

Enhanced Crime Hotspot Prediction and Visualization for Women's Safety Through Deep Learning

A. Asmi

Department of Computer Science, St. Mary's College (Autonomous) Thoothukudi
Affiliated to Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, India.

Abstract

Crime hotspots are geographic areas with elevated levels of criminal activity compared to other regions. Women in these hotspots are at increased risk of experiencing various forms of criminal behavior, including sexual harassment, assault, domestic violence, and human trafficking. Identifying these hotspots is crucial for effective crime prevention and resource allocation by law enforcement agencies. This project presents Safety Locator to identify and map crime hotspots where women are particularly vulnerable. The system utilizes the Deep Explainable Decision Tree model, a machine learning algorithm that analyzes historical crime data to predict the criminal activity in specific areas. The Deep Explainable Decision Tree model classifies data into crime hotspot categories and visualizes these areas on Google Maps. By analyzing factors such as the number and type of reported crimes and crime locations, the system generates a detailed map highlighting high-risk areas. This map can be shared with the public to increase awareness and promote safety. The development process includes data pre-processing, feature selection, model training and prediction. Safety Locator aims to assist law enforcement agencies in preventing crime and enhancing public safety. By creating safer environments for women, the system supports efforts toward gender equality and improved quality of life.

Keywords

Crime hotspot, women safety, Explainable Decision Tree, machine learning, safest route prediction.

1. Introduction

Crimes against women are of various types as crimes involving sex for economic gains including prostitution, wrongful confinement, trafficking, dowry extortion, rape, assault, harassment at work place, gang-rape, acid-attack, kidnapping, and other immoral acts are injurious to the society. In present scenario cases of murder, rape, molestation, sexual abuse, and eve-teasing etc. Women feel discrimination, harassment and domestic violence at work. Use of money and muscle

power to save accused. Politics in the name of caste, religion take benefit as well. India at 108th place according to Global Gender Gap Index 2017. Violence against women and girls is rooted in gender-based discrimination and social norms. Women are so helpless in the Indian society where many female goddesses are worshipped but still people don't respect women. It is high time when the social revolution is needed to root out this evil from Indian society and given respect and recognition to our women. Crime hotspots are areas that have high crime intensity. These are usually visualized using a map. They are developed for researchers and analysts to examine geographic areas in relation to crime. Hot spots are areas with a high occurrence of crime. These areas can be anywhere. These hot spots are areas where crime is more likely to occur, and law enforcement agencies often focus their resources and efforts in these areas to prevent and reduce criminal activity. A holistic framework integrating crime prevention, response, and analysis with an emphasis on women's safety. Utilizing GIS techniques their system identifies crime hotspots and integrates mobile applications, wearable gadgets, and community participation for real-time safety measures^[1]. Crime hot spots can be identified through various methods such as analyzing crime data, conducting community surveys, and mapping criminal activity patterns. By identifying crime hot spots, law enforcement can use targeted strategies to prevent and reduce crime in those areas.

2. Materials and Methods

2.1. Data Analysis Technique

Explainable AI (XAI) Algorithm

Crime hotspot prediction uses machine learning to identify locations with a high likelihood of criminal activity. The deep learning and big data analytics to analyse crime patterns in three U.S. cities. Their research leveraged AI models to detect trends, enhance predictive accuracy, and support law enforcement in crime prevention strategies^[2]. Since law enforcement agencies need to understand and trust AI-generated predictions, Explainable AI (XAI) is crucial.

- **Trust:** If officers understand how the AI predicts hotspots, they can use the insights effectively.
- **Accountability:** Helps in understanding why certain areas are labelled as crime hotspots.

2.2. System

Design

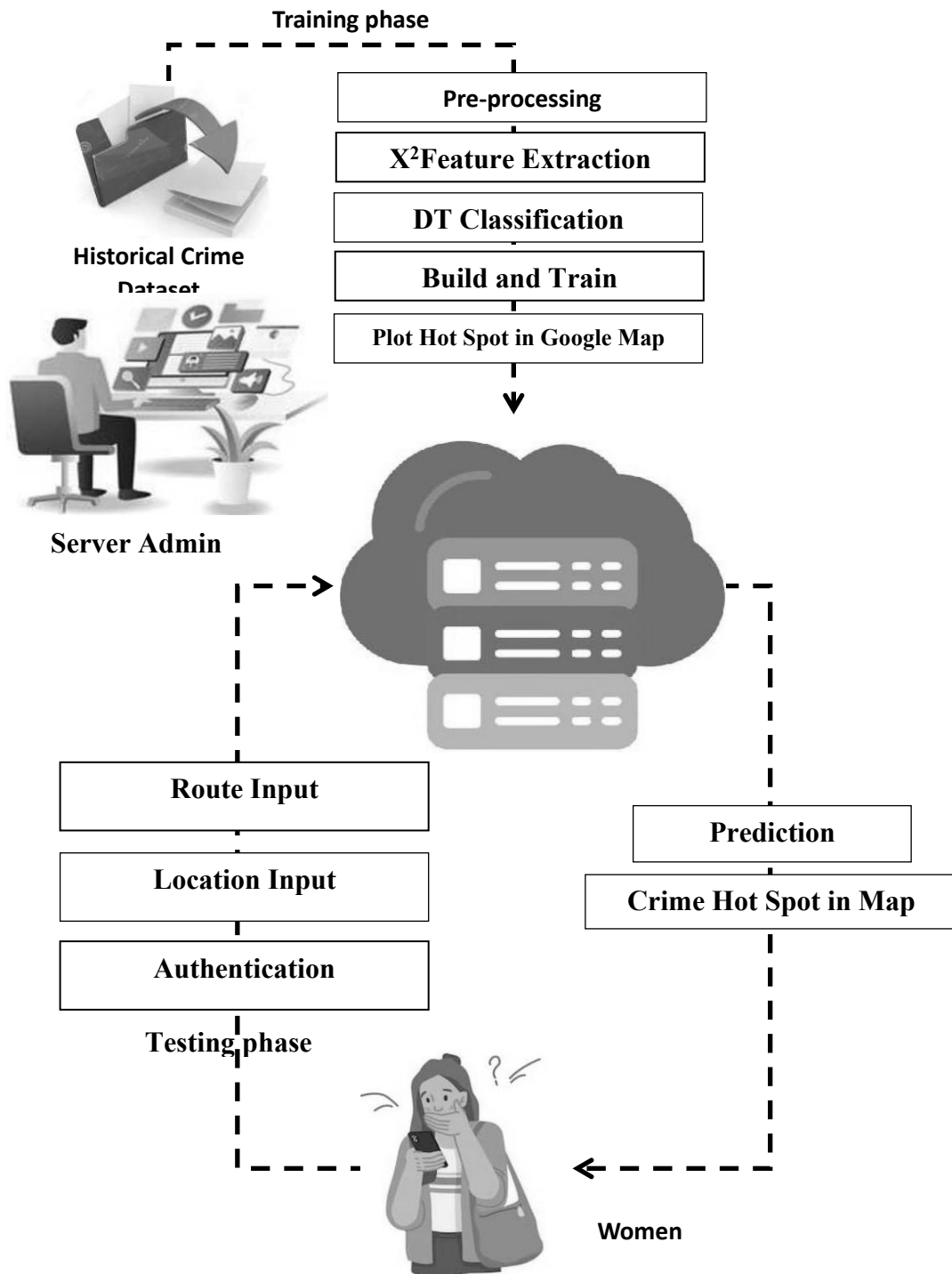


Figure 1. Architecture Design of Crime Hotspot Prediction System

Decision Tree Algorithm

A Decision Tree is a supervised learning algorithm that helps classify locations as high or low crime risk areas based on historical data.

- **Data Collection:** Crime patterns are influenced by historical records (robbery, assault, burglary), environmental factors (street lighting, population density), and time-based trends (weekdays vs. weekends, time of day). Understanding these elements helps enhance safety and crime prevention strategies.
- **Feature Selection and Splitting:** The model selects key crime indicators (e.g., crime count in past weeks, proximity to police stations).
- **Training the Model:** The Decision Tree learns from past data to classify areas as crime hotspots or safe zones.

xDT (eXplainable Decision Tree) Algorithm

- **Feature Handling:** It can handle large datasets with multiple features (like crime type, location, time, etc.) and make predictions about crime hotspots.
- **Speed and Accuracy:** xDT provides faster training and higher accuracy, which is crucial when predicting crime patterns in large cities or multiple regions.
- **Feature Importance:** It can also show which factors (e.g., time of day, neighbourhood, weather) are most important for predicting crime hotspots.

Machine Learning Algorithm

The machine learning techniques for crime prediction, using datasets from Chicago and Los Angeles. Their models improved crime forecasting accuracy, identifying high-risk areas and future crime trends^[3]. A smart policing technique using machine learning to predict crime types and risk scores^[4].

- **Pattern Recognition:** Machine learning algorithms can recognize patterns in crime data, helping to identify areas that are more likely to experience crimes.
- **Predictive Power:** With historical crime data (time, location, type of crime), ML can predict future crime hotspots based on past trends.
- **Adaptability:** It can adapt to new data over time, improving predictions as more data is fed into the system.

K-Means Clustering Algorithm

A graph-based clustering approach for relation extraction from crime data. Using natural language processing, they analysed crime reports to identify

relationships between entities, aiding law enforcement in crime pattern analysis and investigation^[5].

- **Crime Grouping:** K-Means can cluster different locations based on the number and type of crimes. For example, it can group areas with similar crime patterns (e.g., robbery, assault) into "hotspots."
- **Visualizing Hotspots:** The algorithm helps identify which areas have the highest concentration of crime, so law enforcement or city planners can focus on those areas.
- **Improved Decision Making:** By grouping similar incidents together, K-Means helps identify patterns that humans might miss.

Random Forest Algorithm

- **Robust and Accurate:** Random Forest improves the accuracy and robustness of crime prediction by combining the results of multiple decision trees.
- **Feature Importance:** Random Forest identifies important features (e.g., crime type, location, etc.), which can help determine the most influential factors in predicting crime hotspots.
- **Reducing Overfitting:** Since it uses multiple trees, Random Forest reduces the risk of overfitting, making predictions more reliable on unseen data.

2.3. Tools and Software used

Python

Python is a general-purpose interpreted, interactive, object-oriented, and high-level programming language. It was created by Guido van Rossum during 1985-1990. Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is currently the most widely used multi-purpose, high-level programming language. Python programs generally are smaller than other programming languages like Java. Python language is being used by almost all tech-giant companies like – Google, Amazon, Facebook, Instagram, Dropbox, Uber. Python's syntax is simple and mirrors human language, making it easy for beginners to learn. The language emphasizes readability and reduces the complexity of the code. Python is an interpreted language, meaning the code is executed line-by-line by an interpreter, rather than compiled into machine code beforehand. This makes debugging and testing easier and faster. Python includes a vast library of modules and

functions, which makes tasks like file handling, web development, and database interaction easier. You don't need to write code for everything from scratch as you can rely on the standard library. Python code can be run on various platforms such as Windows, macOS, Linux, and others, without modification, making it highly portable. Python supports Object-Oriented Programming (OOP), which helps in organizing and structuring your code more efficiently. Python has an automatic garbage collection system, which means that it takes care of memory management by automatically cleaning up objects that are no longer in use.

3. Results and Discussion

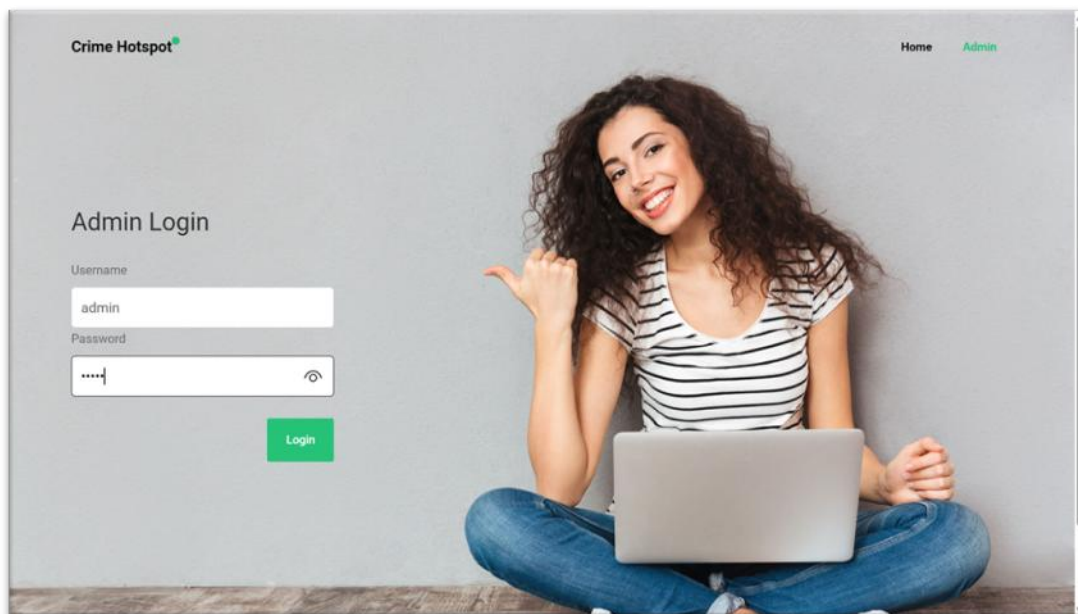


Figure 1. Admin Login

Figure 1. shows Admin Login with username and password

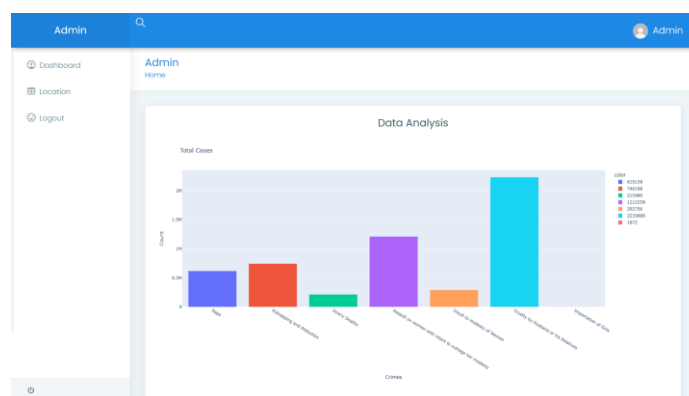
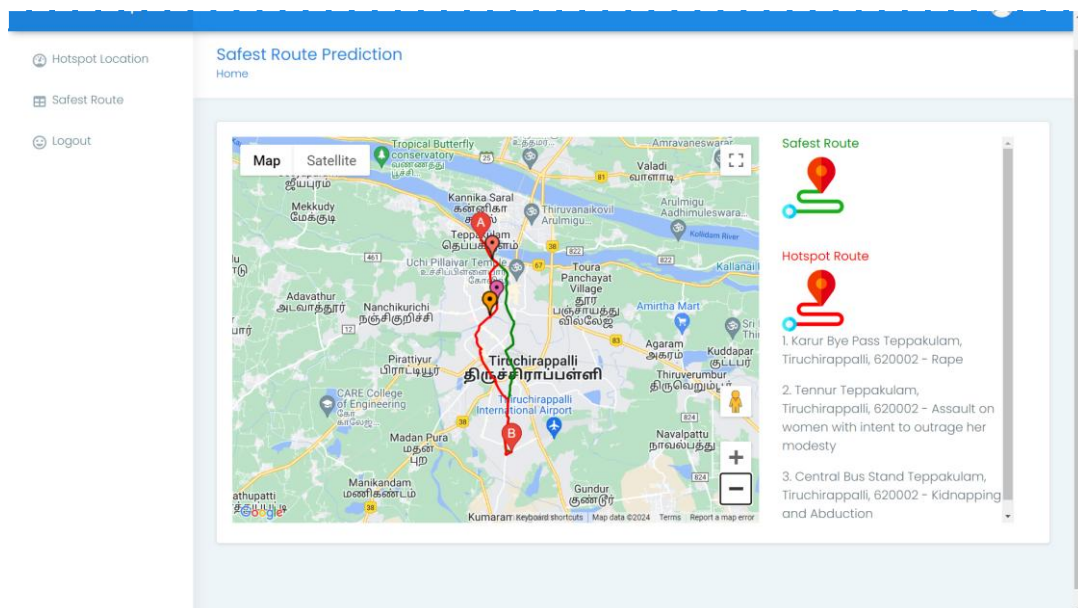


Figure 2. Data Analysis

A woman with curly hair is sitting cross-legged on a wooden floor, using a laptop. She is smiling and pointing towards the login form on the left. The background is a plain grey wall.

Figure 3. shows User signing in with email and password



7

In Figure 4. a map of Tiruchirappalli shows the both safest and hotspot paths in different colours.

4. Conclusion

The proposed system is a useful tool to predict crime hotspots and provide recommendations to women for safer routes. The system employs the explainable Decision Tree (xDT) algorithm for crime hotspot prediction and integrates Google Maps API for visualization and location-based recommendations. The proposed system has many advantages over the existing manual systems and other data mining techniques. It provides a more accurate and efficient way of predicting crime hotspots, which will allow law enforcement agencies to take proactive measures to prevent crime against women. The system is also user-friendly, making it easy for end-users to access and utilize. Overall, the Crime Hot Spot Prediction and Localization System for Women Safety using xDT and Google Map API is a step towards creating a safer environment for women and empowering them to make informed decisions regarding their safety.

5. References

- [1] Meetha V. Shenoy and Smriti Sridhar (2021). A holistic framework for crime prevention, response, and analysis with emphasis on women safety using technology and societal participation. *IEEE Access*, 9, 66188-66207.
- [2] Amir Hussain and Jinchang Ren (2019). Big data analytics and mining for effective visualization and trends forecasting of crime data. *IEEE Access*, 7, 106111–106123.
- [3] Wajiha Safat and Sohail Asghar (2021). Empirical analysis for crime prediction and forecasting using machine learning and deep learning techniques. *IEEE Access*, 9, 70080–70094.
- [4] Wonjoo Park, Jaehong Park, and Kwang-Ho Jang (2021). Smart policing technique with crime type and risk score prediction based on machine learning for early awareness of risk situation. *IEEE Access*, 9, 131906–131915
- [5] J. Nayak, D. Pelusi, and W. Ding (2019). A graph-based clustering approach for relation extraction from crime data. *IEEE Access*, 7, 101269–101282.