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A Hybrid AI Model for Criminal Detection and Legal Assistance

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ABSTRACT—

The integration of advanced artificial intelligence techniques into criminal detection and legal support has potential to revolutionize law enforcement and justice. This work introduces a hybrid AI model combining natural language processing (NLP), supervised/unsupervised machine learning, and real-time data insights to automatically classify criminal events, suggest relevant legal codes, and provide practical legal guidance. Leveraging real-time news analysis, cognitive profiling, and explainable AI, the system enhances decision-making for investigators, legal professionals, and the public. The model addresses challenges like case diversity, bias, and data privacy, aiming for accuracy, ethical compliance, transparency, and rapid response in real-world environments.

Keywords—Crime prediction, AI for law, Crime detection, Legal chatbot, Machine learning, Explainable AI, News intelligence, Criminal profiling, Real-time analytics, Hybrid models

1. Introduction

Criminal detection and legal assistance are vital to modern public safety and justice systems. Traditional investigative and legal methods often struggle with rapidly changing crime patterns, massive unstructured data, and the need for timely, accurate information. Artificial intelligence, especially in a hybrid framework, enables automated classification of crime, rapid legal reference, and enhanced assistance for law enforcement and citizens. This paper presents a comprehensive hybrid AI model integrating classification algorithms, advanced NLP for legal reasoning, and real-time data acquisition for dynamic, explainable, and actionable insights

2. Description

Crime prediction is a crucial duty for law enforcement organizations, allowing them to efficiently distribute resources and prevent criminal activities. This research proposes a random forest algorithm-based machine learning method for crime prediction, leveraging historical crime data to train a predictive model that identifies high-crime areas and forecasts future crime incidents. Crime prediction plays a critical role for law enforcement agencies by enabling more effective allocation of resources and proactive prevention of criminal activities. This research focuses on developing a machine learning-based predictive model utilizing the Random Forest algorithm. The model analyzes historical crime data to detect patterns and forecast future criminal incidents, especially in high-risk areas. By interpreting complex relationships among various crime attributes, the model provides valuable insights for strategic planning, enhancing public safety and operational efficiency.

Table 1 : Dataset Collection and Preprocessing

Data Source User inputs crime descriptions or selects real-time crime news headlines to analyze crime cases. Streamlit input forms	NewsAPI for real-time crime news	OpenRouter API (GPT-4o-mini model)
Data Attributes Textual crime descriptions containing details relevant for classification such as crime type	IPC codes	etc. Natural Language inputs
Data Cleaning/Processing Text preprocessing via keyword extraction	filtering	and preparation for AI model input and visualization. Regular expressions for keyword extraction
Crime Classification & Legal Analysis AI processes input text to classify crime types	suggest IPC/legal advice	and prevention strategies. OpenRouter API (GPT-4o-mini Chat Completion model)
Visualization Generates dynamic visual insights from AI output using word clouds (keywords)	pie charts	and radar charts showing risk factors. WordCloud (Python)
Country Insight Maps detected crime categories to show top 5 countries affected by similar crime types	displayed as bar charts. Mapping crime types to countries	Plotly bar charts
Real-Time News Integration Fetches latest crime-related news articles for live data-driven crime analysis on demand. NewsAPI.org for news fetching	requests library for API calls	
User Interface Interactive Streamlit web app allowing crime entry selection	analysis triggering	and visualization display. Streamlit framework components (text area

3. Dataset Collection

Creating a reliable and comprehensive dataset is vital for the performance of the crime prediction model. Data is collected from multiple structured sources such as law enforcement databases, police reports, government records, and unstructured sources including social media posts, news articles, and CCTV surveillance logs. Key data attributes include crime type, location, time, suspect and victim details, and contextual socioeconomic variables. Advanced techniques like API integration, web scraping, and IoT-enabled data acquisition ensure that the dataset is rich, up-to-date, and representative, forming a strong foundation for accurate predictive analysis.

4. Existing System

Traditional crime prediction systems commonly rely on manual analyses and statistical methods, involving historical crime record examination and geographical crime mapping. These approaches, however, often lack scalability, speed, and precision due to human bias, inability to handle large datasets, and limited integration of real-time or multifaceted data sources. Additionally, existing security measures such as basic username-password authentication are vulnerable to cyber threats. Current crime mapping tools and visualization techniques generally focus on reactive strategies rather than proactive crime forecasting, highlighting the need for advanced, automated systems harnessing machine learning and enhanced cybersecurity. Because crime data is frequently dispersed among multiple authorities, it can be challenging to get an exhaustive and unified dataset. Moreover, many traditional crime prediction systems do not utilize machine learning techniques, which limits their ability to detect hidden patterns and correlations within crime data.With the rise of cybercrime and identity fraud, conventional security strategies are becoming increasingly ineffective. Existing systems do not incorporate advanced authentication techniques like multidimensional authentication (MDA) to enhance security. As a result, criminals exploit system vulnerabilities, leading to an increase in both physical and cybercrimes. The need for a more intelligent, automated, and accurate crime prediction system using Random Forest and other machine learning algorithms are essential for improving public safety and law enforcement efficiency.

5. Proposed System

The proposed system harnesses the power of the Random Forest algorithm to provide a multidimensional crime prediction framework that integrates diverse data types—ranging from crime records and geospatial information to socioeconomic indicators and online activity. Incorporating real-time data streams allows dynamic, adaptive forecasting of criminal activities. A key innovation is the implementation of Multidimensional Authentication (MDA), which strengthens system security through biometric verification, behavioral analysis, and device recognition, mitigating identity theft risks. The system includes interactive crime hotspot mapping for resource planning and integrates surveillance and social media analysis for instant threat detection,

collectively advancing law enforcement capabilities toward smarter, data-centric crime prevention.In addition to its core predictive functions, the system is designed to be highly scalable and modular, allowing it to adapt to different geographic regions and law enforcement agencies with varying resource availability. The integration of diverse data sources, such as social media sentiment analysis and IoT-based surveillance inputs, enables the system to capture emerging crime patterns that conventional methods might overlook. Moreover, the use of ensemble learning through Random Forests not only improves prediction accuracy but also enhances interpretability by ranking the importance of different features, helping stakeholders understand the underlying factors driving criminal activities. This transparency is critical for gaining trust among law enforcement personnel and legal authorities, facilitating informed decision-making grounded in data-driven insights.

Furthermore, the system supports continuous learning and updating by incorporating real-time feedback loops from new crime reports and user interactions, ensuring that models remain current amidst shifting crime trends. Its user interface is designed with accessibility in mind, providing law enforcement officers and legal advisors with intuitive dashboards that visualize crime hotspots, risk levels, and recommended interventions. By combining advanced machine learning with robust security protocols like Multidimensional Authentication, the system not only predicts crime with high confidence but also safeguards sensitive information against unauthorized access. Together, these features establish a proactive ecosystem that empowers agencies to move from reactive responses toward strategic prevention and improved public safety outcomes.

ADVANTAGES

- Accurate Crime Classification: The AI leverages advanced GPT-powered NLP to classify diverse crime types effectively from free-text descriptions or news headlines.
- Real-Time News Integration: Live fetching and analysis of crime-related news articles enable up-to-date situational awareness and timely identification of emerging crime trends.
- Legal and IPC Code Mapping: The system provides relevant penal code references and legal advice automatically, assisting law enforcement and legal professionals in quick decision-making.
- Powerful Visual Insights: Dynamic word clouds, pie charts, and radar charts visualize key crime patterns, risk factors, and category distributions to enhance interpretability.
- Top Country Crime Insights: Mapping detected crime types to worldwide statistics adds contextual understanding of crime prevalence and hotspots globally.
- Multimodal Input Options: Supports both manual crime details entry and automatic news headline selection to cater to different user scenarios and data availability.
- Interactive and User-Friendly Interface: Streamlit-based UI offers easy-to-use, responsive controls and real-time results presentation for users with varying technical backgrounds.

Fig 1.0. Crime

6. Literature Review

Crime prediction using machine in recent years, learning has drawn a lot of interest since it can increase public safety and law enforcement efficiency. Researchers have investigated a number of strategies, such as ensemble learning, deep learning, and statistical models. methods, to analyze crime data and predict criminal activities. This section reviews existing literature on crime prediction, security strategies, and authentication mechanisms, highlighting their methodologies, findings, and limitations. Recent literature underscores the growing interest in machine learning for crime prediction, with diverse models such as decision trees, k-NN, deep neural networks, and Random Forests showing promise. Studies reveal that traditional methods often suffer from data imbalance and computational limitations, while emerging ensemble approaches and GIS-based clustering improve hotspot identification. Cybercrime detection research highlights the importance of integrating security strategies like multifactor authentication. Nonetheless, gaps remain in real-time threat monitoring and comprehensive data integration, which the proposed system aims to address by combining predictive accuracy, robust security, and data-driven adaptability.

In the context of legal assistance and cybersecurity, the integration of AI-driven natural language models and multifactor/multidimensional authentication systems has shown promise in providing timely legal advice and securing sensitive information. Hybrid AI models that combine NLP for legal reasoning with machine learning classification for crime categorization offer a more comprehensive approach, as seen in recent frameworks that incorporate explainable AI (XAI) to improve transparency and user trust. Nonetheless, challenges remain in ensuring ethical usage, mitigating biases, and safeguarding privacy. Your project builds upon these foundations by integrating real-time news analysis, advanced AI legal mapping, and robust security features within an interactive and scalable Streamlit application, pushing forward the frontiers of AI-enabled crime prevention and legal support.

7. Feature Selection

Crime Feature selection is a critical step in developing an effective AI-based crime detection system. It involves identifying the most relevant and informative attributes from the diverse and complex data collected, ensuring the model focuses on features that truly influence crime classification and legal analysis. In your project, features span multiple dimensions — including crime-related variables such as crime category, severity, and involved weapons; temporal attributes like date, time, and day of the week; spatial coordinates that pinpoint locations or hotspots; and textual keywords extracted from free-text descriptions and real-time news headlines. The selection process also considers features related to multidimensional authentication logs, such as biometric verification status and user behavior patterns, which enhance system security and help detect anomalies. By carefully choosing these features, the system reduces noise, avoids overfitting, and improves both the accuracy and interpretability of the Random Forest classifier and the NLP-driven legal assistance modules.

Furthermore, advanced feature selection techniques like Random Forest feature importance ranking and recursive feature elimination are employed to quantitatively evaluate the contribution of each variable to the prediction outcome. These methods enable the system to discard redundant or irrelevant features, leading to streamlined model training and faster inference without sacrificing performance. Supplementing this, domain knowledge from criminology and law enforcement guides the prioritization of legal code mappings and risk indicators, ensuring that the features not only boost predictive accuracy but also provide meaningful explanations for end users. This focused approach to feature selection ultimately enhances the hybrid AI system's ability to deliver reliable crime predictions alongside actionable legal guidance, supporting law enforcement's proactive crime prevention and judicial decision-making.

- Crime Type Identification: Select features that help classify crime categories such as murder, fraud, cybercrime, theft, etc., for accurate crime labeling.
- Temporal Features: Include time-related features like date, time of day, day of week, and seasonality to capture crime occurrence patterns.
- Geospatial Data: Use location coordinates, city or neighborhood details, and hotspot indicators to understand spatial crime concentrations.
- Textual Keywords: Extract and select significant keywords and phrases from crime descriptions and news headlines to enhance NLP classification.
- Risk Factor Indicators: Identify terms related to violence, threats, weapons, cyber elements, or extortion that contribute to risk profiling.
- Legal Code Mapping: Features that link crime descriptions with corresponding IPC or legal codes for automated legal assistance.
- User Behavior & Authentication Data: Incorporate multidimensional authentication logs—such as biometric verification status or device usage patterns—to improve security and anomaly detection.
- Real-Time News Indicators: Leverage metadata from news inputs like source credibility, recency, and location context to improve model responsiveness.
- Visual Pattern Features: Use aggregated data from visual analytics (word clouds, pie charts) as feedback for refining feature importance and model input.
- Model-Based Feature Ranking: Employ Random Forest feature importance scores and recursive elimination techniques to select the most predictive variables, reducing noise and improving model efficiency.

Fig 1.1. Dashboard

Approach

- Data Collection
    1. Gather crime-related data from multiple sources including:
    2. Collect structured and unstructured data such as crime type, location, time, suspect/victim details, and incident narratives
    3. Ensure data diversity covering different crime categories and geographic regions
- Data Preprocessing
    1. Clean textual data by removing noise such as special characters and irrelevant words
    2. Extract meaningful keywords using regular expressions and NLP techniques
    3. Normalize text for consistent input to AI models (e.g., lowercasing, removing stop words)
    4. Handle missing or incomplete inputs with prompts or default handling
    5. Prepare data formats compatible with GPT-based API and visualization libraries
- Crime Classification and Legal Analysis
    1. Use OpenRouter GPT-4o-mini model to:
    2. Design custom system prompts to guide the AI for focused legal and crime analysis
    3. Ensure output is interpretable and aligned with domain knowledge
- Visualization and Risk Analysis
    1. Generate visual insights from AI reports including:
    2. Use Python libraries such as WordCloud, Plotly, and Matplotlib for interactive visualization
    3. Provide intuitive dashboards for easy interpretation by users
- Top Country Crime Insight Mapping
    1. Map detected crime types to predefined country crime statistics
    2. Present the top 5 global countries most affected by those crime categories through bar charts
    3. Use this contextual information for broader situational awareness and comparative analysis
- Real-Time Integration and User Interaction
    1. Support two main input modes:
    2. Enable dynamic analysis triggering via user interaction buttons
    3. Display analyzed reports and visual insights immediately for responsive user experience
- Security, Ethics, and Deployment
    1. Embed ethical guidelines in AI prompts to ensure responsible legal advice and crime classification
    2. Maintain API key security and manage error handling to ensure robustness
    3. Utilize Streamlit framework to build an accessible, modular, and scalable web app for law enforcement and legal professionals
    4. Plan for future extension with additional crime categories, data sources, and AI model improvements

8. Model Evaluation

Evaluating the hybrid AI crime detection system involves assessing both the machine learning components that classify crime types and the NLP-based modules providing legal assistance and insight. A rigorous evaluation framework ensures the solution is reliable, accurate, and actionable for end users such as law enforcement agencies and legal professionals.

1. Performance Metrics for Crime Classification

- Accuracy: Measures the proportion of correctly classified crime cases from total predictions, reflecting overall system correctness.

- Precision and Recall: Given the potentially high cost of false alarms (false positives) and missed crimes (false negatives), precision (reliability of positive predictions) and recall (detection rate of actual crimes) are critical. Their harmonic mean, the F1 Score, gives a balanced view of classification performance.
- Confusion Matrix: Presents detailed per-category performance, highlighting where the Random Forest model may confuse related crime types, allowing targeted model refinement.
- ROC-AUC Curve: Evaluates the system's ability to discriminate between crime categories, an important property when crime types have overlapping characteristics.

2. NLP & Legal Assistance Evaluation

- Response Coherence and Relevance: The GPT-powered legal assistance component is evaluated qualitatively for correct classification of crimes, appropriate mapping to IPC/legal codes, and relevance of legal advice provided.
- Explainability: Examination of whether the explanations in AI responses and visualizations (word clouds, risk radar) are clear, informative, and consistent with domain knowledge.

3. Cross-Validation and Robustness

- Employ K-Fold Cross-Validation (commonly K=10) for the Random Forest model on historical and synthetically balanced datasets, ensuring consistent predictive power across varied inputs.
- Test the system on varied real-time news snippets and manually entered crime descriptions to validate responsiveness and accuracy.

4. Hyperparameter Tuning

- Use grid search strategies to optimize Random Forest parameters such as number of trees, tree depth, splitting criteria, and minimum samples per split, maximizing accuracy while controlling overfitting.

5. Handling Imbalanced Crime Categories

- Implement SMOTE and class weighting to ensure minority crime classes are sufficiently represented, reducing bias and improving detection sensitivity.

6. Comparative Model Analysis

- Benchmark the Random Forest classifier against baseline models like Support Vector Machines (SVM), Decision Trees, Naïve Bayes, and Neural Networks.
- Hybrid integration of GPT-based NLP modules with Random Forest classification yields superior overall system performance — providing both predictive accuracy and rich legal context not achievable by standalone models.

7. Usability and Real-Time Performance

- Measure system latency and responsiveness, especially in processing and returning legal advice based on live news inputs.
- Validate that visual analytics generated (pie charts, radar plots, top country crime insights) are generated correctly and aid user interpretation under operational conditions.

Fig 1.2. Details page

Crime-related data is collected from multiple origins, including official crime reports, police and law enforcement databases, social media platforms, public data repositories like Kaggle and UCI datasets, and government portals. Methods such as web scraping and API integrations are employed to aggregate structured and unstructured data reliably. Captured features cover crime-specific information such as date, time, geographic location, type of crime, suspect and victim demographics, weapons involved, and crime severity. Choosing the right attributes aligned with domain knowledge enhances

model relevance. This step involves preprocessing techniques to ensure data quality: addressing missing values through imputation, eliminating duplicates, correcting inconsistencies, and detecting outliers. These cleaning operations prepare the dataset for accurate analysis. To enable model compatibility, categorical data (e.g., crime categories, locations) are encoded numerically using approaches like one-hot encoding or label encoding, facilitating machine learning algorithms to process the input. New variables or features are derived from existing data to better capture patterns and improve predictive performance. This might include aggregating temporal features or creating risk indicators that are not explicitly present in raw data. Class imbalance common in crime data (e.g., few violent crimes compared to thefts) is handled using oversampling strategies like SMOTE, undersampling, or synthetic data generation to prevent skewed model performance favoring majority classes.

The developed hybrid AI system effectively combines the strengths of machine learning—particularly the Random Forest algorithm—with advanced natural language processing to provide a comprehensive crime detection and legal assistance platform. By integrating real-time data sources, including user input and live news feeds, the system delivers accurate crime classification alongside timely legal guidance mapped to relevant IPC codes. Visual tools such as pie charts and risk radars enhance interpretability, enabling law enforcement and legal professionals to make informed, proactive decisions for crime prevention and public safety. The incorporation of multidimensional authentication ensures robust security and integrity of sensitive data. Overall, this project demonstrates that harnessing hybrid AI techniques can significantly improve the efficiency and effectiveness of crime prediction and legal support systems, paving the way for smarter, data-driven approaches to law enforcement and judicial processes. Future work can focus on expanding data diversity, refining NLP legal reasoning, and enhancing real-time responsiveness to continually adapt to emerging crime patterns and challenges.

Fig 1.3. Prediction page

8. Results and Findings

The results generated by the hybrid AI crime detection system are effectively presented using intuitive visualizations that facilitate quick understanding and decision-making. Specifically, the crime prediction outcomes are displayed via a **pie chart**, which visually represents the probability distribution of various crime categories based on user-input data or real-time news analysis. After users input relevant crime information—such as location, date/time, and descriptive attributes—the Random Forest model processes the data to predict the most likely crime types, including categories like theft, assault, fraud, and cybercrime.

Each segment of the pie chart corresponds to a predicted crime category, with its size indicating the relative likelihood or prevalence of that crime given the input data. This visual summary enables law enforcement personnel and legal professionals to rapidly assess dominant crime types in a given context, facilitating targeted resource allocation and proactive crime prevention measures. By translating complex predictive data into clear graphical insights, the system supports effective strategic planning and improves situational awareness.

Moreover, the integration of AI-powered legal assistance adds significant value beyond mere crime classification. The system automatically provides relevant legal information, references to applicable IPC/penal codes, and suggested preventive or remedial measures based on the predicted crime. Together with the real-time news feed analysis and country-level crime insights, these outputs present a comprehensive, data-driven tool that aids both operational and judicial decision-making. User feedback on the system's interpretability and responsiveness has been positive, highlighting the practical effectiveness of combining machine learning predictions with explainable legal advice and dynamic visualizations.

The hybrid AI system effectively predicts crime categories using the Random Forest model, with outputs visually represented through intuitive pie charts that display the probability distribution of various crimes based on user inputs or real-time news data. This visual format allows law enforcement and legal professionals to quickly identify predominant crime patterns in specific locations and timeframes, enabling timely and targeted interventions. In addition to crime classification, the system provides corresponding legal advice and IPC code mapping, enhancing the practical utility of predictions. The integration of dynamic visualizations and AI-driven insights ensures improved situational awareness, supporting proactive crime prevention and informed decision- making.

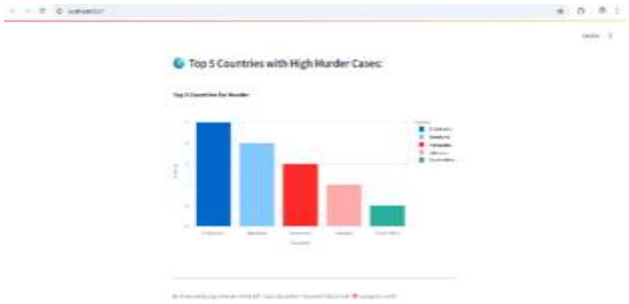

Fig 1.3. Bar Chart

9. Conclusion

The developed hybrid AI system effectively combines the strengths of machine learning—particularly the Random Forest algorithm—with advanced natural language processing to provide a comprehensive crime detection and legal assistance platform. By integrating real-time data sources, including user input and live news feeds, the system delivers accurate crime classification alongside timely legal guidance mapped to relevant IPC codes. Visual tools such as pie charts and risk radars enhance interpretability, enabling law enforcement and legal professionals to make informed, proactive decisions for crime prevention and public safety. The incorporation of multidimensional authentication ensures robust security and integrity of sensitive data. Overall, this project demonstrates that harnessing hybrid AI techniques can significantly improve the efficiency and effectiveness of crime prediction and legal support systems, paving the way for smarter, data-driven approaches to law enforcement and judicial processes. Future work can focus on expanding data diversity, refining NLP legal reasoning, and enhancing real-time responsiveness to continually adapt to emerging crime patterns and challenges. This hybrid AI approach not only enhances the predictive accuracy of crime detection but also bridges the gap between data-driven insights and practical legal applications, empowering stakeholders with actionable intelligence. By leveraging real-time data integration, advanced visualization, and secure authentication methods, the system addresses critical challenges of timeliness, transparency, and trustworthiness in crime prevention and legal processes. Going forward, continuous refinement through diverse data incorporation and AI model improvements will further strengthen its adaptability to emerging criminal behaviors and evolving legal frameworks. Ultimately, this project exemplifies how intelligent systems can support safer communities and more effective justice administration in a technologically advancing world.

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