# Proactive Models for Information Support of the Judicial System

# Modelos Proativos de Apoio à Informação do Sistema Judiciário

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## Abstract

In the modern dynamic world, crime is becoming increasingly technologically supported and transnational. This demands that the justice systems of different countries apply innovative approaches and state-of-the-art information technologies to effectively combat it. The presented research proposes a new proactive approach to identifying crime trends, which combines associative rule models and geospatial models. The article aims to develop an information model and implement a new predictive approach to studying crime trends to uncover complex patterns and strong relationship in crime data. The research utilized a comprehensive methodology, incorporating experimental procedures, synthesis methods, associative rule mining for pattern recognition, and geospatial predictive modeling for spatial trend identification and forecasting. Applied models were constructed using real data on criminal cases in the Ternopil region (Ukraine) from 2013 to 2023. Types of crimes and periods with elevated levels of criminal activity, as well as indicators of involvement by organized groups, were identified. Zones of concentrated offenses within the region were visualized. The higher prevalence of crime in urban areas was confirmed. These models can be easily adapted to new data and integrated into a unified information system to support decision-making within the judicial systems of Ukraine and the European Union.

**Keywords:** judicial system, judiciary, court, information technologies, information system, information support, law enforcement agencies.

## Resumo

No mundo moderno e dinâmico, o crime está a tornar-se cada vez mais transnacional e apoiado tecnologicamente. Isto exige que os sistemas judiciais de diferentes países apliquem abordagens inovadoras e tecnologias de informação de última geração para combatê-lo eficazmente. A pesquisa apresentada propõe uma nova abordagem proativa para identificar tendências criminais, que combina modelos de regras associativas e modelos geoespaciais. O artigo visa desenvolver um modelo de informação e implementar uma nova abordagem preditiva para estudar tendências criminais para descobrir padrões complexos e fortes relacionamentos em dados criminais. A pesquisa utilizou uma metodologia abrangente, incorporando procedimentos experimentais, métodos de síntese, mineração de regras associativas para reconhecimento de padrões e modelagem preditiva geoespacial para identificação e previsão de tendências espaciais. Os modelos aplicados foram construídos utilizando dados reais sobre casos criminais na região de Ternopil (Ucrânia) de 2013 a 2023. Foram identificados tipos de crimes e períodos com níveis elevados de atividade criminosa, bem como indicadores de envolvimento de grupos organizados. Foram visualizadas zonas de concentração de ofensas dentro da região. A maior prevalência da criminalidade nas áreas urbanas foi confirmada. Estes modelos podem ser facilmente adaptados a novos dados e integrados num sistema de informação unificado para apoiar a tomada de decisões nos sistemas judiciais da Ucrânia e da União Europeia.

**Palavras-chave:** sistema judicial, judiciário, tribunal, tecnologias de informação, sistema de informação, suporte de informação, agências de aplicação da lei.

# Introduction

The justice system is the foundation of a state's internal security and is aimed at preventing, investigating, and punishing law violations (Kovalchuk *et al.*, 2023. p. 59). It is a complex structure composed of institutions, laws, procedures, and resources directed towards ensuring justice and addressing legal issues within society. The main components of the justice system are the court system, law enforcement agencies, and the Department of Corrections (Singh *et al.*, 2020, p. 143) Courts serve as the central body of the justice system, responsible for hearing various types of cases, including civil, criminal, and administrative. Judges make their decisions based on the law and the facts presented in the case. Law enforcement agencies are responsible for investigating crimes, maintaining public order, and apprehending criminals. The Department of Corrections is involved in rehabilitation and reformation measures for convicts, including imprisonment and alternative forms of punishment. These components interact within a unified informational space to ensure the fair and effective functioning of the justice system in the country.

Even in technologically advanced countries today, there is still no unified comprehensive information system (IS) that could integrate data flows between different components of the justice system and provide reliable information support for decision-making in each of them (Teremeckyi; Zhuravel, 2020, p. 110). Applied developments in this area are fragmented and only concern the functionality of individual modules of a complex judiciary system. Additionally, different regions have significant differences in the functioning of such structures, and the legislation of different countries around the world is diverse. An integrated decision support system in the field of justice must take into account all national legal norms and peculiarities of the judicial process (Teremeckyi; Duliba, 2020, p. 133).

The justice system remains a relatively under-researched area within academic circles, with few exceptions in developed countries, despite the continued increase in crime rates worldwide. Building theoretical knowledge for the effective administration of the justice system requires complex and sensitive work, as it grapples with the issue of crime, which is one of the most complex in the modern world. Currently, the police in most countries still primarily operate using traditional investigation methods, without utilizing scientific approaches and innovative technologies (Rahman *et al.*, 2020, p. 35). The criminal environment is changing. In the modern smart world, criminals use technological innovations to commit their crimes and exploit the global information space for their unlawful activities. Crime is increasingly becoming transnational. Therefore, there is an urgent need to develop effective national decision-support information systems within the justice system that can easily integrate into a comprehensive intergovernmental IS. This need is particularly acute for Ukraine

and the European Union in light of Russia's full-scale invasion of Ukraine (Berezka; Kovalchuk, 2023, p. 73).

The modern justice system has to deal with vast amounts of data that need to be carefully analyzed to make effective, informed decisions. Moreover, the volume of this information is constantly growing at exponential rates. This, coupled with the continual emergence of new technologies, underscores the urgent need to leverage advancements in data science and cutting-edge information technologies (IT) to create reliable information support for all components of the judiciary. Specifically, courts and law enforcement agencies require appropriate technologies and specialized information systems to adequately detect and counter new threats. Data mining and big data methods provide invaluable opportunities for investigations, suspect identification, and the detection or prediction of crime patterns or connections between previously unrelated events or subjects (Kovalchuk *et al.*, 2023, p. 303). It is necessary to handle extensive, intricate, and unorganized datasets for gathering, standardizing, processing, integrating, prioritizing, and visualizing data (comprising text, images, audio, and video) in a manner that streamlines real-time data extraction while guaranteeing compatibility between current systems and standards among various member states. Additionally, solutions for temporal and geospatial analysis are required.

The presented study employs a multidisciplinary approach to analyzing crime trends. The goal of our research is to develop and implement a new proactive approach to forecasting crime trends – a synthesis of an association rules model for identifying non-obvious patterns and stable interrelationships in crime data structures and geospatial models for detecting criminal trends.

The article is divided into five sections. The first section "Introduction" contains a brief description of the current state of implementation of innovative IT in the judiciary system and the urgency of developing effective information support for optimizing decision-making in the judiciary. In the second section "Literature Review", we review analytical research on the application of innovative IT for detecting non-obvious connections, interesting patterns, and stable trends in crime data. In the third section "Materials and Methods", we present the author's proposal for an information model of the decision-making process for crime prevention and detection, "Results and Discussion", we present the results of applying association rule mining to identify interesting non-obvious patterns and strong interrelationships in crime data and geospatial models for detecting criminal trends. In the fifth section "Conclusions", we conclude the study and discuss the limitations and future studies. The new knowledge and ideas obtained as a result can provide the justice system with reliable information for making appropriate judicial decisions free from subjective judgments.

## Literature Review

Over recent years, there has been a significant increase in the number of scientific studies dedicated to the application of quantitative data analysis algorithms in the legal sphere. The researchers S.-H. Park *et al.* have analyzed the themes and trends in Legal Tech development based on data analytics. They concluded that it is a multidisciplinary field, associated with computer science, social sciences, and more (Park *et al.*, 2021).) According to R. Wang, the information technologies used in judicial systems have characteristics closely linked to the political situation, legal system, and judicial structure of each country (Wang, 2020). R.P. Dempsey *et al.* examined the impact of integrating artificial intelligence technologies, such as predictive policing and autonomous vehicles, on community and law enforcement jurisdiction interactions (Dempsey, 2023). According to M. Burgin and K. d.V. Mestdagh, any judicial process is a complex information process in the legal sphere involving one or several legal systems. Researchers have developed theoretical and practical tools to assess the complexity of information processes in the legal sphere to improve the functioning of legal systems (Burgin; Mestdagh, 2022). K. Berezka *et al.* applied logistic regression to model support decision-making in criminal justice (Berezka *et al.*, 2022, p. 3). The authors A.Z. Spyropoulos *et al.* have developed an information system that could form the basis of criminalistic ontologies and assist law enforcement agencies in solving crimes (Spyropoulos *et al.*, 2023). Despite a series of theoretical and practical studies on various aspects of creating information support for the judiciary system, courts and law enforcement agencies of different countries today need to have a clear strategy for obtaining high-quality dynamic datasets and a thorough understanding of the possibilities of applying data science methods and cutting-edge information technologies for effective data analysis (Kovalchuk; Banakh, 2024, p. 75).

## Materials and methods

This article proposes the development of one of the decision support system modules in the judiciary system, which can provide law enforcement agencies with timely relevant information for preventing and investigating offenses. This research employed a multifaceted approach, drawing upon a diverse array of methods and techniques. These included experimental procedures, model development, forecasting analyses, field data collection, statistical examinations synthesis method, case study investigations, comparative evaluations, associative rule mining for uncovering patterns and relationships, and geospatial predictive meta-analytical techniques, modeling to uncover spatial trends and make projections. By leveraging this comprehensive methodological toolkit, the study aimed to gain a holistic

understanding of the phenomena under investigation, triangulating insights from various analytical angles and data sources. The integration of these complementary methods facilitated a robust and nuanced exploration of the research questions, enhancing the validity and generalizability of the findings.

We developed information models based on real data about criminal offenses committed in the Ternopil region during the period from 2013 to 2023. The information was provided by the Analytical Support Department of the Main Directorate of the National Police in the Ternopil region, Ukraine. The information model of the decision-making process for preventing and investigating offenses is presented in Fig. 1.

To uncover hidden patterns and connections within criminal offense data, we analyzed 1,975 criminal cases from the Ternopil region of Ukraine, covering offenses committed between 2012 and 2023 (Unified register of pre-trial investigations, 2024).

The data set used for identifying associative rules among criminal acts contained the following attributes:

- crime type: illegal appropriation, robbery, theft;
- location: city or village;
- month when the offense occurred;
- weekday of the offense;
- lighting conditions at the crime scene: well-lit or dark;
- whether the crime was committed by a group or alone.

By mining this comprehensive data set, we aimed to reveal underlying significant correlations and relationships that could aid in better understanding criminal behaviors and informing prevention strategies.

**Figure 1.** Flowchart of the information model for the decision-making process regarding the prevention and investigation of offenses
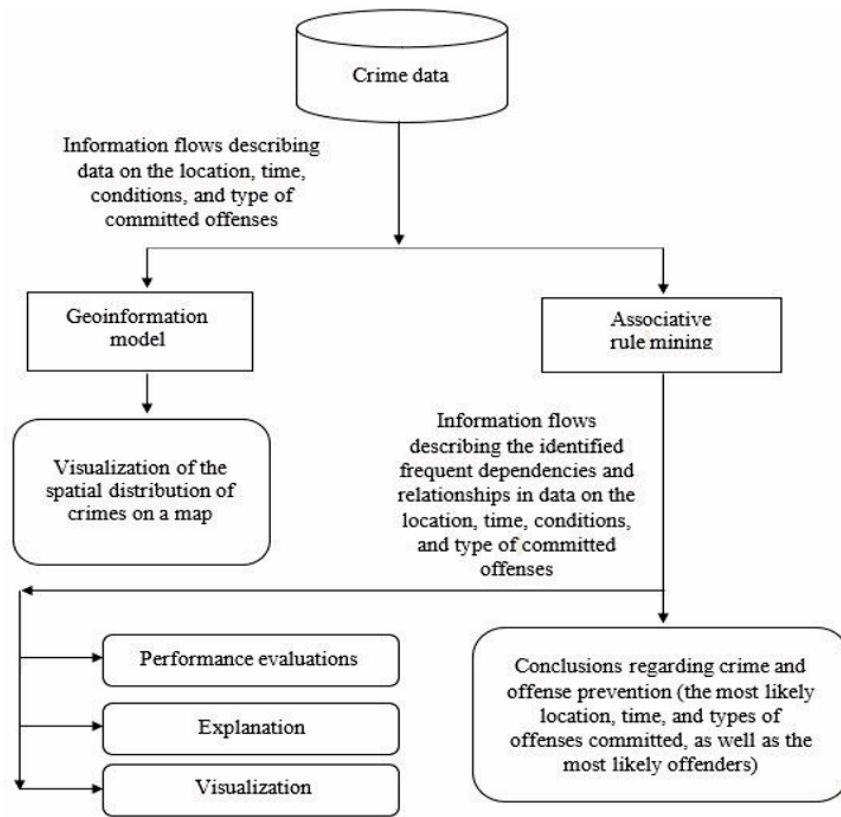


**Source:** compiled by the authors

**Association Rule Mining**. Association rules are a fundamental concept in data mining, focusing on uncovering patterns and hidden relationships within data streams (Rai, 2022). These rules represent if-then statements, where those surpassing specified thresholds are deemed significant, enabling actions based on identified patterns and aiding in decision-making processes (Mathur, 2024).

The task of association rule mining involves a set of attributes (items) $I = \{i_1, i_2, …, in\}$ and a set of transactions (database) $T = \{t_1, t_2, …, tm\}$. A transaction is a subset of the set I, comprising multiple simultaneous events. An association rule is defined as (1):

$$X \Rightarrow Y, \quad (1)$$

where $X$ and $Y$ are distinct item sets, with $X$ being the antecedent and $Y$ being the consequent.

To identify interesting rules, various significance and interest metrics are used, with the most renowned constraints being minimum thresholds of support and confidence.

Support measures the frequency of a transaction's occurrence in the database, specifically the portion containing both antecedent and consequent. It is calculated as (2):

$$supp(X) = \frac{|\{t \in T; X \subseteq t\}|}{|T|} \qquad (2)$$

Confidence quantifies the rule's execution frequency, indicating its accuracy. It is defined as the ratio of transactions containing both the antecedent and consequent to those containing solely the antecedent (3):

$$conf(X \Rightarrow Y) = \frac{supp(X \cup Y)}{supp(X)}. \qquad (3)$$

When support and confidence meet certain thresholds, it suggests a high probability that any forthcoming transaction featuring the antecedent will also entail the consequent.

Other metrics used include lift, which measures the ratio of the antecedent's frequency in transactions containing the consequent to the consequent's overall occurrence frequency, and conviction, which measures the implication strength of a rule (4)–(5):

$$lift(X \Rightarrow Y) = \frac{supp(X \cup Y)}{supp(X) \times supp(Y)} \qquad (4)$$

$$conv(X \Rightarrow Y) = \frac{1 - supp(Y)}{1 - conv(X \Rightarrow Y)}. \qquad (5)$$

The algorithm for discovering association rules typically involves two steps: identifying all item frequencies in the database using a minimum support threshold (yielding frequent if-then associations), and applying a minimum confidence constraint to the itemset frequencies for rule formation.

While association rule mining can be computationally complex, especially as the number of items increases, it allows the transformation of vast amounts of data into a concise set of insightful statistical patterns, uncovering valuable connections between items within transactions.

**Geospatial Modeling**. To develop geospatial models for detecting criminal trends, geospatial predictive modeling was employed (Malloy, 2020). It is a modeling approach based on the principle of events entering with constraints in the distribution. The occurrence of events is a manifestation of spatial environmental factors (infrastructure, topography, etc.) that limit the influence on the location of events. Geo-informational models of crime locations were developed using Python, utilizing the GeoPandas library for working with geographic data. We aimed to achieve the following results:

- Visualization of the spatial distribution of crimes on a map. This allows for the identification of crime "hotspots" areas with heightened risk, and the

detection of spatial patterns in crime occurrence.

- Analysis of the relationship between crime and various environmental factors, such as demographic, socio-economic, and infrastructural characteristics of regions. This helps understand the factors contributing to crime.
- Prediction of future crimes based on past patterns and environmental factors using spatial modeling and analysis.
- Optimization of the placement of police patrols, surveillance cameras, and other law enforcement resources in areas with high crime risk.
- Support for investigations, establishing links between individual criminal events, and identifying potential serial offenders based on geographic data.
- Identification of potential routes or movement zones of criminals based on crime analysis and environmental factors.

Geoinformational models are powerful tools for visualizing, analyzing, and predicting crime, assisting law enforcement agencies in crime prevention and investigation. The developed computer model of associative rules for detecting hidden patterns and robust correlations in crime data structures was synthesized with a geospatial model for identifying criminal trends. Both models can become part of a decision support system module designed for informational support in preventing and investigating offenses. They can further be adapted into a unified comprehensive information system for decision support in the judiciary system of Ukraine and integrated for use in a shared information space with a similar system in the European Union.

## Results and Discussion

**Association Rule Mining**. The results produced by association rule mining algorithms consist of two main components: frequent itemsets and the association rules themselves. Table 1 presents the frequent itemsets that were identified.

**Table 1.** Frequent Itemsets

| Support | Item 1 | Item 2 | Item 3 |
|---------|--------|--------|--------|
| 0.565 | complicity | theft | |
| 0.540 | complicity | dark conditions | |
| 0.450 | complicity | light conditions | |
| 0.285 | complicity | illegal appropriation of a vehicle | |
| 0.245 | complicity | Ternopil | |
| 0.180 | complicity | Wednesday | |
| 0.155 | complicity | Saturday | |

| Support | Item 1 | Item 2 | Item 3 |
|---|---|---|---|
| 0.150 | complicity | April | |
| 0.150 | complicity | Friday | |
| 0.320 | complicity | dark conditions | |
| 0.255 | theft | light conditions | |
| 0.185 | theft | Ternopil | |
| 0.155 | theft | illegal appropriation of a vehicle | |
| 0.310 | complicity | theft | dark conditions |
| 0.255 | complicity | theft | light conditions |
| 0.185 | complicity | theft | Ternopil |
| 0.155 | complicity | dark conditions | illegal appropriation of a vehicle |

**Source:** compiled by the authors

The constructed model of association rules simplifies the understanding of the following interesting patterns that characterize criminal activities:

- Theft is usually committed by a group, regardless of the lighting conditions at the crime scene.
- Most thefts occurred in Ternopil.
- Group crimes most often take place in the latter half of the week (Thursday, Friday, and Saturday).
- Theft is frequently accompanied by the illegal appropriation of a vehicle.
- Criminal groups intensify their activities in April.
- Illegal vehicle appropriation is mainly committed by groups under dark conditions.

We identified a strong association rules related to the attributes of offenses of the crime dataset with confidence greater than 0.75, which are presented in the following table (Table 2):

**Table 2.** The Metrics of the Strong Association Rules

| Premises | Conclusion | Support | Confidence | Lift | Conviction |
|---|---|---|---|---|---|
| light conditions | complicity | 0.45 | 1.0 | 1.010 | ∞ |
| Illegal appropriation of a vehicle | complicity | 0.285 | 1.0 | 1.010 | ∞ |
| Ternopil | complicity | 0.245 | 1.0 | 1.010 | ∞ |
| Wednesday | complicity | 0.18 | 1.0 | 1.010 | ∞ |
| April | complicity | 0.15 | 1.0 | 1.010 | ∞ |
| Friday | complicity | 0.15 | 1.0 | 1.010 | ∞ |
| theft, light conditions | complicity | 0.255 | 1.0 | 1.010 | ∞ |
| theft, Ternopil | complicity | 0.185 | 1.0 | 1.010 | ∞ |

| Premises | Conclusion | Support | Confidence | Lift | Conviction |
|---|---|---|---|---|---|
| dark conditions, illegal appropriation of a vehicle | complicity | 0.155 | 1.0 | 1.010 | ∞ |
| theft | complicity | 0.565 | 0.98 | 0.993 | 0.575 |
| dark conditions | complicity | 0.54 | 0.98 | 0.992 | 0.55 |
| Saturday | complicity | 0.155 | 0.97 | 0.979 | 0.32 |
| theft, dark conditions | complicity | 0.31 | 0.97 | 0.979 | 0.32 |
| Ternopil | theft | 0.185 | 0.76 | 1.313 | 1.76 |
| Ternopil | complicity, theft | 0.185 | 0.76 | 1.336 | 1.78 |
| complicity, Ternopil | theft | 0.185 | 0.76 | 1.3132 | 1.74 |

**Source**: compiled by the authors

The following network diagrams illustrate the strong association rules generated for the city of Ternopil, where the highest number of thefts occurred. In most cases, these offenses were committed by groups of individuals (Fig. 2).

Fig. 3 depicts the association rules obtained from analyzing the crime data, specifically the rules related to offenses committed by multiple perpetrators acting together. It was found that group crimes peaked in April. Thursday and Friday were the most favored days for group criminal activity. When acting as a group, perpetrators most frequently committed theft in Ternopil under lighted conditions and illegally appropriated vehicles under dark conditions.

**Figure 2.** Visualization of Association Rules for Offenses in Ternopil city
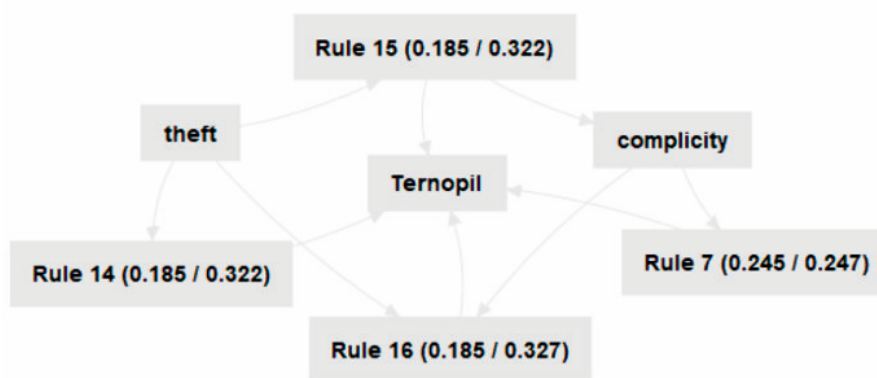


**Source:** compiled by the authors.

**Figure 3.** Network diagram of Group Crime Association Rules
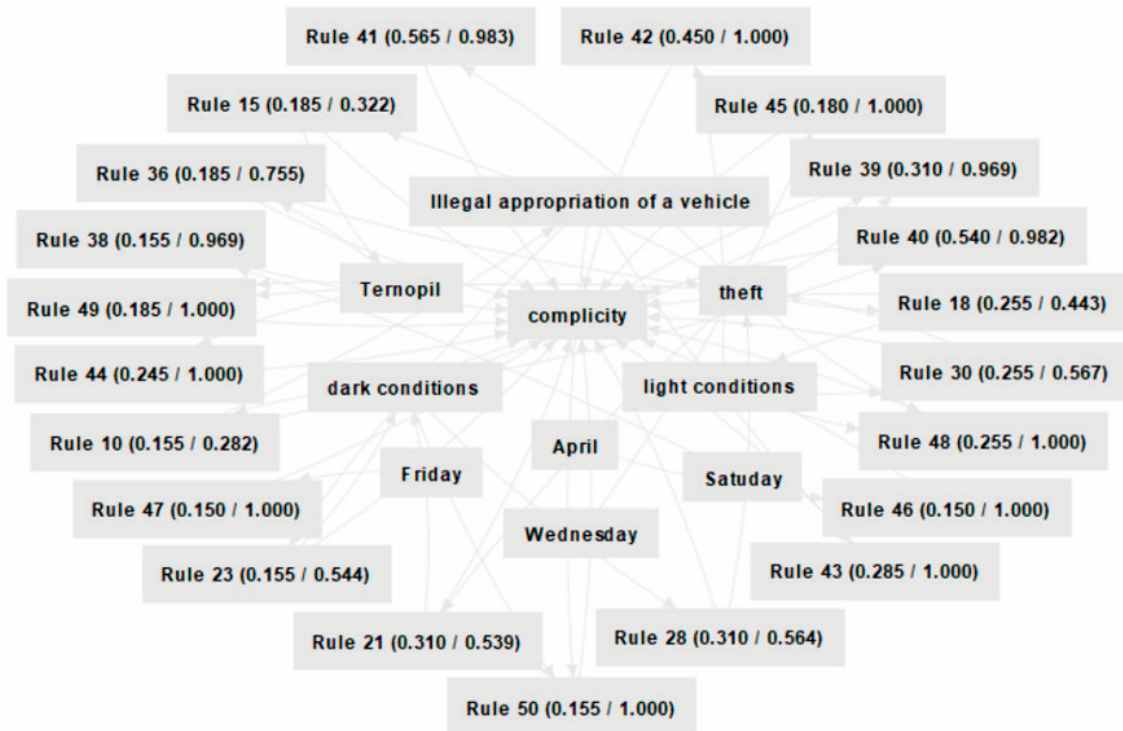


**Source:** compiled by the authors.

Our ongoing research endeavors to uncover intriguing trends within crime datasets, which encompass not only the time and location of incidents but also factors such as crime type (including theft, robbery, and illegal appropriation), illumination at the crime scene, and indications of organized criminal activity. Through experimental analysis involving 1,975 criminal cases from the Ternopil region of Ukraine spanning 2012 to 2023, we have validated existing findings that highlight the prevalence of crimes in densely populated areas, notably cities.

However, our study goes beyond mere confirmation by introducing a model of association rules that offers deeper insights into local criminal dynamics. This model enables us to discern which types of crimes are more likely to occur in specific regions, as well as identify peak periods of criminal activity, be it certain days or months. Furthermore, our model has the potential to furnish law enforcement agencies with valuable intelligence regarding organized crime operations within particular locales.

**Geospatial Modeling.** Our proposal includes the development of a geo-informational model for visualizing the level of crime (low, medium, high) in the territory of the Ternopil region. We have constructed maps of crime for the following types of offenses: illegal appropriation, robbery, theft, and cybercrime (Fig. 4). Green markers denote settlements with a low level of corresponding types of offenses, orange indicates a medium level, and red represents areas with a high level of crime. The constructed maps demonstrate that offenses of all analyzed types are

predominantly concentrated around the city of Ternopil. It can be concluded that criminals prefer larger cities for their illicit activities where it is easier to go unnoticed. The constructed maps facilitate the identification of areas with the highest incidence of crime. Such knowledge can provide law enforcement agencies with significant insights for developing effective crime prevention strategies and conducting successful investigations. The input data for the proposed geo-informational model is a table with crime data. When changes are made to the data table, the crime maps are automatically updated. Thus, law enforcement officials can access dynamic crime maps without additional configuration. This is crucial as high-risk spatial-temporal zones are always variable in space and time. Regions near hotspots simultaneously carry this higher risk. The proposed geoinformational model can be adapted for analyzing crime in any region of Ukraine or beyond. The modularity of the proposed model ensures easy adaptability to other information systems.

**Figure 4.** Crime maps in Ternopil region, Ukraine



b) theft

a) robbery

d) cybercrime

c) illegal appropriation
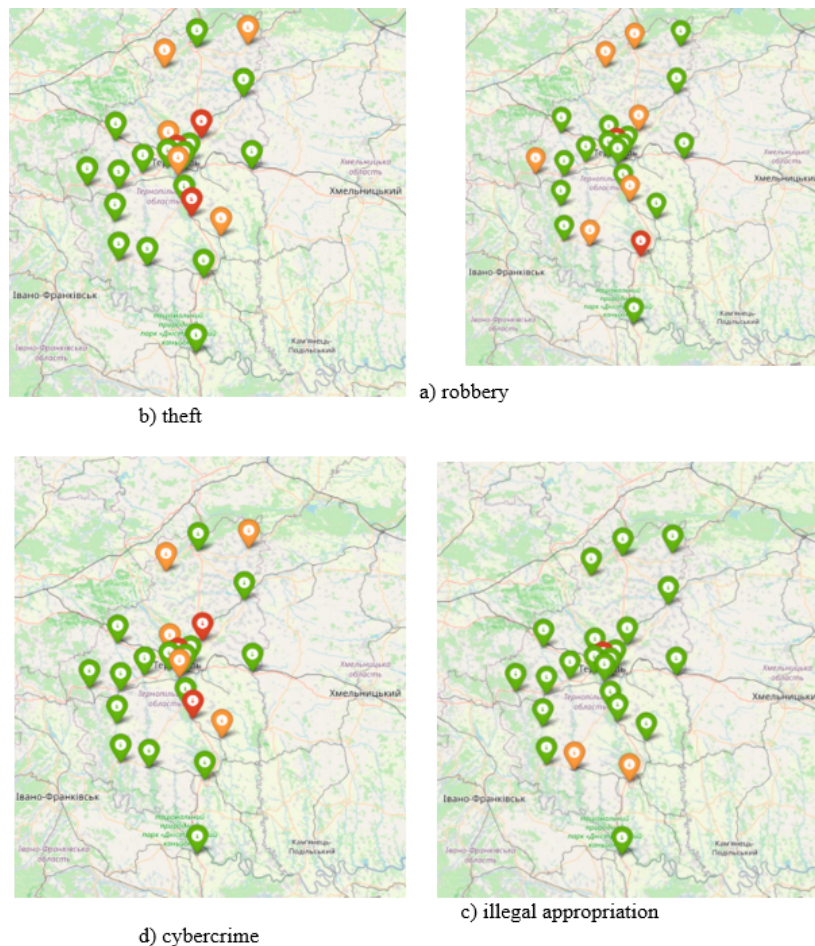
The identification of "crime hotspots" (areas of crime concentration) plays a significant role in crime forecasting and prevention. Identified crime hotspots are a key indicator of crime heterogeneity. This information helps identify areas or regions at high risk of offenses and develop policies for crime prevention or deterrence. Crime

hotspots, in combination with identified associative rules, can be used to determine factors influencing crime concentration.

Selecting optimal methods for monitoring and predicting criminal activities is a complex and non-trivial challenge. Solving it requires developing innovative and effective approaches to identify non-obvious, interesting patterns within crime data. The difficulty arises from the intricate and heterogeneous spatio-temporal relationships present in crime data across space and time. Building an adequate model to capture these correlations is arduous. Furthermore, crime data is sparse in both spatial and temporal dimensions, further complicating prediction efforts. Such predictions are meaningful only in the short term and for specific regions. Diverse regional studies on crime forecasting are crucial to identifying a generalized model and factors that significantly influence criminal activities across most countries worldwide. This information can provide law enforcement agencies with insights not only for effective crime detection but also for preventing and combating criminal activities proactively.

Identifying hotspots of crime is vital for pinpointing areas with concentrated criminal activity, thus facilitating the strategic allocation of resources for crime prevention. Despite the existence of multiple techniques for hotspot detection, there has been limited systematic evaluation of their effectiveness, particularly regarding their capability to identify intricate patterns of crime hotspots.

Researchers Z. He *et al.* quantitatively compared four classical methods for identifying crime hotspots based on synthetic and real crime data. They proposed an evaluation system and indicators that can describe the characteristics of the size, concentration, and shape of the identified hotspots (He *et al.*, 2022). F. Denegri and J. Ley-García investigated the spatial distribution and persistence of theft targeting commercial establishments in Mexicali, Mexico, from 2009 to 2011. Using the Gini coefficient, Lorenz curve, and decile maps, the analysis reveals a significant concentration of theft occurrences within a limited portion of the city's urban geostatistical áreas (Denegri; Ley-García, 2021). Authors S.P. Chainey *et al.* developed police patrol routes based on the results of spatial crime models (Chainey *et al.*, 2021). J.A. Boschan and C.G. Roman applied geospatial analysis to assess spatiotemporal changes in gun violence before, during, and after the implementation of the Philadelphia-focused deterrence initiative (Boschan; Roman, 2024). The researchers Z. He *et al.* applied a multi-scale analysis method to study the relationship between the main geographic space and crime distribution (He *et al.*, 2023). The results of these studies confirmed our assessments: criminal activity is concentrated around "hotspots", characterized by spatial heterogeneity and associated with multi-scale characteristics. The persistence of criminal hotspots indicates that resources for crime prevention should be concentrated in specific high-crime areas. Identifying crime concentration points and associated significant factors facilitates understanding

effective police intervention tactics and making efficient decisions regarding crime prevention, detection, and deterrence.

This work proposes a new interdisciplinary approach to identifying crime trends based on the synthesis of associative rule models and geospatial models. Computer models based on real data on criminal offenses committed in the Ternopil region of Ukraine from 2013 to 2023 are presented. The results of the created models can provide law enforcement agencies with relevant information for the prevention, detection, and deterrence of offenses. The proposed solutions are easily adaptable to new datasets and can be implemented in a unified decision support system in the judiciary.

Decision-making in the judiciary system requires the utilization of various methods and techniques for effective investigation of criminal environments, analysis of case facts, forecasting recidivism risk, ensuring fairness, and so forth (Alikhademi, 2022, p, 7; Berk, 2021, p. 213) In this context, spatial models and data analytics models, such as associative rules, become essential tools that aid in objective and efficient decision-making. Spatial models in the judiciary are used to analyze the geographical distribution of criminal activity and other aspects of offenses. They enable the identification and study of geographic areas with high criminality, facilitating the efficient allocation of resources for preventive measures and response to criminal events. Through geospatial models, zones with elevated crime risks can be identified, leading to the development of strategies for enhanced patrolling or other security measures.

The application of data analytics models in the judiciary allows for the effective processing of large volumes of information and the identification of complex patterns in data. For instance, associative rule models can identify correlations between various aspects of a case or detect typical patterns in criminal activity. This enables judicial authorities to conduct objective analysis of situations and make informed decisions. The use of spatial models and data analytics models in the judiciary enhances decision-making efficiency, providing an objective and adaptive approach to law enforcement management and ensuring fairness. The utilization of these tools contributes to increased effectiveness of the judicial system and fosters greater public trust in judicial decisions.

## Conclusions

The presented study proposes a novel proactive approach to identifying crime trends, which is based on the synthesis of an association rules model and geospatial models. This comprehensive approach allows for detecting hidden patterns and interrelationships in criminal data structures, as well as visualizing the spatial distribution of crime.

It has been established that thefts are more frequently committed in larger cities with higher population densities. In most cases, these offenses were committed by

groups of individuals. It was found that the peak of group crimes occurred in April. The most favorable days for group criminal activity were Thursday and Friday. Acting as a group in Ternopil, perpetrators most often committed thefts in the illuminated part and illegally seized vehicles in the dark hours. The developed association rules model provides a deeper understanding of the characteristics of criminal activity in a particular region. It allows for identifying the types of offenses that most commonly occur, periods and days of the week with increased crime rates, as well as detecting signs of involvement of organized criminal groups. This data is extremely valuable for law enforcement agencies in developing effective strategies for crime prevention, detection, and counteraction. The developed geospatial model provides a visual representation of crime concentration zones in the Ternopil region. The results confirm the general trend of higher crime rates in densely populated urban areas. Identifying such crime hotspots is a key factor for deploying law enforcement forces and planning preventive measures.

The proposed approach is based on real criminal case data collected in the Ternopil region during 2013-2023. The developed models can be easily adapted to new data sets and integrated as modules into a unified decision support information system in the judicial system of Ukraine. Moreover, they can be adapted for use in a shared information space with similar systems of the European Union.

The comprehensive application of various analytical tools, such as spatial models, data mining models, association rules, etc., is necessary for the effective study of the criminal environment and objective decision-making in the justice system. These tools help to conduct a comprehensive analysis of the facts of the case, predict the risks of recidivism, ensure fairness, and restore public trust in the judicial system. The presented study demonstrates the promise of applying the latest information technologies and data mining methods in the field of justice. Further development and integration of such solutions can significantly improve the efficiency of courts, police, and other law enforcement agencies in combating crime and protecting citizens.

The main areas for further scientific research in the development of reliable decision-support information systems in the judiciary system may involve the application of data mining tools and language models based on artificial intelligence for analyzing court decisions.

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