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*ivan.dominik1996@gmail.com***THE NEW POSSIBILITIES OF GEOGRAPHIC INFORMATION SYSTEMS  
DURING CRIMINAL INVESTIGATION****Abstract**

The use of visual aids (maps) to determine criminal activity is not a new concept in the world of law enforcement. In the beginning, the common practice meant putting pins into paper maps displayed on the walls, then entering the data into a spreadsheet. Currently, the number of different software companies providing Geographic Information System (GIS) services are growing each year. This increase is accompanied by the development of the data entry process, the maintenance costs of the system, and the increase in the number of users using the system. When we look at the challenges that law enforcement agencies face daily, the implementation of the GIS can provide another strategic tool for the police force against crime. This study aims to present and analyze the methods offered by GIS and their applications. Furthermore, the aspects of GIS related to crime analysis will be examined, and its concrete application in practice will be presented.

**Keywords:** geographic information system, geography of crime, predictive policing, geoinformatics, crime

**1. Introduction**

Geographic profiling basically requires the use of GIS, which is an automated system for recording, storing, retrieving, analyzing, and displaying spatial data. (Márkus 2020)

The data describe both the location and the attributes of spatial features. For example, describing a road requires reference to its location (i.e., where it is) and its attributes (e.g., length, name, speed limit, and direction). GIS enables the user to manage road information and many other geospatial data, thus distinguishes them from corporate management and other IT systems dealing with non-spatial data. Commercial or open-source GIS software includes programs and applications that a computer can run for data management, data analysis, data

visualization, and other tasks. In a GIS, additional applications can be used for special data analyses. (Steele 2018, Chang 2016).

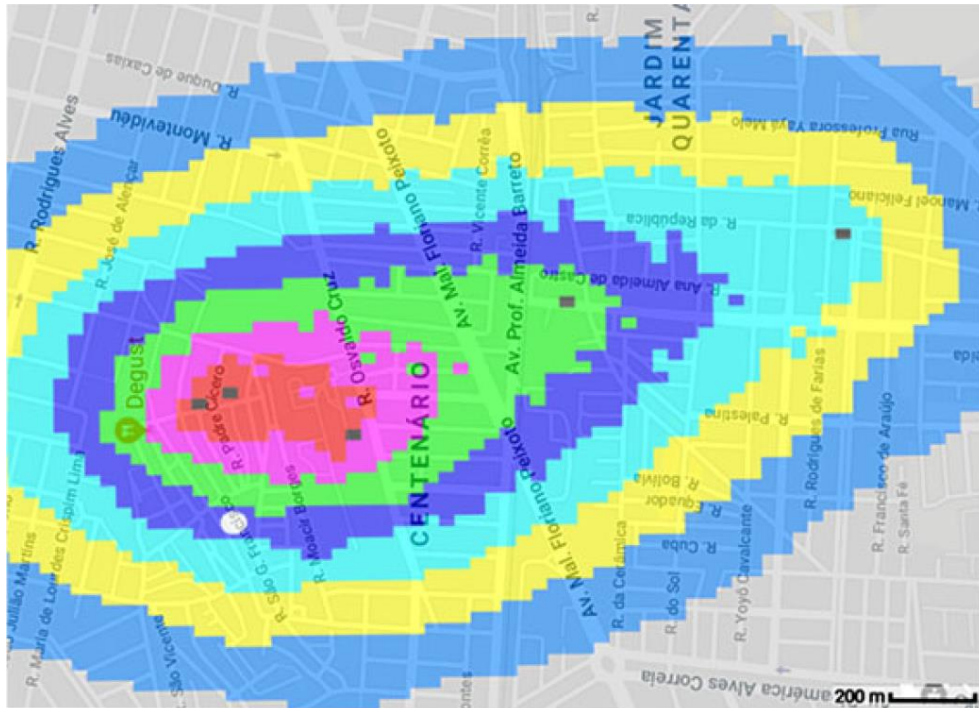
GIS is a complex database system that contains information about the coordinates of the location of spatial objects and allows various procedures to be performed. In addition, GIS is a tool for micro-, meso-, and macro-scale geographic research, which leads to visualization, but also to the solution of spatial planning, management, and modeling problems (Bujdosó 2009). It should be added that the ways and methods of processing data on geographic objects, as well as the goals of the systems, can differ significantly. The created model of the geographic environment included in the database is the starting point for the analysis of the objects, after determining their characteristics, location, class, quantitative and qualitative characteristics but also the relationships among them. GIS provides an insight into crime prevention efforts by predicting hot spots. These hot spots are key to taking a proactive stance to stop crimes before they happen. The collected data are useful in identifying trends (Goniewicz 2021).

## **2. Geographic Information Systems in Law Enforcement**

### **2.1. The Dragnet Geographic Information System**

Currently, there are four popular GIS systems used for profiling (Dragnet, Rigel, CrimeStat, Predator), which are used by law enforcement agencies in many countries. These systems can be considered as useful estimation tools for the probable determination of crime areas (Willmott et al. 2021).

For example, Dragnet is a GIS that was developed specifically as an operational decision support tool in response to the need to provide investigators with greater opportunities to identify and apprehend serial offenders. Based on the principle of minimum effort, Dragnet uses a negative exponential algorithm based on the distance decreasing function. If crime location information within a given crime sequence has been once calculated and entered into the GIS, Dragnet creates mathematically based models of crime scenes, allowing potential search regions to be determined (Figure 1) (Steele 2018).



1. Figure: Dragnet in practice

Source: Willmott et al. 2021

The software is able to present the results of this mathematical algorithm projected onto the identified crime scenes even more significant from the detective's point of view, with the help of such an empirically generated model (Figure 1). It is worth noting to Dragnet, that there are several alternative geographic profiling systems, such as the Rigel Criminal geographic system and the Predator system, which are based on similar mathematical algorithmic principles as Dragnet (Willmott et al. 2021). As with any predictive modeling technology or system, results depend on the accuracy and relevance of the data. As the nature and context of crime and forensics continue to evolve and change, so must the empirical evidence supporting geographic profiles from these systems to ensure accuracy and effectiveness. As the probability regions move outward through the green, purple, blue, and yellow regions, the likelihood that the offender lives in these areas decreases. It is therefore necessary to consider the factors that can influence the offender's lifestyle or activities, regardless of the expected value (Lino et al 2018). Currently, the study area of systems that are based on geographic profiling are all based on data found in the tangible world, so the geographic profiling of perpetrators of crimes committed in cyberspace is more difficult to solve.

## 2.2. The hardship of Geographic Information Systems

The construction of a GIS system is a complex task, in addition to the cost of the hardware, there is also the cost of training. Frequent updating of the database can lead to errors in the results. Managing growing data sets is a comprehensive challenge for the GIS system. It was mentioned earlier that the accuracy of the map depends on the quality of the input data. As a result, the quality of the collected data directly affects the accuracy of the final system. Geographical errors also affect the final results, since the GIS system handles large-scale data. Not to mention that non-spatial data related to location can also be inaccurate. Inaccuracies can be caused by a variety of errors. The accuracy of non-spatial data can also show large differences. The user group is not limited to authorized persons. Therefore, the use of data displayed from the GIS system is at risk. Incorrect interpretation can lead to the failure of the implementation of the result, and errors may occur at the start, so additional efforts may be needed for the full implementation of the GIS system (Goniewicz 2021).

## 3. The connection between GIS and crime analysis


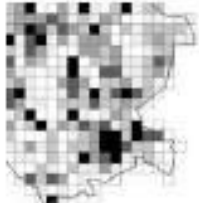

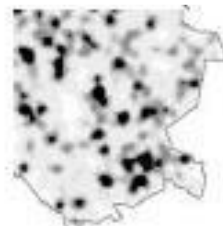
Geospatial information plays a fundamental role in mapping and analyzing crime. The ability to connect and process information, and to display it spatially and visually, allows law enforcement agencies to be faster and more successful. A GIS transforms the physical elements of the real world, such as roads, rivers, mountains, buildings, into forms that can be visualized and analyzed. GIS uses two types of models, vector and raster. The vector deals with discrete objects, and the raster deals with continuous objects (Zahra 2018).

Computer crime maps were created for the first time in the 1960s and 1970s. In the 1990s, Geographic Information Systems became widely available on the market, and in the late 1990s, criminologists and police units began GIS analysis. Spatial analysis of crime using a geographic system and spatial statistics is now widely used to analyze the mass occurrence of crimes to reveal the unequal distribution of crime risks and the spatial interactions between crimes. In 1978, Robert A. Baron and his colleagues found a correlation between violent crime and temperature. A series of experiments were conducted on the effects of high temperatures on aggressive behavior. These researches suggest that there is a connection between aggression and high temperatures, i.e. aggression increases under the influence of heat. The use of modern techniques, machines and computers presents new challenges to the police in every country. With the help of the GIS module, the police and investigative authorities can assess the geographical location of crimes and predict the place where the crime was committed.

#### 4. Hotspot analysis

The concept of hotspot is used by science in two areas. In geological science, the meaning of a hot spot is nothing more than an area on the tectonic plate where magma from the depths of the mantle pierces to the surface. Criminology, on the other hand, uses the term hotspot for small areas where crime is more frequent than in neighboring areas (Mátyás 2020). The hotspot technique is basically used to identify areas with high crime rates. The analysis tool identifies spatial groups of statistically significant high or low value attributes. Hotspot mapping is based on the hypothesis that high crime region points will appear as groups in a spatial distribution. Hotspots provide crime analysts with a graphical representation of crime-related problems. Detecting the location and cause of crime can improve the fight against crime. In the near future, hot spot mapping and geospatial information may support law enforcement activities. Geospatial informatics and crime analysis can show a comprehensive connection between the crime, the victim and the perpetrators (Zahra 2018).

Commonly used types of hotspot analysis are:

Name	Method	Advantages
<b>Spatial Ellipse</b> 	It uses spatial and temporal analysis of crime to identify hotspot areas and fits an ellipse to each hotspot.	The size and location of each hot spot becomes easily visible. There is no need to rely on defined geographical boundaries.
<b>Grid Based Mapping</b> 	By drawing uniform grids over a survey area, it shades the area within each grid square according to crime data.	Grid squares of the same size mean that hotspot areas can be easily identified without risk of misinterpretation.
<b>Geographic Area Based Mapping</b> 	Hotspots are based on specific administrative or political areas. Each is thematically mapped based on the number of crimes that occur in them.	It reflects the areas and boundaries used by organizations. The prepared thematic maps are logical and easy to understand.
<b>Density Estimation</b> 	Creates a spatially distributed plot by aggregating point data within a defined search radius.	It represents the spatial distribution of criminal events. There is no need to rely on specific geographical boundaries.

The analysis of hotspots has become the most widespread application method used by GIS with regard to criminal data, which can be used in a variety of ways these days. For example, crime hotspot maps can be presented during strategic or tactical planning meetings so that decision makers know where to deploy resources such as patrols. Furthermore, police analysts are able to use hotspot analysis when creating a profile of a given crime problem in order to better understand the criminological background that causes it. The better a problem is understood, the better prepared decision makers are to implement successful crime prevention interventions. In addition to the previously mentioned applied forms of criminal analysis, GIS data can be used in various ways in criminological and criminal justice research (Zahra 2018).

#### 4.1. The importance of geographical factors

Geographical knowledge is also necessary for an eligible GIS analysis. The first standpoint is how to represent the data on a two-dimensional map. This involves the use of a projection system, which is a method of projecting the spherical surface of the earth onto a flat plane. Distortions may occur if the projection is not done correctly. Furthermore, in countries with large territories, such distortions can be large. It is not possible to map all data in its original format; sometimes geocoding is required. Geocoding is the process of finding related geographic coordinates from other geographic data, such as street addresses or zip codes. Data useful for criminological and criminal justice work are often collected at the level of administrative areas. Thematic figures, which are shaded in polygonal shapes according to state, county or administrative boundaries, are generally more popular because it is easier for the user to find the connection points.

#### 5. Summary

Computerization and the development of geographic information systems enabled the digital representation of space for the interactive analysis of multiple data in the form of models or simulations. On the other hand, the computerization of the environment has become a new source of danger for the state, society and the individuals themselves, especially in the area of personal data protection. However, technical and technological development seems indispensable nowadays, due to the many possibilities it provides, for example in the field of geographic information. Even today, the GIS system enables the collection, storage, processing, and display of spatial data, which adds a new dimension to public administration activities. For example, in crisis management, the preparedness of the services, inspections, and guards in the event of a disaster is now incomparable compared to previous years. Unfortunately, a GIS system requires appropriate hardware, software, spatial databases, and appropriate procedures for processing and sharing information. This requires not only expensive modernization, but also the maintenance of professional human resources.

The most obvious limitation to the reliability and accuracy of the geographic profiles produced is based on the underlying assumptions that, if inaccurate, can distort or change the likely location of the featured offender and the recommended investigative strategies.

Another limitation of systems that support geographic profiling, such as Dragnet, is that they do not contain information known about the actions of criminals during the commission of their crimes. Computer systems for geographic profiling are generally not able to directly integrate with important information about large numbers of offenders stored in police databases. The

combination of such information would undoubtedly offer greater investigative value than analysis of crime geography alone. Even though geographic information systems that also use geographic profiling make it possible to significantly narrow the range of suspects or to predict the crime itself, investigators must keep in mind the limitations of the method. Any geographic profile should be treated as a possible direction of investigation, while keeping an open eye on other avenues of investigation. Notably, offenders may also be commuter criminals or, because of factors such as limited data sharing between different police forces or agencies, the additional information may result in a slightly different geographic profile.

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