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# ARTIFICIAL INTELLIGENCE FOR CRIME PREDICTION AND PREVENTION – A LITERATURE REVIEW

**Paul Iacobescu[1], Cătălin Anghel[2]**

*[1*]School for Doctoral Studies in Engineering, University "Dunărea de Jos" of Galati*
*[2]Department of Computer Science and Information Technology, University "Dunărea de Jos" of Galati – Romania, 2 Științei, 800146 Galati, Romania*
*[*]Corresponding author e-mail: paul.iacobescu@ugal.ro*

**Abstract:** Crime prevention is a key concern in modern society, with significant implications for public safety and informed law enforcement decision-making. An innovative approach in this direction is the use of Artificial Intelligence (AI) to analyze statistical data on crime history. This paper explores the current state of the art of using AI in crime assessment and prevention, presenting current methods, and techniques, such as Machine Learning and Deep Learning, which are applied to identify crime patterns and trends. Throughout the analysis, the advantages, and challenges of using AI in this context are discussed and relevant case studies are highlighted where AI has had a significant impact in reducing crime. Finally, it outlines emerging research directions, including improving crime prediction algorithms and applications integrating data from various sources and developing robust mechanisms for evaluating the performance of AI models. By exploring these issues, the paper provides a broad perspective on the current state and future directions for crime prevention using Artificial Intelligence.

**Keywords:** AI, artificial intelligence, machine learning, deep learning, crime prevention, crime prediction.

## 1. INTRODUCTION

Crime is one of the key concerns of any society, as its increasing prevalence often has a significant negative impact on people's quality of life. A society where crime rates are high is a society where people feel unsafe. They fear for the safety of their own families, they shy away from going out in public or leaving their children unattended at home. These issues lead to limited freedom of movement and expression, fear, anxiety, and a decrease in people's quality of life. Increasing crime levels also have the knock-on effect of lowering people's trust in state institutions. People no longer trust the police system, the judiciary, or the authorities, which can lead to social and political instability.

The general causes that can lead to increased levels of crime are social, economic, cultural, and psychological, low levels of education and training, substance abuse, trauma, etc. Crime prevention is an achievable goal through the implementation of effective strategies.

These strategies can be built by using specific techniques to assess crime history data. Law enforcement authorities have practiced such strategies for decades. It has been referred to as hot spot analysis, which has required a substantial number of human resources and an abundant amount of time. Developments in all areas of activity have led to a need to generate a predictive mechanism that can identify and anticipate future criminal trends.

Artificial intelligence (AI) techniques are the most appropriate methods to manage this task because of their ability to exploit large amounts of data and identify latent features, which can be subtle and difficult to observe with other analysis methods. The use of advanced artificial intelligence technologies

helps achieve this goal by identifying risk areas and taking corrective action in a more efficient and faster way. AI systems can be used to identify patterns and trends in crime-related data, including the locations and times when crimes occur, types of crime, and offender profiles. By knowing this information, crime prevention strategies can be developed, such as placing patrols in high-risk areas, installing surveillance cameras, or increasing the number of police in areas where crime is more likely to occur. In addition, AI systems can be used to analyze social and environmental data to identify factors that contribute to crime.

The use of AI in crime prevention has the potential to improve the efficiency and effectiveness of public order and safety systems, enabling authorities to take proactive measures through the development of policies and programs to increase the safety of citizens.

By synthesizing information from a wide range of sources, our study contributed to a well-rounded literature review that not only presents the current state of AI in crime prevention comprehensively but also addresses the strengths and weaknesses of the techniques used, providing valuable insights for future research and application.

The paper is structured as follows: the second section outlines the areas where artificial intelligence is used for crime prevention. Section number three assess the main artificial intelligence techniques for crime prediction. Section number four presents the real-world applications used by law enforcement agencies to address potential threats and implement effective crime prevention strategies. Finally, the "Conclusion" section summarizes the challenges and the future research in this field.

## 2. MAIN AREAS WHERE AI IS USED FOR CRIME PREVENTION

Artificial Intelligence techniques are being applied in a variety of areas to help authorities better understand the causes of crime and develop more effective prevention strategies.

### *2.1 Analysis of historical data*

By using artificial intelligence algorithms and crime history data analysis technologies, predictive models can be developed to identify areas, types of crime and time periods of increased crime risk. This area involves processing various types of statistical or historical crime data, such as reports of past crimes, geospatial data, information about social and economic conditions in specific areas, and weather or seasonal factors. By applying predictive analytics technologies, AI makes a significant contribution to identifying risk areas (Changalasetty, *et al.*, 2021). As a result, models identify geographical areas, or neighborhoods with a higher frequency of crime, thus helping law enforcement to target crews in these areas before these negative events occur.

By forecasting crime trends (Safat, *et al.*, 2021), developments are shown according to types of crime, such as an increase in criminal activity at certain times of the year, days of the week or in certain areas. This allows authorities to anticipate the need to allocate resources and plan preventive operations such as additional patrols or increased surveillance of certain areas, all leading to an optimized distribution of resources (Zhang, *et al.*, 2022). The information provided by predictive models can help policy makers to take evidence-based action and develop effective strategies to support decision-making (College of Computer Studies, 2023) for crime prevention.

### *2.2 Image analysis and video monitoring*

Video surveillance systems have become a natural part of our lives and are mostly used to deter and capture criminal activity. Many of these systems use simple artificial intelligence algorithms for face detection or intrusion detection. However, today's artificial intelligence has the capacity to do much more. Thus, technological developments in hardware as well as the development of machine learning techniques have the potential to analyze and interpret images and video content to spot suspicious activity and unusual events before they lead to serious consequences. These technologies have become strong levers for law enforcement and national security agencies to assess and prevent crime.

AI algorithms are used to detect suspicious activities (Kumbhar, *et al.*, 2023) by recognizing suspicious behavior and activities, such as illegal entries into restricted areas, detection of aggressive behavior or changes in behavior that may signal possible threats or crimes in progress. They monitor video traffic flows, then trigger real-time alerts when unusual activity is detected. Real-time analysis of images and video content makes it easier to identify objects and people (Boukabous and Azizi, 2023) by recognizing people or vehicles being tracked. AI technologies applied to crowd monitoring (Xu, *et al.*, 2021) enable the detection of crowds and unusual movements in public areas or during mass events, thus contributing to public safety and efficient management of large-scale events. AI algorithms have been programmed to detect incidents (Ijjina, *et al.*, 2019), such as fires, traffic accidents or other emergencies, which require automatic and immediate notification of the competent authorities. It can also manage and optimize passenger flows (Aljuaid, *et al.*, 2023) to avoid overcrowding, which can help reduce the risk of crime.

*2.3 Social networks analysis*

Analyzing posts on social media platforms using AI is an effective way to assess and prevent online crime and identify potential threats or criminal activity. By monitoring and analyzing data from social media platforms, AI provides valuable information, thus contributing to cyber and public security. Identifying patterns of suspicious behavior (Savyan and Bhanu, 2017) is done by analyzing posts, comments, and interactions on social media to highlight patterns of suspicious or potentially dangerous behavior such as signs of incitement to violence or spreading false information or threats.

The use of intelligent AI techniques helps to prevent online radicalization (Tundis, *et al.*, 2020) by identifying radical or extreme speech in online posts and comments, thus helping to prevent radicalization and counter extremist propaganda. Analysis of social media data can help detect victims or exploitation (Granizo, *et al.*, 2020) such as sexual exploitation or human trafficking. Analyzing sentiments and opinions (Ahmad, *et al.*, 2019) expressed on social networks through AI, reveals changes in public attitudes towards certain crime and security issues. AI algorithms are being used to centralize and analyze information from various sources, thus assisting police investigations (Shafia and Chachoo, 2022) by identifying links between criminals.

*2.4 Cybercrime prevention*

Preventing cybercrime through Artificial Intelligence is a key approach to protect information systems, data, and digital infrastructure from increasingly sophisticated cyber threats. The use of AI in cybercrime prevention involves applying machine learning and data analytics algorithms to identify, detect and counter cyber-attacks. AI monitors activities in networks and computer systems for anomalies (Pang, *et al.*, 2022) and identifies unusual behaviors that indicate a cyber-attack. This involves analyzing large volumes of data to identify irregular patterns. Intelligent algorithms detect intrusion attempts into systems and networks (Nie, *et al.*, 2022) by analyzing alarm signals, unusual events or known signatures of cyber-attacks. It also analyses vulnerabilities (Lin, *et al.*, 2020) associated with software and infrastructure to identify potential vulnerabilities and recommend corrective measures. NLP technologies are used to filter emails and messages (Baccouche, *et al.*, 2020) by detecting suspicious content or phishing attacks. AI analyses malicious code (Hemalatha, *et al.*, 2021) by identifying signatures or features that indicate its presence in the system.
In most cases, AI takes automatic action to stop attacks or to isolate compromised systems, thus preventing damage from spreading.

*2.5 Financial data analysis*

The use of Artificial Intelligence in the financial field, for the assessment and prevention of financial crime, is an increasingly common approach in the modern world. AI technologies can help identify fraudulent schemes, money laundering and other illegal financial activities. Thus, AI detects abnormal patterns (Rocha-Salazar, *et al.*, 2021) by analyzing financial transactions to identify abnormal or irregular patterns that indicate money laundering, fraud, or other suspicious activities. Examining banking transactions (Esenogho, *et al.*, 2022), online payments and other financial activities using AI, helps to identify potential criminal or unusual activities. Intelligent algorithms can monitor (Widiputra *et al.*, 2021) rapid changes in financial markets to detect speculative transactions or price manipulation. Computer fraud crimes (Stojanović, *et al.*, 2021), are prevented by identifying suspicious activities in financial data sets. Financial risk (Du, *et al.*, 2021) associated with uncertain bank loans or transactions is assessed to support lending or investment decisions.

## 3. AI TECHNIQUES USED TO PREDICT CRIME

Crime prediction is a complex problem that requires advanced analytical tools to effectively address shortcomings in existing detection mechanisms. With the increasing availability of crime data and the evolution of technology, researchers have been given a unique opportunity to study and predict crime using machine learning and deep learning techniques.

Machine learning algorithms have been used to analyze historical crime data and make predictions. Algorithms such as Decision Tree, Random Forest and Support Vector Machines have been trained on historical crime data from specific cities to predict crime patterns with high accuracy (Saraiva, *et al.*, 2022). In addition to anticipating crime patterns, these algorithms can provide valuable insights into crime trends and patterns. These capabilities enable the effective deployment of resources and tactics to fight crime.

*3.1 Statistical approaches*

This approach uses statistical data such as crime rates, types of crime, location of crime, victim, and offender characteristics to identify patterns and trends that can be used to predict crime. This approach is relatively simple and can be implemented with relatively few resources. However, it may be limited by the quality of the data that is available. The ARIMA (autoregressive integrated moving average) model and the ARIMAX (autoregressive integrated moving average with exogenous variables) model are both statistical analysis models that use time series data to predict future trends.

The Autoregressive Integrated Moving Average (ARIMA) model was used to forecast the crime rate in the Visegrad group of countries (Poland, Czech Republic, Hungary, and Slovakia). The authors of the study (Ghani, *et al.*, 2023) suggest that several variables influence crime rates, including unemployment. Different types of crime are considered predictable, such as robbery, murder, burglary, a total of 8 types of crime.

An application was created to predict motorcycle robberies by assessing the external consequences of crimes, using ARIMAX (Autoregressive Integrated Moving Average with Exogenous Variables), a time series analysis model used in statistics and in data analysis that extends the ARIMA, by adding exogenous variables to the analysis. The accuracy of ARIMAX model was measured in the study (Da Silva, et al., 2020), using the mean absolute percentage error (MAPE) and the root mean square error (RMSE).

Social media data from Twitter was incorporated by authors (Lydia and Hari, 2021) in the Kernel Density Estimation (KDE) method for crime prediction. They employed a technique called topic modeling to extract meaningful patterns from Twitter posts and then used these patterns to predict crime rates. While this method does not require any prior knowledge about crime patterns, it has limitations due to its reliance on a fixed bandwidth, which can lead to inaccurate predictions. Additionally, it fails to consider the dynamic nature of crime, which can change over time. To address these limitations, a more advanced method called Kernel Spatial-Temporal Density Estimation (ST-KDE) has been proposed (Brunsdon, *et al.*, 2007). ST-KDE incorporates both time and space into its analysis, allowing for more accurate predictions of crime hotspots and patterns. This method has been successfully applied to various applications, including predicting crime hotspots and demand for medical services.Despite its limitations, statistical methods can be a valuable tool for crime prediction. When used in conjunction with other crime prediction methods, such as machine learning and data mining, statistical methods can help to improve the accuracy of crime predictions.

### *3.2 Machine learning approaches*

Machine learning has several major advantages over traditional statistical techniques, and it can identify complex patterns in data, even when they cannot be easily detected. It is also managing large volumes of data and can adapt to real-time changes in crime patterns. Machine learning techniques can also handle unbalanced data, to minimize bias. All these advantages lead to more accurate predictions compared to traditional statistical techniques.

Conventional machine learning algorithms have demonstrated their effectiveness in crime prediction. Methods like Decision Trees, Support Vector Machines, Logistic Regression, and Random Forests have exhibited high accuracy in forecasting crime trends. Unlike deep learning, which demands vast amounts of data, traditional machine learning models operate on smaller datasets and offer greater interpretability. For instance, a logistic regression model can assess the probability of a specific crime type based on factors such as time of day, location, and demographic characteristics of the area. A decision tree model pinpoints the most influential factors contributing to a particular crime's occurrence. Random Forest models scrutinize a broad spectrum of features to generate crime pattern predictions. Moreover, traditional machine learning models are employed for anomaly detection and outlier analysis in crime data. By identifying atypical patterns or outliers in data, law enforcement agencies can detect potential criminal activity and take proactive measures to prevent it. In the subsequent sections, we delve into the latest advancements in the utilization of machine learning-based regression and classification models for crime forecasting.

### *3.3 Deep learning approaches*

Deep learning is a branch of machine learning that uses deep neural networks to analyze and extract complex features from data. Deep learning technologies used for crime prevention, focus on accurately capturing spatial and temporal dependencies within relevant data, to uncover patterns and trends associated with criminal activities and identify complex correlations and interdependencies.

Deep learning has become a popular method for crime forecasting in recent years. The studies included in the reference research articles use a range of deep learning algorithms, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), to analyze different types of data, including text, images, sound, and social media. These algorithms can detect patterns and anomalies in the data that could indicate certain criminal activities.

One of the main advantages of deep learning is its ability to handle large and complex data sets, which makes it suitable for the crime forecasting tasks. For example, image analysis algorithms detect threatening objects in certain places and make predictions about the occurrence of a crime. Text mining techniques are used to analyze suspicious tweets and make predictions about crime patterns. Using ConvLSTM (Convolutional Long Short-Term Memory), the authors (Yuan, *et al.*, 2018) predicted road traffic accidents and solved the problem of spatial heterogeneity.

The results indicate that different features have different importance depending on the type of regions, urban or rural. Another study (Solomon, *et al.*, 2022) proposed a framework based on a LSTM (Long short-term memory) and GRU (gated recurrent unit) for predicting burglaries in the city of Tel Aviv, Israel. The results suggested that the framework was able to determine the importance of contextual factors like location, time of day, and weather conditions for predicting burglaries with improved accuracy.

Researchers have used deep learning techniques to address both regression and classification problems in crime forecasting. These models analyze the context and shape of textual data to classify patterns that may indicate criminal activity. Studies demonstrate the versatility of deep learning algorithms in crime-related classification tasks, as they can be applied to a wide range of data types, including images, text, audio, and social media data.

Compared to general machine learning techniques, it offers several advantages such as identifying latent features which may be subtle and difficult to observe with other analysis methods, scalability to large data sets, high generalization capability with accurate predictions when using new data, understanding nonlinear data to capture complex relationships between variables in datasets, autonomy in learning features without intensive manual preprocessing and flexibility in representation, which allows adaptation to different types of crime data.

## 4. APPLICATIONS BASED ON ARTIFICIAL INTELLIGENCE FOR CRIME PREDICTION

Applications for crime prevention play a crucial role in enhancing public safety and fostering safer communities. These tools leverage advancements in technology, particularly artificial intelligence (AI) and machine learning (ML), to analyze vast amounts of data and identify patterns and trends associated with criminal activity. By harnessing these insights, law enforcement agencies, community organizations, and individuals can proactively address potential threats and implement effective crime prevention strategies.

ModeRad is a crime prediction application developed by the University of Illinois at Urbana-Champaignis, that uses machine learning to analyze historical crime data to identify patterns and predict where future crimes are likely to occur (Gallar, *et al.*, 2020). ModeRad can be used by law enforcement agencies to allocate resources more effectively and deter crime before it happens. It can also be used to identify areas with a high risk of crime, so law enforcement agencies can focus crime prevention efforts in those areas.

COMPAS (Correctional Offender Management Profiling for Alternative Sanctions) was developed by Northpointe (now Equivant), a software company that specializes in risk assessment tools for the criminal justice system. The tool has been used by courts and probation departments in over 40 states in the United States. COMPAS is a risk assessment tool used by the criminal justice system to assess the risk of recidivism among offenders (Brennan and Dieterich, 2018). The tool uses a variety of factors, including demographic data, criminal history, and psychological assessments, to generate a risk score for each offender. This score can then be used to inform decisions about sentencing, parole eligibility, and other interventions.

PRECOBS (Pre-Crime Observation System) was developed by IfmPt, the Institute for Pattern-based Prediction Technique from Oberhausen, Germany. It is a surveillance system that uses cameras and sensors to monitor public spaces for suspicious activity (Seidensticker, *et al.*, 2018). The system uses machine learning to analyze the data collected from the cameras and sensors to identify potential threats. PRECOBS can then alert law enforcement agencies in real time so that they can intervene and prevent crimes.

XLAW is a software platform developed by RR Software, a company that specializes in developing software solutions for the public sector, which helps law enforcement agencies collect, manage, and analyze crime data. (Bertassi, 2018), The platform can be used to track crime trends, identify crime patterns, and develop targeted crime prevention strategies.

PredPol (Predicting Policing) is a crime prediction tool developed by PredPol Inc., a company that specializes in developing crime prediction technology (Ensign, *et al.*, 2018). The application uses a variety of data sources, including crime data, social media data, and economic data, to predict where future crimes are likely to occur. The tool can be used by law enforcement agencies to deploy resources more effectively and deter crime before it happens (Meijer and Wessels, 2019).

VAAK (Vide Analytics for Awareness and Knowledge) is an innovative crime prevention tool developed by the Netherlands Police Academy in collaboration with TNO, a Dutch research organization. It utilizes a combination of machine learning and social media data to identify individuals who are at risk of becoming involved in crime (Belova, 2020). The tool can then be used to provide these individuals with interventions to help them avoid criminal activity.

HunchLab is a crime prediction system developed by Azavea, a Philadelphia-based company specializing

in geospatial data solutions. The application uses a meta-model to combine multiple forecasting methods into a single forecast (Shapiro, 2019). The meta-model uses machine learning to learn from the historical performance of each forecasting method and then weights each method accordingly. This allows HunchLab to generate more accurate forecasts than any single forecasting method on its own.

These are just a few of the many applications that use artificial intelligence for crime prevention. As AI technology continues to develop, we can expect to see even more innovative and effective applications in the years to come.

## 5. CONCLUSIONS

Artificial intelligence is a rapidly evolving field with the potential to revolutionize crime prediction and prevention. However, there are also significant challenges that need to be addressed before AI can be widely adopted in this domain. One of the main challenges is the lack of high-quality data. Crime data is often incomplete, inaccurate, and biased, which can make it difficult to train AI models that are accurate and fair. Additionally, there is a need for more research on how to interpret and explain AI models, so that law enforcement officials can understand why a model is making a particular prediction.

Despite these challenges, AI has the potential to be a powerful tool for crime prediction and prevention. The complexity of crime has increased with technological development, creating difficult problems for law enforcement agencies. Researcher's interest in using machine learning and deep learning to predict crime has also increased recently, with focus on finding patterns and trends in crime occurrence and improving the effectiveness of crime prediction models by leveraging large datasets and sophisticated algorithms.

The use of machine learning and deep learning algorithms to predict and identify criminal activity has shown significant promise in solving the crime prediction tasks.

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