

A Spatiotemporal Analysis of Police Efficiency and the Prediction of Crime by Type in Philadelphia

Dhruv Sharma zccads0@ucl.ac.uk

Jonathan Lim zcahwsj@ucl.ac.uk

Raghavendra Narayan Rao rn436@cam.ac.uk

Vivian Wang ww404@cam.ac.uk

July 16, 2023

Abstract

The use of predictive policing in tackling crime has been largely employed in recent years, however it is yet determined whether it has been effective in distributing police force. In this paper, we propose an approach using heatmaps to analyse the effectiveness of such methods in improving urban safety. Moreover, a ML model was created to determine the types of crime that are most likely to occur at a given location and time. Experiments demonstrate that our method achieves high accuracy.

Introduction

Predictive policing has been extensively studied, with recent models achieving over 90% accuracy [1]. However, this is not without pushback. The use of such models can create a bias in police response and reduce accountability, leading to the excessive use of force by police [2]. Such concerns have led to the boycott of work in predictive policing by over 1,400 researchers in the American Mathematical Society [3].

In this paper, we examined whether such predictive policing models are required in improving urban safety. To do so, we plotted spatiotemporal data of crime in Philadelphia to determine whether police are efficient in predicting the location of crimes without the use of predictive policing software. We then proceeded to create a model which predicts the types of crimes which will occur to help police be ‘well equipped’ for the time the crime occurs. This allows police to be able to respond to crime usefully without instilling bias of where the crime may occur.

Spatiotemporal analysis

To determine whether the police are effective in predicting crime without the use of predictive policing, we could plot heatmaps of where police conduct traffic stops and the places where the traffic stops

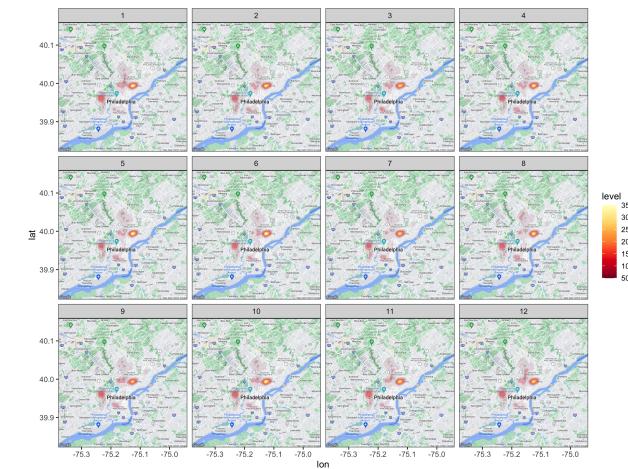


Figure 1: Heatmap of all traffic stops between 2014-2017 in Philadelphia, plot using R.

result in someone being arrested for a crime. If the heatmaps are target the same locations, police strategy is effective.

Data from 2014-2017 was used. From both figures, we can see that the police target traffic stops effectively around where crimes occur. Thus, predictive policing software may not be needed as police are already effective in locating crime. The use of such models may just reinforce bias of crimes occurring in these neighbourhoods and lead to the excessive use of force and decreased accountability.

ML Model

Since the spatiotemporal analysis suggests the effectiveness of current methods deployed by the police in determining location of the crime, it may serve useful to also know the type of crime so strength can be allocated efficiently.

Type of Model

An Artificial Neural Network from tensorflow.keras is trained on Date and Time data (from crimes.csv) as inputs and the corresponding type of crime is used

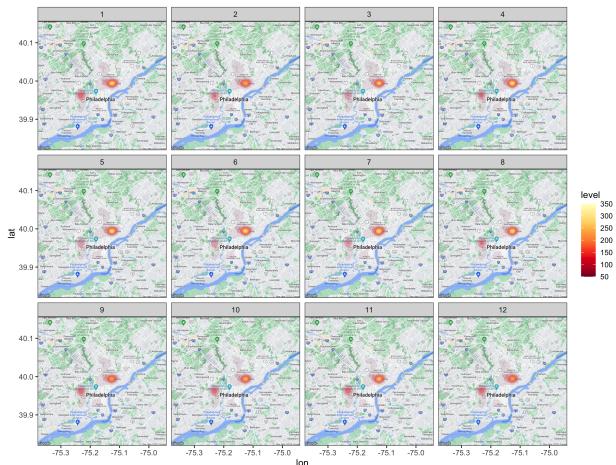


Figure 2: Heatmap of traffic stops where a person was arrested between 2014-2017 in Philadelphia, plotted using R.

as output. Fine tuning an existing model was ruled out due to the niche data set.

Avoid Over Fitting

The loss is plotted against epochs to determine the ideal number of epochs to avoid over fitting. The loss function used for our model is categorical cross-entropy. From Figure 3, optimal epochs = 46

Best Model Architecture

Cross validation is used to compare the mean loss of 3 models with different number of layers capped at 46 epochs (**optimal**). The best model is the model with 2 layers (Figure 4).

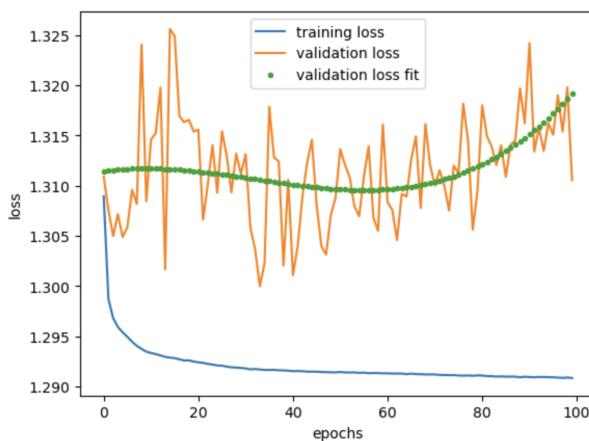


Figure 3: Loss against Epochs

Models	Mean Loss
Dense(64) Dense(32) Dense(16) Dense(6)	0.443
Dense(32) Dense(16) Dense(6)	0.420
Dense(16) Dense(6)	0.416

Figure 4: Cross Validation

Conclusion

In this paper, we examined the usefulness of predictive policing for crime and came to the conclusion that the use of such methods is minimal as currently police locate crime rather accurately. That being said, it is possible that our method for accuracy measurement can be improved by utilising a more rigorous correlation than Heatmaps.

Furthermore, we proposed a machine learning model which predicts the type of crime that may occur. This could help police in effectively distributing forces and ensuring the safety and success of response to crime.

References

- [1] Matt Wood. *Algorithm predicts crime a week in advance, but reveals bias in police response*. June 2022. URL: <https://biologicalsciences.uchicago.edu/news/features/algorithm-predicts-crime-police-bias>.
- [2] Jonathan Li et al. *Pitfalls of Predictive Policing: An Ethical Analysis*. May 2022. URL: <https://vce.usc.edu/volume-5-issue-3/pitfalls-of-predictive-policing-an-ethical-analysis/>.
- [3] Davide Castelvecchi. *Mathematicians urge colleagues to boycott police work in wake of killings*. June 2020. URL: <https://www.nature.com/articles/d41586-020-01874-9>.