

Methods and application of strategic GIS analyses of different crime types

Identifying statistically significant crime hotspots/coldspots over a macro environment for annual reviews in an automated workflow

Kantonspolizei AG (Kapo AG) currently uses kernel density estimation (KDE) to visualize the distribution of crime in the canton of Aargau. Kapo AG wants to overcome the limitations of KDE and provide more precise information on crime hotspots. This thesis focuses on the evaluation of hotspot methods and the definition of optimal parameters for three different crime types (Fig. 1a) to facilitate the work of Kapo AG through an automated workflow.

KDE Limitations

Although the KDE is aesthetically pleasing (Fig. 1b), the results are prone to subjectivity. KDE often only reflects densely built-up areas and smooths into areas without crime, like bodies of water. The most important limitation: KDE does not use statistics to determine which area is significantly hot/cold. The literature shows that **Getis-Ord Gi*** and **Local Moran's I** are best suited to overcome KDE limitations.

What is a hotspot?

A hotspot is an area with a high/low concentration of crime compared to the distribution of crime throughout the study area (Chainey & Ratcliffe, 2005). Both methods detect hotspots based on spatial statistics. While Gi* informs the user about hotspots with confidence levels, Local Moran's I enables the detection of outliers in addition to the hotspots. They both require an aggregation of points (Fig. 1a) into polygons.

Exploring the input parameters

The experiment includes several analyses in ArcGIS to determine the optimal parameters for three crime types - burglaries, thefts from vehicles and violence in public spaces. Both methods require similar input parameters - including input features with numerical values (>0, 0 and NULL) and neighborhood definition (e.g. distance band). An interview with Kapo AG defined the aggregation form and size to a hexagonal 25ha shape for all three crime types. The exploration resulted in crime type dependent parameters for the neighborhood definition and input features.

To evaluate the detected hotspots for Getis-Ord Gi* (Fig. 1d) or Local Moran's I (Fig. 1c), the literature recommends to use more than one method, as shown in Fig. 1b, 1c, 1d and 1e. The results are only comparable if the same parameters are used, wherever possible.

Facilitating the visual interpretation and execution of analyses

Although ArcGIS provides intuitive default legends for both methods (Fig. 2), the colors are not optimal for grayscale. The exploration leads to a change in the color of the Local Moran's I legend (Fig. 2a). Gi* colors should be checked as soon as coldspots occur, because the results in Fig. 1d show no coldspots. An additional visualization in the form of bar charts indicating the number of incidents supports the interpretation of the hotspot map (Fig. 1f).

The manual workflow is the basis of the created toolset in ArcGIS. The aim is to minimize user input and make the annual analyses as simple as possible. Each nested model can be used individually for further exploration. The toolset was successfully tested for each crime type and the years 2020 - 2023, achieving the same results as the manual workflow.

Key take-aways and outlook

The results show that two methods - Getis-Ord Gi* and Local Moran's I - allow to detect hotspots/coldspots using spatial statistics and they minimize KDE limitations. The experiments using both methods with varying parameters conclude crime type dependent user input. The thesis lists the recommendation in the form of an interpretation catalog, where an adequate visual representation is also provided. The created toolset aims to facilitate annual hotspot analyses using the recommended input parameter. In summary, this thesis successfully created a catalog of methods, recommendations and visualization as well as a toolset that facilitates the work of Kapo AG in strategic crime analysis.

In the future, Kapo AG will integrate and test the created toolset and expand the interpretation catalog. If it proves successful, the thesis recommends further research into the use of spatio-temporal analysis and visualization using space-time cubes.

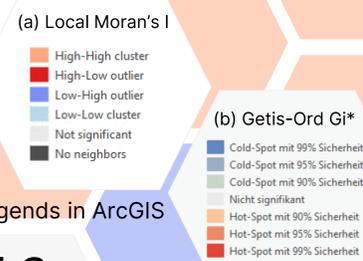


Fig. 2: Legends in ArcGIS

Fig. 1: All results from the explorative analyses based on initial crime points for burglaries 2022

