Efficient allocation of law enforcement resources using predictive police patrolling

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Abstract

- In this work we adapt and fully implement Mohler et al. (2011) crime prediction model to the operative routines of the District Security Office and the Metropolitan Police of Bogota, Colombia.
- The results of the model serve as a tool for the efficient allocation of police resources.

Motivation

- Criminality is one of the biggest challenges mega-cities face.
- Policy makers have to efficiently allocate scarce law enforcement resources on a vast and highly dynamic environment: hard problem with no trivial solution.
- During 2012 and 2015 all murders and 25% of all crimes reported in Bogota took place in just 2% of street segments. Yet, these same road segments received less than 10% of effective police patrolling time.

Spatio-temporal model

- The model implemented to estimate crime intensity in Bogota, follows closely the methodology proposed by Mohler et al. (2011) in their work *Self-Exciting Point Process Modeling of Crime*.
- In a previous study, Barreras et al. (2019) found that this model has the greatest predictive power among a family of crime prediction models applied to real data from Bogota.

Methodology review

This model is constructed under three assumptions:

1. Criminality concentrates in specific areas of the city.
2. Higher incidence of crime at certain times of the day and certain days of the week.
3. Crime spreads from place to place as seismic activity.

Methodology review

With these considerations we estimate the following intensity function:

$$\lambda(x, y, t) = \underbrace{\mu(x, y, t)}_{\substack{\text{spatio-temporal} \\ \text{patterns}}} + \sum_{\substack{\text{past} \\ \text{crimes}}} \underbrace{g(x - x_k, y - y_k, t - t_k)}_{\substack{\text{aftershock} \\ \text{patterns}}}$$

The estimation is based on stochastic declustering techniques and Kernel Density Estimation with variable bandwidth.

Methodology adaptation

The temporal unit of analysis is defined as follows:

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
22:00 - 05:59	**Shift 1**				**Shift 4**		
06:00 - 13:59	**Shift 2**				**Shift 5**		
14:00 - 21:59	**Shift 3**				**Shift 6**		

Table: Temporal unit of analysis.

- Takes into account the 3 patrol turns defined by the Police.
- Create two groups of days to capture differences in criminal behavior: weekdays and weekends.

Methodology adaptation

- A kernel μ was estimated for each shift, capturing spatial patterns of the crimes occurring in the respective Police turn.
- The final output of the model are two hotspots for each locality.

Predictive power

- To evaluate the predictive capacity of the model of crime we use the following metrics:

$$\text{Hit Rate} = \frac{\#\text{ Crimes in predicted hotspots}}{\#\text{ Crimes}}$$

$$\text{Predictive Accuracy Index} = \frac{\text{Hit Rate}}{\%\text{ Covered area}}$$

Train-test procedure

- Training set: 15 May - 15 August, 2018.
- Test set: 16 August - 16 October, 2018.
- It is considered that the model correctly identifies a crime if it occurs within a radius of 100m from the centroid of a hotspot.

Results

- On aggregate, the model captures 3.11% of the crimes, on average for each shift.
- Bearing in mind that for each shift the 38 hotspots (2 for each locality) considered cover 0.14% of Bogota's area, a PAI equal to 22.29 is obtained.

Implementation

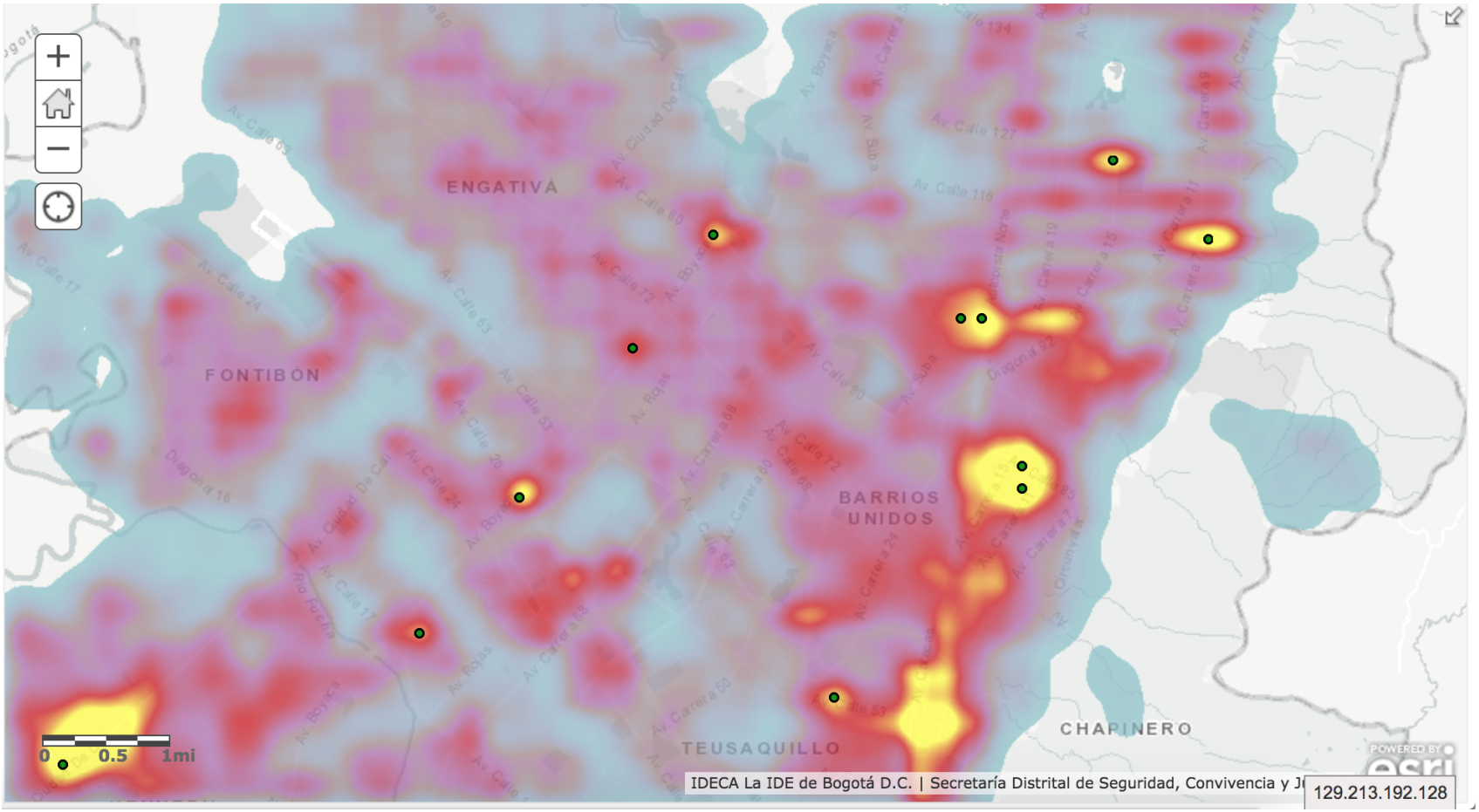
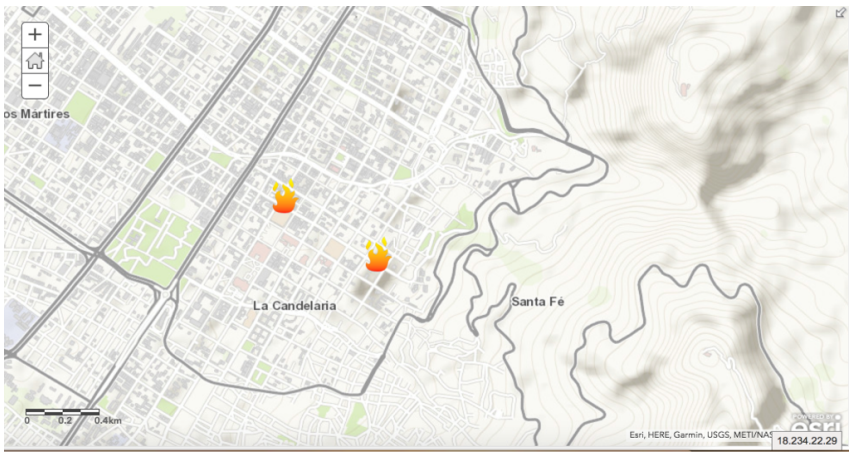
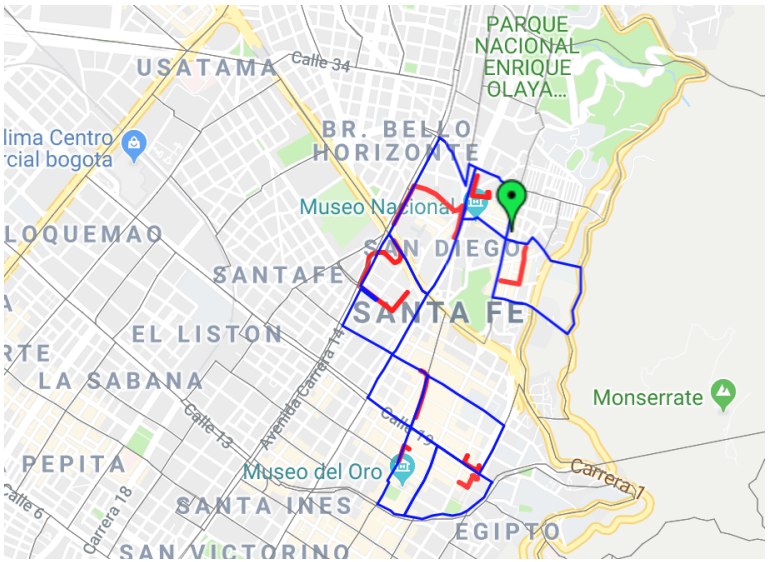


Figure: Heat map in the GIS server of the Security Office.

Implementation



(a) Identified critical hotspots.



(b) Suggested patrol routes.

Figure: Main features of the deployed model.

Application to the surveillance cameras system

- The hotspots prediction model extends naturally to the city's surveillance cameras system.
- Allows to prioritize the cameras that must be watched.
- Based on the estimated intensity of crime in places that have cameras installed.

Adaptation

For this exercise the temporal unit of analysis is defined as follows:

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
22:00 - 05:59	**Shift 1**	**Shift 4**	**Shift 7**	**Shift 10**	**Shift 13**	**Shift 16**	**Shift 19**
06:00 - 13:59	**Shift 2**	**Shift 5**	**Shift 8**	**Shift 11**	**Shift 14**	**Shift 17**	**Shift 20**
14:00 - 21:59	**Shift 3**	**Shift 6**	**Shift 9**	**Shift 12**	**Shift 15**	**Shift 18**	**Shift 21**

Table: Temporal unit of analysis.

- Takes into account the 3 patrol shifts defined by the Police for each day of the week.
- Same train-test procedure.
- Hit Rate as a measure of predictive power.

Results

Monitoring the 10% of the cameras with the highest estimated intensity of crime, the model identifies:

- 21.77% of the reported crimes.
- 25.01% of the reported crimes occurring near any surveillance camera.

Implementation

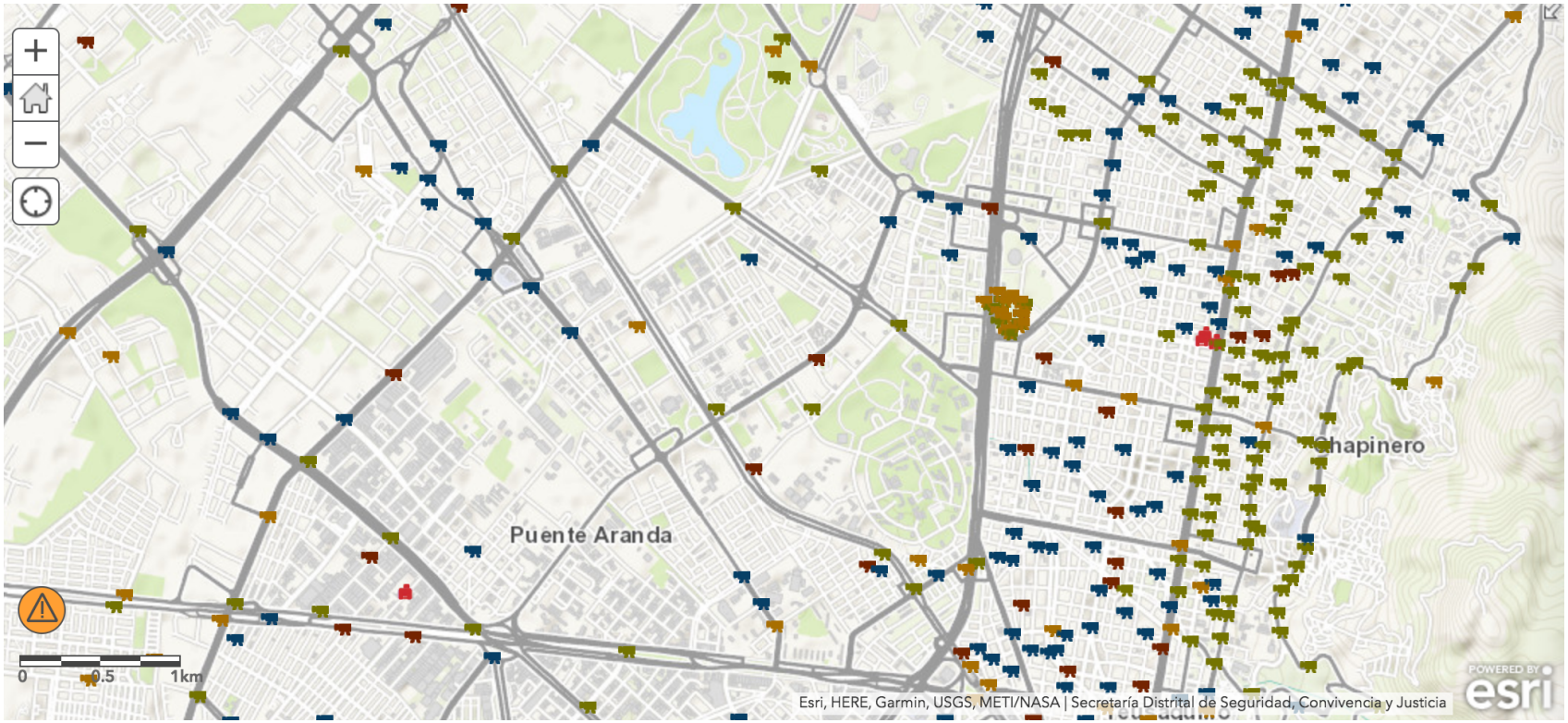


Figure: Surveillance cameras system prioritized.

Input for the Location-allocation of new police stations

- Using isochronous analysis and the heat map predicted by the trained model, we were able to identify highly vulnerable regions of the city without a nearby police station.
- Then the Location-allocation problem is solved suggesting where a new police station should be placed.

Results

Figure: Suggested location of new police station.

(Principal) References

- Mohler, George O and Short, Martin B and Brantingham, P Jeffrey and Schoenberg, Frederic Paik and Tita, George E. (2011). Self-exciting point process modeling of crime. *Journal of the American Statistical Association Volume 106, Issue 493.* Pages 100-108.
- Barreras, F., Diaz, C., Riascos, A. y M. Ribero (2019). Comparación de diferentes modelos para la predicción del crimen en Bogotá. *Economía y seguridad en el posconflicto.* H. Zuleta, Ed.