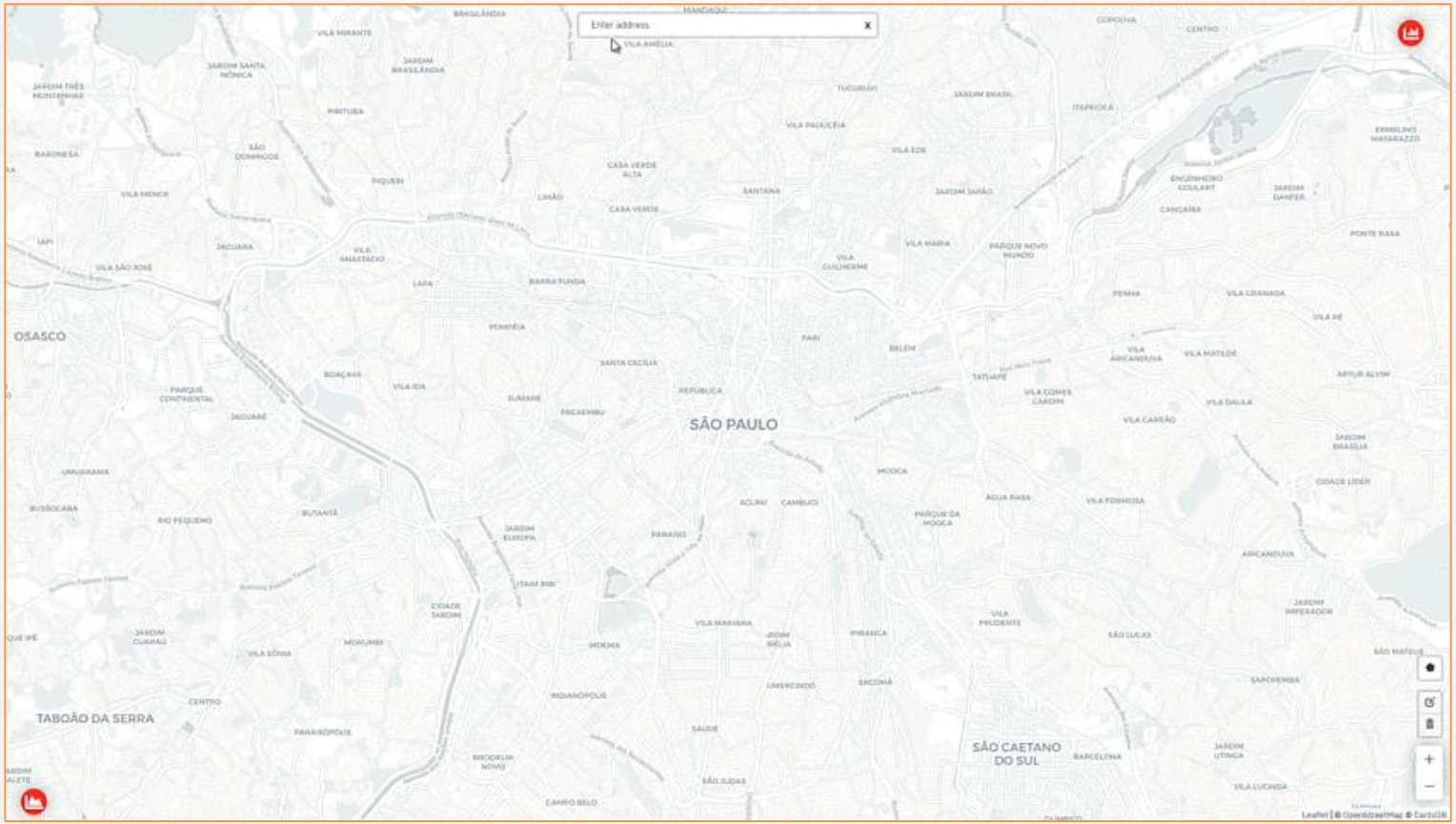

http://crimeanalyzer.vicg.icmc.usp.br/
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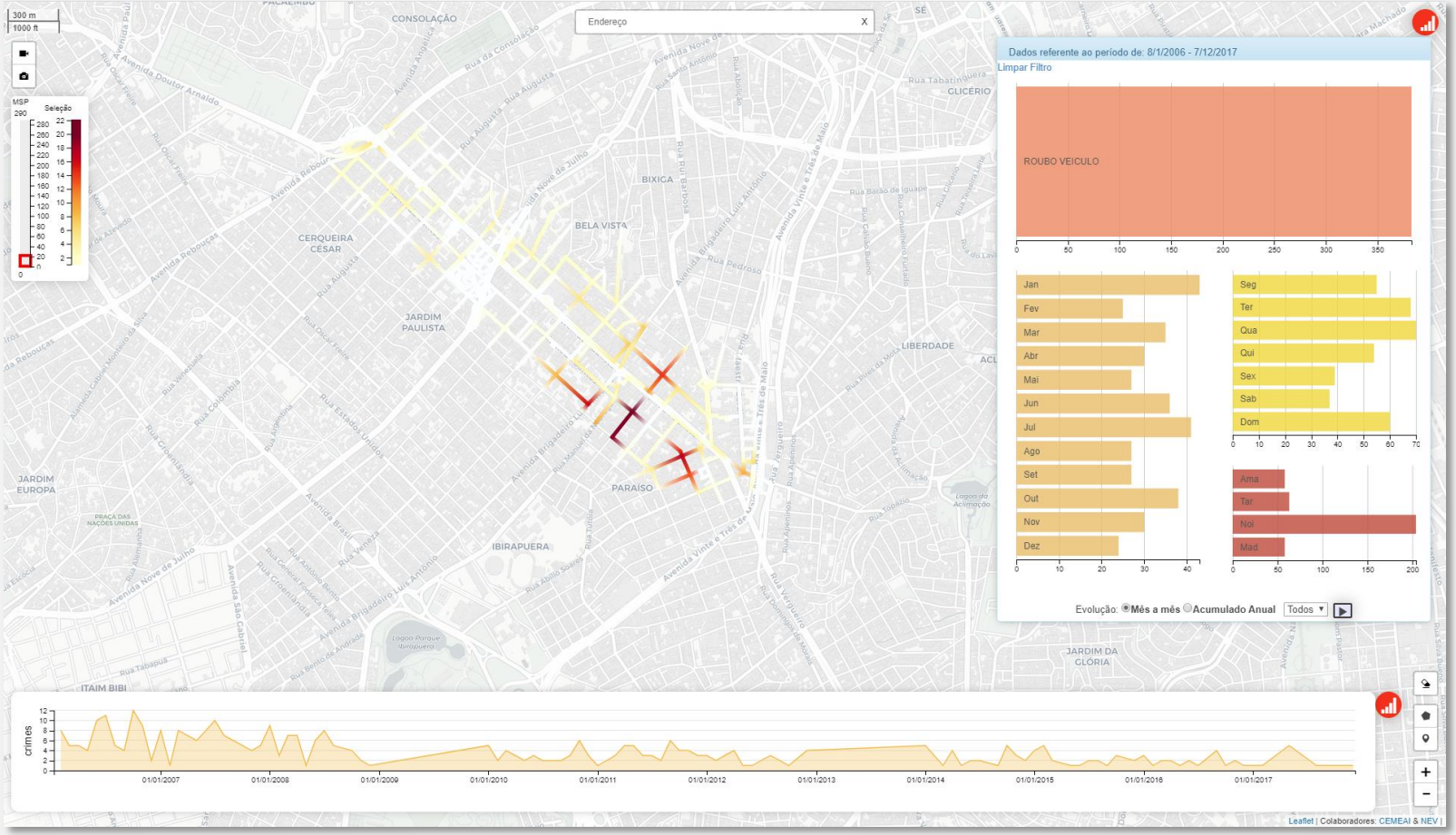
MIRANTE - Framework



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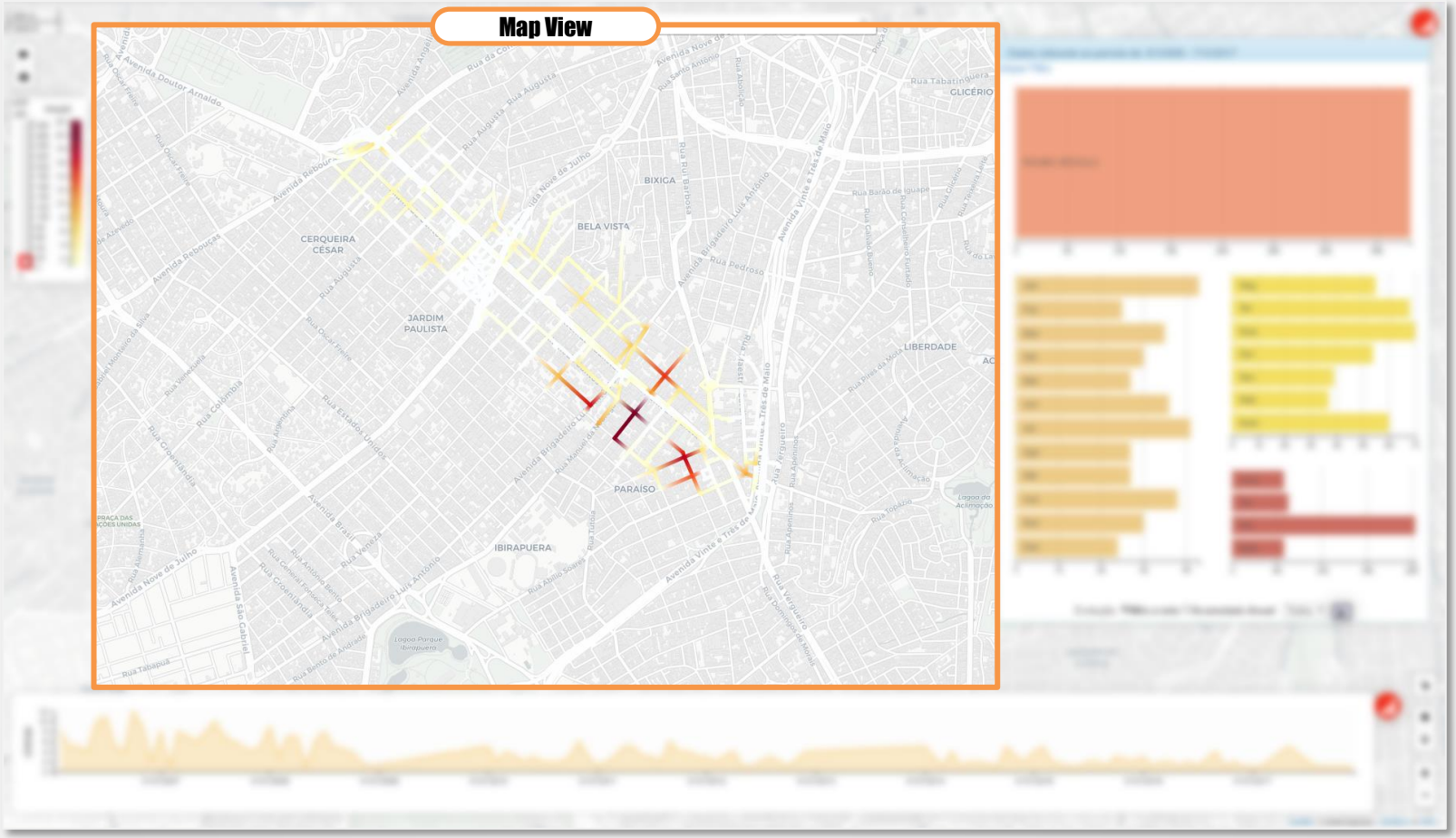

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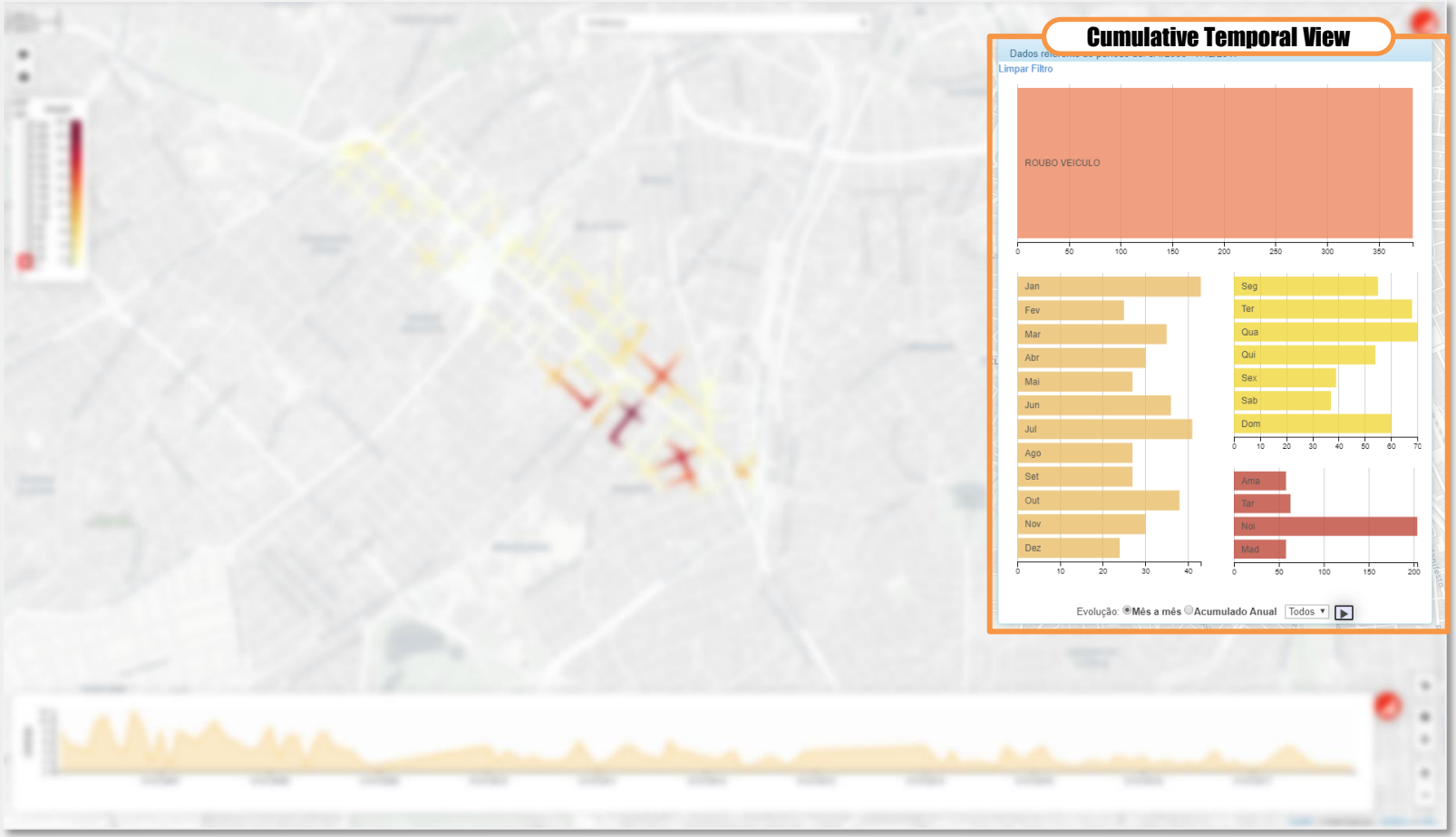

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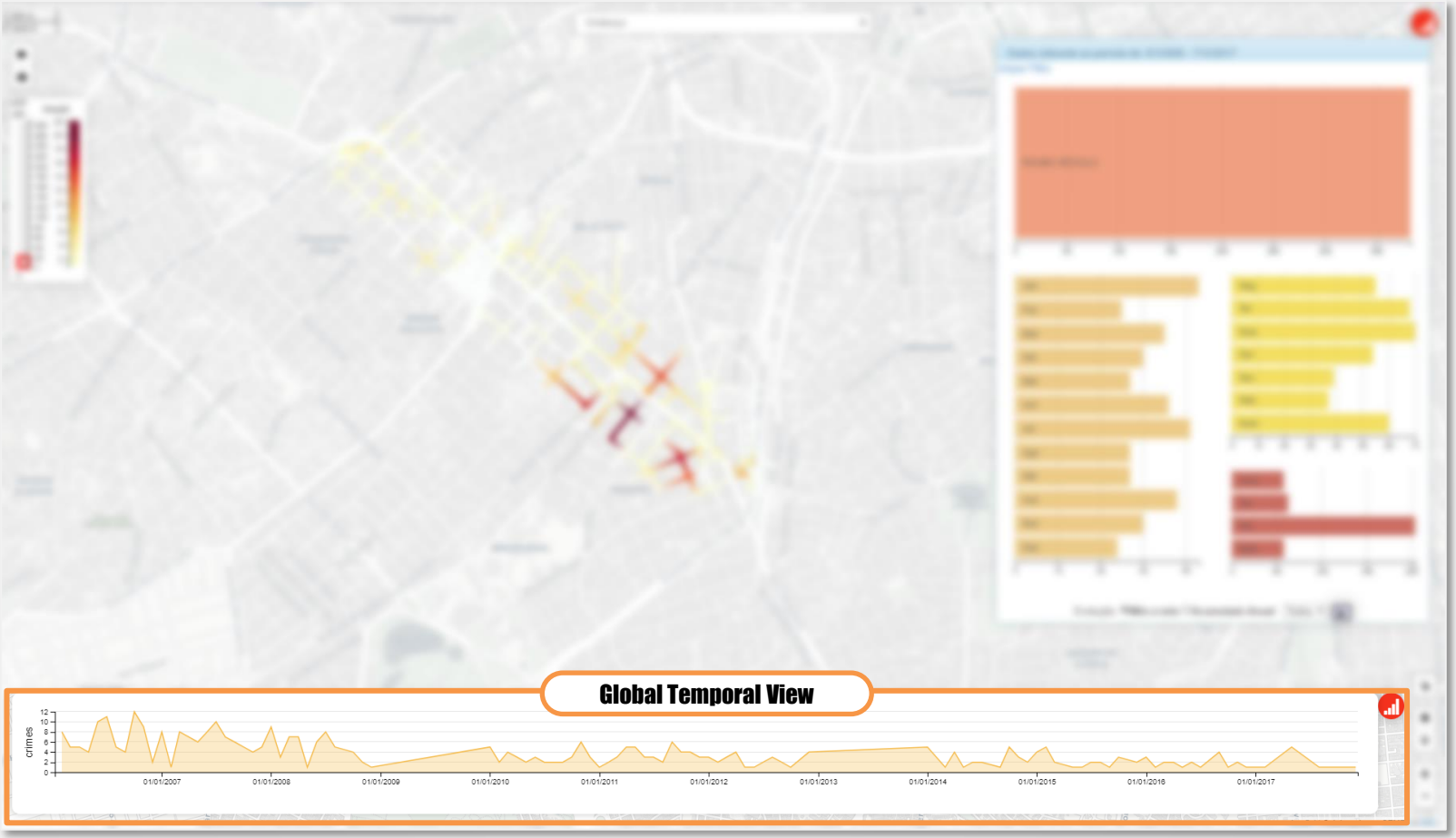
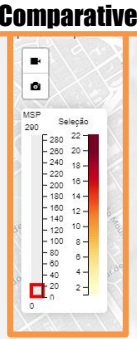
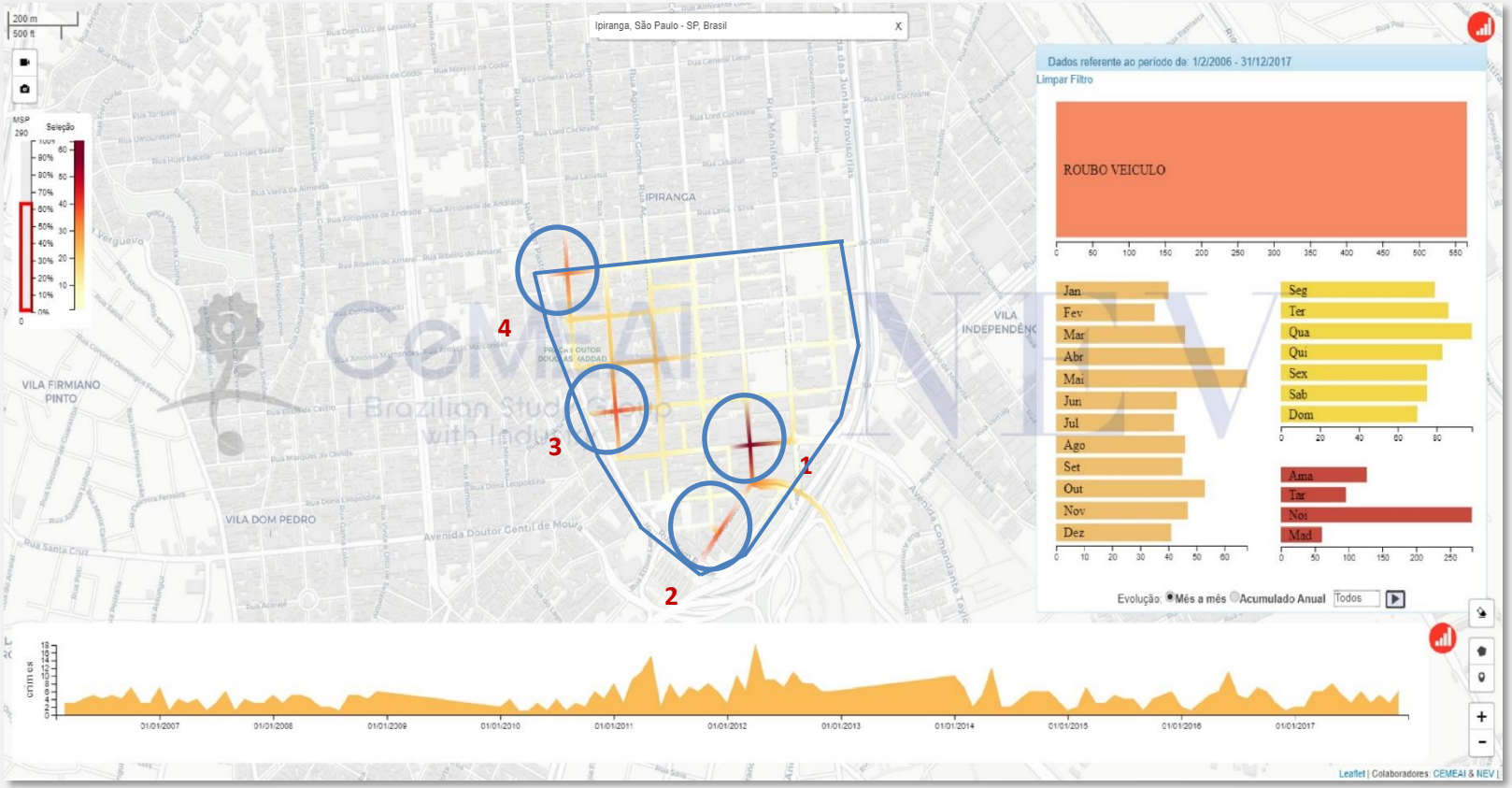


MIRANTE - Framework

Comparative

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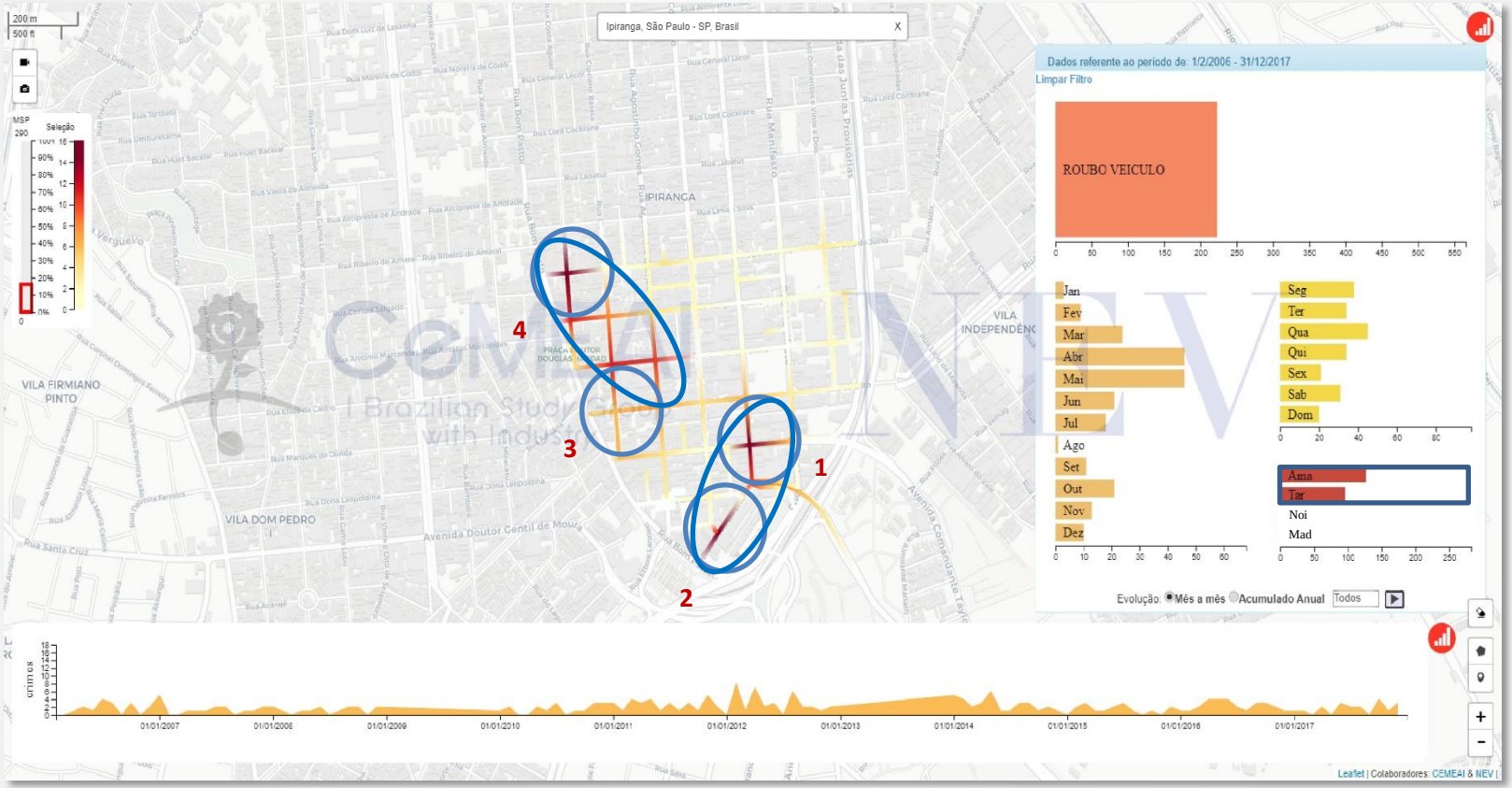
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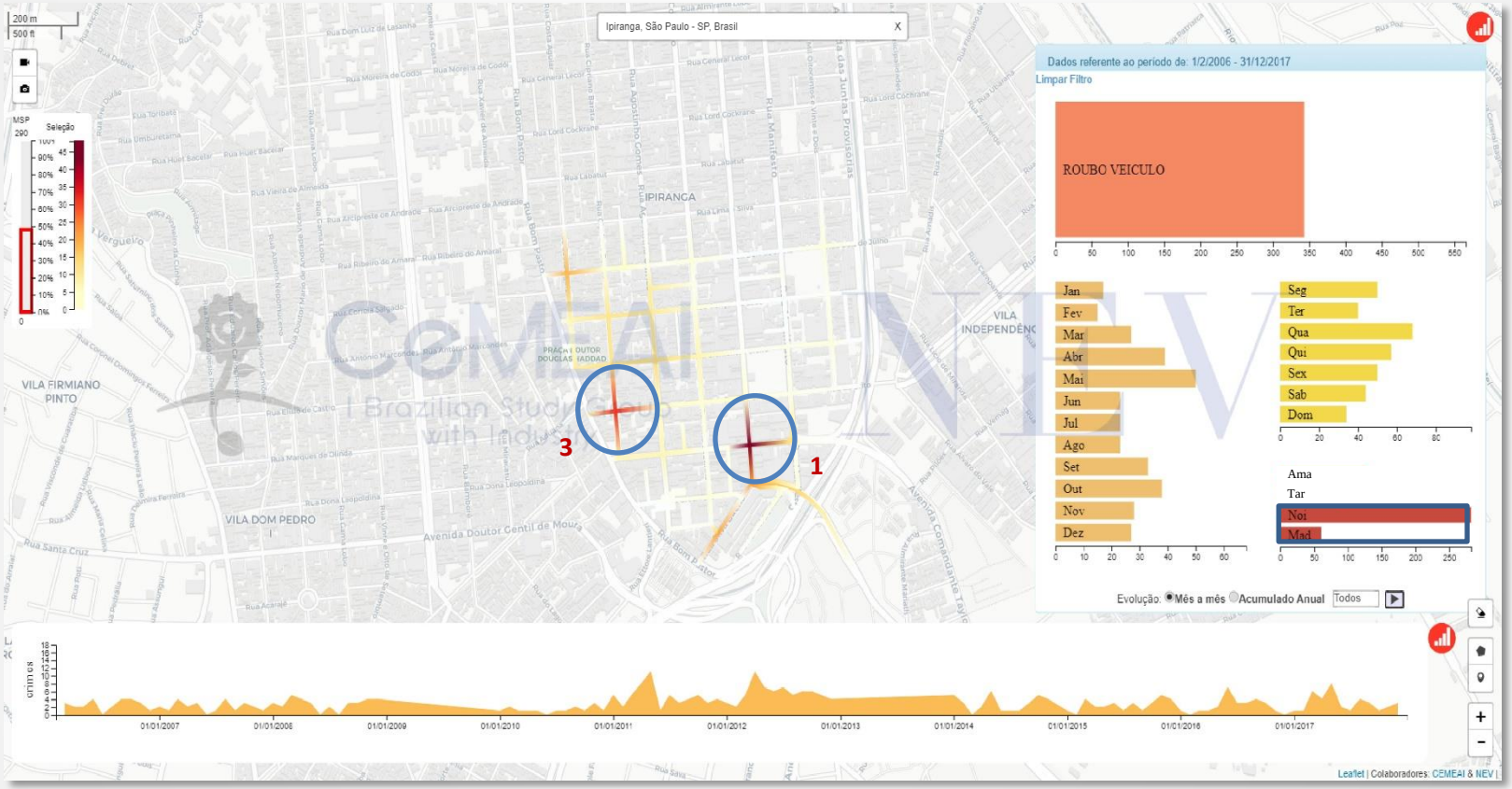
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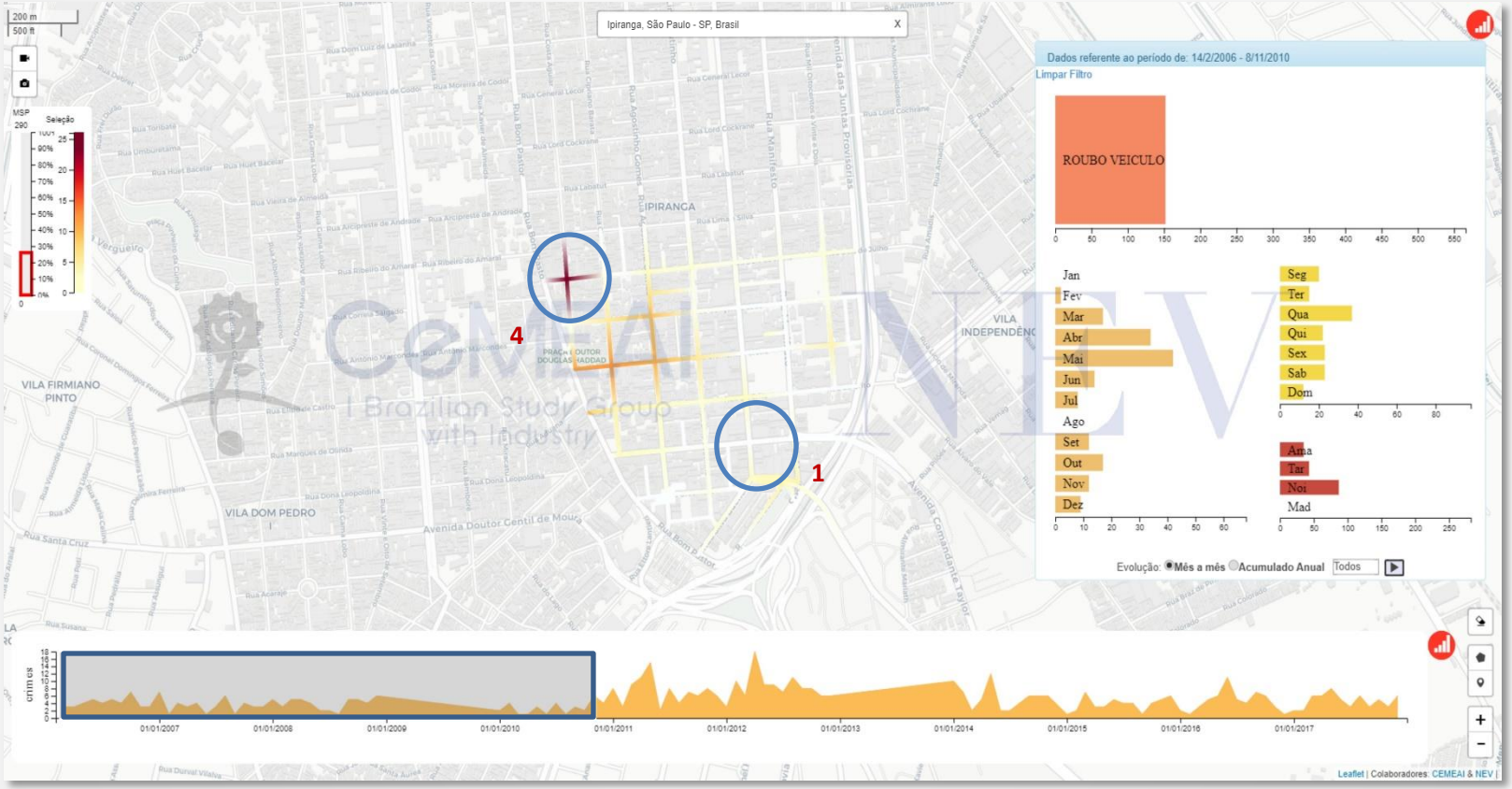
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Avenida Doutor Centil de Moura
Avenida Comandante Taylor
CeMEAI
Brazilian Study Group with Industry
NEV
Leaflet | Colaboradores: CEMEAI & NEV

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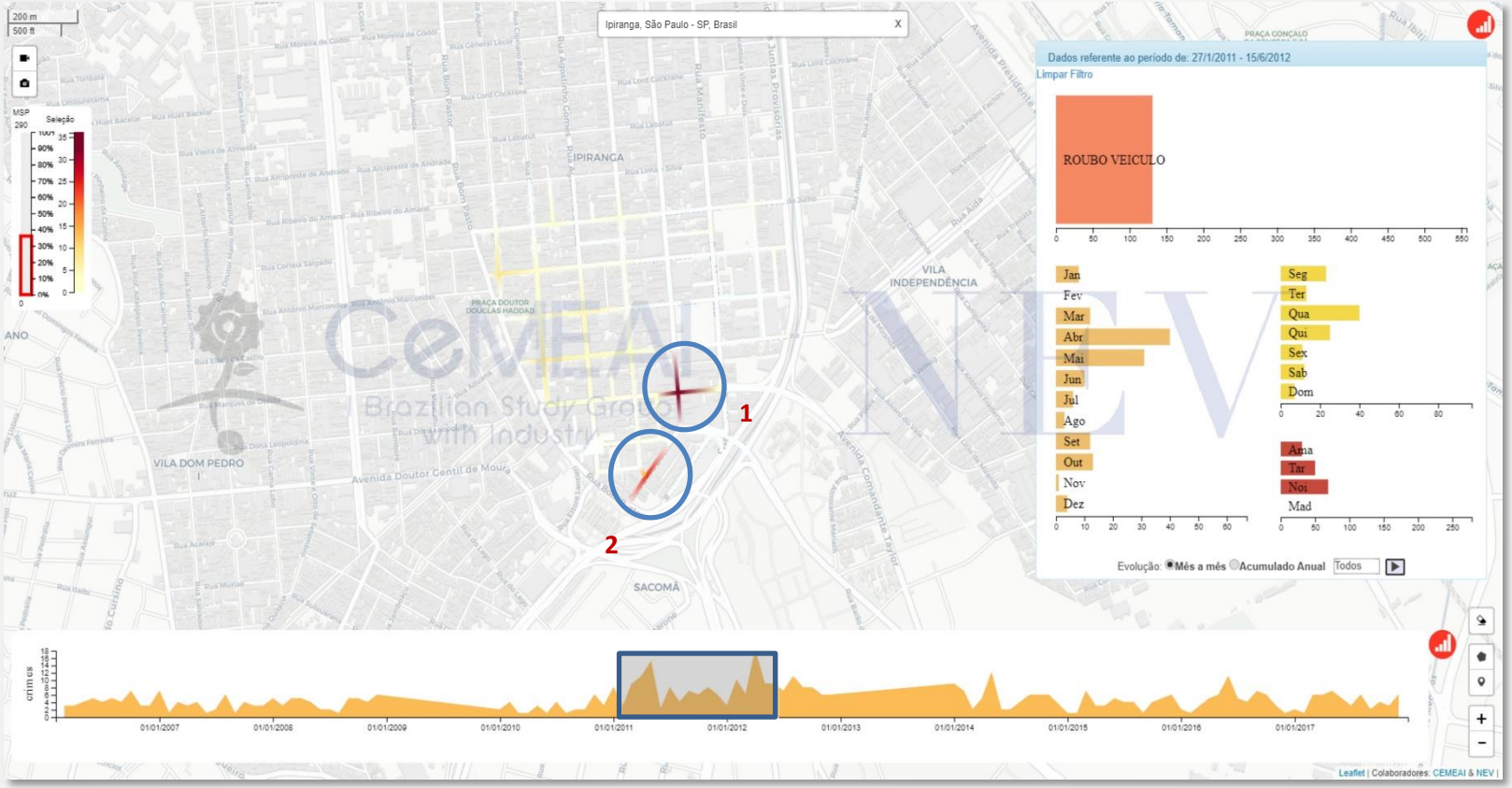
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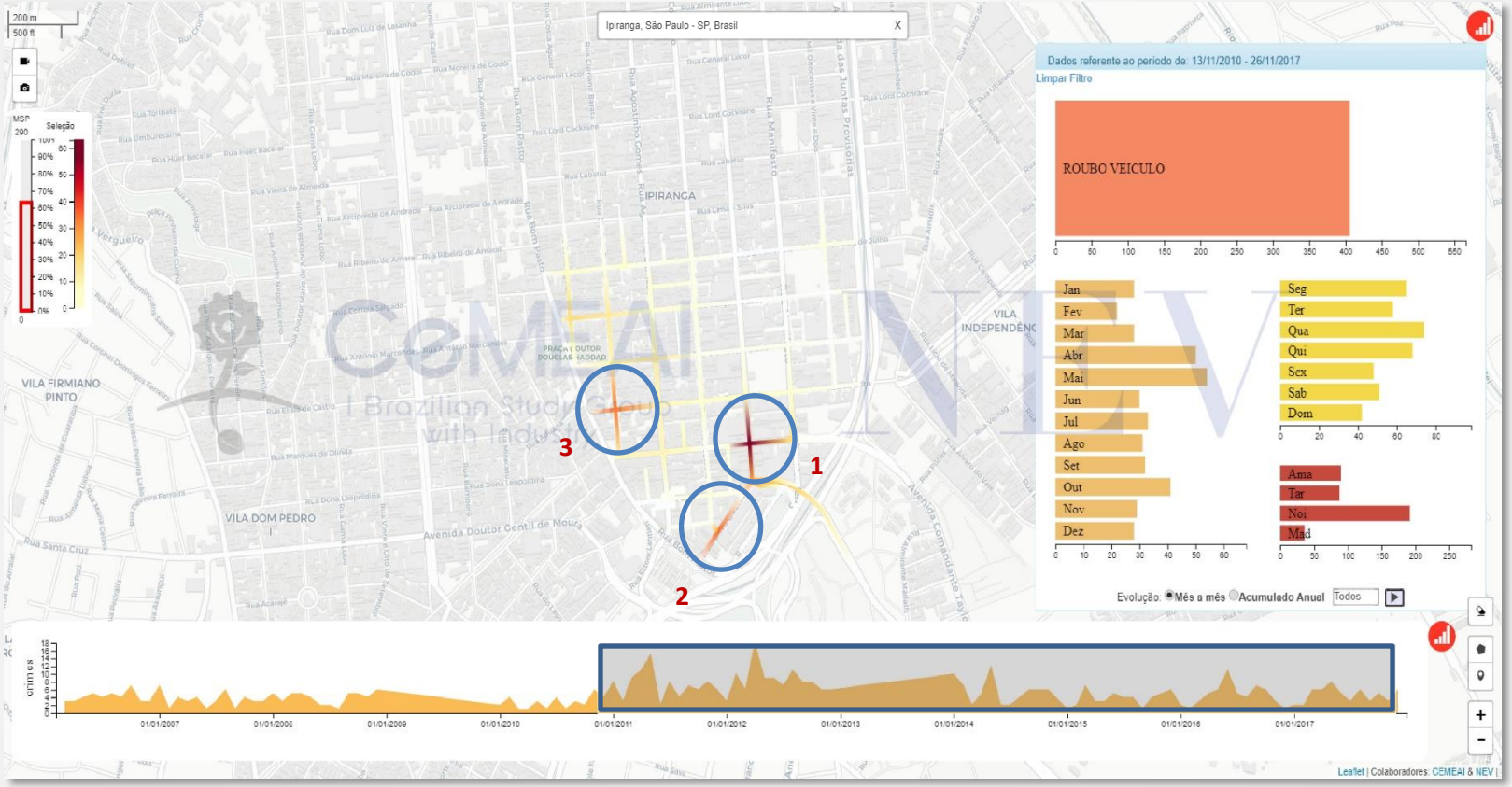
MIRANTE


Ipiranga, São Paulo - SP, Brasil
Dados referente ao periodo de: 13/11/2010 - 26/11/2017
Limpar Filtro
ROUBO VEICULO
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
Evolução: Mês a mês Acumulado Anual Todos
IPIRANGA
VILA FIRMIANO PINTO
VILA DOM PEDRO
VILA INDEPENDÊNC
1
2
3
01/01/2007
01/01/2008
01/01/2009
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
Leaflet | Colaboradores: CEMEAI & NEV

MIRANTE


2006 - 8/11/2010
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
Acumulado Anual
Todos
crimes
01/01/2007
01/01/2008
01/01/2009
01/01/2010
01/01/2011
01/01/2012
01/01/2013
01/01/2014
01/01/2015
01/01/2016
01/01/2017
Leaflet | Colaboradores: CEMEAI & NEV

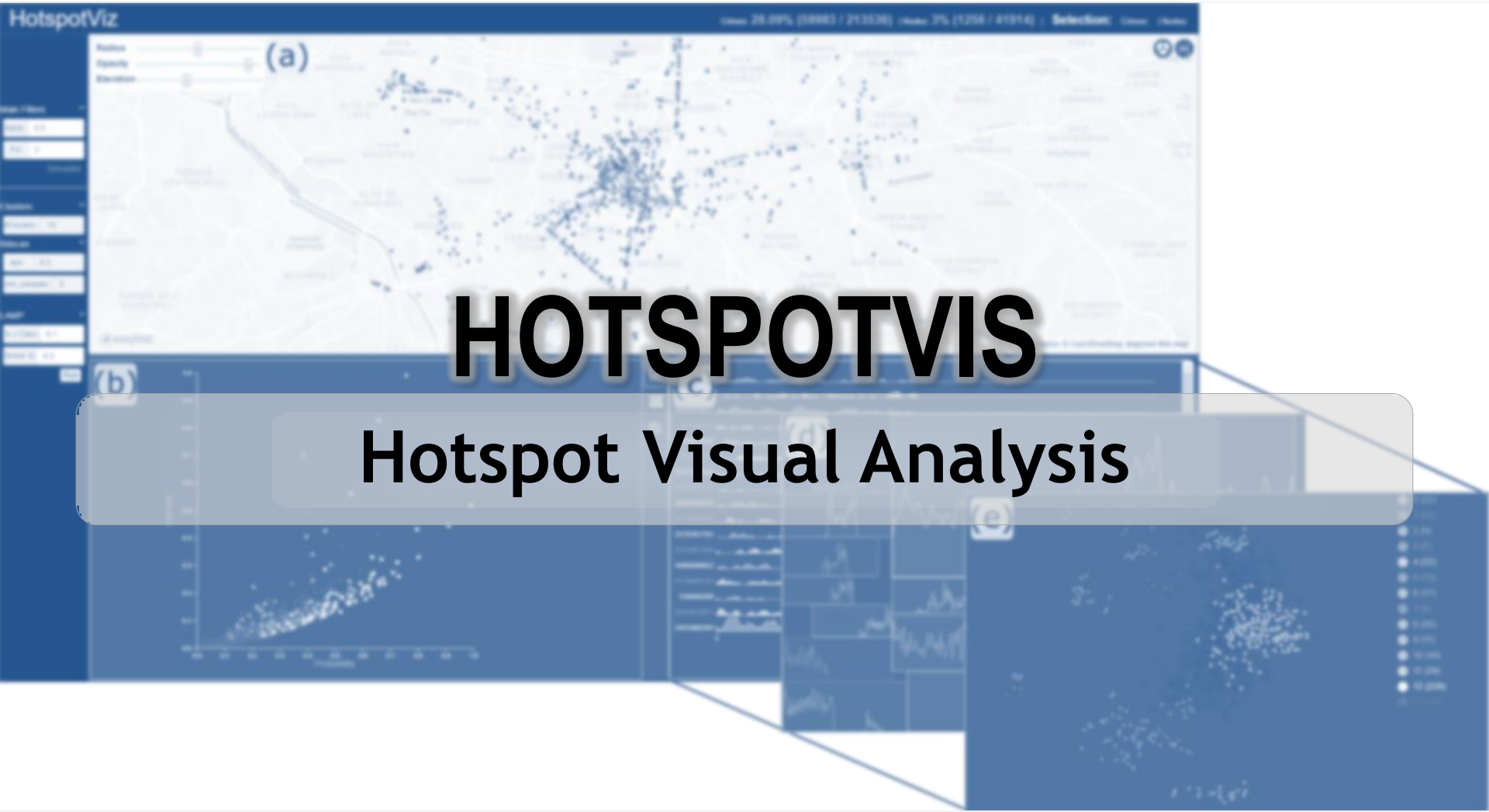
MIRANTE


Ipiranga, São Paulo - SP, Brasil
Dados referente ao período de: 1/2/2006 - 31/12/2017
Limpar Filtro
Leaflet | Colaboradores: CEMEAI & NEV

MIRANTE

Problem Analysis (2)

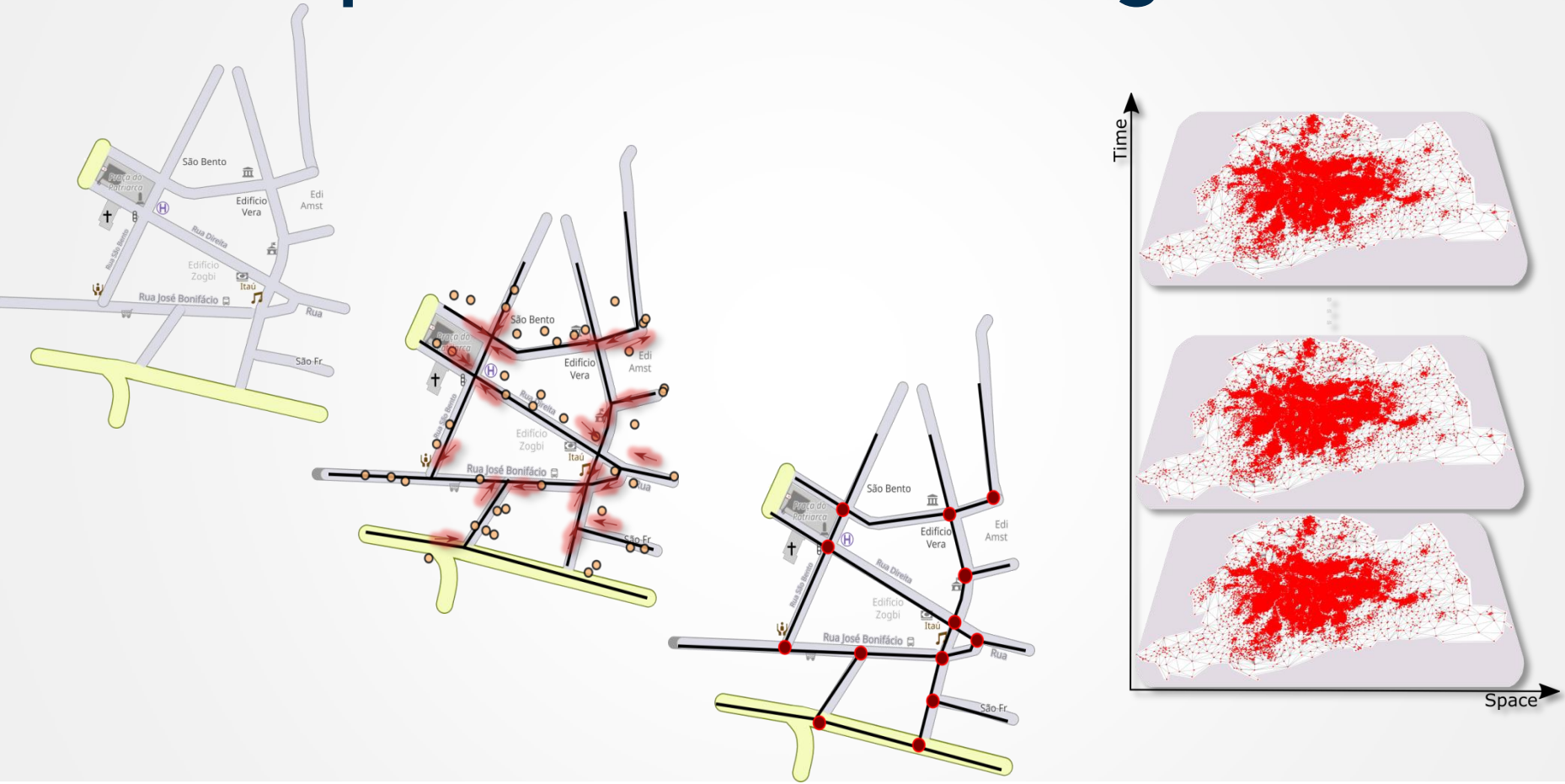
- **R1**. *Exploring and analyze physical characteristics of particular place.*
- **R2**. *Detecting hotspots based on the probability and intensity.*
- **R3**. *Inspecting similar time series.*
- **R4**. *Clustering similar patterns.*
- **R5**. *Explaining and understanding crime patterns.*



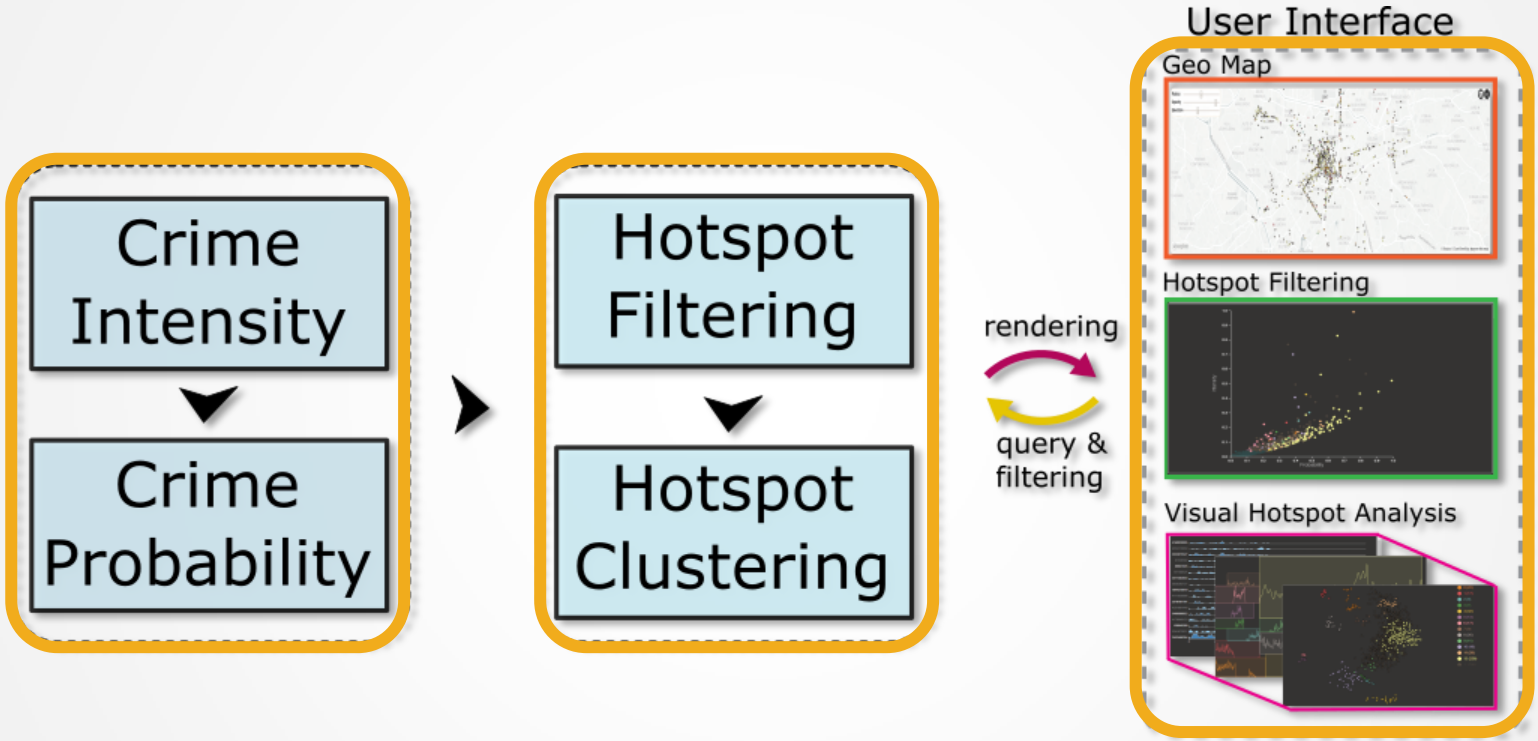
HOTSPOTVIS

Hotspot Visual Analysis

HotspotVis - Data Modeling



HotspotVis - Pipeline



HotspotVis

10 km diameter with center in Praça da Sé

- More than 50.000 nodes
- Crimes are aggregated in the nodes (street corners)

HotspotVis - Probability

A =

	0	1	2	3	4	5	...	n
T0	2	1	0	9	5	0	0	1
T1	0	1	0	0	1	0	0	0
T2	3	1	4	2	2	1	0	1
Tt	0	0	0	1	1	1	0	0

$t \; x \; n$

A =

	0	1	2	3	4	5	...	n
T1	1	1	0	1	1	0	0	1
T2	0	1	0	0	1	0	0	0
T3	1	1	1	1	1	1	0	1
Tt	0	0	0	1	1	1	0	0

$t \; x \; n$

$$P = A.A^T$$

$$P = P / \sum_{i=0}^{n} p_{ij}$$

$$P = A.A^T$$

P =

	0	1	2	3	4	5	n	
0	1	1		1	1		1	+
1	1	1		1	1		1	+
2								
3	1	1		1	1		1	+
4	1	1		1	1		1	+
n	1	1		1	1		1	+

$n \; x \; n$

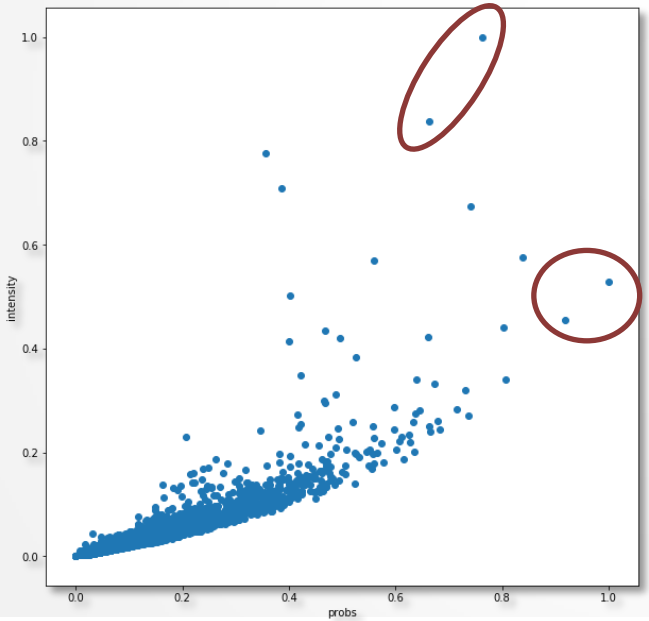
Co-Ocurrency Matrix

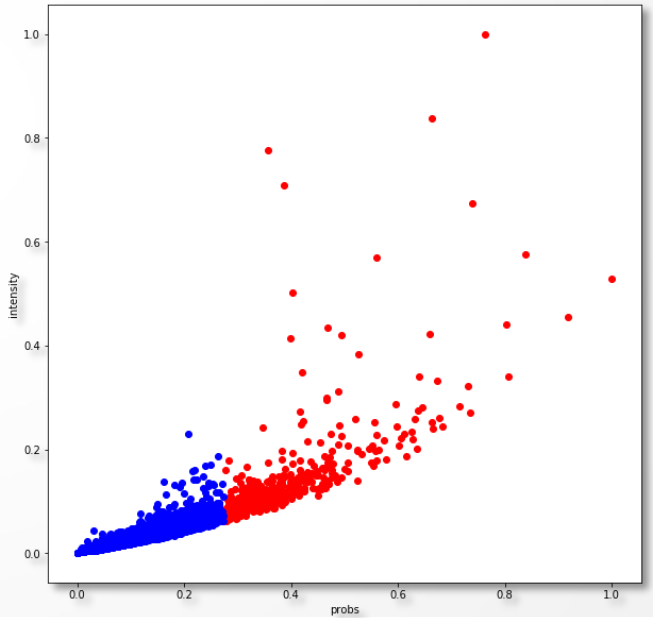
	0	1	2	4	3	5	6	7	...	n-1	n
Prob.	0.1	0.5	0.8	0.2	0.3	0.7	0.9	0.2	...	0.1	0.8

HotspotVis

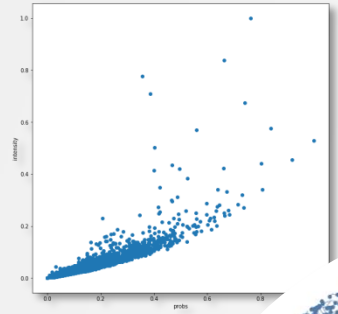
- Hotspot based not only in the number of crimes, but also in the probability

	0	1	2	4	3	5	6	7	...	n-1	n
Prob.	0.1	0.5	0.8	0.2	0.3	0.7	0.9	0.2	...	0.1	0.8
Int.	4	7	1	9	10	2	5	12	...	1	8





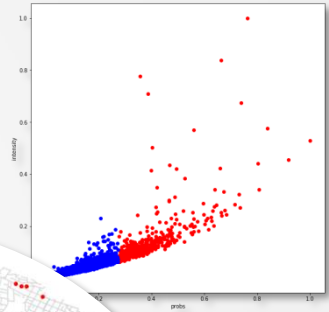
HotspotVis

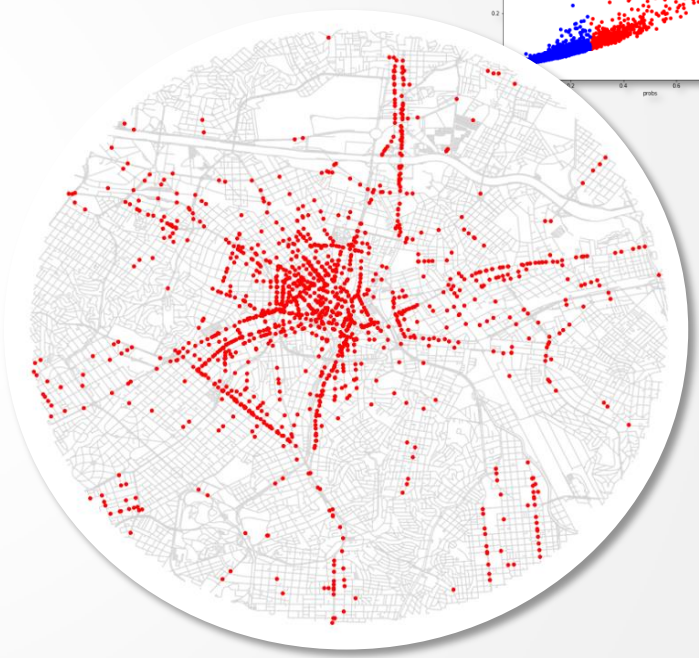


Passerby Crime Location
(19.971)

130,043 crimes

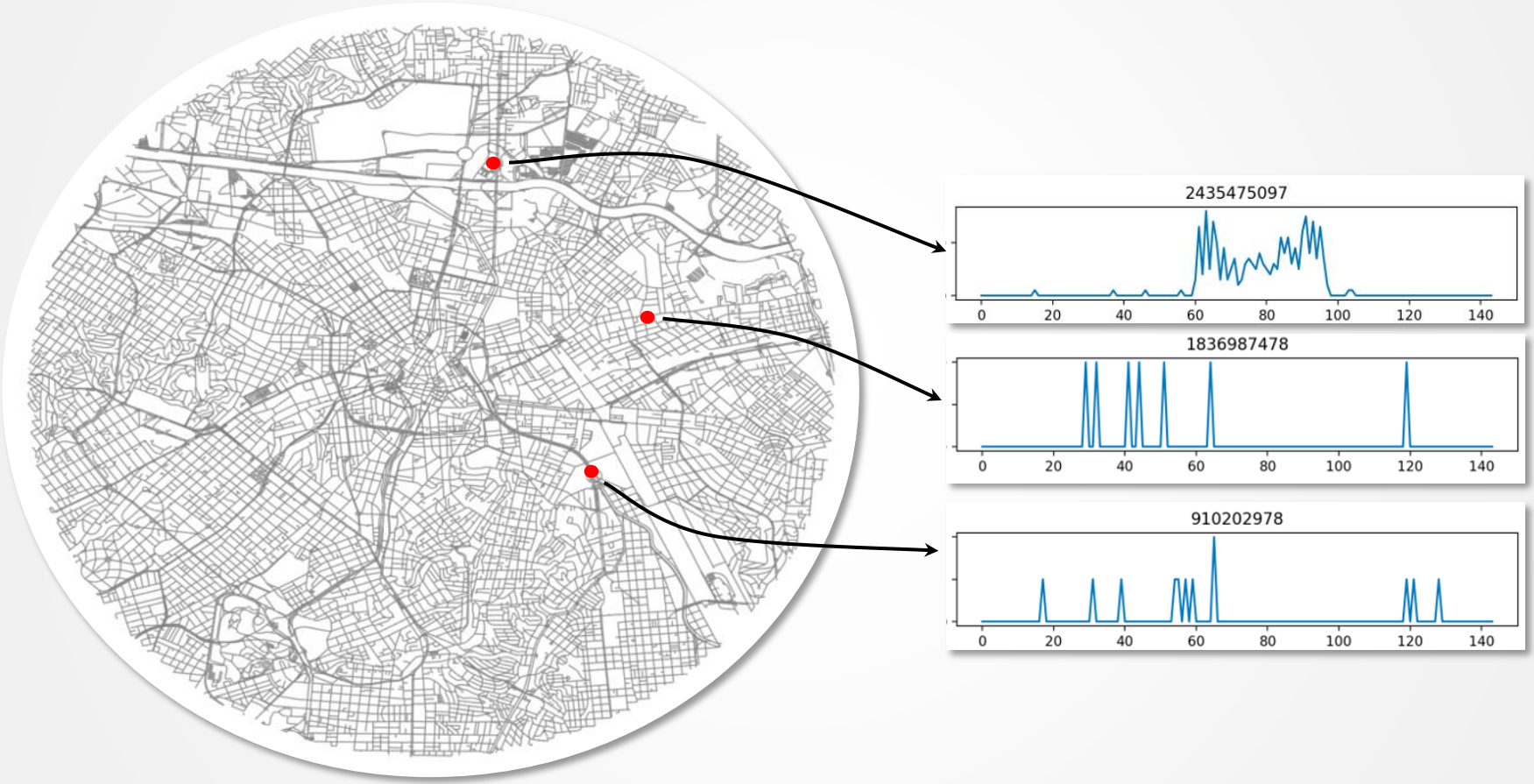
Most Likely Hotspots
(1.522, 7.6%)



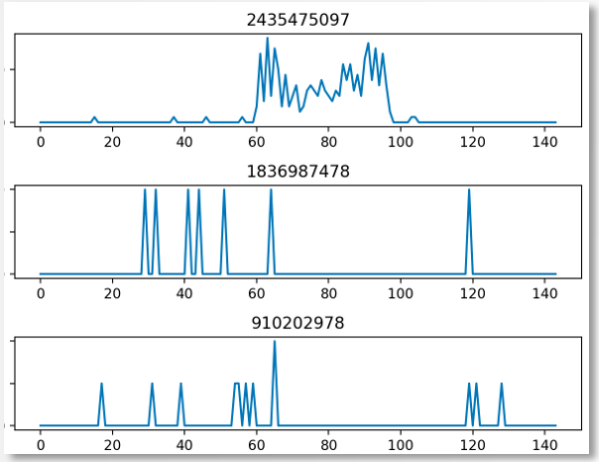


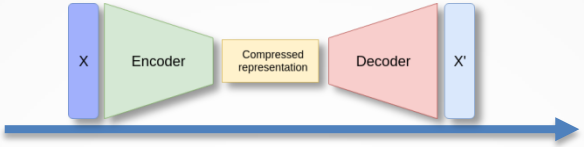
58,634 crimes (45%)

HotspotVis - Crime Pattern Analysis

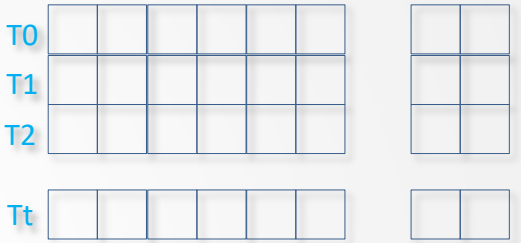


HotspotVis - Crime Pattern Analysis



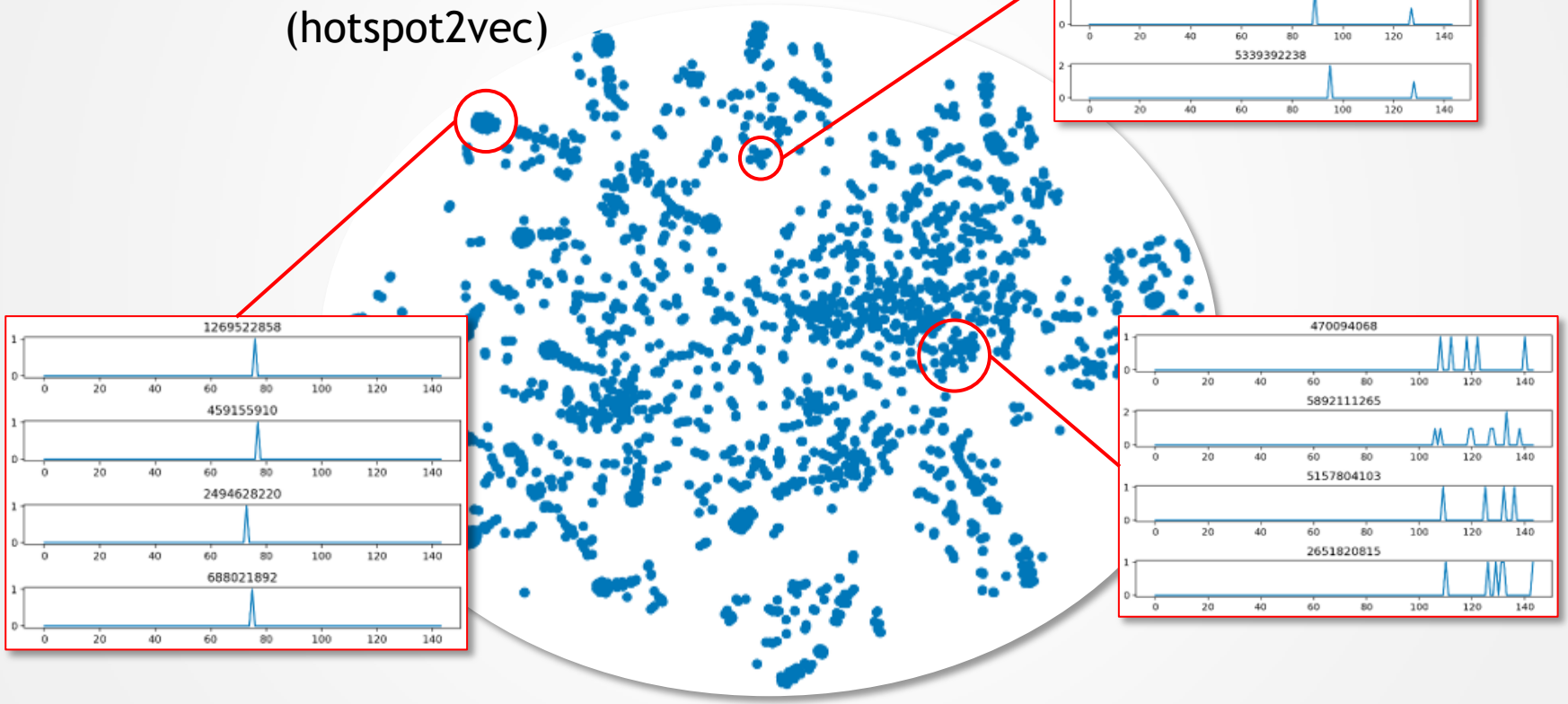


Hotspot Embedding
(hotspot2vec)

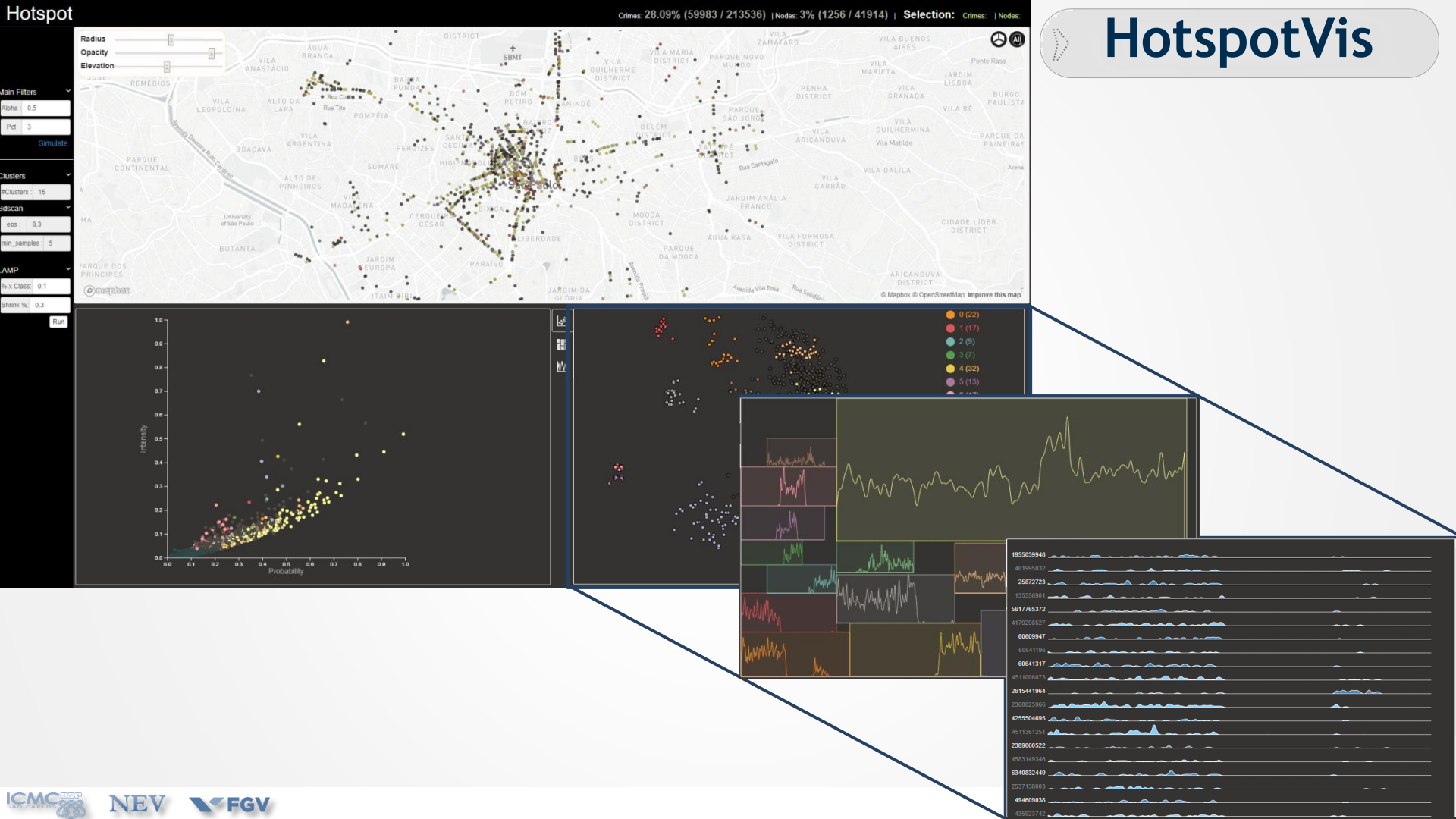


Research Planning

Hotspot Embedding
(hotspot2vec)



HotspotVis - Crime Pattern Analysis

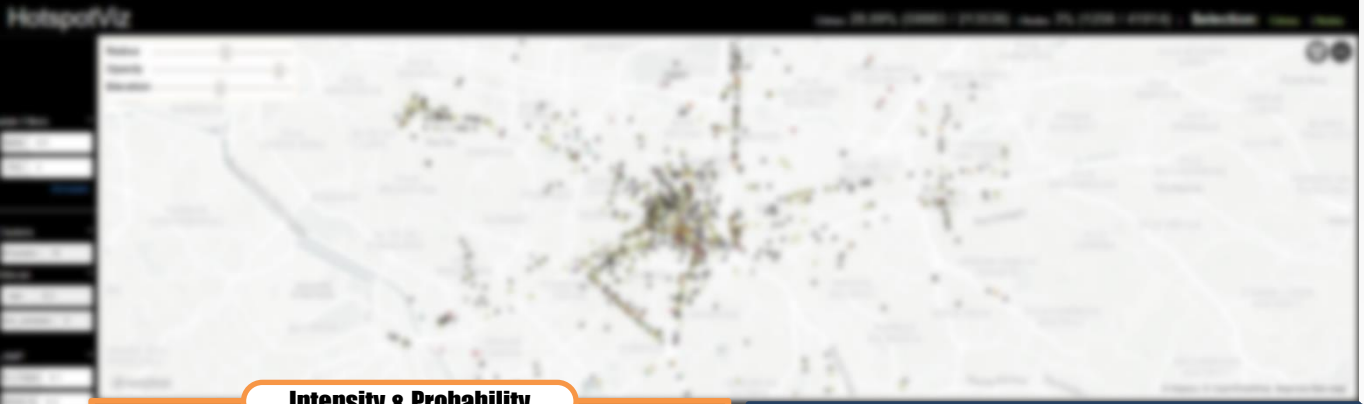

Hotspot
Crimes: 28.09% (59983 / 213536) | Nodes: 3% (1256 / 41914) | Selection: Crimes: | Nodes:
Radius
Opacity
Elevation
Main Filters
Alpha 0,5
Pct 3
Simulate
Clusters
#Clusters 15
dbscan
eps 0,3
min_samples 5
LAMP
% x Class 0,1
Shrink % 0,3
Run
Intensity
Probability
0 (22)
1 (17)
2 (9)
3 (7)
4 (32)
5 (13)
1955039948
461995032
25872723
135556901
5617765372
4179298527
60609947
60641196
60641317
4511006073
2615441964
2368025968
4255504695
4511361251
2389060522
4583149346
6340832449
2537138003
494609038
435923742

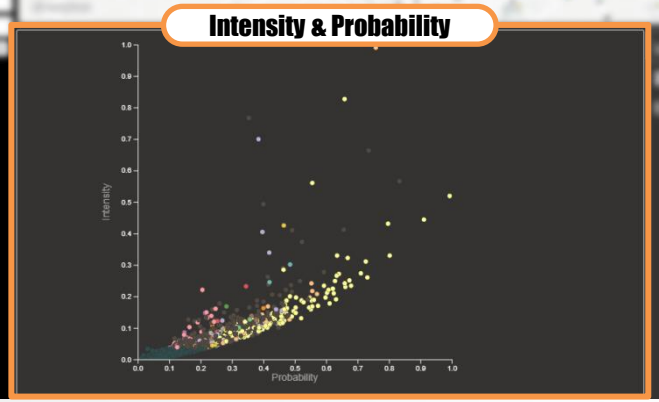
HotspotVis

HotspotVis


Map View
Radius
Opacity
Elevation
SBMT
São Paulo
© Mapbox © OpenStreetMap Improve this map

HotspotVis



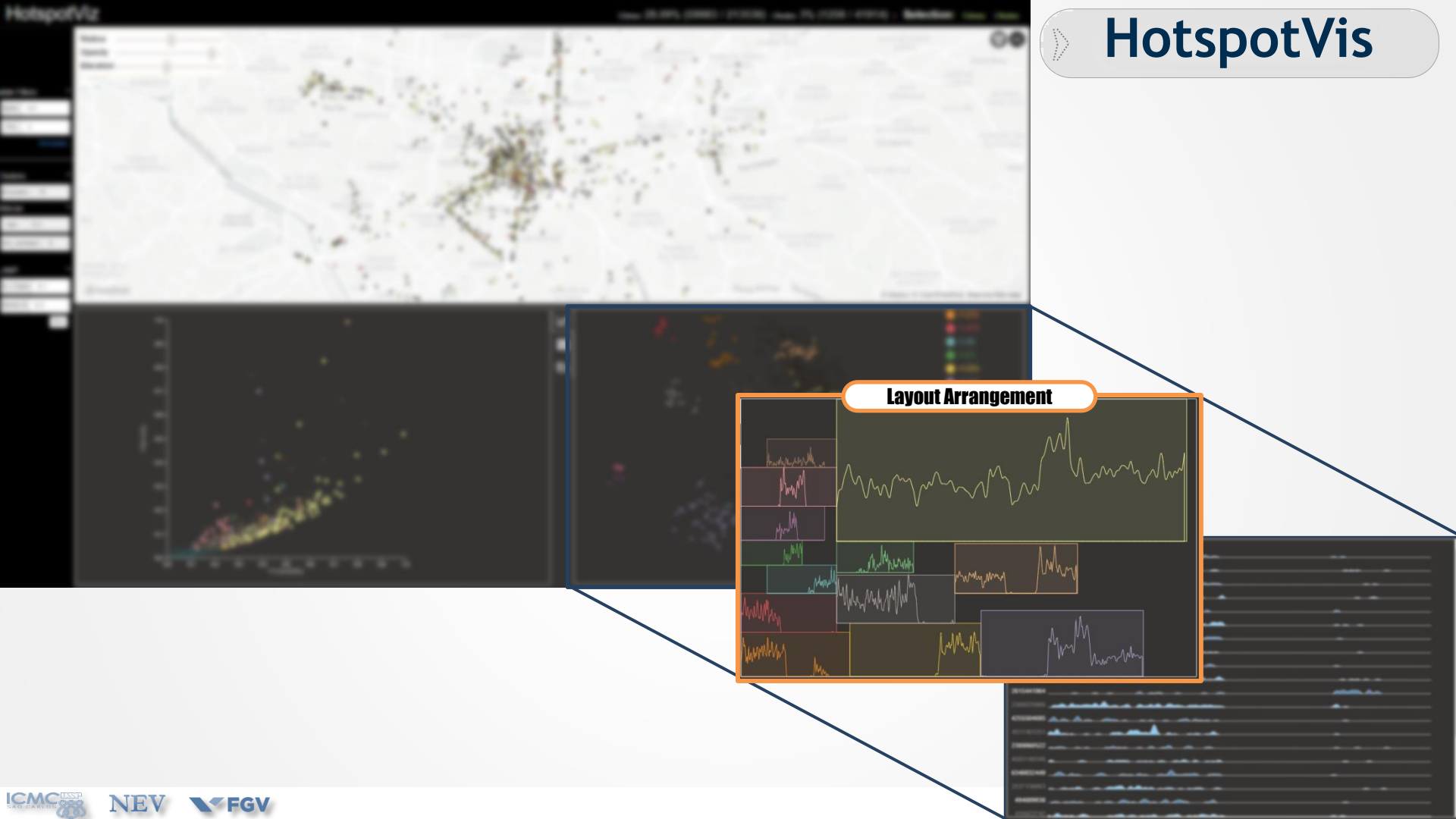


HotspotVis


HotspotViz

Hotspot Scatter Plot
0 (22)
1 (17)
2 (9)
3 (7)
4 (32)
5 (13)
6 (17)
7 (9)
8 (26)
9 (11)
10 (49)
11 (28)
12 (228)

HotspotVis



HotspotVis


Group Joy Plot
1955039948
461995032
25872723
135556901
5617765372
4179298527
60609947
60641196
60641317
4511006073
2615441964
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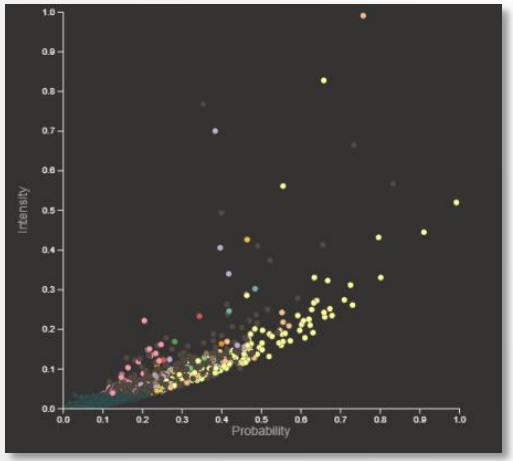
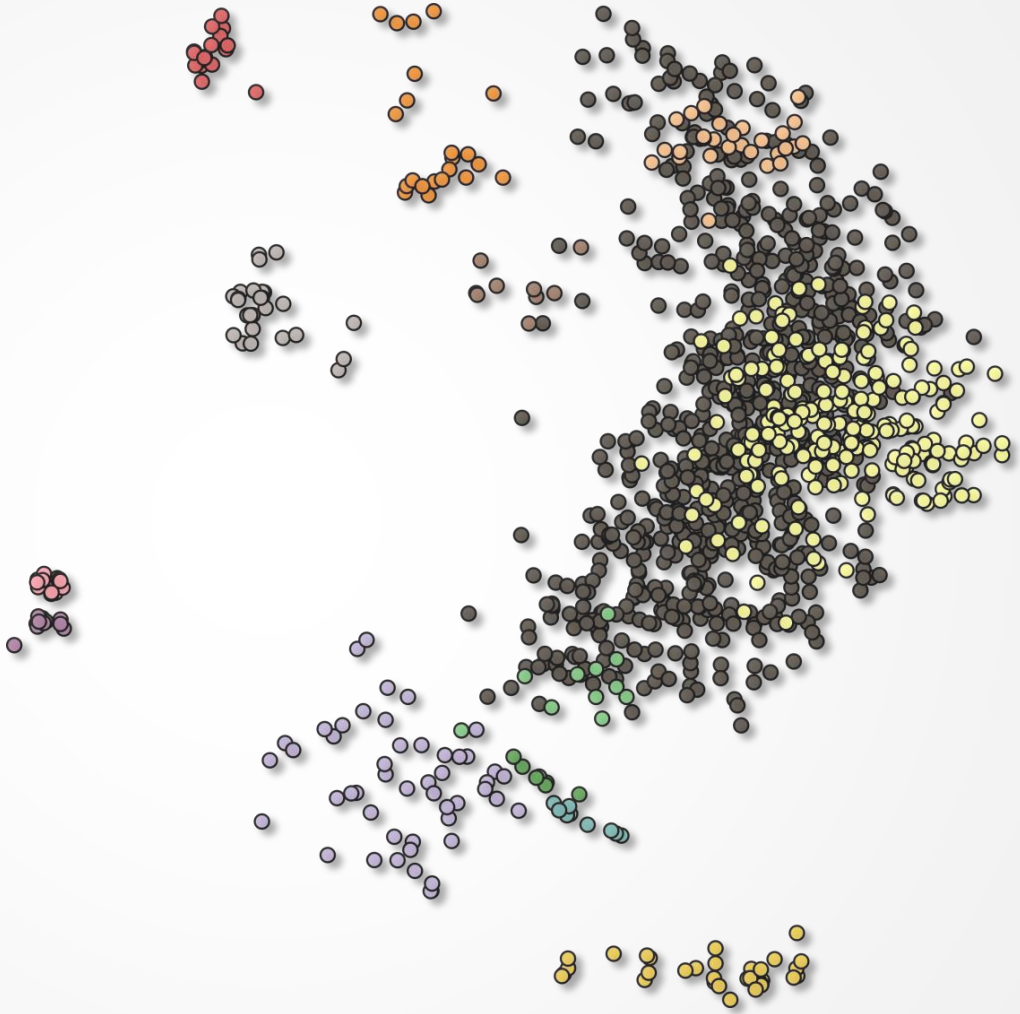
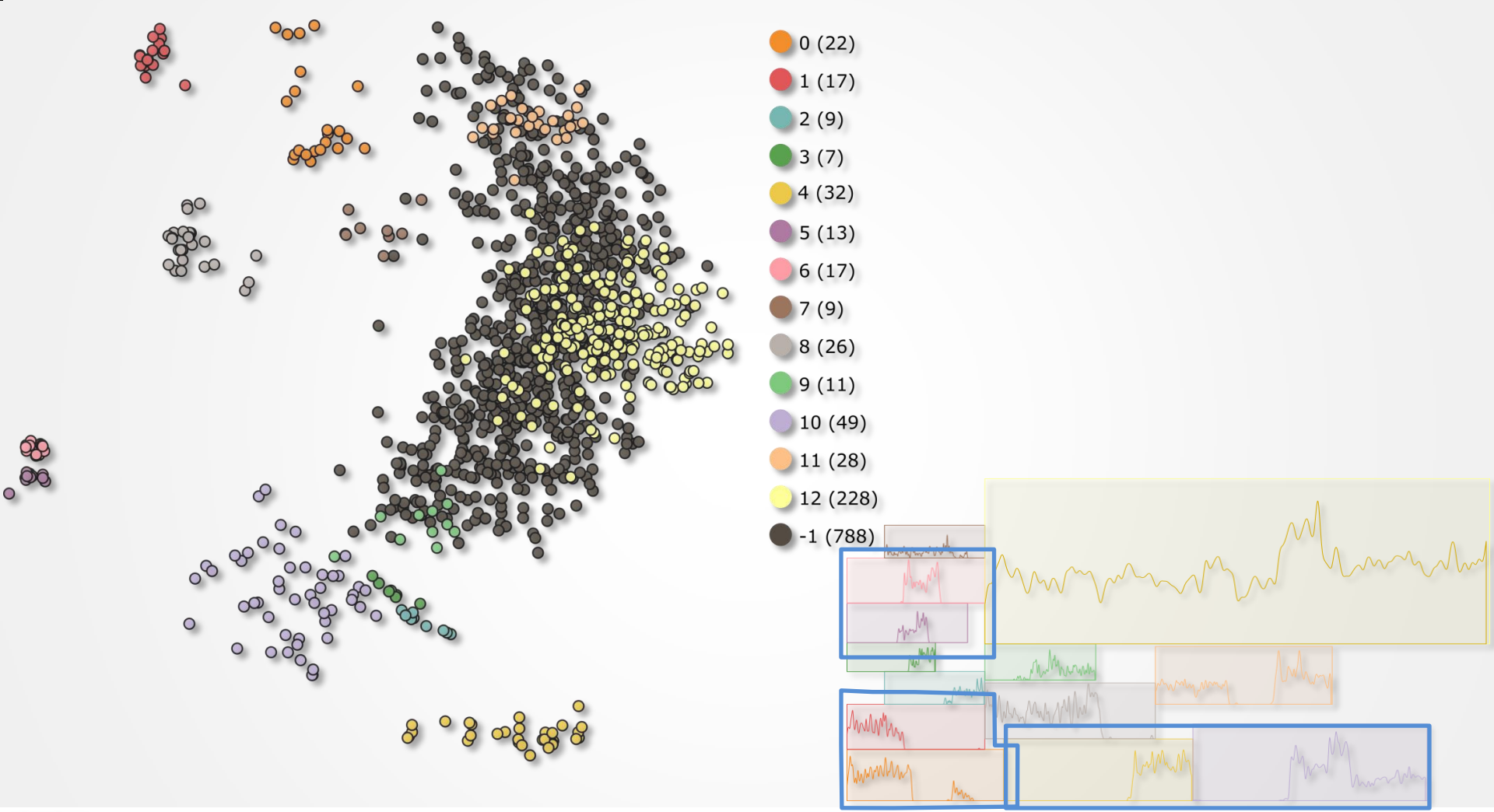
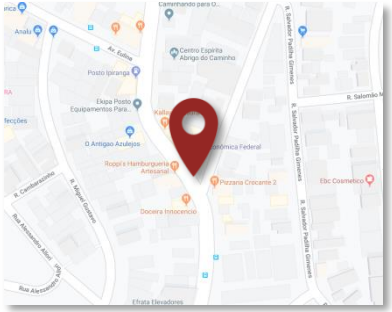
4583149346
6340832449
2537138003
494609038
435923742


Intensity
Probability
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


0 (22)
1 (17)
2 (9)
3 (7)
4 (32)
5 (13)
6 (17)
7 (9)
8 (26)
9 (11)
10 (49)
11 (28)
12 (228)
-1 (788)


0 (22)
1 (17)
2 (9)
3 (7)
4 (32)
5 (13)
6 (17)
7 (9)
8 (26)
9 (11)
10 (49)
11 (28)
12 (228)
-1 (788)

Example 1:



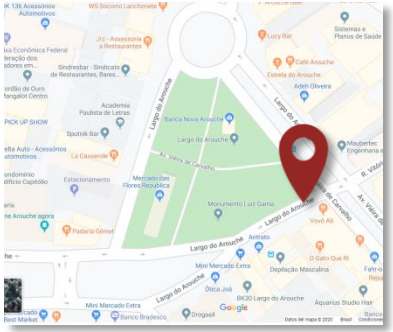
cid: 494609038,
class: 0,
inte: 38,
lat: -23.4891319,
lng: -46.6755504


Google
Street View - oct. 2015
VILA MARIA LUISA
Google


Google
Street View - jul. 2017
CAIXA
VILA MARIA LUISA
Google


Google
Street View - oct. 2017
CAIXA
VILA MARIA LUISA
Google

Example 2:



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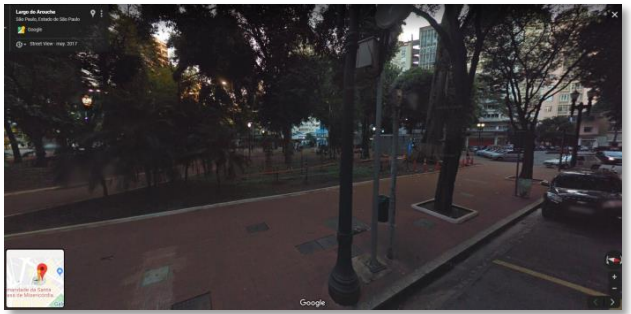
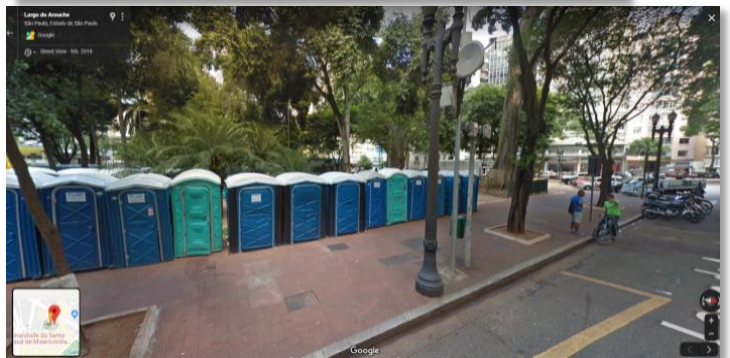
inte: 76,
lat: -23.5410622,
lng: -46.6444054





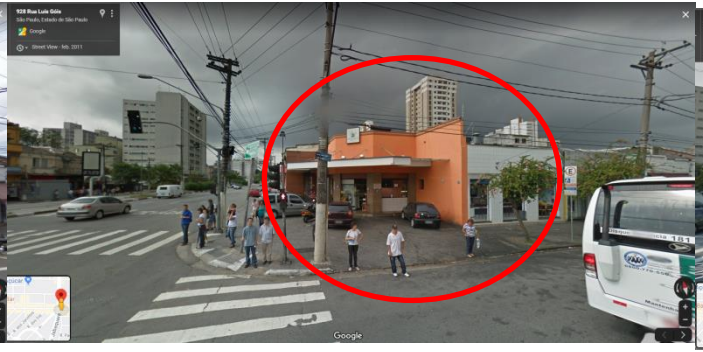
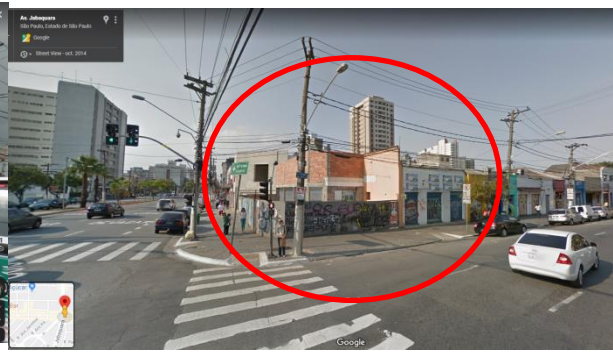
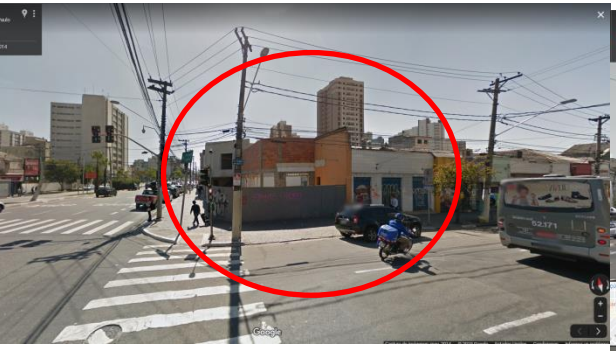
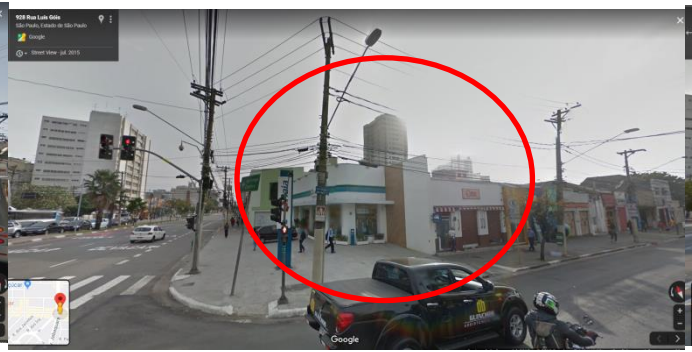
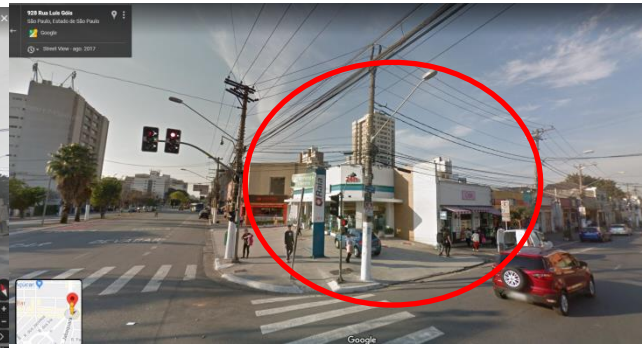
1

- cid: 2577302644, class: "1", inte: 24, lat: -23.6107653, lng: -46.6774362

Gas station Construction

0

- cid: 2466086492, class: "0", inte: 31, lat: -23.6040577, lng: -46.6365428

Pharmacy Construction

0

- cid: 135556901, class: "0", inte: 39, lat: -23.5616755, lng: -46.5623344

Shopping Construction

Conclusions:

- We introduced **CrimAnalyzer**, a visual analytics tool to support the analysis of crimes in local regions. We also propose a technique based on **NMF** to identify hotspots.
- We introduced **MIRANTE**, a visual analytics tool to represent São Paulo crime data based on **network city modeling**.
- We introduced **HotspotVis**, a visual analytical tool to identify and explain crime hotspots. We also propose a new method to identify hotspots based on the **probability** and **intensity** in a **street-level of detail**.
- There are some sings that there is a **direct relation** between the **infrastructure** and **criminality** in some places.

Visual Crime Analysis in Big Cities: A practical application for crime data in São Paulo

Thank you
Obrigado
Gracias

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