Universidade de São Paulo

ICMC USP SÃO CARLOS

Visual Analytics for Urban Crime Analysis

Germain García Zanabria

Advisor: Prof. Dr. Luis Gustavo Nonato

Instituto de Ciências Matemáticas e de Computação
USP - São Carlos

Visual Processing Geometric Group
USP - São Carlos

2021

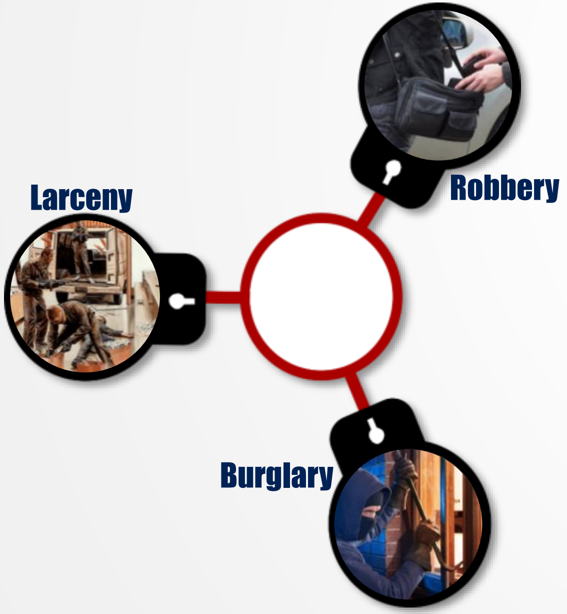
Outline:

- Introduction/Motivation
- Crime Data
- Contributions
  - CrimAnalyzer
  - Mirante
  - CriPAV
- 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 [1].



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

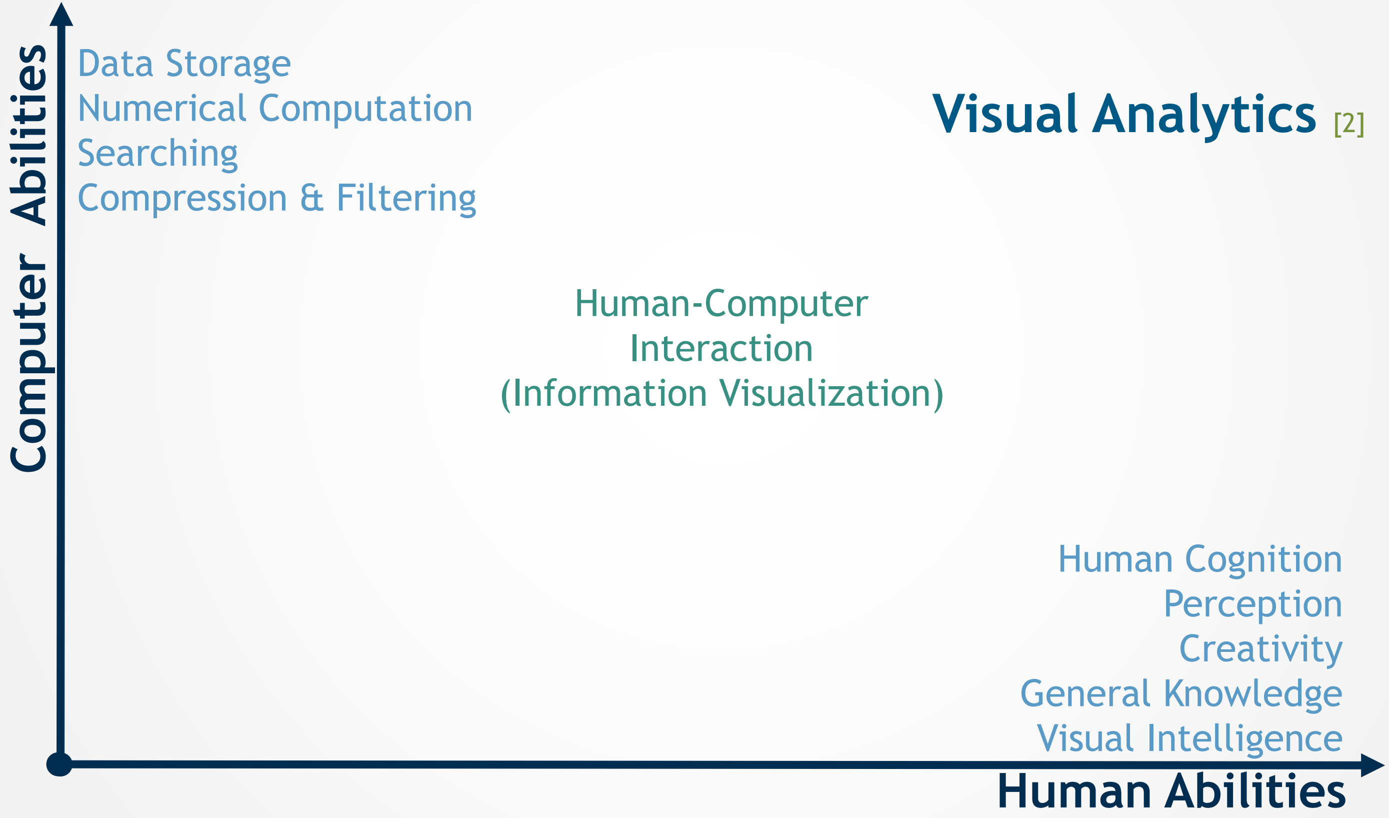
Law enforcement agencies deploy resources in a more effective manner to:

- Prevent
- Control
- Reduce

Crime activities

Introduction/Motivation

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

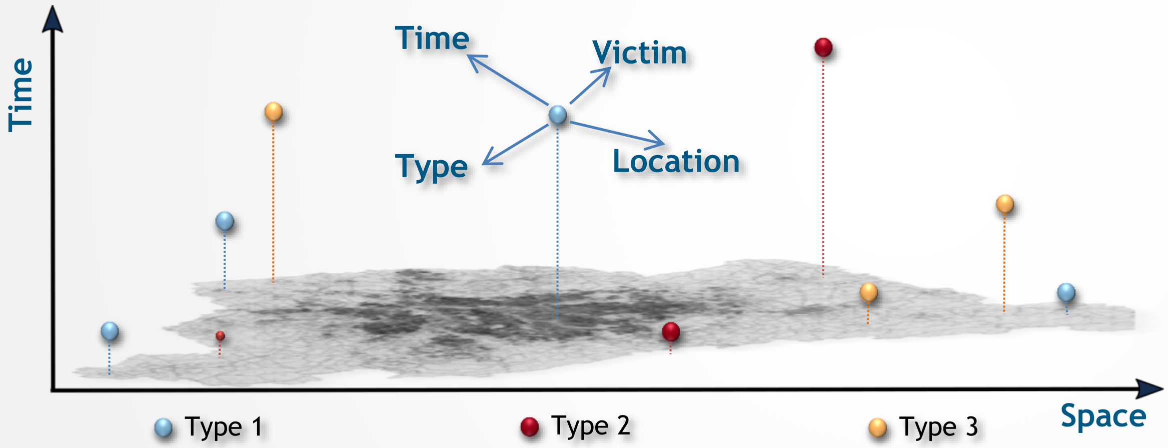


Keim et al. (2008)

Introduction/Motivation

Crime Mapping

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

[3,4]

Introduction/Motivation

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

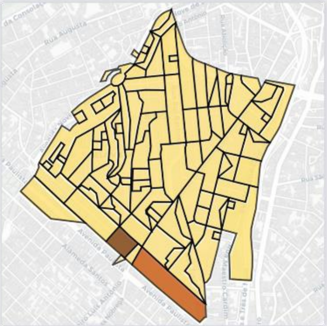
NEV

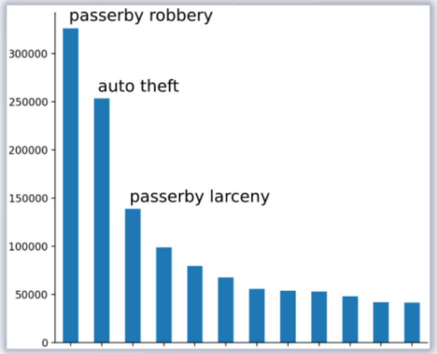
Prefeitura de SÃO CARLOS

* http://metrocosm.com/homicides-brazil-vs-world/ - https://dataunodc.un.org/

Data Set 1 - São Paulo

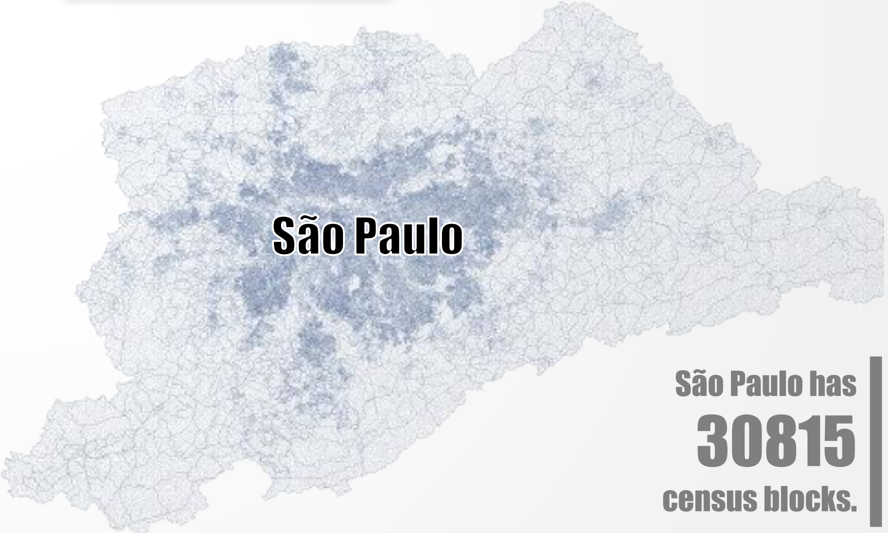
- From **2000** to **2006**





- 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 **121** categories:
  - Passerby robbery
  - Auto theft
  - Larceny
  - ...



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

São Paulo has **30815** census blocks.

1 574 920 crime records

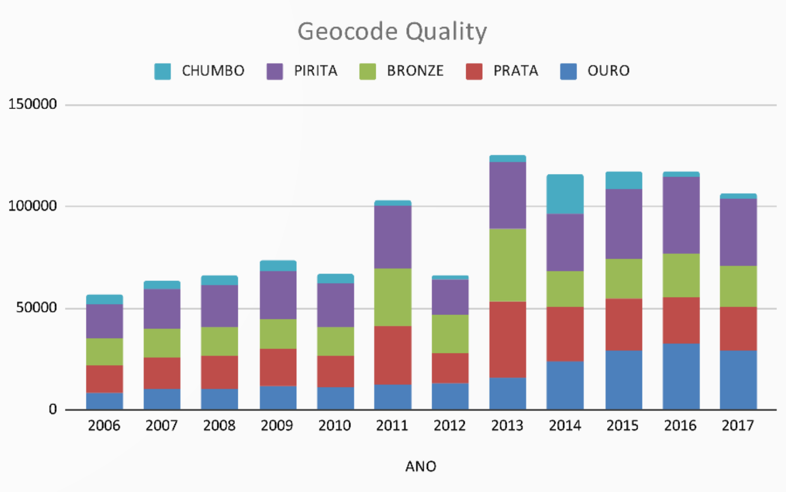
Data Set 2 - São Paulo

NEV

- From **2006** to **2017**
  - **Attributes**:
    - **ANO_OCORR:** Year of occurrence.
    - **DATA_OCORRENCIA_BO:** Date of occurrence.
    - **HORA_OCORRENCIA_BO:** Hour of occurrence (many of them nominal: Madrugada, amanhã, 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

São Paulo has **30815** census blocks.

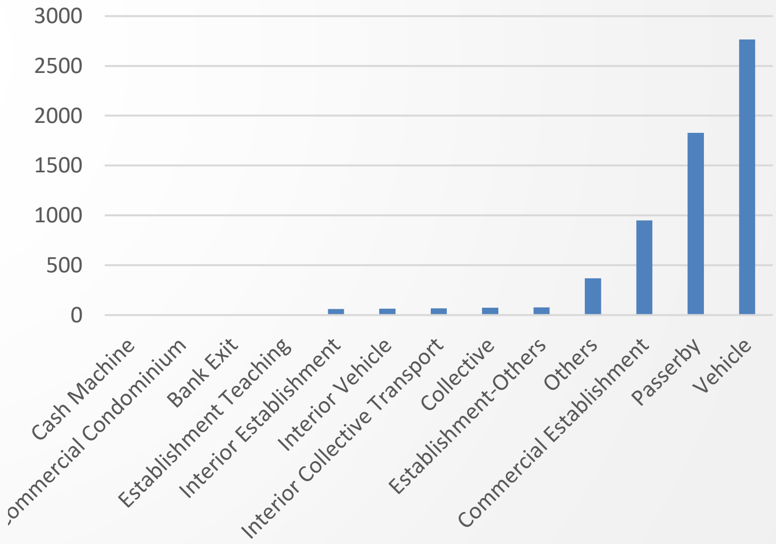
- **Crime types** range in **3** categories:
  - Passerby robbery
  - Commercial establishment robbery
  - Vehicle robbery



Data Set 3 - São Carlos

- Data set from **2014** to **2019**

- **Atributes**:
  - **ANO:** Year of occurrence.
  - **DATA_OCORRENCIA_BO:** Date of occurrence.
  - **HORA_OCORRENCIA_BO:** Hour of occurrence.
  - **FLAGRANTE:** Flagrant
  - **CONDUTA:** Type of crime (**13** types)
  - **LATITUDE:** lat
  - **LONGITUDE:** lng



The focus of this thesis is to study and analyze crime patterns considering different factors. To do this, we have to sort out different crime analysis problems: ***hotspot definition and detection***, ***space discretization***, ***and spatio-temporal dynamics***.

Introduction/Motivation

Hotspot definition and detection

Given the crime events in an urban space, we propose different methods (depending on the spatial discretization) to identify and present hotspots considering not only the intensity but also the frequency of crimes;

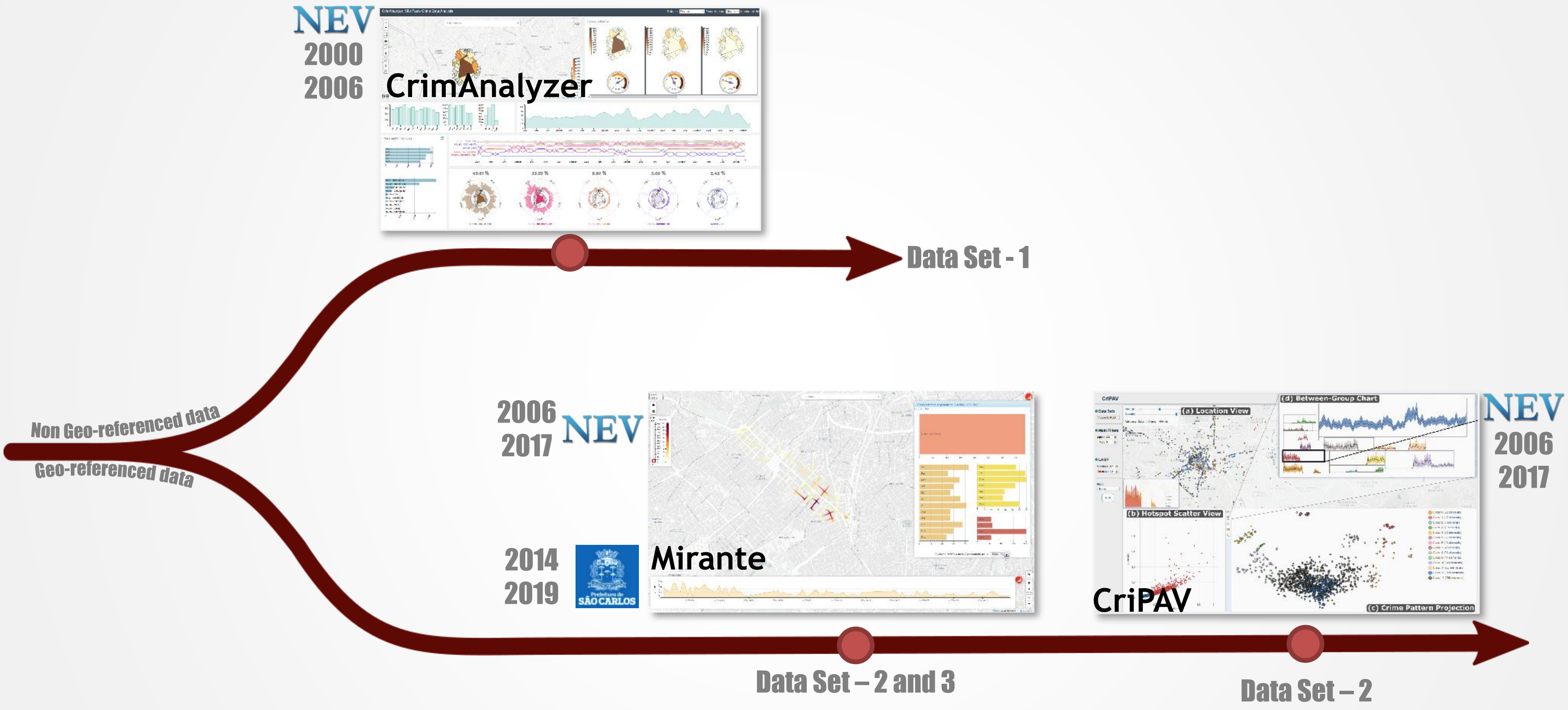
Space discretization

Different domain discretization, switching from grid-based to a street-based spatial discretization;

Spatio-temporal dynamics

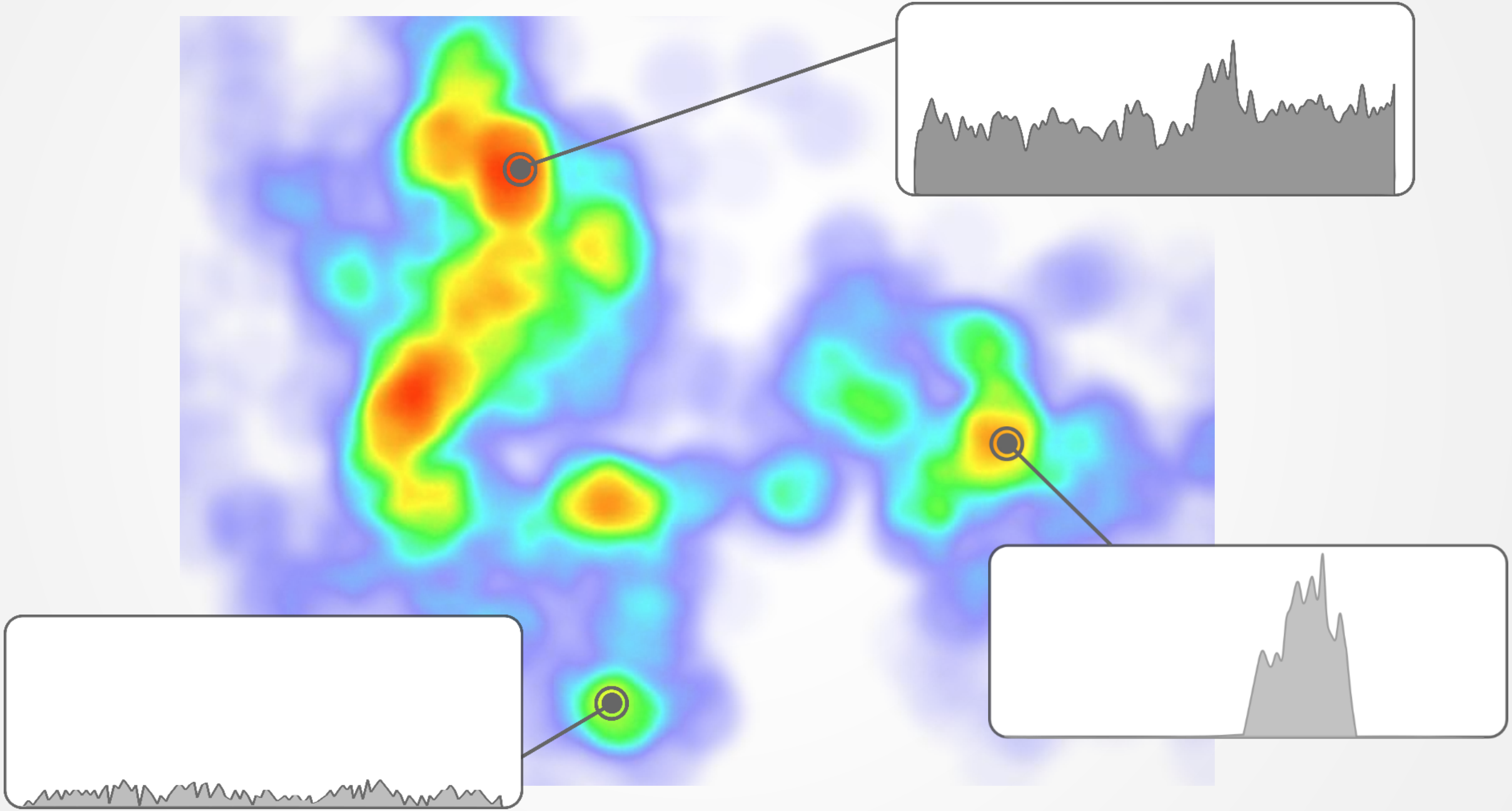
Spatio-temporal crime patterns analysis, supported by visualization and machine learning mechanisms to extract and visually present different spatio-temporal patterns.

Introduction/Projects

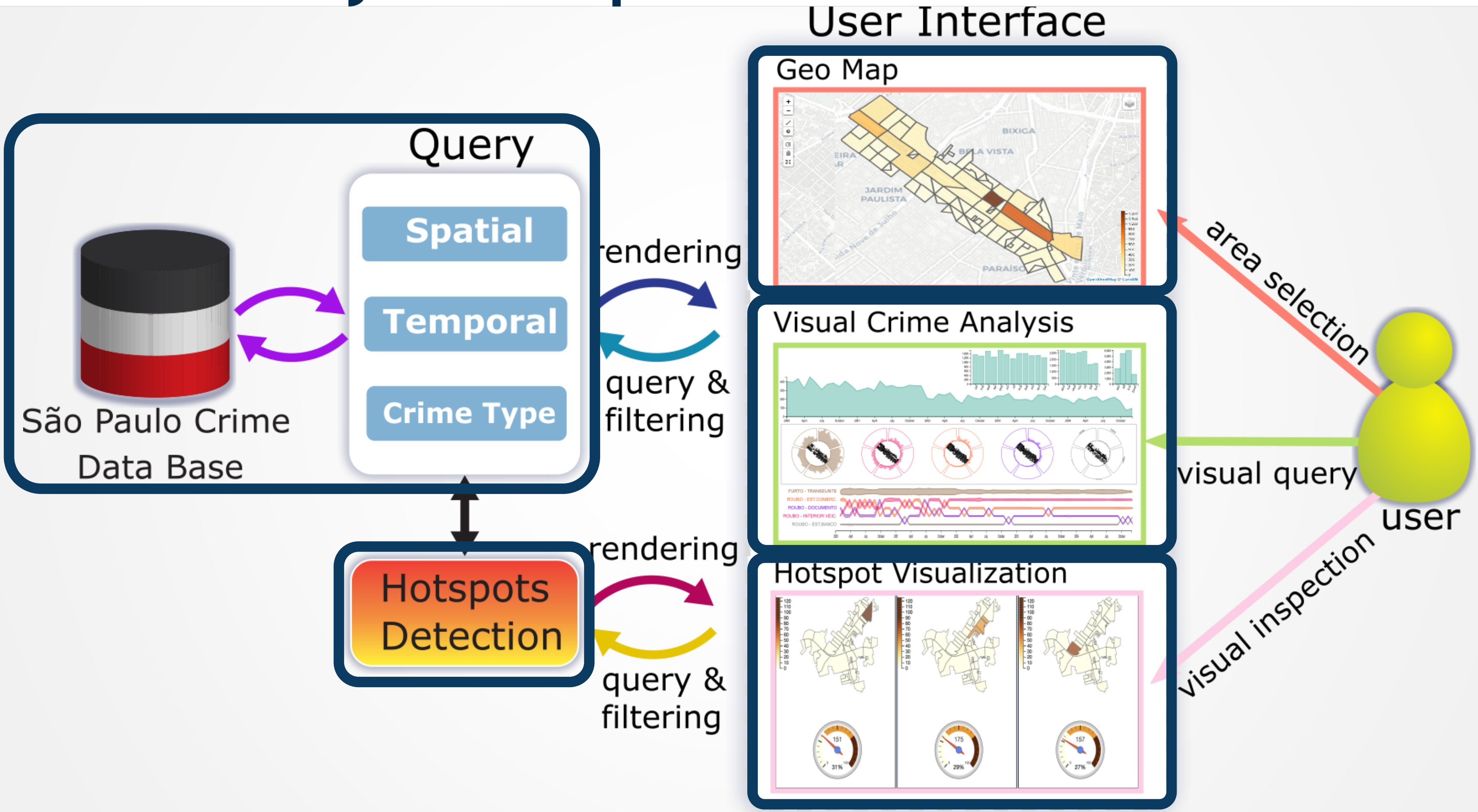


CrimAnalyzer

CrimAnalyzer - Problem Analysis



CrimAnalyzer - Pipeline



CrimAnalyzer

Hotspot Identification Model

Non-Negative Matrix Factorization (NMF)

An $m\,x\,n$ matrix X is said *non-negative* if all entries X are greater or equal to zero $(X \geq 0)$. The goal of NMF is to decompose X as a product $W.H$, where W and H are *non-negative* with dimensions $m\,x\,k$ and $k\,x\,n$, respectively.

$$\arg\min_{W,H} \|X - WH\|^2 \quad \text{subject to} \quad W, H \geq 0$$

$$\begin{bmatrix} | & & | & & | \\ x_1 & \dots & x_j & \cdots & x_n \\ | & & | & & | \end{bmatrix} = \begin{bmatrix} | & | & & | \\ w_1 & w_2 & \cdots & x_k \\ | & | & & | \end{bmatrix} \begin{bmatrix} | & & h_{1j} & & | \\ h_1 & \cdots & h_{2j} & \cdots & h_n \\ & & \vdots & & \\ | & & h_{kj} & & | \end{bmatrix}$$

A set of basis vectors w_i (columns of W), and a set of coefficients h_j (columns of H), such that each column x_j of X is approximated as linear combination $x_j \cong \sum_i h_{ij} w_i$, (or $x_j = W h_j$) [22].

Identifying Hotspot with NMF

NMF to identify hotspots, their frequency and “intensity”. The matrix X to be decomposed as the product $W.H$ comprises crime information in a particular region of interest.

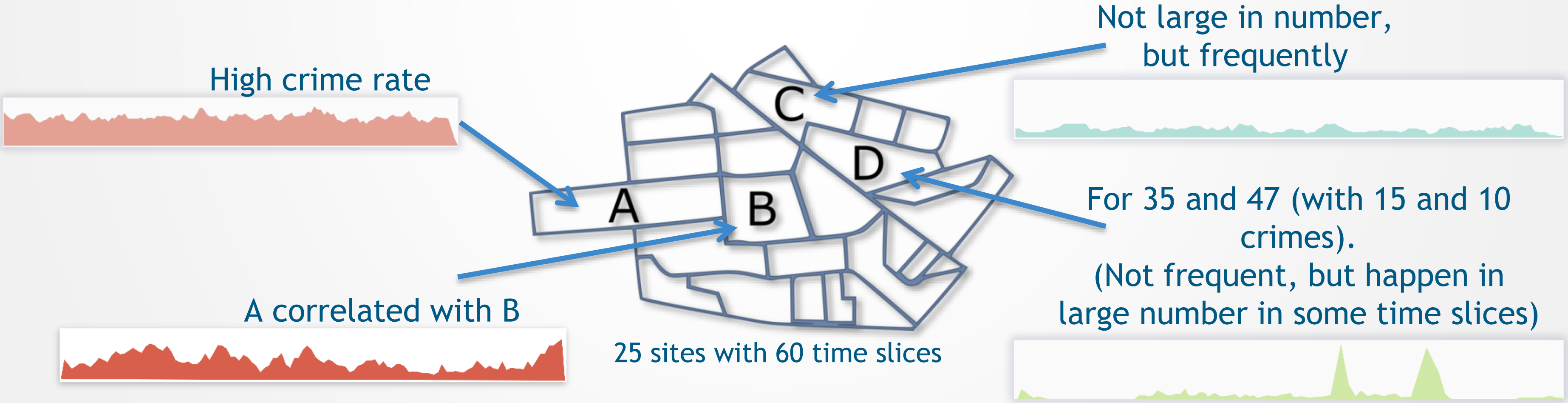
Sites

$$\begin{bmatrix} | & & | & & | \\ x_1 & \dots & x_j & \cdots & x_n \\ | & & | & & | \end{bmatrix}$$

Time slice

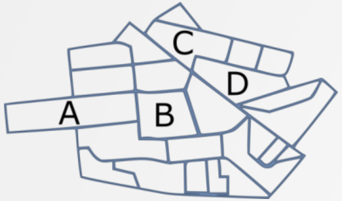
$$\begin{bmatrix} 5 & \dots & 10 \\ \vdots & \ddots & \vdots \\ 1 & \dots & 2 \end{bmatrix}_{25\times 60}$$

First site has 5 crime activities in the first time slice (first month)

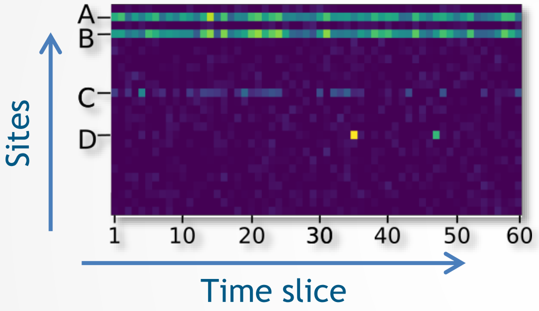


25 sites with 60 time slices

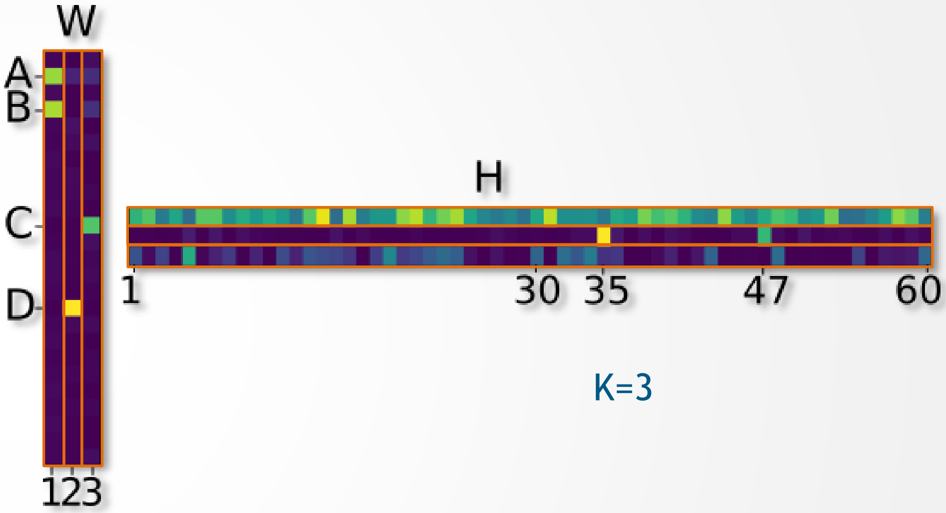
Data Modelling with NMF



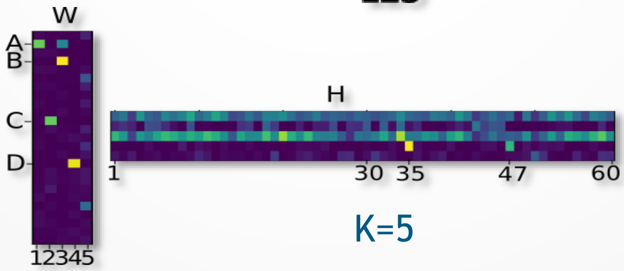
X $=$ $W.H$



$=$



K=3



K=5

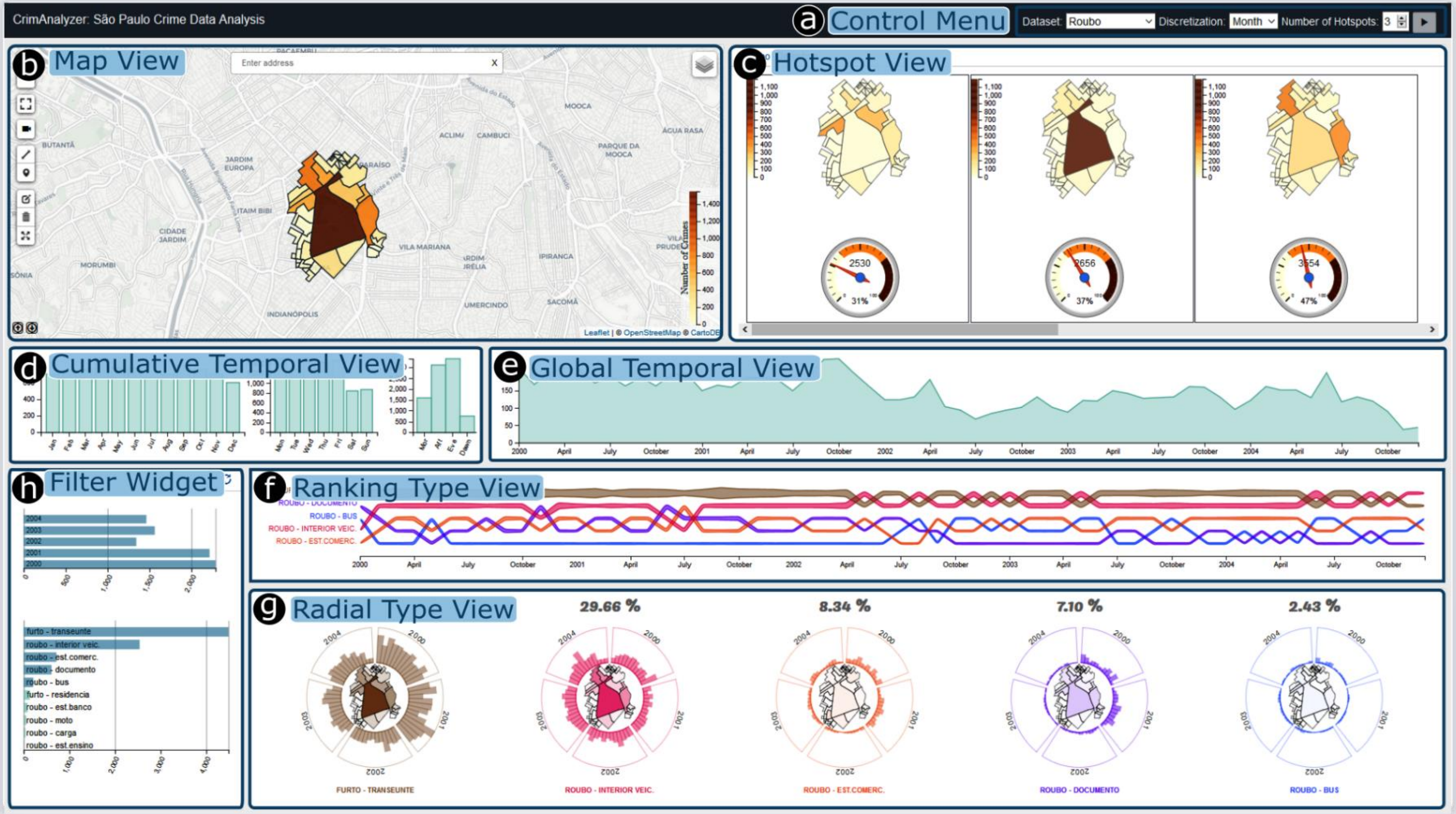
KIM, H.; PARK, H. Sparse non-negative matrix factorizations via alternating non-negativity constrained least squares for microarray data analysis, 2007

CrimAnalyzer

Visual Analytic Tool

CrimAnalyzer

CrimAnalyzer

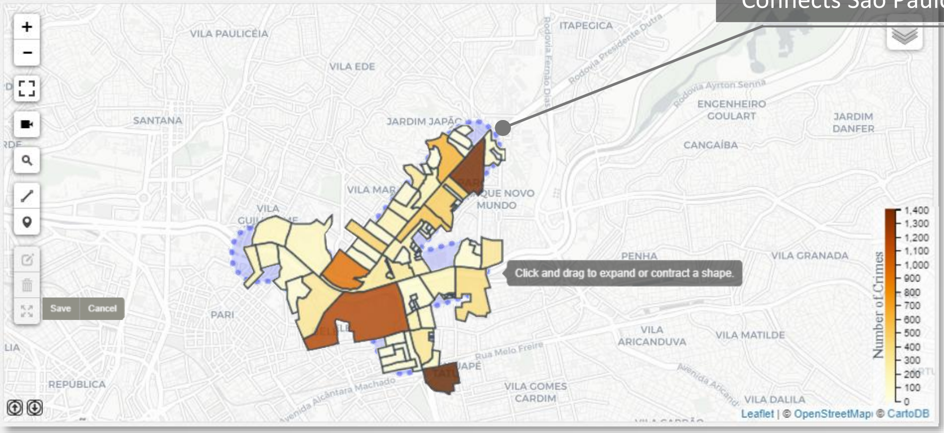


CrimAnalyzer

Case Studies

CrimAnalyzer - Case Study 2

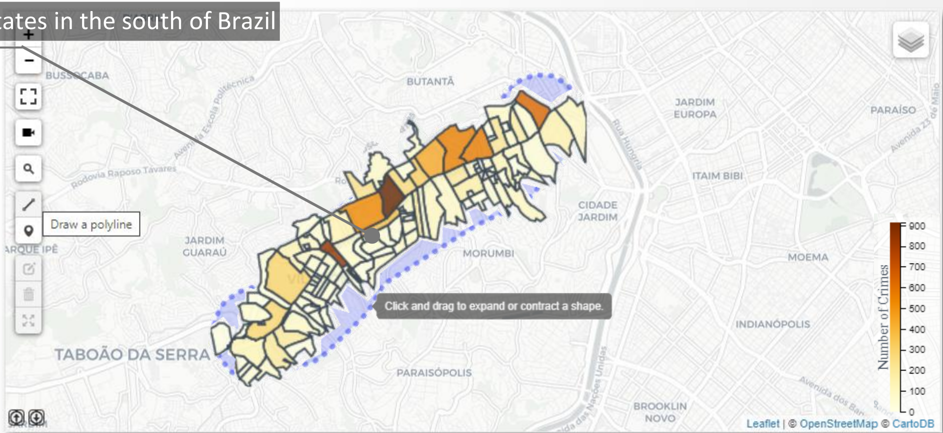
Connects São Paulo to Rio de Janeiro



BR116

SP230

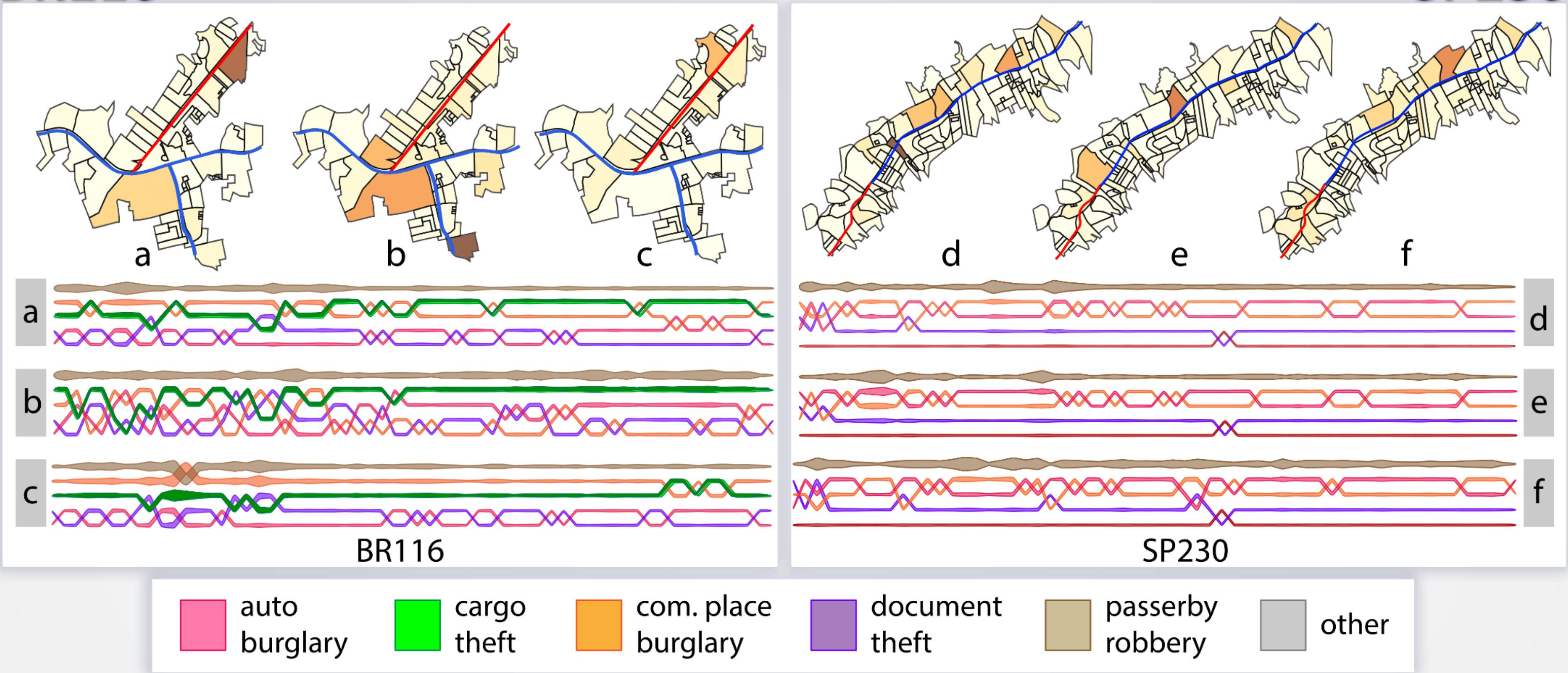
Connects São Paulo to states in the south of Brazil

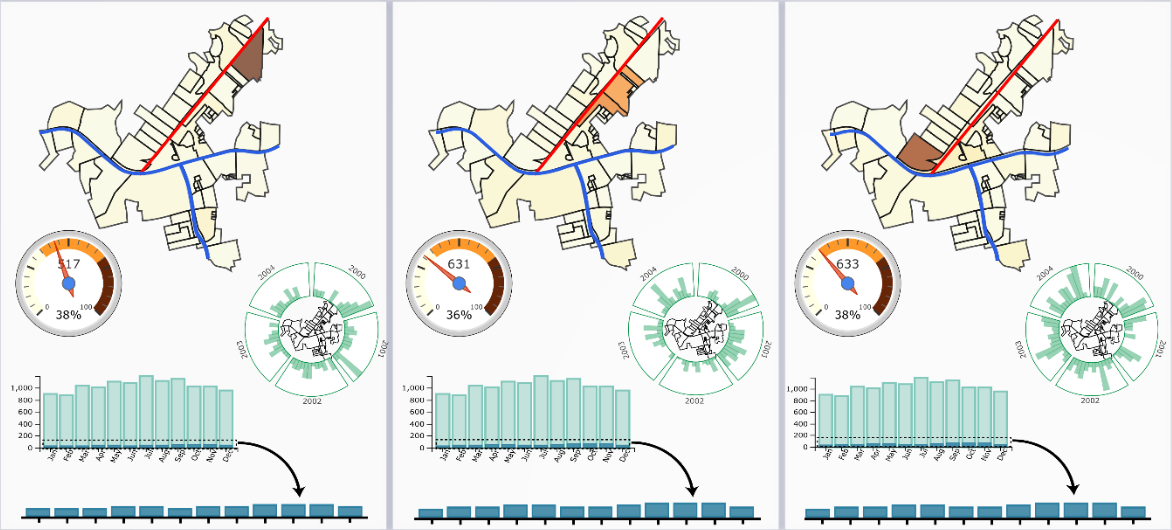


CrimAnalyzer - Case Study 2

BR116

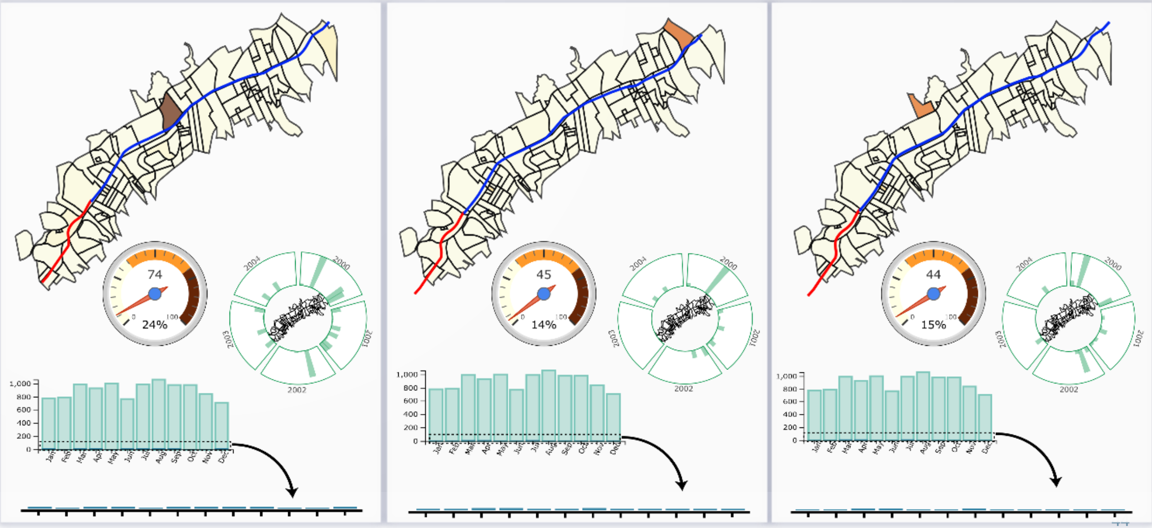
SP230




517
38%
631
36%
633
38%
2000
2001
2002
2003
2004
1,000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

BR116

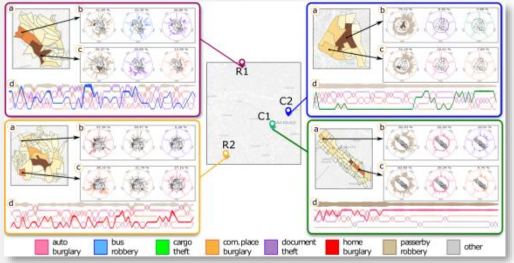
SP230


74
24%
45
14%
44
15%
2000
2001
2002
2003
2004
1,000
800
600
400
200
0

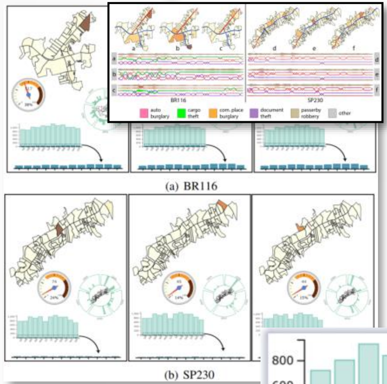
CrimAnalyzer - Case Studies

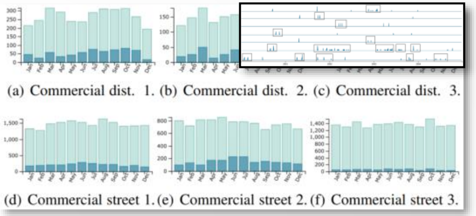
Case Studies

Comparing Crime Patterns over the City



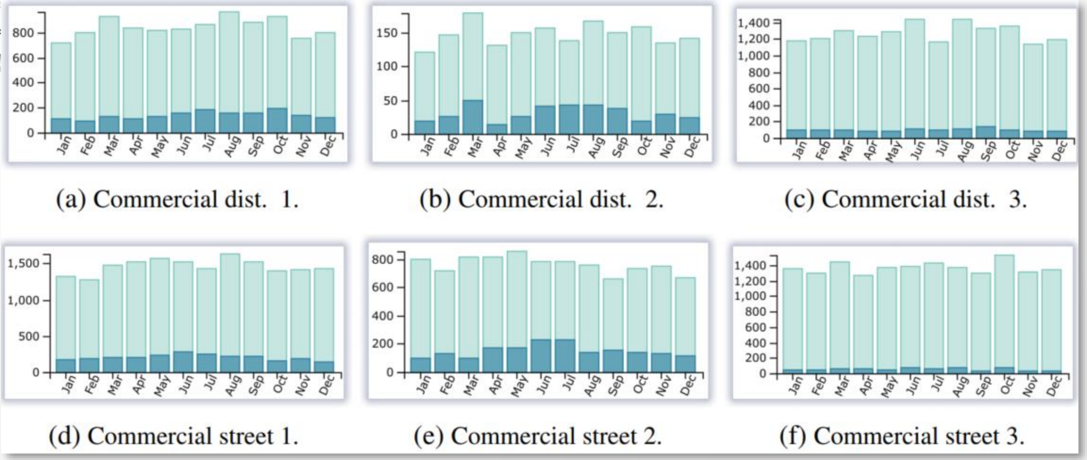
Hotspot Analysis and Cargo Theft



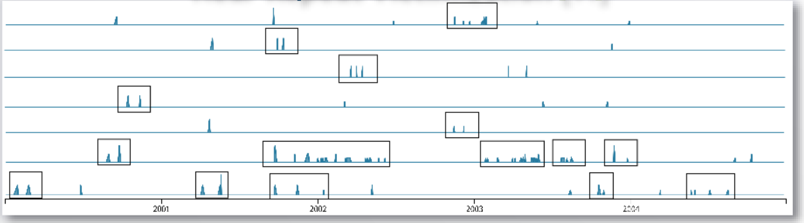


Seasonality and the Temporal Element of Crime

Seasonality [10]



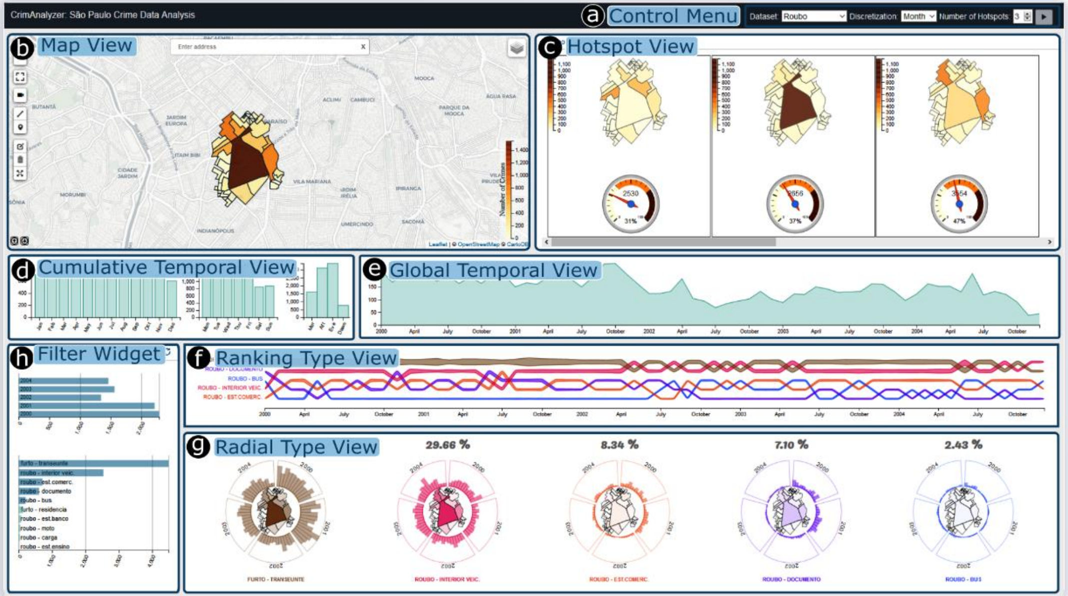
Near Repeat Victimization [11]



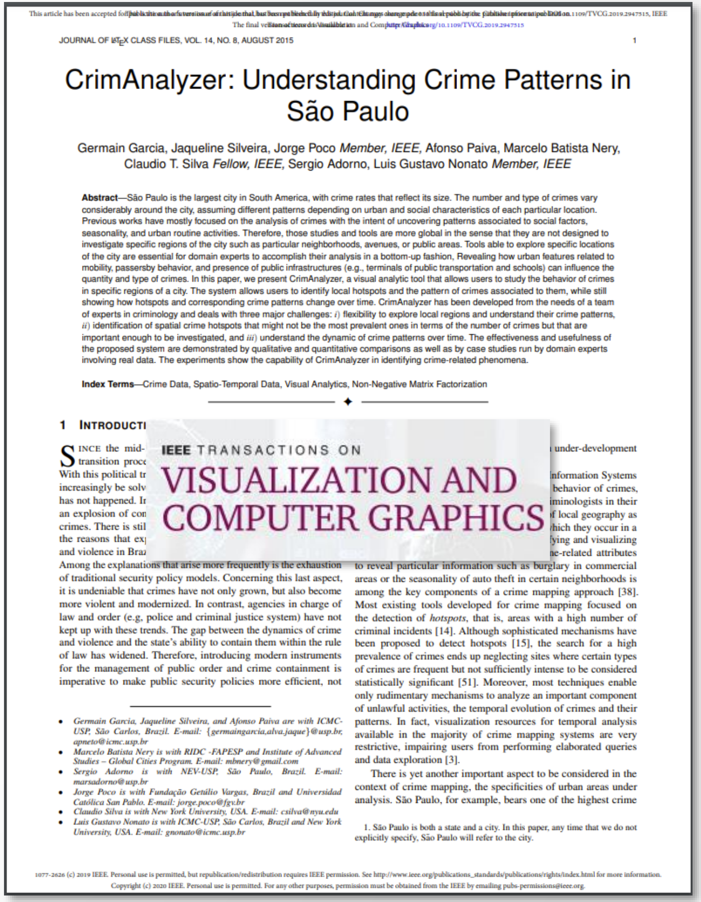
CrimAnalyzer - Publication

CrimAnalyzer: Understanding Crime Patterns in São Paulo

Published in: IEEE Transactions on Visualization and Computer Graphics



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



This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/TVCG.2019.2947515, IEEE Transactions on Visualization and Computer Graphics
The final version of record is available at http://dx.doi.org/10.1109/TVCG.2019.2947515

CrimAnalyzer: Understanding Crime Patterns in São Paulo

Germain Garcia, Jaqueline Silveira, Jorge Poco *Member, IEEE,* Afonso Paiva, Marcelo Batista Nery, Claudio T. Silva *Fellow, IEEE,* Sergio Adorno, Luis Gustavo Nonato *Member, IEEE*

Abstract—São Paulo is the largest city in South America, with crime rates that reflect its size. The number and type of crimes vary considerably around the city, assuming different patterns depending on urban and social characteristics of each particular location. Previous works have mostly focused on the analysis of crimes with the intent of uncovering patterns associated to social factors, seasonality, and urban routine activities. Therefore, those studies and tools are more global in the sense that they are not designed to investigate specific regions of the city such as particular neighborhoods, avenues, or public areas. Tools able to explore specific locations of the city are essential for domain experts to accomplish their analysis in a bottom-up fashion, Revealing how urban features related to mobility, passersby behavior, and presence of public infrastructures (e.g., terminals of public transportation and schools) can influence the quantity and type of crimes. In this paper, we present CrimAnalyzer, a visual analytic tool that allows users to study the behavior of crimes in specific regions of a city. The system allows users to identify local hotspots and the pattern of crimes associated to them, while still showing how hotspots and corresponding crime patterns change over time. CrimAnalyzer has been developed from the needs of a team of experts in criminology and deals with three major challenges: *i)* flexibility to explore local regions and understand their crime patterns, *ii)* identification of spatial crime hotspots that might not be the most prevalent ones in terms of the number of crimes but that are important enough to be investigated, and *iii)* understand the dynamic of crime patterns over time. The effectiveness and usefulness of the proposed system are demonstrated by qualitative and quantitative comparisons as well as by case studies run by domain experts involving real data. The experiments show the capability of CrimAnalyzer in identifying crime-related phenomena.

Index Terms—Crime Data, Spatio-Temporal Data, Visual Analytics, Non-Negative Matrix Factorization

1 INTRODUCTI

SINCE the mid- ... transition proc ... With this political tr ... increasingly be solv ... has not happened. Ir ... an explosion of con ... crimes. There is stil ... the reasons that ex ... and violence in Braz ... Among the explanations that arise more frequently is the exhaustion of traditional security policy models. Concerning this last aspect, it is undeniable that crimes have not only grown, but also become more violent and modernized. In contrast, agencies in charge of law and order (e.g, police and criminal justice system) have not kept up with these trends. The gap between the dynamics of crime and violence and the state's ability to contain them within the rule of law has widened. Therefore, introducing modern instruments for the management of public order and crime containment is imperative to make public security policies more efficient, not

IEEE TRANSACTIONS ON
VISUALIZATION AND COMPUTER GRAPHICS

... under-development ... Information Systems ... behavior of crimes, ... iminologists in their ... f local geography as ... hich they occur in a ... fying and visualizing ... ne-related attributes to reveal particular information such as burglary in commercial areas or the seasonality of auto theft in certain neighborhoods is among the key components of a crime mapping approach [38]. Most existing tools developed for crime mapping focused on the detection of *hotspots*, that is, areas with a high number of criminal incidents [14]. Although sophisticated mechanisms have been proposed to detect hotspots [15], the search for a high prevalence of crimes ends up neglecting sites where certain types of crimes are frequent but not sufficiently intense to be considered statistically significant [51]. Moreover, most techniques enable only rudimentary mechanisms to analyze an important component of unlawful activities, the temporal evolution of crimes and their patterns. In fact, visualization resources for temporal analysis available in the majority of crime mapping systems are very restrictive, impairing users from performing elaborated queries and data exploration [3].

There is yet another important aspect to be considered in the context of crime mapping, the specificities of urban areas under analysis. São Paulo, for example, bears one of the highest crime

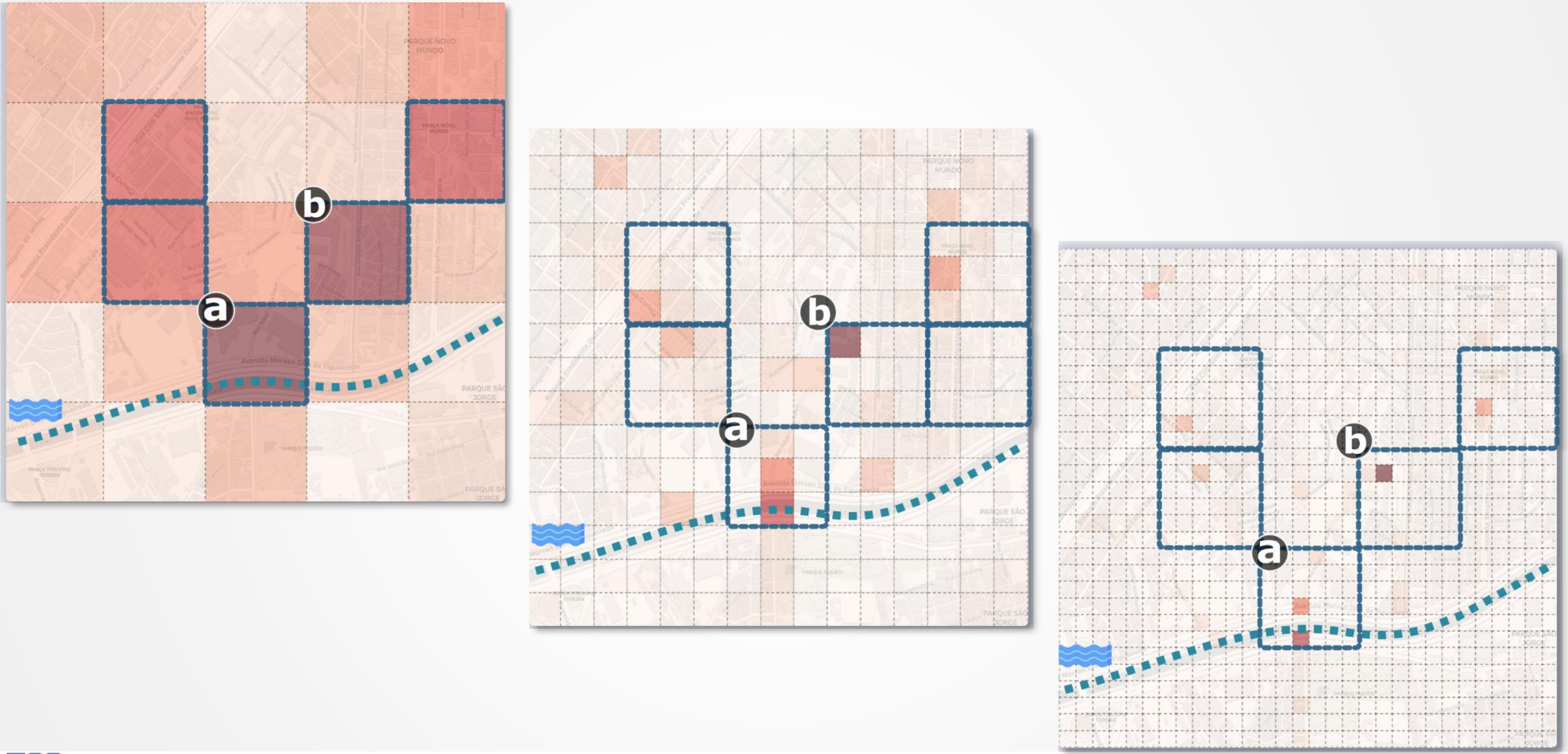
- *Germain Garcia, Jaqueline Silveira, and Afonso Paiva are with ICMC-USP, São Carlos, Brazil. E-mail: {germaingarcia,alva.jaque}@usp.br, apneto@icmc.usp.br*
- *Marcelo Batista Nery is with RIDC -FAPESP and Institute of Advanced Studies – Global Cities Program. E-mail: mbnery@gmail.com*
- *Sergio Adorno is with NEV-USP, São Paulo, Brazil. E-mail: marsadorno@usp.br*
- *Jorge Poco is with Fundação Getúlio Vargas, Brazil and Universidad Católica San Pablo. E-mail: jorge.poco@fgv.br*
- *Claudio Silva is with New York University, USA. E-mail: csilva@nyu.edu*
- *Luis Gustavo Nonato is with ICMC-USP, São Carlos, Brazil and New York University, USA. E-mail: gnonato@icmc.usp.br*

1. São Paulo is both a state and a city. In this paper, any time that we do not explicitly specify, São Paulo will refer to the city.

Invited TVCG paper presented at IEEE VIS 2020

Mirante

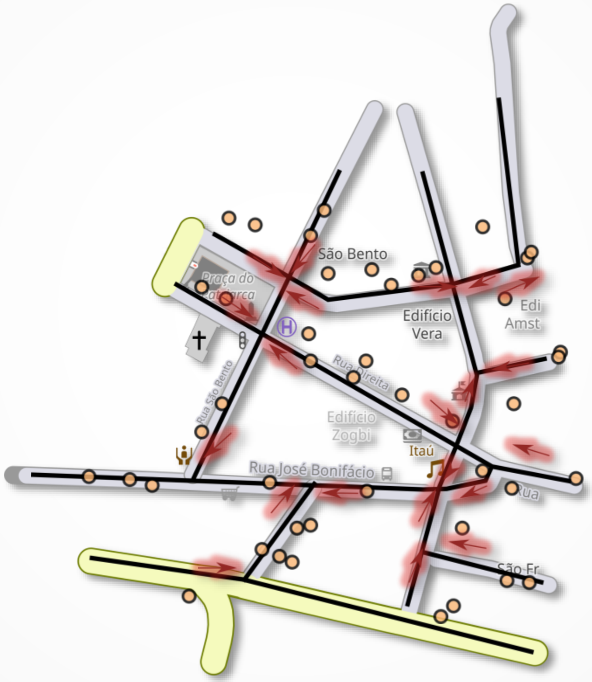
Mirante – Motivation

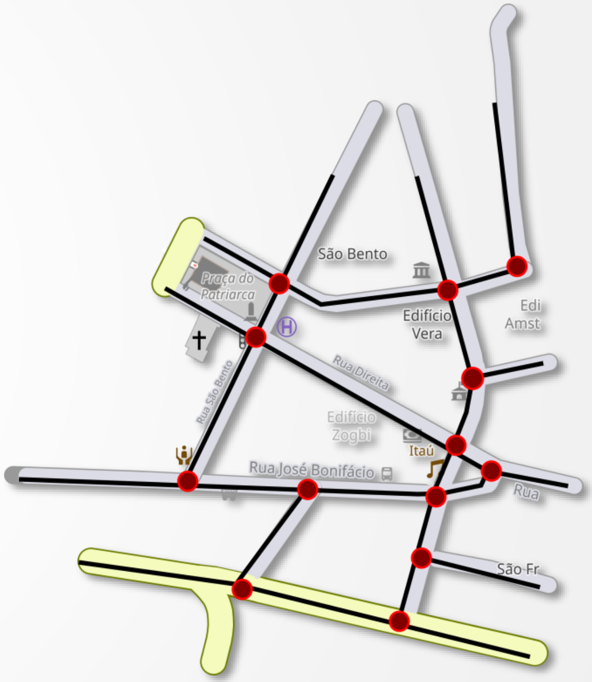


Mirante

Data Modeling

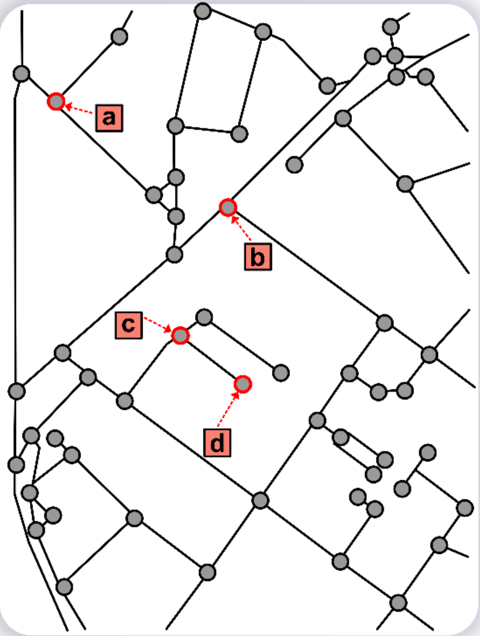
Mirante - Data Modeling



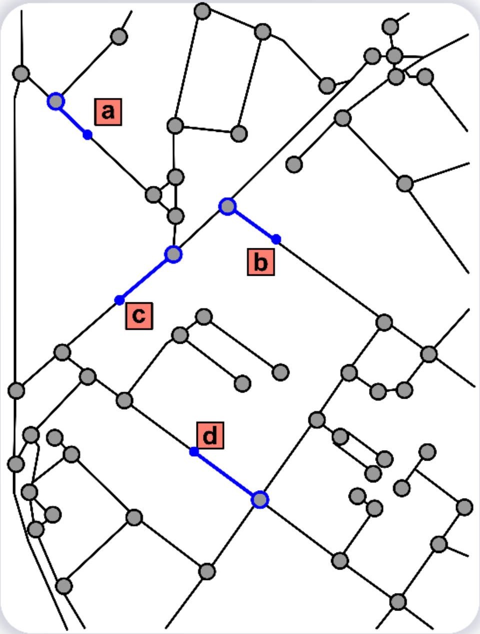


Mirante - Algorithm

$L_{crime} = \{c_0, c_1, .., c_n\}$ $G = (V, E)$



Closest node strategy



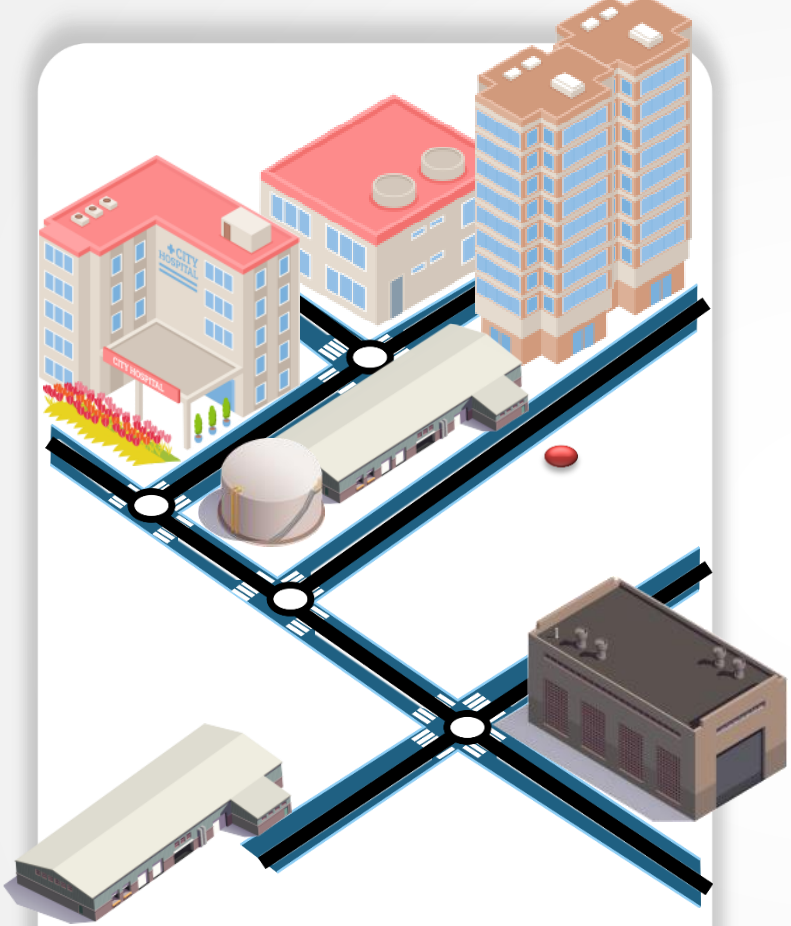
Edge-node strategy

Algorithm 1 – Assigning crimes to vertices.

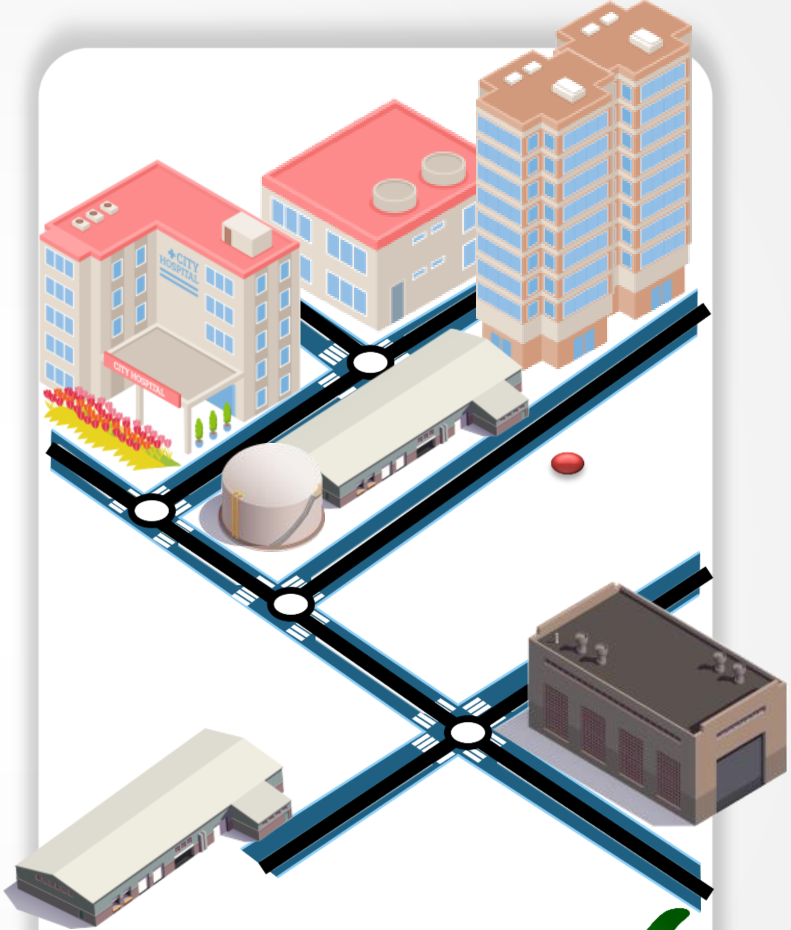
Input: Graph G, List L_{crime}
Output: Graph G

v_i.crimes $\leftarrow$ [], $\forall v_i \in G.vertices$
for $i \leftarrow 1$ **To** length(L_{crime}) **do**
  $c_{curr} \leftarrow L_{crime}[i]$
  $e_{near} \leftarrow G$.get_nearest_edge(c_{curr})
  (v_1,v_2) $\leftarrow G$.get_vertices(e_{near})
  $d_1 \leftarrow$ greatCircleDistance(c_{curr}, v_1)
  $d_2 \leftarrow$ greatCircleDistance(c_{curr}, v_2)
  if $d_1 < d_2$ **then**
    v_1.crimes.append(c_{curr})
  else
    v_2.crimes.append(c_{curr})
  end if
end for


CITY HOSPITAL
CITY HOSPITAL

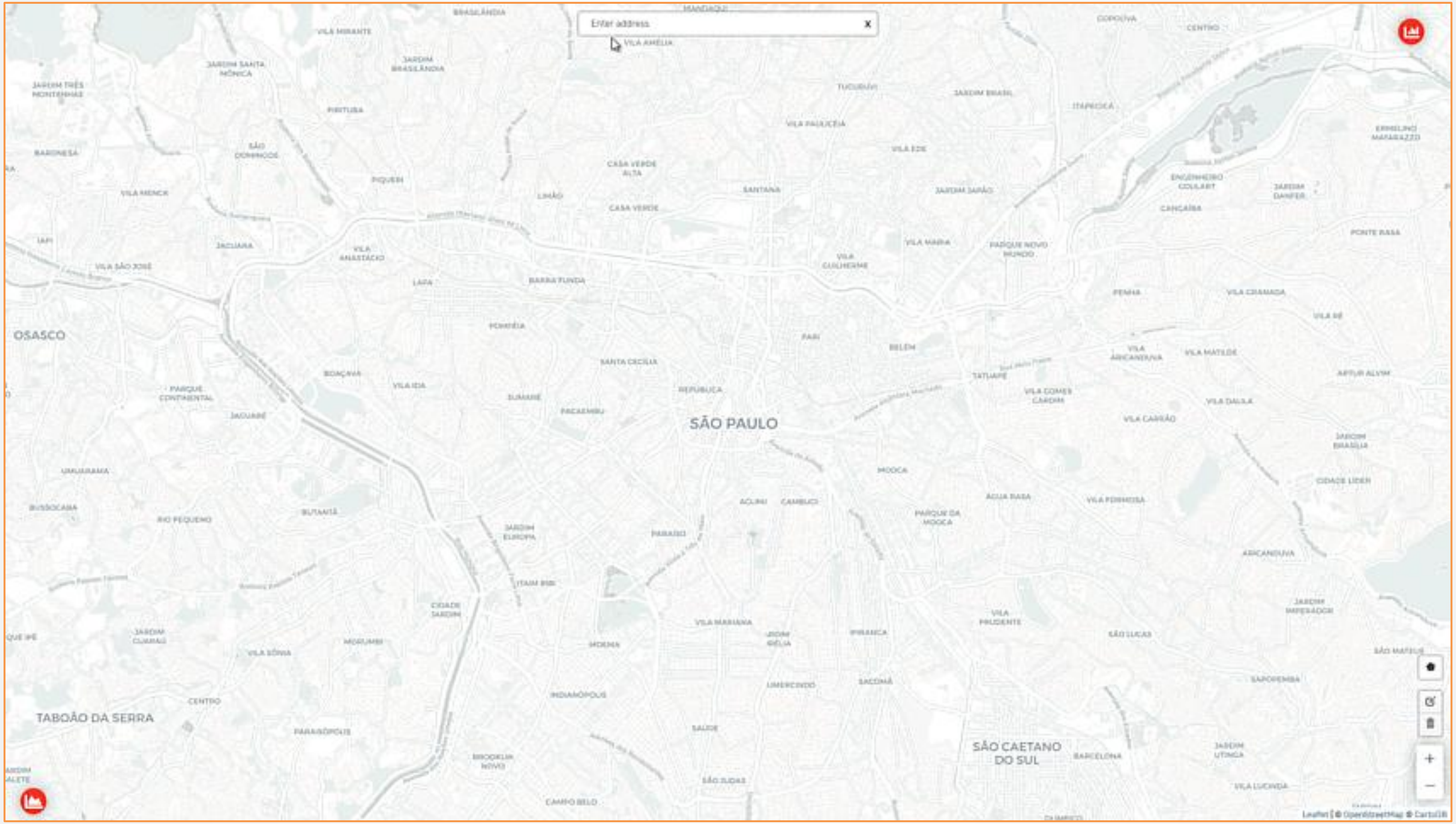


Closest Node Strategy ✗



Edge-Node Strategy ✓

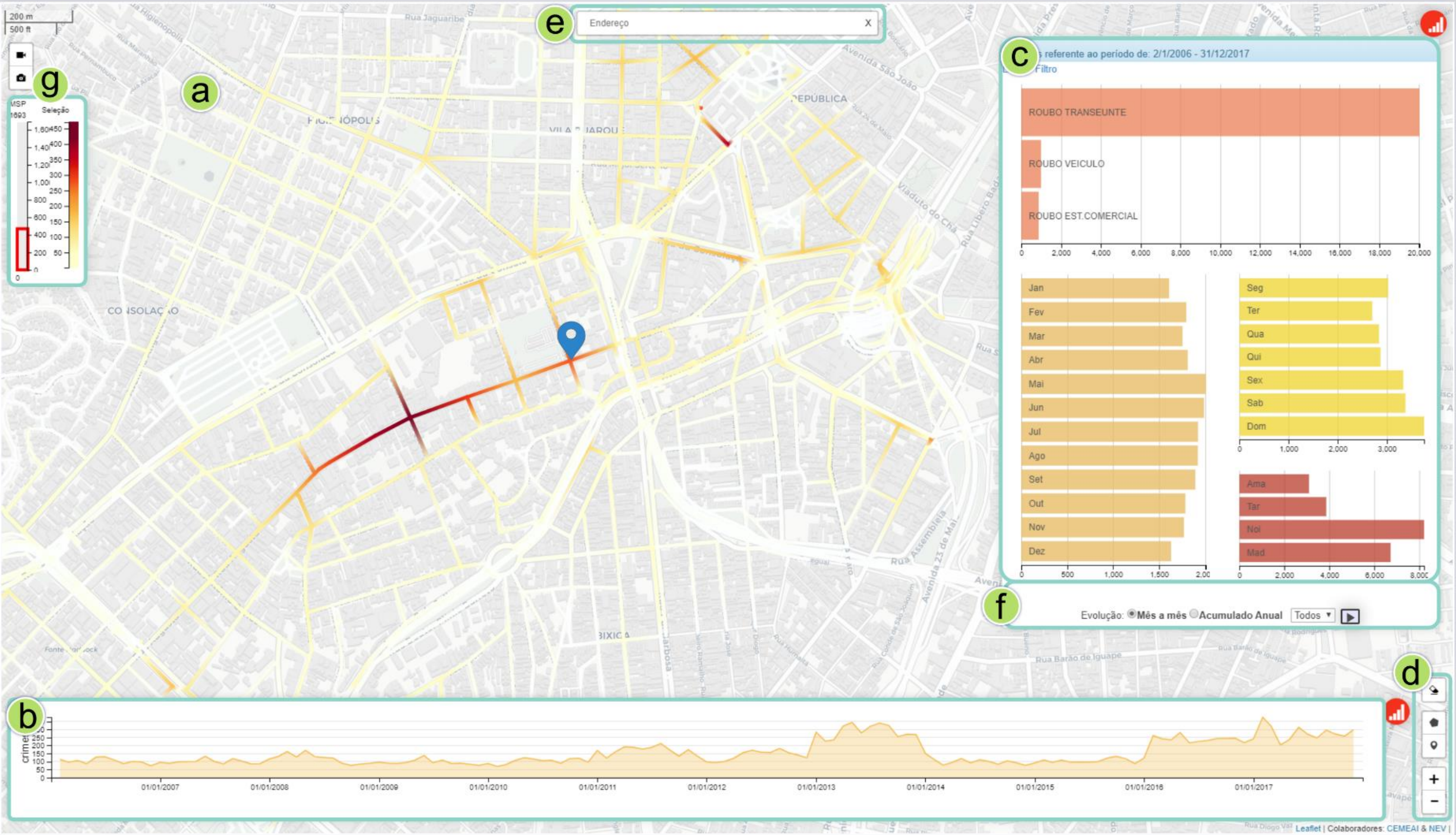
Mirante - Data Modeling



Mirante

Visualization Tool

Mirante



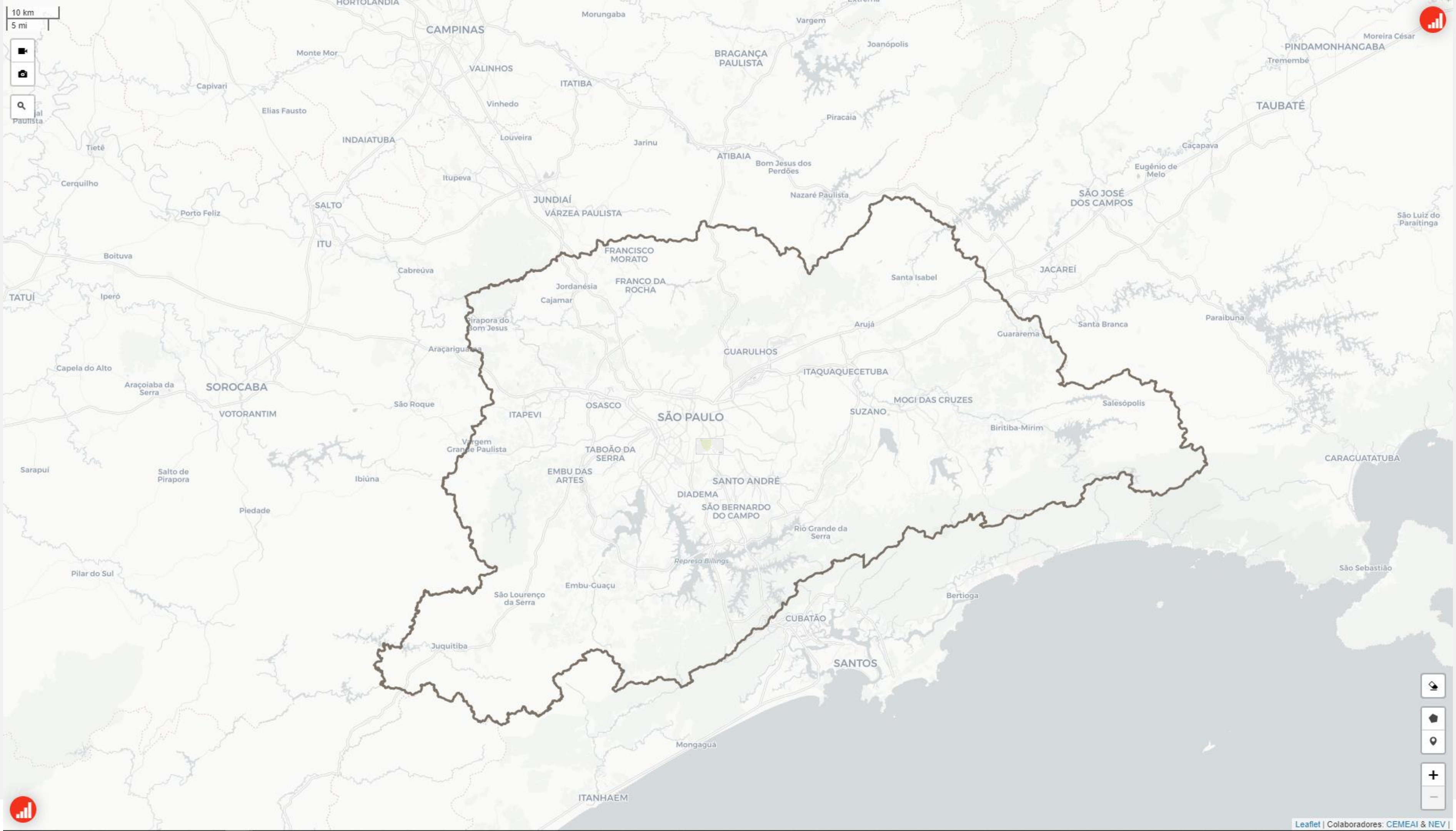
e
Endereço
c
referente ao período de: 2/1/2006 - 31/12/2017
Filtro
ROUBO TRANSEUNTE
ROUBO VEICULO
ROUBO EST.COMERCIAL
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
f
Evolução: Mês a mês Acumulado Anual Todos
a
g
Seleção
b
crimes
d
REPÚBLICA
CONSOLAÇÃO
BIXIGA
Leaflet | Colaboradores: CEMEAI & NEV

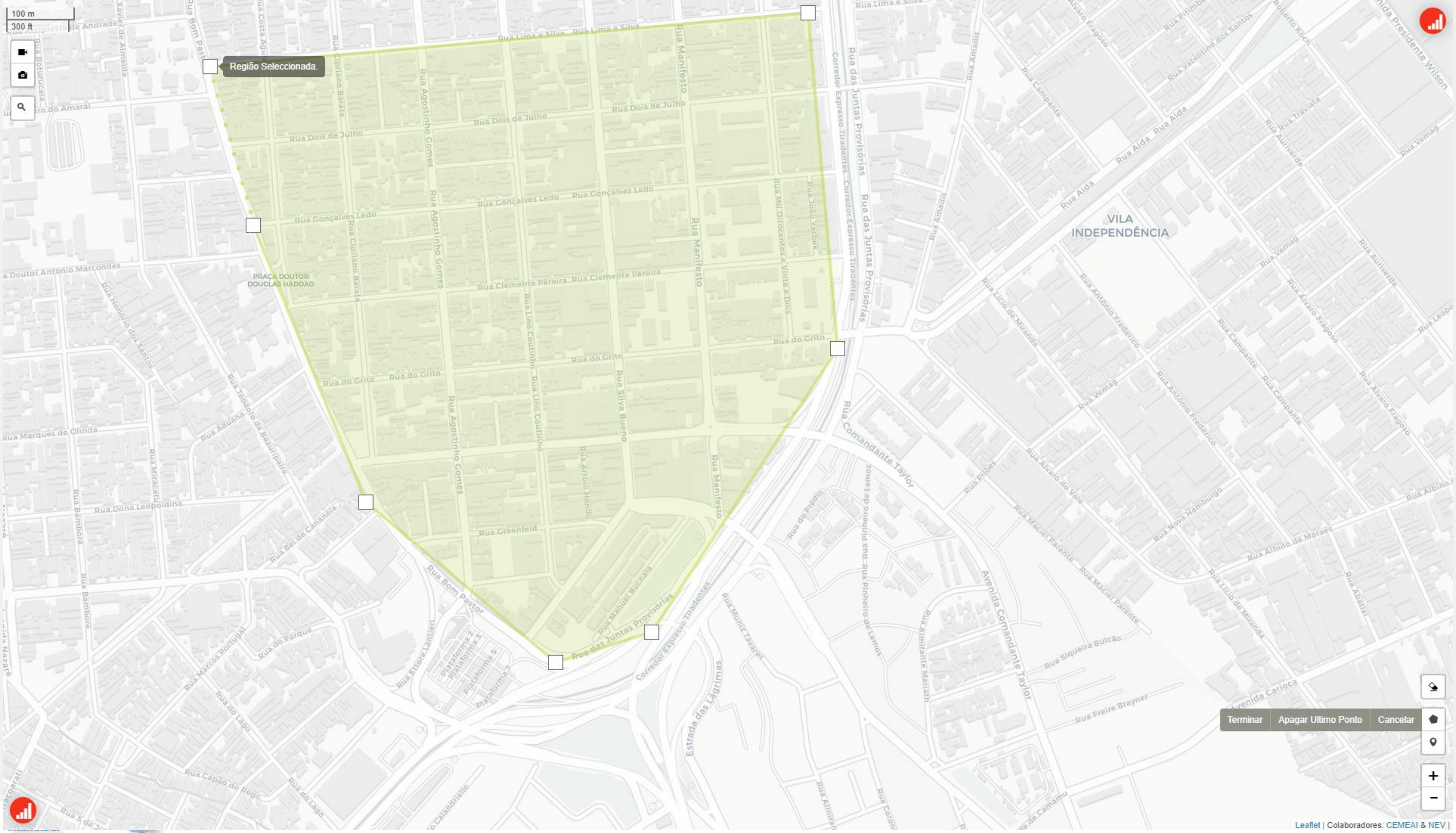
Mirante

Case Studies

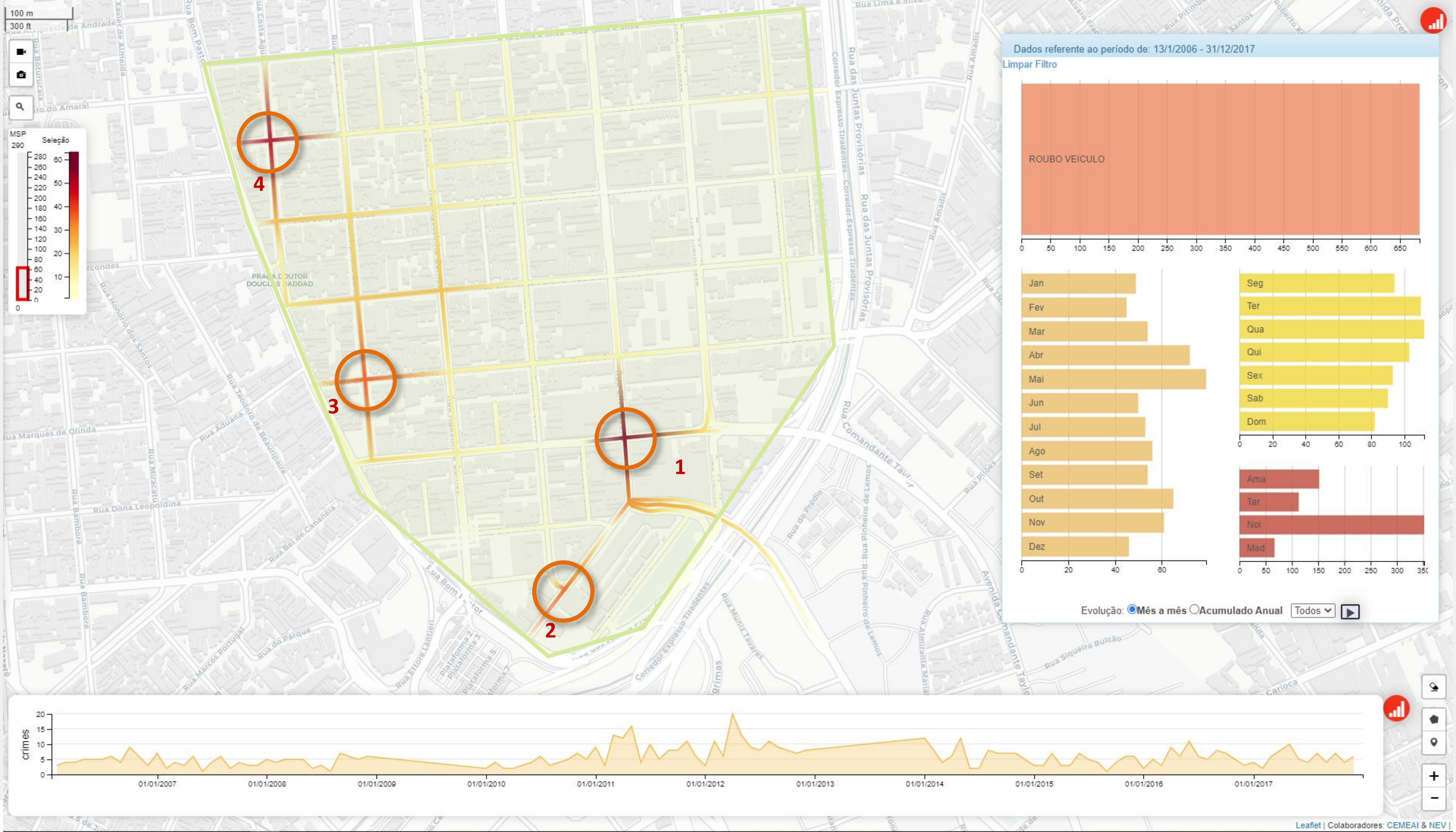
Case Study 1

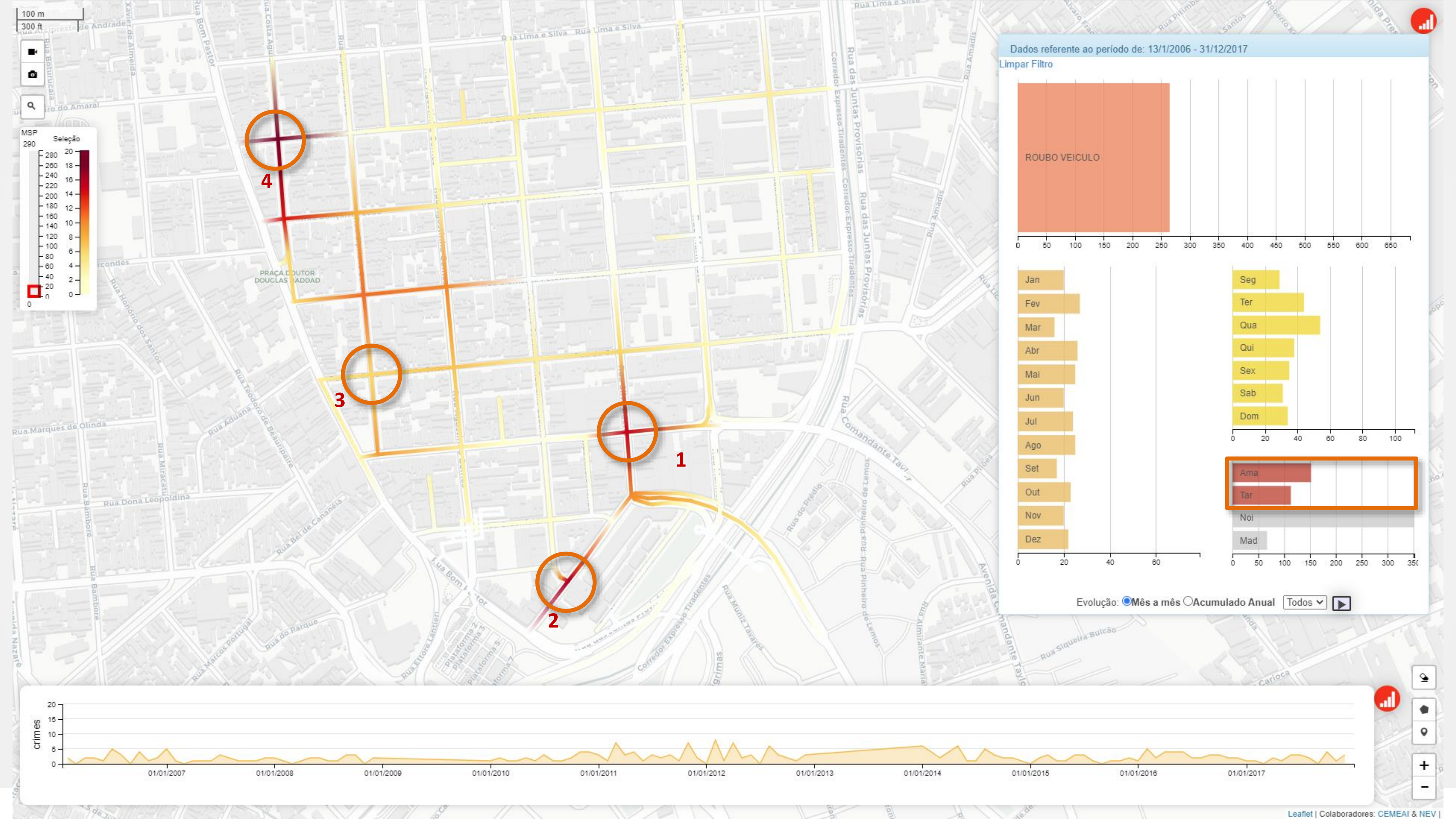
Vehicle Robbery in São Paulo


10 km
5 mi
CAMPINAS
Morungaba
Vargem
Joanópolis
Moreira César
PINDAMONHANGABA
Tremembé
Monte Mor
VALINHOS
BRAGANÇA PAULISTA
Capivari
ITATIBA
Vinhedo
Elias Fausto
Piracaia
TAUBATÉ
INDAIATUBA
Louveira
Jarinu
Tietê
ATIBAIA
Bom Jesus dos Perdões
Caçapava
Eugênio de Melo
Cerquilho
Itupeva
Nazaré Paulista
SÃO JOSÉ DOS CAMPOS
SALTO
JUNDIAÍ
Porto Feliz
VÁRZEA PAULISTA
São Luiz do Paraitinga
ITU
Boituva
FRANCISCO MORATO
Cabreúva
Santa Isabel
JACAREÍ
Jordanésia
FRANCO DA ROCHA
TATUÍ
Iperó
Cajamar
Pirapora do Bom Jesus
Arujá
Santa Branca
Paraibuna
Guararema
Araçariguama
GUARULHOS
Capela do Alto
ITAQUAQUECETUBA
Araçoiaba da Serra
SOROCABA
MOGI DAS CRUZES
São Roque
OSASCO
Salesópolis
VOTORANTIM
ITAPEVI
SÃO PAULO
SUZANO
Biritiba-Mirim
Vargem Grande Paulista
TABOÃO DA SERRA
CARAGUATATUBA
Sarapuí
Salto de Pirapora
EMBU DAS ARTES
Ibiúna
SANTO ANDRÉ
DIADEMA
SÃO BERNARDO DO CAMPO
Piedade
Rio Grande da Serra
Represa Billings
São Sebastião
Pilar do Sul
Embu-Guaçu
São Lourenço da Serra
Bertioga
CUBATÃO
Juquitiba
SANTOS
Mongaguá
ITANHAEM
Leaflet | Colaboradores: CEMEAI & NEV |

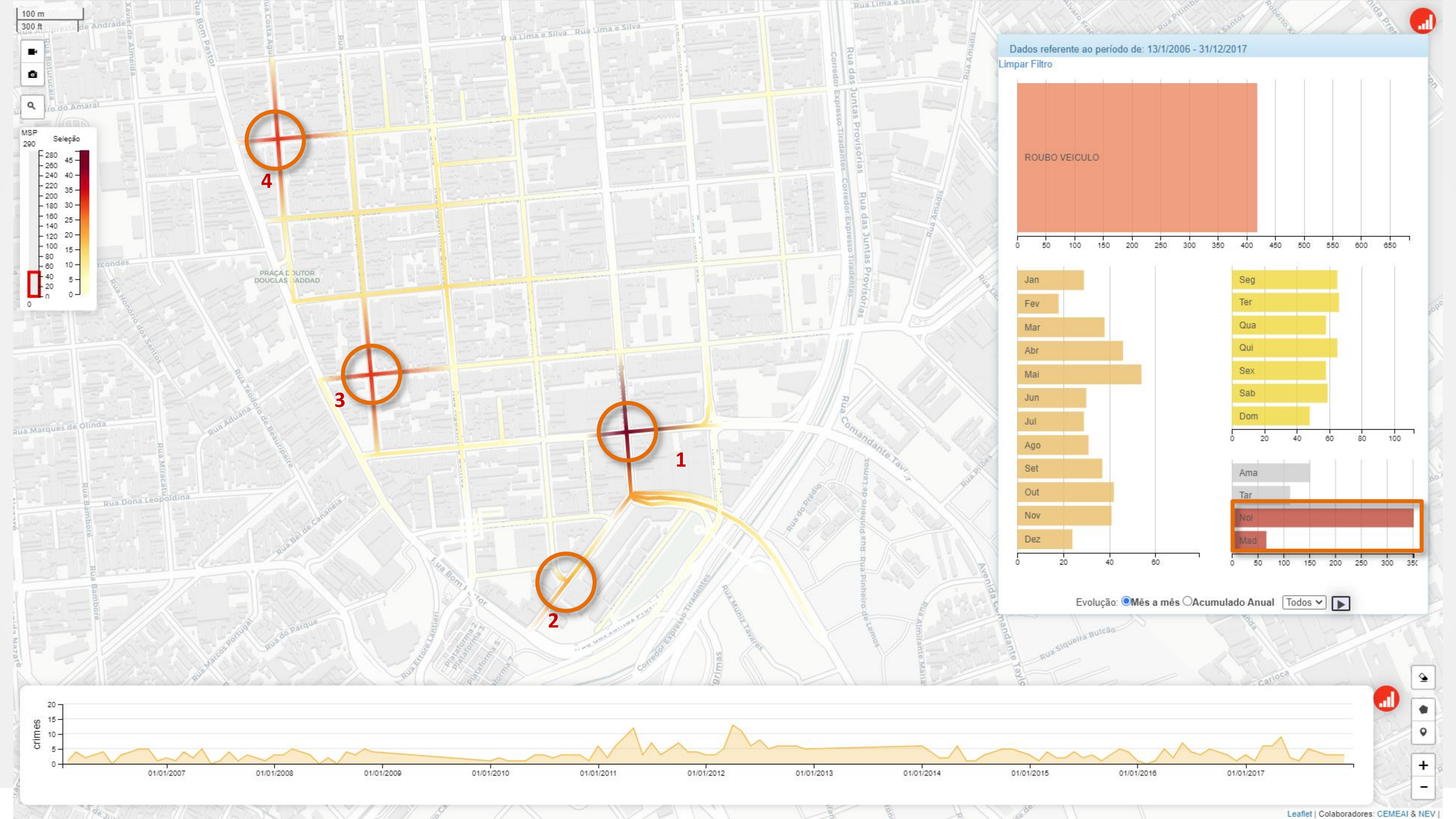


100 m
300 ft
Região Seleccionada.
Rua Lima e Silva
Rua Dois de Julho
Rua Gonçalves Ledo
Rua Clemente Pereira
Rua do Grito
Rua Greenfeld
Rua das Juntas Provisórias
Rua Manuel Buchala
Rua Agostinho Gomes
Rua Cipriano Barata
Rua Lino Coutinho
Rua Silva Bueno
Rua Manifesto
Rua Arroio Hondo
Rua Mil Oitocentos e Vinte e Dois
Rua João Vasbek
Corredor Expresso Tiradentes
Rua Bom Pastor
PRAÇA DOUTOR DOUGLAS HADDAD
Rua Doutor Antônio Marcondes
Rua Honório dos Santos
Rua Teodoro de Beaurepaire
Rua Aduana
Rua Marquês de Olinda
Rua Miracatu
Rua Dona Leopoldina
Rua Bambora
Rua Bel de Cananéia
Rua do Parque
Rua Marcos Portugal
Rua do Lago
Rua Capão do Rego
Rua Ettore Lantieri
Plataforma 2
Plataforma 5
Plataforma 7
VILA INDEPENDÊNCIA
Rua Aida
Rua Amadis
Rua Campante
Rua Lício de Miranda
Rua Antônio Frederico
Rua Álvaro Fragoso
Rua Vemag
Rua Auriverde
Rua Traviata
Rua Valentino dos Santos
Rua Roberto Koch
Avenida Presidente Wilson
Rua Comandante Taylor
Avenida Comandante Taylor
Rua Álvaro do Vale
Rua Maciel Parente
Rua Nova Hamburgo
Rua Albino de Moraes
Rua Pinheiro de Lemos
Rua Almirante Mariath
Rua Siqueira Bulcão
Rua Freire Brayner
Avenida Carioca
Rua Muniz Tavares
Estrada das Lágrimas
Rua do Prelo
Rua Pilões
Terminar
Apagar Ultimo Ponto
Cancelar
Leaflet | Colaboradores: CEMEAI & NEV |

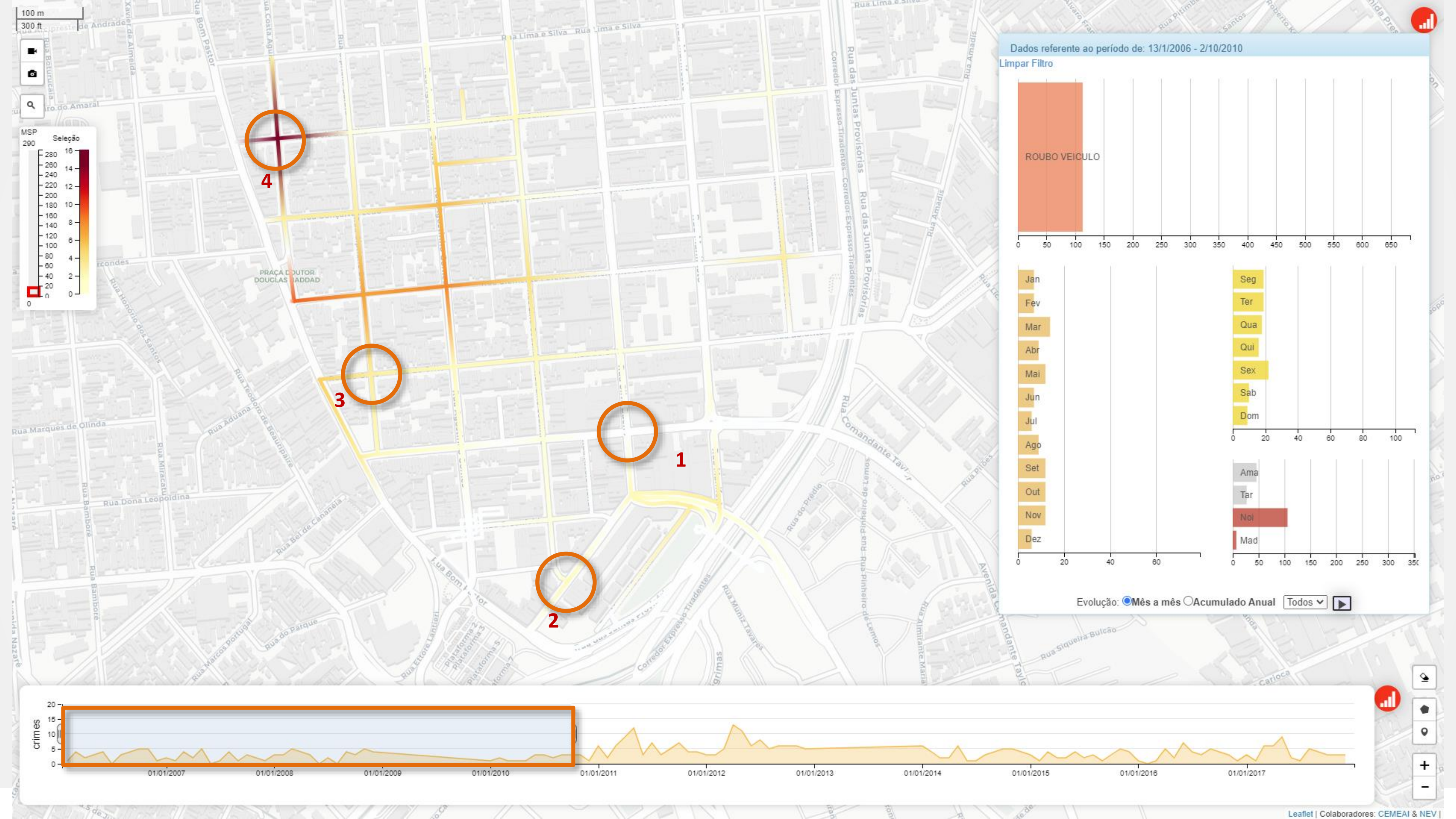

100 m
300 ft
MSP
Seleção
PRAÇA DOUTOR DOUGLAS HADDAD
4
3
1
2
Dados referente ao período de: 13/1/2006 - 31/12/2017
Limpar Filtro
ROUBO VEICULO
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
Evolução: Mês a mês Acumulado Anual Todos
crimes
01/01/2007
01/01/2008
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 |

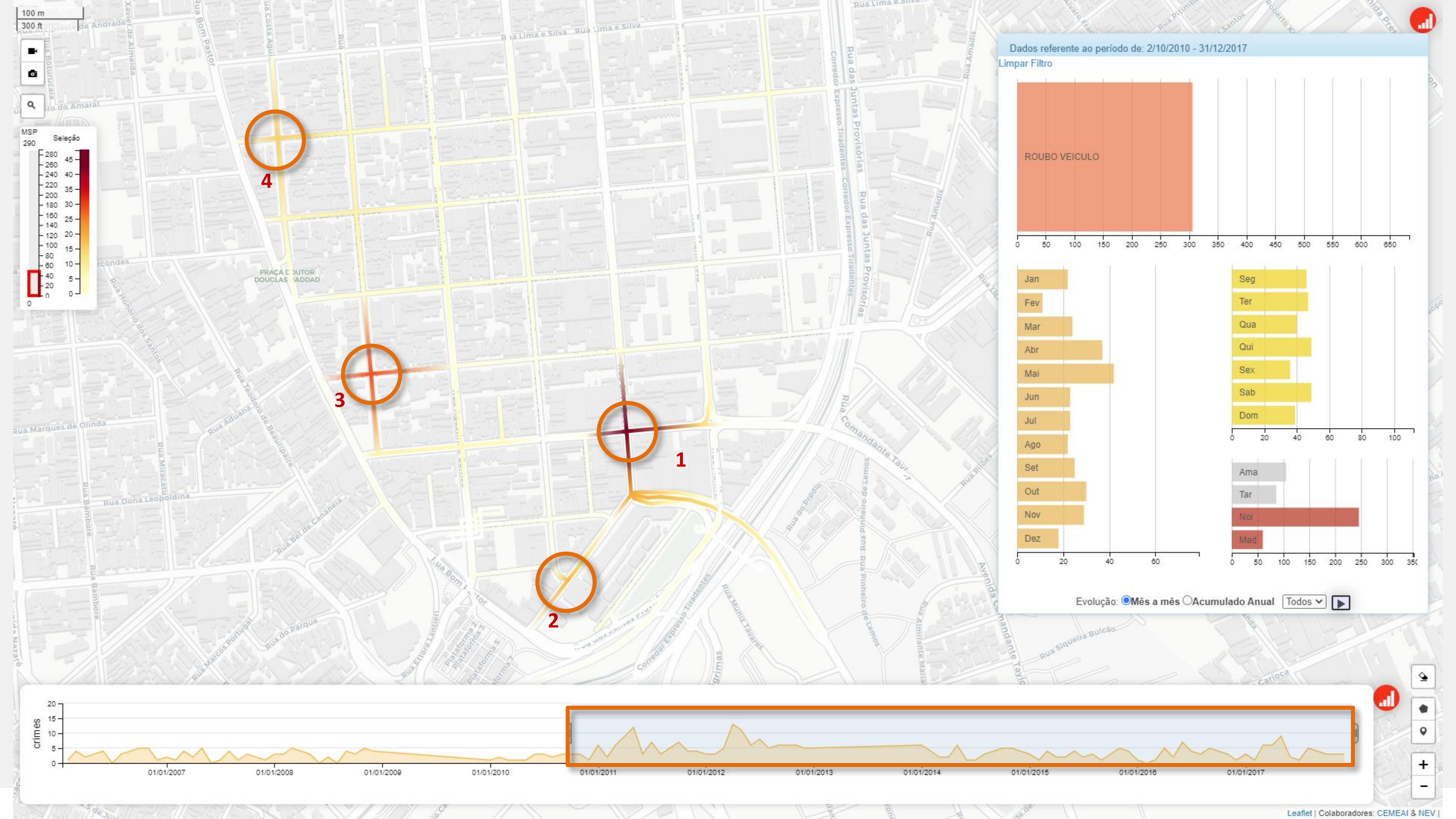


Dados referente ao período de: 13/1/2006 - 31/12/2017
Limpar Filtro
ROUBO VEICULO
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
Evolução: Mês a mês Acumulado Anual Todos
MSP
Seleção
1
2
3
4
crimes
Leaflet | Colaboradores: CEMEAI & NEV



100 m
300 ft
MSP
Seleção
290
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
45
40
35
30
25
20
15
10
5
0
PRAÇA DOUTOR DOUGLAS HADDAD
Rua Lima e Silva
Rua Bom Pastor
Rua Marquês de Olinda
Rua Dona Leopoldina
Rua Teodoro de Beaurepaire
Rua Comandante Taylor
Corredor Expresso Tiradentes
Rua das Juntas Provisórias
Rua Siqueira Bulcão
Rua Bambore
1
2
3
4
Dados referente ao período de: 13/1/2006 - 31/12/2017
Limpar Filtro
ROUBO VEICULO
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
0
20
40
60
Seg
Ter
Qua
Qui
Sex
Sab
Dom
0
20
40
60
80
100
Ama
Tar
Noi
Mad
0
50
100
150
200
250
300
350
Evolução: Mês a mês Acumulado Anual Todos
crimes
20
15
10
5
0
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


100 m
300 ft
MSP
290
Seleção
1
2
3
4
PRAÇA DOUTOR DOUGLAS HADDAD
Rua Bom Pastor
Rua Lima e Silva
Rua Marquês de Olinda
Rua Dona Leopoldina
Rua Comandante Taylor
Rua das Juntas Provisórias
Corredor Expresso Tiradentes
Dados referente ao período de: 13/1/2006 - 2/10/2010
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
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



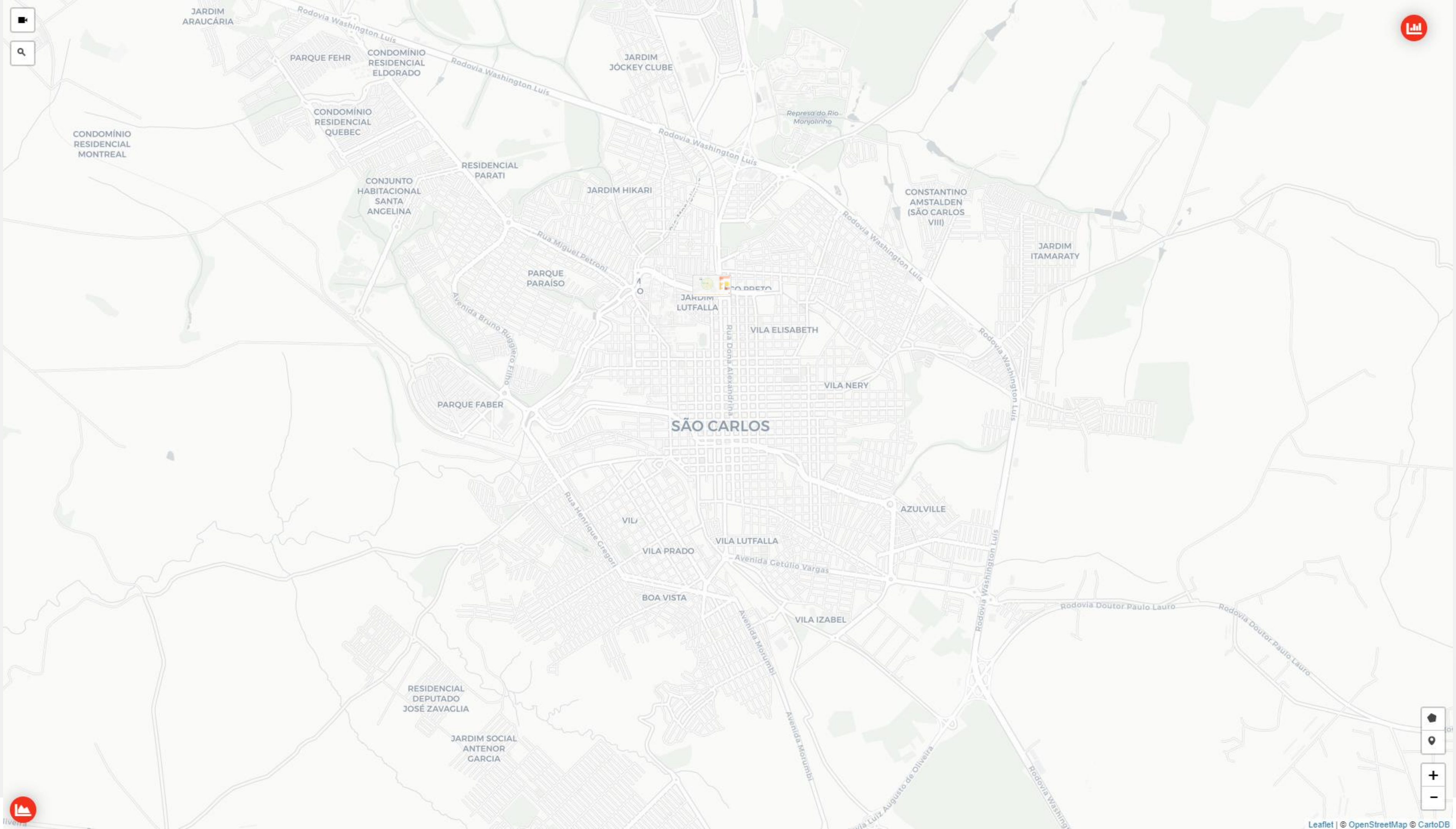
Dados referente ao período de: 2/10/2010 - 31/12/2017
Limpar Filtro
ROUBO VEICULO
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
Seg
Ter
Qua
Qui
Sex
Sab
Dom
Ama
Tar
Noi
Mad
Evolução: Mês a mês Acumulado Anual Todos
MSP
Seleção
crimes
1
2
3
4
Leaflet | Colaboradores: CEMEAI & NEV

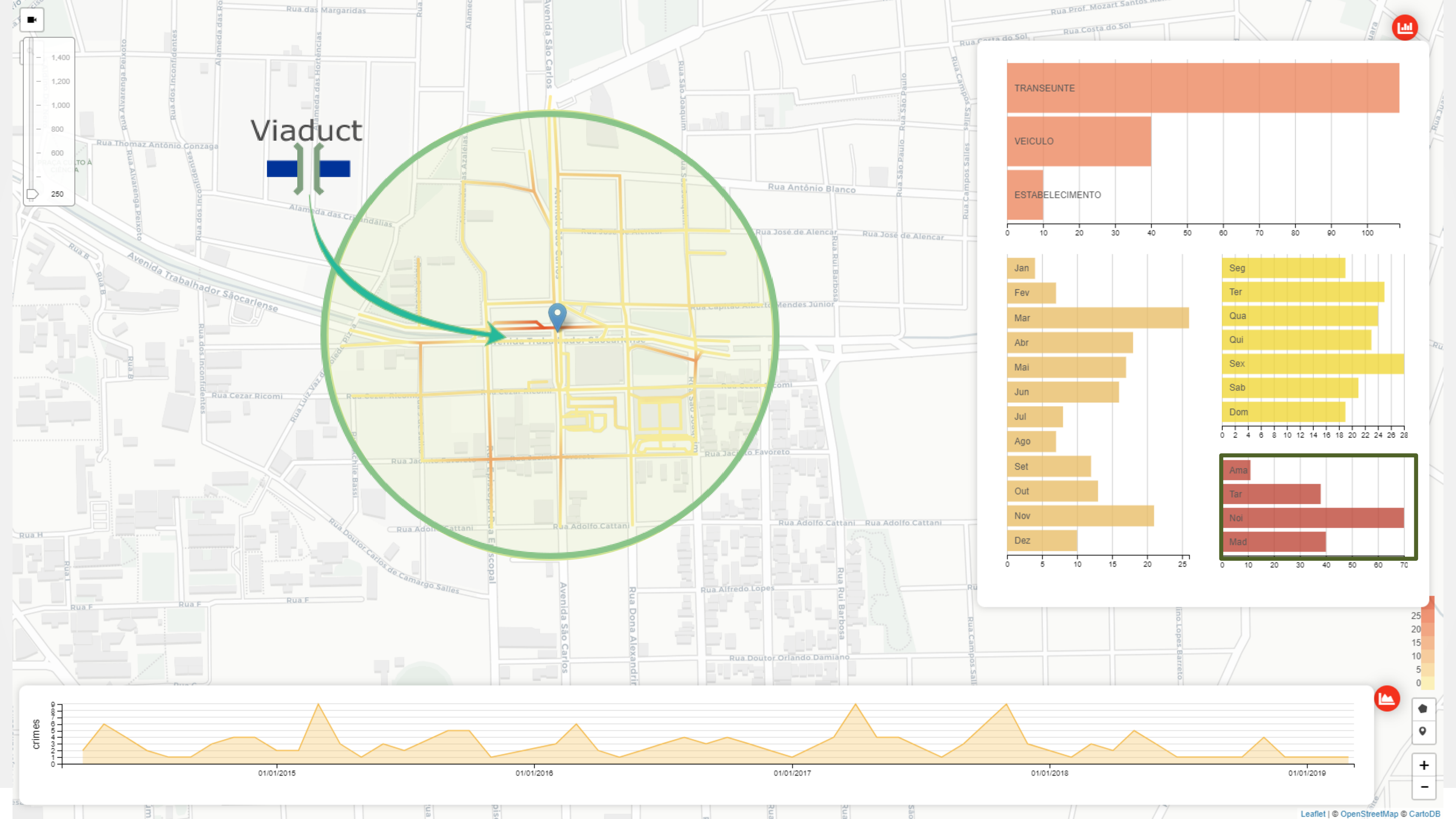

100 m
300 ft
MSP
290
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
12
10
8
6
4
2
0
Rua Lima e Silva
Rua Marques de Olinda
Rua Dona Leopoldina
Rua Bambore
Rua Miracatu
Rua Teodoro de Beaurepaire
Rua Aduana
Rua do Parque
Rua Marcos Portugal
Rua Bel de Canancia
Rua das Juntas Provisórias
Corredor Expresso Tiradentes
Rua Amadis
PRAÇA DOUTOR DOUGLAS HADDAD
Dados referente ao período de: 13/1/2006 - 2/10/2010
Limpar Filtro
ROUBO VEICULO
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Jan
Seg
R. Dois de Julho
PARE
Google
crimes
20
15
10
5
0
01/01/2007
01/01/2008
Leaflet | Colaboradores: CEMEAI & NEV |

2010
2011
100 m
Dados referente ao período de: 2/10/2010 - 31/12/2017
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
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
Rua Marques de Olinda
Rua Lima e Silva
Leaflet | Colaboradores: CEMEAI & NEV

Case Study 2

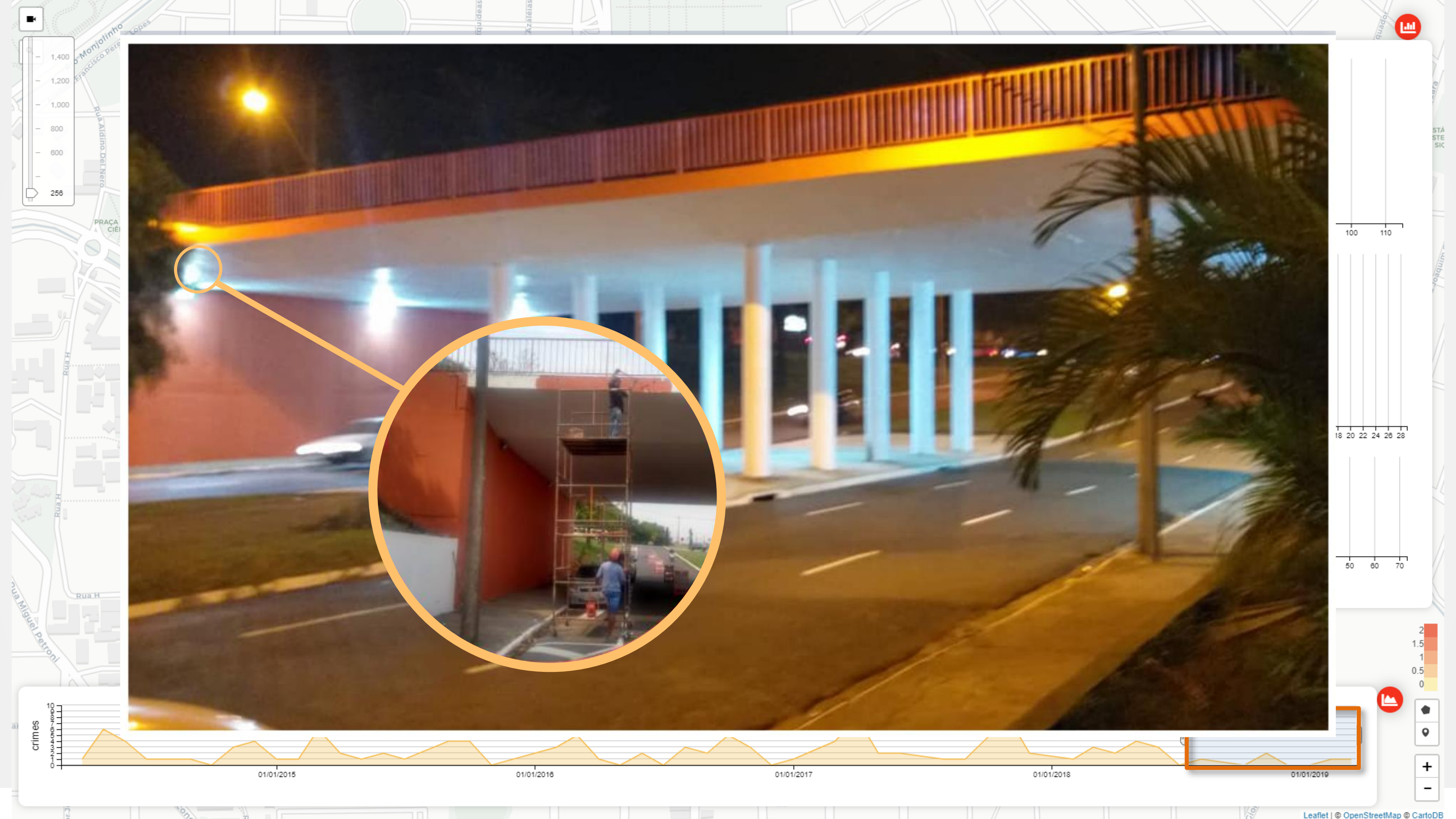
Passerby Robbery in São Carlos


JARDIM ARAUCÁRIA
Rodovia Washington Luís
PARQUE FEHR
CONDOMÍNIO RESIDENCIAL ELDORADO
JARDIM JÓCKEY CLUBE
Represa do Rio Monjolinho
CONDOMÍNIO RESIDENCIAL QUEBEC
CONDOMÍNIO RESIDENCIAL MONTREAL
RESIDENCIAL PARATI
CONJUNTO HABITACIONAL SANTA ANGELINA
JARDIM HIKARI
CONSTANTINO AMSTALDEN (SÃO CARLOS VIII)
JARDIM ITAMARATY
Rua Miguel Petroni
PARQUE PARAÍSO
JARDIM LUTFALLA
VILA ELISABETH
Avenida Bruno Ruggiero Filho
Rua Dona Alexandrina
VILA NERY
PARQUE FABER
SÃO CARLOS
AZULVILLE
Rua Henrique Gregori
VILA LUTFALLA
VILA PRADO
Avenida Getúlio Vargas
BOA VISTA
VILA IZABEL
Rodovia Doutor Paulo Lauro
Avenida Morumbi
RESIDENCIAL DEPUTADO JOSÉ ZAVAGLIA
JARDIM SOCIAL ANTENOR GARCIA
Leaflet | © OpenStreetMap © CartoDB


Viaduct
1,400
1,200
1,000
800
600
250
Rua das Margaridas
Avenida São Carlos
Rua Thomaz Antônio Gonzaga
Alameda das Crisandálias
Avenida Trabalhador Sãocarlense
Rua Antônio Blanco
Rua José de Alencar
Rua Capitão Alberto Mendes Júnior
Rua Cezar Ricomi
Rua Jacinto Favoreto
Rua Adolfo Cattani
Rua Doutor Carlos de Camargo Salles
Rua Alfredo Lopes
Rua Doutor Orlando Damiano
Rua Costa do Sol
Rua Dona Alexandrina
Rua Rui Barbosa
TRANSEUNTE
VEICULO
ESTABELECIMENTO
0 10 20 30 40 50 60 70 80 90 100
Jan
Fev
Mar
Abr
Mai
Jun
Jul
Ago
Set
Out
Nov
Dez
0 5 10 15 20 25
Seg
Ter
Qua
Qui
Sex
Sab
Dom
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Ama
Tar
Noi
Mad
0 10 20 30 40 50 60 70
25 20 15 10 5 0
crimes
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Leaflet | © OpenStreetMap © CartoDB

205 Av. Trab. São Carlense
São Carlos, Estado de São Paulo
Google
Street View
O VENENO
ESTÁ NA MESA
Av. Trab.
Google
McDonald's
crimes
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Leaflet | © OpenStreetMap © CartoDB

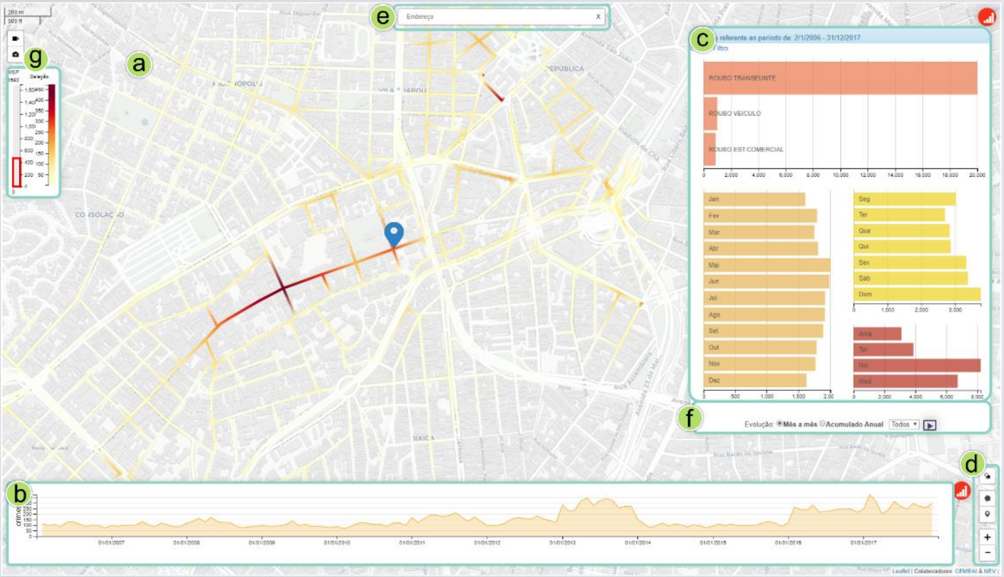
338 Av. Trab. São Carlense
São Carlos, Estado de São Paulo
Google
Street View
Av. Trab. São Carlense
McDonald's
Google
crimes
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Leaflet | © OpenStreetMap © CartoDB


1,400
1,200
1,000
800
600
256
Rua Aldino Del Nero
Rua H
Rua Miguel Petroni
100
110
18 20 22 24 26 28
50
60
70
2
1.5
1
0.5
0
crimes
01/01/2015
01/01/2016
01/01/2017
01/01/2018
01/01/2019
Leaflet | © OpenStreetMap © CartoDB

Mirante - Publication

Mirante: A visualization tool for analyzing urban crimes

Published in: 33rd Conference on Graphics, Patterns and Images



https://ieeexplore.ieee.org/abstract/document/9265984

Mirante: A visualization tool for analyzing urban crimes

Germain Garcia-Zanabria, Erick Gomez-Nieto, Jaqueline Silveira
Universidade de São Paulo
{germaingarcia, erick.gomez, alva.jaque}@usp.br

Jorge Poco
Fundação Getúlio Vargas
jorge.poco@fgv.br

Marcelo Nery, Sergio Adorno, Luis G. Nonato
Universidade de São Paulo
mbnery@gmail.com, sadorno@usp.br, gnonato@icmc.usp.br

Abstract—Visualization assisted crime analysis tools used by public security agencies are usually designed to explore large urban areas, relying on grid-based heatmaps to reveal spatial crime distribution in whole districts, regions, and neighborhoods. Therefore, those tools can hardly identify micro-scale patterns closely related to crime opportunity, whose understanding is fundamental to the planning of preventive actions. Enabling a combined analysis of spatial patterns and their evolution over time is another challenge faced by most crime analysis tools. In this paper, we present *Mirante*, a crime mapping visualization system that allows spatiotemporal analysis of crime patterns in a street-level scale. In contrast to conventional tools, Mirante builds upon street-level heatmaps and other visualization resources that enable spatial and temporal pattern analysis,
uncovering fine-
over time. Miran
domain experts,
versatile to be im
demonstrate the
run by domain
different charact
were capable of
of the cities whil
certain types of

Understanding
problem due to the interplay between the spatial and temporal dynamics of crimes, the great variability of patterns among the different types of crimes, and the large amount of data involved in such analysis. In this context, the branch of Geographic Information Systems (GIS) called *Crime Mapping* focuses on developing tools to explore and analyze the spatio-temporal behavior of crimes, leveraging the importance of local urban, social, and environmental characteristics as determinants for crime opportunity [1], [2]. Current crime mapping tools combine techniques from different fields such as mathematics and statistics [3]–[5], machine learning [6], [7], optimization and visualization [8]–[10], and social sciences [11], [12]. Examples of crime mapping systems implemented to increase transparency for the population and to support agencies in charge of public security are *LexisNexis*[1], *NYC Crime Map*[2], *CitizenRIMS*[3], and *CrimeMapping*[4].

An important aspect of crime mapping is the spatial discretization. Most techniques rely on regular grids with crime data aggregated on grid cells, each covering hundreds of square meters. However, recent studies point out the importance of analyzing micro places [13]–[16], as crime rarely concentrates on regions larger than a street segment or corner. In fact, several researchers have shown that crimes mostly occur near specific locations such as bars, fast-food restaurants, check-cashing centers, and pawnshops, since those places attract distracted and vulnerable people who carry money and valuables [14], [17]. In other words, the environment of those places creates a crime opportunity. Therefore, relying on spatial discretizations such as the regular grids renders fine-grained crime analysis a quite challenging task, since the
identification
is not so
a cell contain-
grid resolution
segments,
hampering the
possible causes.
the analysis of
suppose that a
corner during a
orner. In a grid
representation, such a temporal behavior can hardly be caught if both corners lie on the same grid cell.

In collaboration with domain experts, we designed *Mirante*, a scalable and versatile visualization tool tailored to explore crime data in a street-level of detail. Considering street corners as nodes and street segments as edges, Mirante assumes city street maps as the spatial discretization. Crime data is spatially aggregated on street corners using an *edge-node* strategy rather than Euclidean distance, which avoids several issues present in grid cell aggregation. Mirante provides a number of interactive resources to explore the spatial distribution of crimes and their dynamics over time, making it possible to identify temporal patterns such as the shift of crime hotspots among nearby locations. Interactive filters allow users to focus their analysis on particular hours of the day, days of the week, and months of the year, making it possible to easily scrutinize the seasonality of crimes. Using different selection mechanisms, users can interactively select regions of interest in various scales, enabling the spatio-temporal analysis of large regions as well as quite specific locations of the city, a trait not

[1] communitycrimemap.com [2] maps.nyc.gov/crime/ [3] crimegraphics.com
[4] crimemapping.com

https://sibgrapi2020.cin.ufpe.br/awards/

Conclusions

General - Conclusions

We presented different methodologies that allow a visual Spatio-temporal crime pattern analysis of urban areas considering different characteristics. For that, we have proposed different solutions to tackle the presented problems:

1. we proposed two different methods based on **NMF** and **Stochastic mechanisms** for hotspots identification considering not only the intensity of crimes but also the frequency;
2. we have worked with different levels of spatial discretization such **as census blocks grid-based and a high-level discretization** based on street-network to do more accurate analysis;
3. we developed different visual frameworks to represent and visualize **Spatio-temporal crime patterns**.

Each of the proposed approaches has been **designed in close collaboration with domain experts** and deal simultaneously with multiple requirements. These **requirements** are translated into **analytical tasks** that guide the development of victimization systems. Moreover, the set of case studies, experiments, and experts' feedbacks have shown the **usefulness and effectiveness of the proposed methodologies**.

1

Supported by the experiments, the results, and the positive feedbacks, it is safe to say the proposed methodologies have the capability and functionalities to analyze successfully different crime patterns in different scenarios.

2

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 , considering the intensity and frequency.

3

We introduced **MIRANTE**, a crime mapping visualization system that allows spatio-temporal analysis of crime patterns in a street-level of detail.

4

We introduced **CriPAV** (Crime Pattern Analysis and Visualization), a **street-level** visualization-assisted analytical tool. It is a new methodology to identify crime hotspots based not only on intensity but also on the probability of occurrence, a hotspot grouping technique based on the similarity of crime time series.

Thanks to FAPESP for financial support

Thank you !

References (1)

[1] AKPINAR, E. **Using geographic information systems in analysing the pattern of crime incidents and the relationship between landuse and incidents**.

[2] Keim et al., **Visual analytics: Definition, process, and challenges**, 2008.

[3] EMIG et al., **Crime analysis–a selected bibliography**. Washington, DC: US National Criminal Justice Reference Service, 1980

[4] FELSON, M.; BOBA, R. L. **Crime and everyday life**. [S.l.]: Sage, 2010.

[5] SANTOS, R. B. **Crime analysis with crime mapping.** [S.l.]: Sage publications, 2016

[6] WANG, T.; RUDIN, C.; WAGNER, D.; SEVIERI, R. **Learning to detect patterns of crime**. In: SPRINGER

[7] EAGLIN, T.; CHO, I.; RIBARSKY, W. **Space-time kernel density estimation for real-time interactive visual analytics.** In: Proceedings of the 50th Hawaii International Conference on System Sciences

[8] NETO, J. F. de Q.; SANTOS, E. M. dos; VIDAL, C. A. **Mskde-using marching squares to quickly make high quality crime hotspot maps**. In: IEEE. Graphics, Patterns and Images.

[9] ZHOU, G.; LIN, J.; ZHENG, W. **A web-based geographical information system for crime mapping and decision support**. In: IEEE. Computational Problem-Solving (ICCP), 2012 International Conference on

References (2)

[10] XIANG, Y.; CHAU, M.; ATABAKHSH, H.; CHEN, H. **Visualizing criminal relationships: Comparison of a hyperbolic tree and a hierarchical list. Decision Support Systems.**

[11] CALHOUN, C. C.; STOBBART, C. E.; THOMAS, D. M.; VILLARRUBIA, J. A.; BROWN, D. E.; CONKLIN, J. H. **Improving crime data sharing and analysis tools for a web-based crime analysis toolkit: Webcat 2.2.** In: IEEE.

[12] MALIK, A.; MACIEJEWSKI, R.; COLLINS, T. F.; EBERT, D. S. **Visual analytics law enforcement toolkit.** In: IEEE.

[13] GODWIN, A.; STASKO, J. **Hotsketch: Drawing police patrol routes among spatiotemporal crime hotspots**. In: Proceedings of the 50th Hawaii International Conference on System Sciences.

[14] SILVA, L. J. S.; GONZÁLES, S. F.; ALMEIDA, C. F.; BARBOSA, S. D.; LOPES, H. **Crimevis: An interactive visualization system for analyzing crime data in the state of Rio de Janeiro**. 2017

[15] POVEDA, A. C. **Violence and economic development in colombian cities: a dynamic panel data analysis.** Journal of international development,

[16] ALVES, L. G.; RIBEIRO, H. V.; MENDES, R. S. **Scaling laws in the dynamics of crime growth rate**. Physica A: Statistical Mechanics and its Applications,

References (3)

[16] GRUENEWALD, P. J.; FREISTHLER, B.; REMER, L.; LASCALA, E. A.; TRENO, **A. Ecological models of alcohol outlets and violent assaults: crime potentials and geospatial analysis.**

[17] MCCORD; RATCLIFFE. **Intensity value analysis and the criminogenic effects of land use features on local crime patterns.** Crime Patterns and Analysis

[18] CAPLAN, J. M.; KENNEDY, L. W. **Risk terrain modeling manual**. Rutgers Center on Public Security, Newark, 2010.

[19] BENNETT, T.; HOLLOWAY, K.; FARRINGTON, D. P. **Does neighborhood watch reduce crime? a systematic review and meta-analysis.** Journal of Experimental Criminology

[20] PATTAVINA, A.; BYRNE, J. M.; GARCIA, L. **An examination of citizen involvement in crime prevention in high-risk versus low-to moderate-risk neighborhoods.** Crime & Delinquency.

[21] http://produtos.seade.gov.br/produtos/ivj/index.php?tip=map&mapa=12,

[22] KIM, H.; PARK, H. **Sparse non-negative matrix factorizations via alternating non-negativityconstrained least squares for microarray data analysis.** Bioinformatics, Oxford University Press

References (4)

[17] **Garcia-Zanabria, G.,** Silveira, J. A., Poco, J., Paiva, A., Nery, M. B., Silva, C. T., & Nonato, L. G. (2019). CrimAnalyzer: Understanding crime patterns in São Paulo. IEEE TVCG.

[18] **Garcia-Zanabria, G.,** Gomez-Nieto, E., Silveira, J., Poco, J., Nery, M., Adorno, S., & Nonato, L. G. (2020, November). Mirante: A visualization tool for analyzing urban crimes. In 2020 33rd SIBGRAPI Conference on Graphics, Patterns and Images (SIBGRAPI) (pp. 148-155). IEEE.

[19] **Garcia-Zanabria, G.,** Raimundo, M., Poco, J., Batista Nery, M., Silva, C., Adorno , S., Nonato, G. CriPAV: Street-Level Crime Patterns Analysis and Visualization. IEEE Transactions on Visualization and Computer Graphics. **Submitted: TVCG, 2020**.

[20] Alvarenga Silveira, J., **Garcia-Zanabria, G.,** Paiva A., Piccirillo D.,Batista Nery, M., Adorno S., Luis Gustavo Nonato. TensorAnalyzer: A New Approach to Identify Representative Patterns Based on Tensor Decomposition. Submitted: TDS, 2020.

[21] Alvarenga Silveira, J., **Garcia-Zanabria, G.,** Paiva A., Piccirillo D.,Batista Nery, M., Adorno S., & Luis Gustavo Nonato(2019). São Paulo City Schools and Their Surroundings: from Non-Negative Tensor Factorization to Pattern Identification. XL Congresso Nacional de Matemática Aplicada e Computacional.

Thank you
Obrigado
Gracias

Germain García Zanabria
germaingarcia@usp.br

Visual Analytics for Urban Crime Analysis

Visual Geometric Processing Group
USP - São Carlos