Force Contact Predictions

Data Analytics Lab

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2 Executive Summary

In an era of funding awareness and a general aim of maximising the use of resources, police forces must maximise efficiency and demonstrate value for money to maintain high service standards. A key strategy for optimising limited resources lies in ensuring appropriately trained personnel are deployed to the right places at the right times.

Given the need to provide the best service with the resources available, this project aims to provide information as to the best patrolling strategy over both time and space; best being the greatest potential for crime harm reduction.

The output is patrolling plans based on a number of factors including length of time at each hotspot and timing of patrol.

3 Introduction

In an era of funding awareness and a general aim of maximising the use of resources, police forces must maximise efficiency and demonstrate value for money to maintain high service standards. A key strategy for optimising limited resources lies in ensuring appropriately trained personnel are deployed to the right places at the right times. This project aims to help with this via exploring how targeted patrol planning, leveraging geospatial analytics and large-scale simulation, can achieve this.

"Right place" in this case refers to deploying officers to crime hotspots, a practice already employed in initiatives like Targeted Guardian Patrols. However, "right time" is equally crucial as crime is temporal, fluctuating throughout the day and varying by type. Effective crime reduction / prevention (via patrolling) would require patrolling hotspots during their peak activity periods.

Officers conduct patrolling tours, visiting various hotspots during their shifts. Optimising these tours requires considering multiple factors: the daily and weekly variation in crime rates at each hotspot (e.g., school zones versus nightlife areas), the distances between hotspots to minimise travel time, and the impact of time of day and day of week on travel speeds.

This report details a novel approach using geospatial analytics to identify hotspots and their crime rates, combined with large-scale simulation to generate optimal patrol plans for diverse scenarios. For example, given a unit being available for patrol in Walsall between 2 PM and 8 PM, the simulation can determine the most impactful sequence of hotspot visits to maximise crime reduction.

4 Methodology

4.1 Hotspot Identification

Crime hotspots were automatically identified using Kernel Density Estimation (KDE). This method overlaid a fine grid (20m squares) across the West Midlands and smoothed historical crime location data to generate a crime intensity value for each grid square. Higher values indicate a greater concentration of past crime. The analysis focused on specific crime types (which are listed in the Appendix).

To ensure the identification of both major and minor hotspots, the KDE calculation was performed at the sector level, rather than the larger Local Policing Area (LPA) level. Analysing at the LPA level would have risked masking smaller, but still significant, hotspots due to the overwhelming intensity of city centre crime (analogous to the sun's brightness obscuring stars).

A relatively small sigma (80m) was used in the KDE calculation to enhance the identification of smaller hotspots. The crime intensity of each grid square was then ranked, and the top 4% were selected. Contiguous high-intensity squares were aggregated into single hotspot polygons. Polygons smaller than 0.04 km^2 were excluded, as they were deemed too small to warrant dedicated patrols. Each sector's hotspots were visualised, and the sigma altered to produce the expected amount and sizes of polygons.

4.2 Simulation – Hotspot Patrol Sequences

A simulation approach was employed to identify optimal hotspot patrol sequences. This involved exploring all possible sequences and ranking them based on a defined scoring methodology (see below).

The number of possible sequences grows exponentially. For example, with four hotspots (A, B, C, and D), there are four possible one-hotspot tours, twelve two-hotspot tours (AB, AC, AD, BA, etc.), and so on. With 20 hotspots and a desire to visit 7, the number of possible sequences reaches approximately 390 million. These are permutations without replacement, as each hotspot can be visited only once.

The simulation models real-time patrols. Given a patrol window (e.g., 7 AM to 1 PM), the simulation begins with the officer leaving the station at the start time. For each potential sequence, the simulation proceeds as follows:

1. Travel Time Estimation: Based on the time of day, day of the week, and distance, the expected travel speed between the station and the first hotspot is estimated.
2. Arrival Time Calculation: Using the estimated speed and the Manhattan distance, the expected arrival time at the first hotspot is calculated.
3. Patrol and Repeat: The officer remains at the hotspot for a designated patrol duration (e.g., 0.5, 1, or 2 hours) and then departs. Steps 1-3 are repeated until the end of the current sequence (returning to the station).

4.3 Scoring Methodology

The simulation assigns points for each hotspot visited. Recognising that an optimal tour maximises visits to the most active hotspots during peak crime times, the scoring system incentivises this behaviour.

Each visited hotspot earns points equal to half of its average hourly Cambridge Crime and Harm Index (CCHI). This ensures the most active hotspots are visited. The value was halved as without this reduction, the results were too heavily biased towards the larger NTE hotspots, even at 8am. Additionally, a bonus score is awarded based on the average of the CCHI values at the arrival, mid patrol and departure times, rewarding patrols during peak crime periods. The scoring system does not explicitly penalise factors like long travel times; however, these factors implicitly lead to lower scores, as they reduce the number of hotspots that can be visited within a given timeframe.

5 Exploratory Data Analysis

As can been from the chart below (and as would perhaps be expected given the crime types), the greater number of crimes occur on a Friday and Saturday.

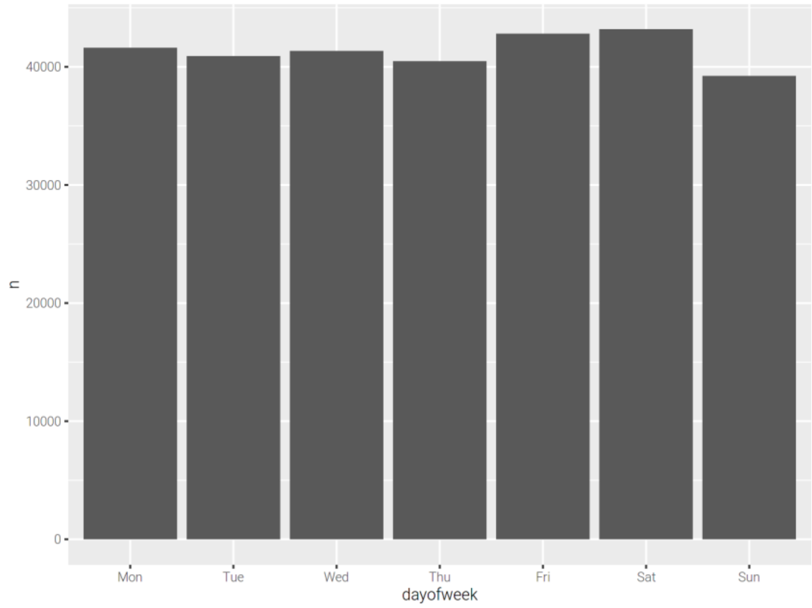

Figure 1: Crimes on days of the week

There are however some differences between the different crime types:

Figure 2: Crime numbers and day of the week by crime type

Theft and vehicle offences have a different profile with Monday – Wednesday having a higher number of crimes. The Friday and Saturday are prevalent for violence against the person.

In terms of the harm arising from crime, the profile is similar to the number of crimes:

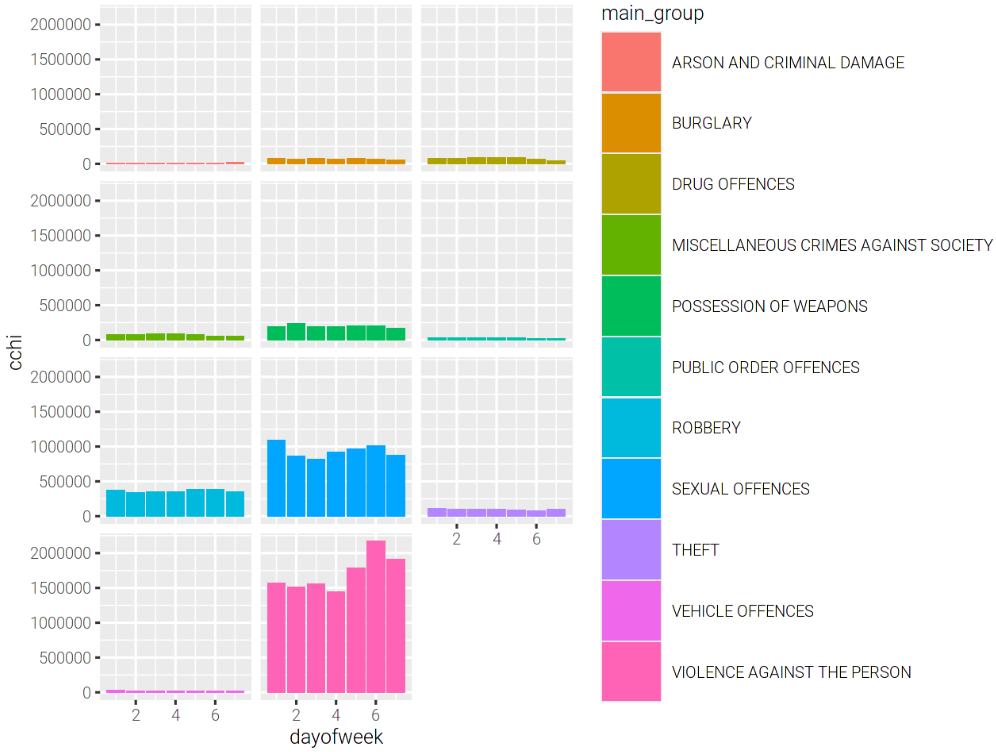

Figure 3: Harm arising from crime by day and type

In terms of the hour of the day, overall the largest frequency of crimes is between 15:00 and 0:00 the following day:

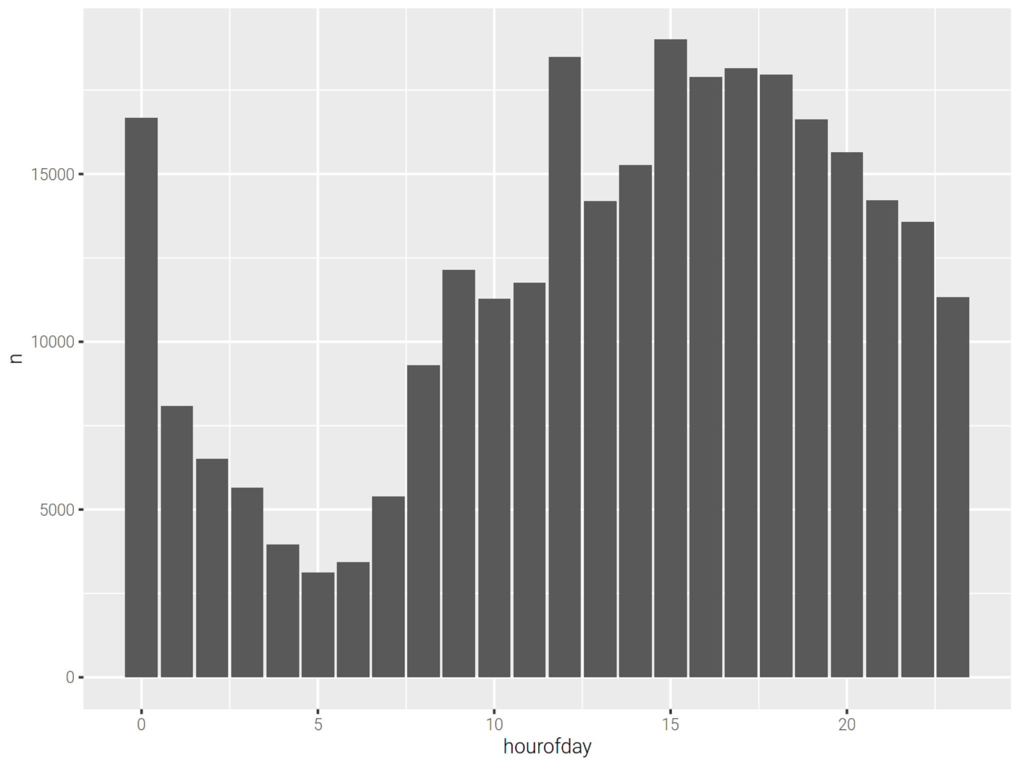

Figure 4: Number of crimes by hour

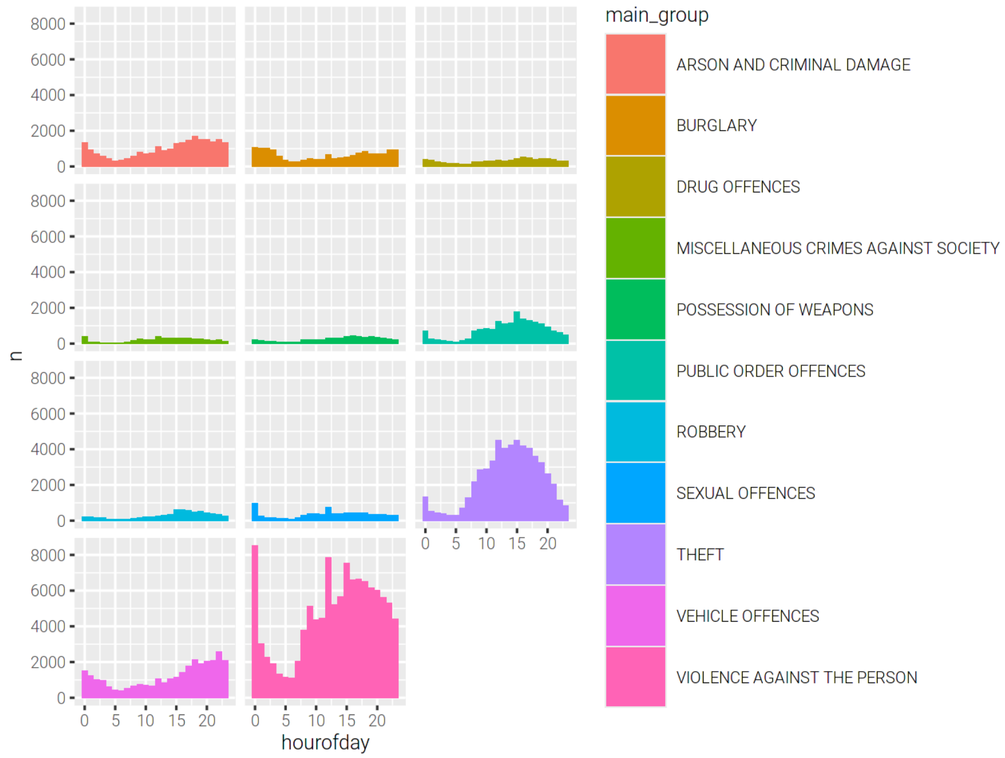

Figure 5: Number of crimes by hour of day by type

All the crime types in this case follow the same pattern as the total crime shown in figure 4 (albeit to varying degrees). Crime harm also shows essentially the same hourly pattern.

An example of the hotspots is provided below for Wolverhampton outer (the sector that excludes the Wolverhampton City Centre):

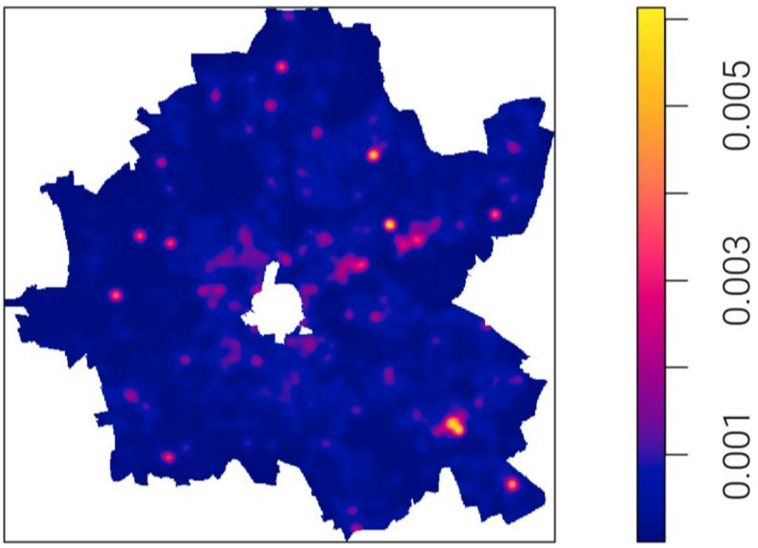

Figure 6: Example of hotspots, Wolverhampton Outer

6 Conclusion

Given the need to provide the best service with the resources available, this project aims to provide information as to the best patrolling strategy over both time and space; best being the greatest potential for crime harm reduction.

An example, starting and ending from Wolverhampton central station during a weekday with 30 minutes at each hotspot for a total of 4 hours by 1 unit:

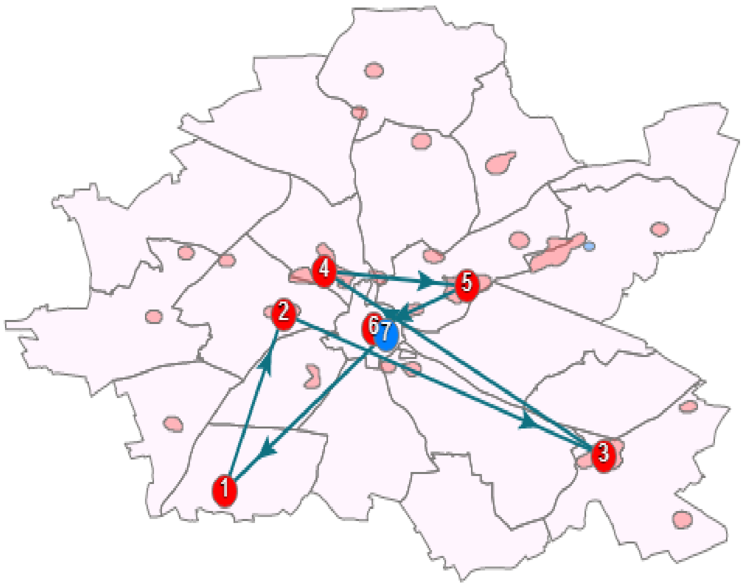

Figure 7: Example of output

Appendix

Crime types

'ARSON AND CRIMINAL DAMAGE', 'BURGLARY', 'DRUG OFFENCES', 'MISCELLANEOUS CRIMES AGAINST SOCIETY', 'POSSESSION OF WEAPONS', 'PUBLIC ORDER OFFENCES', 'ROBBERY', 'SEXUAL OFFENCES', 'THEFT', 'VEHICLE OFFENCES', 'VIOLENCE AGAINST THE PERSON'

Crimes Excluded:

'DEATH OR SERIOUS INJURY-UNLAWFUL DRIVING'