International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

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

[1] Mr P. Rajapandian, [2] A.Puvviyarasi

[1]Associate Professor, Department of Computer Applications, Sri Manakula Vinayagar Engineering college (Autonomous), Puducherry 605008, India.

[2]Post Graduate Student, Department of Computer Applications, Sri Manakula Vinayagar Engineering college (Autonomous), Puducherry 605008, India.

*Corresponding author's email address: puvviyarasi@gmail.com

Abstract- Crime hotspots are geographic areas with elevated levels of criminal activities 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, stalking, and human trafficking. Identifying these hotspots is crucial for effective crime prevention and resource allocation by law enforcement agencies. This project presents Safety Locator, a predictive system that uses multimodal deep learning 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 likelihood of 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, the timing of incidents, 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, evaluation, hyperparameter tuning, and prediction. This model's performance is assessed using metrics like accuracy, precision, recall, and F1-score, with hyperparameters optimized through cross-validation. Safety Locator aims to assist law enforcement agencies in preventing crime and enhancing public safety by pinpointing areas with high crime probabilities. By creating safer environments for women, the system supports efforts toward gender equality and improved quality of life.

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 unlawful acts are injurious to the society. In present scenario cases of murder, rape, molestation, sexual abuse, and eve-teasing etc. Women feel insight, harassment and domestic violence etc at work. Use of money and muscle power to save accused. Politics in the name of caste, religion etc take benefit as well.

Brutality 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 the women. Crime hotspots are areas that have high crime violence. These are usually visualized using a map. It is 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. They can be bars, malls, neighbourhoods, pretty much anywhere criminals target.

These hotspots 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. Crime hot spots can be

identified through various methods such as analysing 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. The goal of this project is to develop a Crime Hotspot Prediction System that specifically focuses on women's safety using Machine Learning. The system will be designed to be user-friendly, accessible, and easy to use, with the aim of empowering women to take control of their safety. The Crime Hot Spot Prediction System using Machine Learning will be a valuable tool for law enforcement agencies, policymakers, and community organizations, enabling them to develop targeted strategies for preventing and reducing crime in hot spot areas.

The aim of the project is to develop a predictive system that utilizes deep learning techniques, specifically the Deep Explainable Decision Tree model, to identify and visualize crime hotspots where women are at an increased risk of criminal activity. This system will analyze historical crime data to predict high-risk areas and provide a comprehensive tool to assist law enforcement and the general public in improving safety and crime prevention strategies.

2. PROPOSED SYSTEM

The primary objective of this project is to design and develop a robust, intelligent, and user-centric system aimed at predicting and localizing crime hotspots, with a special focus on enhancing the safety of women. At the core of the system lies the Explainable Decision Tree (xDT) algorithm, which ensures transparency in the decision-making process by offering interpretable outputs that reveal the underlying factors influencing each crime prediction. This approach fosters trust and improves the comprehensibility of the system among users and stakeholders. To complement this, the integration of the Google Map API enables precise geospatial visualization of predicted high-risk areas. The real-time mapping functionality enhances situational awareness by delivering up-to-date safety information and supporting dynamic response strategies. A user-friendly web-based interface further amplifies the system's accessibility, allowing individuals of varying technological backgrounds to interact with ease. Moreover, real-time crime prediction capabilities equip both law enforcement agencies and the general public with the tools necessary for proactive intervention and timely decision-making. An additional key feature is the integrated alert and notification system, which delivers safety alerts tailored to the user's location and customizable preferences. This ensures a personalized and proactive approach to user safety, significantly contributing to increased public awareness and crime prevention. Overall, the system combines machine learning, spatial intelligence, and user-centric design to offer a comprehensive solution for women's safety in urban environments.

2.2 PROPOSED TECHNIQUE WORKS

1. Feature Extraction and Aggregation

- Group By and Sum: The code groups the data by state and sums the total crimes.

Example:

```
state_all_crimes=
df.groupby('STATE/UT').sum()
```

- Total Crimes Calculation: It calculates the total number of crimes against women in each state.

Example:

```
state_all_crimes['Total']=
state_all_crimes[col_list].sum(axis=1)
```

2. K-Means Clustering

- K-Means Algorithm minimizes the inertia (within-cluster sum of squares):

$$\text{inertia} = \sum_{i=1}^{k} \sum_{x \in C_i} \| x - \mu_i \|^2$$

Where C_i is the set of points in cluster i and $μ_i$ is the centroid of cluster i.

3. Support Vector Machine (SVM)

- The optimization problem for SVM can be expressed as:

min_{w, b} (1/2) ||w||^2 subject to y_i(w^T x_i + b) ≥ 1, ∀ i

Where w is the weight vector, b is the bias, and y_i is the label of the i-th sample.

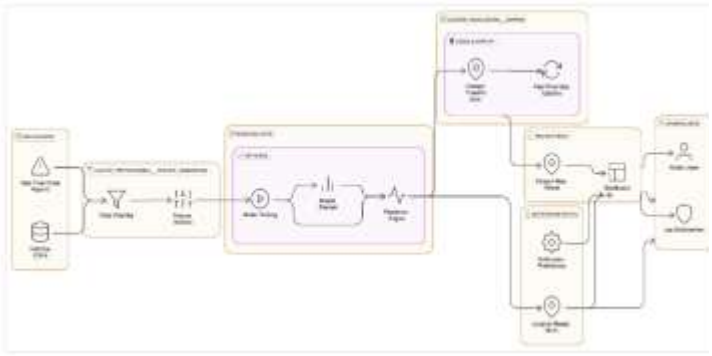

Figure 1: Safety Locator System Architecture

2.3 ADVANTAGE OF THE PROPOSED SYSTEM

The proposed system offers a data-driven and user-centric approach to crime hotspot detection, specifically designed to enhance women's safety. It employs a Deep Explainable Decision Tree (xDT) model capable of analyzing historical crime data and delivering real-time predictions for high-risk zones. Unlike traditional black-box models, xDT provides interpretable outputs, enhancing system transparency and fostering user trust. Integration with the Google Maps API enables clear geospatial visualization through color-coded markers, allowing users to easily understand and navigate potential threat zones. A web-based interface ensures accessibility for users with varying technical expertise, and the system's alert and notification feature proactively warns users when they are near crime-prone areas. Furthermore, law enforcement agencies benefit from predictive insights for patrol optimization and resource distribution, while NGOs and policymakers can utilize the data for strategic planning. The system distinctly focuses on crimes affecting women such as harassment, domestic abuse, and assault making it more socially relevant than generalized platforms. Its modular architecture, built using Python, Flask, and MySQL, supports scalability and future enhancements, including mobile integration and voice-based alerts. With embedded performance metrics such as accuracy, precision, recall, and F1-score, the system supports continuous improvement. Overall, it contributes to public awareness, informed mobility, and safer urban environments by making predictive crime data actionable and accessible.

3. CONCLUSION AND FUTURE ENHANCEMENTS

The proposed Crime Hotspot Prediction and Localization System offers a data-driven, interpretable, and user-centric solution for enhancing women's safety in urban environments. Utilizing an Explainable Decision Tree (xDT) model, the system enables real-time crime hotspot prediction while maintaining transparency in decision-making. The integration of the Google Maps API provides intuitive and geospatially accurate visualization of high-risk zones, allowing users to make informed decisions regarding their safety. With a modular architecture encompassing preprocessing, classification, and visualization modules, the system ensures scalability, ease of use, and high predictive performance. Experimental results during feasibility and testing phases confirmed its effectiveness through high accuracy, precision, and recall values.

Looking ahead, the system can be enhanced by integrating with real-time data feeds from law enforcement agencies and expanding its reach to other regions and crime categories. Further improvements may include integration with mobile platforms for location-based alerts, collaboration with emergency services for faster incident response, and data enrichment through social media channels. These enhancements would not only improve prediction accuracy but also increase system responsiveness and public engagement. Overall, the proposed system is a step toward proactive safety management and empowerment of women through accessible technology.

4. REFERENCES

1. Mohler, G. O., Short, M. B., Brantingham, P. J., Schoenberg, F. P., & Tita, G. E. (2011). Self-exciting point process modeling of crime. Journal of the American statistical Association, 106(493), 100-108.

2. Malik, O. M., Hussain, I., & Rehman, A. (2019). Predicting crime hotspots using deep learning. In 2019 International Conference on Innovative Computing (ICIC) (pp. 1-6). IEEE.

3. Gerber, M. S., Johnson, M. P., & Berman, M. (2011). Predictive policing and reasonable suspicion. Emory Law Journal, 60, 585.

4. Liu, Y., & Jiang, S. (2019). Crime prediction using data mining techniques: A comprehensive review. IEEE Transactions on Cybernetics, 49(4), 1249-1269.

5. Ratcliffe, J. H., & Rengert, G. F. (2008). Near repeat patterns in Philadelphia shootings. Security Journal, 21(1-2), 23-40.

6. Bowers, K. J., & Johnson, S. D. (2005). Predictive mapping of crime by ProMap: Accuracy, units of analysis, and the problem of vagueness. In Crime mapping: New tools for law enforcement (pp. 221-248). Taylor & Francis.

7. Chainey, S., Tompson, L., & Uhlig, S. (2008). The utility of hotspot mapping for predicting spatial patterns of crime. Security Journal, 21(1-2), 4-28.

8. Li, X., Liu, L., Lv, T., & Cheng, T. (2017). Crime hotspot detection using spatial filtering and density peaks clustering. Journal of Ambient Intelligence and Humanized Computing, 8(6), 905-914.

9. Wang, Y., Chen, L., & Zhang, J. (2019). A novel approach for spatio-temporal prediction of crime hotspots based on deep learning and multi-source data fusion. Information Fusion, 47, 60-68.

10. Wu, Y., & Leung, Y. (2018). Crime hotspot prediction using deep learning. In Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining (pp. 2354-2363).

11. Badea, A., Popescu, D., & Antonie, M. L. (2017). Crime prediction using spatio-temporal clustering and SVM classification. In 2017 IEEE 13th International Conference on Intelligent Computer Communication and Processing (ICCP) (pp. 227-234). IEEE.

12. Ratcliffe, J. H. (2010). The spatial extent of criminogenic places: A changepoint regression of violence around bars. Geographical Analysis, 42(3), 215-231.

13. Ratcliffe, J. H., Taniguchi, T., & Groff, E. R. (2011). Mapping the criminogenic environment: Hot spots analysis using kernel density estimation. In Place matters (pp. 67-97). Springer, New York, NY.

14. Zhu, H., Xiong, H., Shen, H. T., & Cheng, X. (2014). Discovering spatio-temporal crime hotspots through exploratory space-time analysis. In 2014 IEEE 30th International Conference on Data Engineering (pp. 880-891). IEEE.