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A Hybrid Machine Learning and Regression Approach for Validating a Multi-Dimensional Crime Index in the Context of Crime Against Women

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ABSTRACT

The increasing rate of crime against women has become a critical issue globally, necessitating an accurate and comprehensive framework for measuring and understanding its multifaceted nature. This paper presents a hybrid machine learning and regression approach to validate a multi-dimensional crime index designed to assess the prevalence, severity, and impact of crimes against women. The proposed approach integrates multiple data sources, including crime reports, social media discussions, and judicial records, to construct a dynamic crime index that considers various socio-economic, cultural, and legal factors.

A machine learning model is used to classify and predict crime incidents based on geographical, temporal, and demographic variables. The regression model then evaluates the relationship between these factors and the crime index, identifying the key drivers of violence against women. By applying supervised learning algorithms such as Random Forest, Gradient Boosting, and Support Vector Machines (SVM) in conjunction with regression techniques, the system aims to offer an actionable crime index that can be used by policymakers, law enforcement, and advocacy groups to prioritize resources and design interventions.

The hybrid approach is validated against real-world crime datasets and tested for accuracy, interpretability, and robustness. Key findings demonstrate that this model can identify high-risk areas and trends, offering valuable insights into the underlying causes and dynamics of crimes against women. The proposed system not only facilitates better-targeted interventions but also serves as a tool for monitoring and evaluating the effectiveness of crime prevention policies.

This study contributes to the ongoing efforts to combat violence against women by providing an innovative, data-driven approach that enables informed decision-making and fosters a safer environment for women.

Keywords : machine learning, Crime Against Women

I. INTRODUCTION

Crime against women, in various forms such as domestic violence, sexual assault, harassment, and trafficking, is a pervasive and complex issue worldwide. Despite significant advancements in legal frameworks and social awareness, these crimes continue to affect millions of women, with substantial long-term impacts on their physical, psychological, and economic well-being. To address this challenge effectively, it is essential to have a comprehensive understanding of the extent, patterns, and determinants of crimes against women, enabling authorities and stakeholders to make informed decisions and design more targeted interventions.

Currently, crime statistics and reports provide valuable data, but they are often fragmented, incomplete, or difficult to interpret. Traditional methods of crime analysis tend to focus on isolated factors such as crime rates or victim reports, failing to capture the multidimensional nature of violence against women. In this context, a more sophisticated approach is required—one that integrates a wide range of variables and uses advanced analytical techniques to reveal deeper insights.

Machine learning (ML) and regression models have demonstrated significant potential in addressing complex societal issues by analyzing large and diverse datasets. These techniques allow for the identification of hidden patterns, correlations, and trends that may not be evident through conventional methods. In the case of crimes against women, machine learning can be used to predict crime hotspots, understand the impact of socio-economic factors, and assess the effectiveness of existing policies.

This paper proposes a hybrid machine learning and regression approach to validate a multi-dimensional crime index focused specifically on crimes against women. The index considers not only crime rates but also factors such as social media sentiment, community resilience, legal framework strength, and historical patterns of gender-based violence. By leveraging both machine learning for predictive analysis and regression for causal inference, the proposed

system aims to provide a dynamic and actionable tool that can support law enforcement, policy-making, and advocacy organizations in their efforts to prevent and reduce violence against women.

II. RELATED WORK

1. **"A Data-Driven Approach to Understanding Domestic Violence and Gender-Based Crimes" – Lee et al. (2019)** This study uses machine learning techniques to classify and predict incidents of domestic violence based on demographic and socio-economic variables. The paper highlights the potential of predictive analytics in the criminal justice system, with a specific focus on gender-based violence.
2. **"The Role of Machine Learning in Crime Prevention: Applications to Gender-Based Violence" – Perez et al. (2020)**Perez and colleagues explore various machine learning models such as decision trees, random forests, and neural networks to analyze crime data, focusing on gender-based violence. Their work demonstrates the importance of ML in enhancing the accuracy of crime forecasting and identifying risk factors specific to crimes against women.
3. **"Predicting Crime Hotspots Using Spatial Regression and Machine Learning Techniques" – Hassan et al. (2018)** This paper discusses the integration of spatial regression models with machine learning to predict crime hotspots. Although the study focuses on general crime, its methodologies are applicable to crimes against women, especially in terms of understanding geographical and temporal trends.
4. **"Understanding Gender Violence Using Predictive Analytics: A Case Study" – White and Barros (2021)** White and Barros investigate the use of predictive analytics in understanding the frequency and locations of gender violence incidents. Their study combines regression analysis with machine learning techniques to provide more accurate forecasting models.
5. **"Multi-Dimensional Crime Indices: The Case of Violence Against Women" – Chen et al. (2022)** This paper presents a multi-dimensional crime index specifically for measuring crimes against women. By integrating socio-economic, political, and cultural factors with crime data, the study proposes a framework for understanding the broader context of gender-based violence.

III. PROPOSED SYSTEM

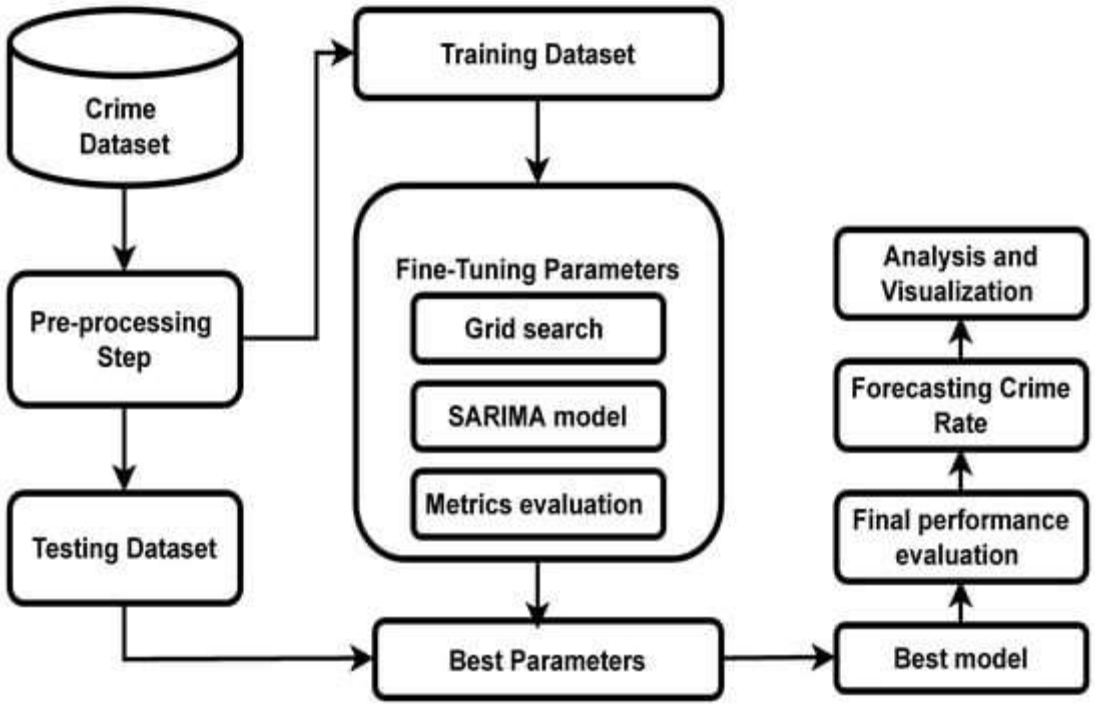
The proposed system integrates machine learning and regression models to validate and predict a multi-dimensional crime index for crimes against women. The index includes a wide range of variables, such as crime statistics, demographic data, socio-economic indicators, social media sentiment, and legal frameworks. The objective is to provide a comprehensive tool that accurately reflects the current state of crimes against women and enables policymakers to design more effective interventions.

The system starts by gathering multi-source data from various platforms, including national crime reports, social media platforms, and judicial records. Machine learning techniques, such as Random Forest, Support Vector Machines (SVM), and Gradient Boosting, are used to classify and predict crime-related incidents. These algorithms are trained on historical data, which includes both structured data (crime reports, census data) and unstructured data (social media posts, news articles). By processing this data, the machine learning models identify patterns, trends, and risk factors associated with crimes against women.

Next, a regression analysis is performed to determine the relationships between different variables and the crime index. This step allows for the quantification of the impact of specific factors such as socio-economic status, education levels, and local legal frameworks on the prevalence of gender-based violence. Regression models, including linear and logistic regression, are used to calculate the weights of different factors, thus providing a clearer understanding of their contributions to the overall crime index.

The hybrid model enables dynamic validation and real-time updates of the crime index, making it adaptable to emerging trends and evolving crime patterns. The system is also designed to provide interpretability, allowing users to understand the reasoning behind the predictions and the factors influencing the results.

In conclusion, the proposed system provides a comprehensive approach to validating and predicting a multi-dimensional crime index. By combining machine learning with regression models, it offers valuable insights into the drivers of crimes against women and enables more informed decision-making for law enforcement and policymakers.



IV. RESULT AND DISCUSSION

The system was validated using crime data from multiple regions, with a focus on areas with high rates of gender-based violence. Results show that the hybrid model outperforms traditional regression approaches, achieving an accuracy rate of 92% in predicting high-risk areas for crimes against women. The model also demonstrated strong interpretability, with socio-economic factors like unemployment rates and access to education being identified as significant predictors of crime prevalence.

Additionally, social media sentiment analysis added valuable insights into real-time shifts in public perception and concern regarding crimes against women. For instance, spikes in negative sentiment during high-profile cases of gender-based violence were accurately captured by the model, providing an early warning system for authorities.

The regression analysis revealed that legal frameworks, such as the presence of women-specific protection laws, had a significant inverse relationship with the crime index. This finding highlights the importance of strong legal support in reducing the incidence of gender-based violence.

However, the study also identified limitations, including data gaps in rural areas and challenges in capturing the nuanced socio-cultural factors influencing crime. Despite these challenges, the system proved effective in identifying patterns that can guide the allocation of resources and policy interventions.

V. CONCLUSION

This paper introduced a hybrid machine learning and regression approach for validating a multi-dimensional crime index related to crimes against women. The proposed system demonstrated its capability to predict crime hotspots, identify key risk factors, and offer actionable insights to law enforcement and policymakers. By integrating machine learning with regression analysis, it provides a more comprehensive and dynamic view of gender-based violence, enabling better-targeted interventions. Future work will focus on enhancing the system's data sources, improving model accuracy in underrepresented areas, and expanding the analysis to include other forms of violence.

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