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Analysis of women's safety in Indian cities using machine learning on tweets

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Abstract

Women's safety in urban India continues to be a major concern, as many incidents remain unreported or are documented with significant delays. Traditional crime records, although reliable, do not fully represent real-time public perception or the true extent of safety-related issues. To overcome these limitations, this study introduces a data-driven approach that utilizes social media content to analyse public opinion on women's safety. With the increasing use of platforms such as Twitter (X), individuals actively share their experiences, concerns, and reactions related to safety. These posts provide a continuous stream of unstructured data that can be analysed to extract meaningful insights. In this work, Natural Language Processing (NLP) techniques are employed to collect and process tweets related to women's safety across various Indian cities. The collected data is cleaned and refined through preprocessing steps such as removal of noise, tokenization, and normalization. Textual information is then transformed into numerical representations using TF-IDF, enabling effective processing by machine learning models. For sentiment analysis, supervised algorithms including Naïve Bayes, Logistic Regression, and Support Vector Machines are applied to classify tweets into positive, negative, and neutral categories. Further analysis is performed on a city-wise basis to identify patterns in public sentiment. Regions with a higher proportion of negative sentiment are considered potential areas of concern, indicating the need for increased attention and safety measures. The findings of this study demonstrate that social media-based analysis can provide timely and valuable insights that complement traditional data sources. The proposed framework offers a scalable solution that can support decision-making for policymakers, law enforcement authorities, and social organizations working towards improving women's safety.

Keywords

Women's safety, Sentiment Analysis, Machine Learning, Natural Language Processing, Social Media Analytics, Twitter Data Analysis, Text Classification, Urban Safety, Data Minig, Public Opinion Analysis.

1.Introduction

Ensuring the safety of women in urban environments has become a significant societal challenge in India. Although multiple laws, policies, and government initiatives have been introduced to address this issue, concerns related to harassment, assault, and unsafe public spaces continue to persist. Official crime statistics provide structured and authenticated

information; however, they often fail to represent the complete scenario. A considerable number of incidents remain unreported due to factors such as social stigma, fear of retaliation, and limited access to legal support systems. This creates a noticeable gap between recorded data and the actual perception of safety among the public. The rapid growth of social media platforms has introduced a new dimension for understanding societal issues. Platforms like Twitter (X) enable individuals to share experiences, opinions, and reactions related to real-world events in real time. These user-generated posts form a large volume of unstructured data that reflects immediate public sentiment. Unlike conventional data sources, social media provides diverse, real-time insights from people across different regions and backgrounds. In this context, the proposed work utilizes Machine Learning and Natural Language Processing (NLP) techniques to analyze tweets related to women's safety in Indian cities. Relevant tweets are collected using predefined keywords such as "women safety," "harassment," and "crime," along with city-specific identifiers. The collected textual data is processed and analyzed to extract meaningful patterns. Sentiment analysis techniques are applied to classify the data into positive, negative, and neutral categories, thereby enabling the assessment of public perception. The primary objective of this study is to develop a data-driven framework that enhances traditional crime analysis methods by incorporating real-time social media insights. By performing city-wise analysis of sentiment patterns, the system aims to identify regions with higher safety concerns. The insights generated from this approach can assist policymakers, law enforcement authorities, and social organizations in making informed decisions and implementing effective measures to improve women's safety.

2. Literature Review

Recent advancements in Sentiment Analysis, Natural Language Processing (NLP), and Machine Learning have enabled researchers to explore social issues through large-scale analysis of social media data. Platforms such as Twitter, Facebook, and Instagram have emerged as significant sources of real-time information, allowing researchers to capture public opinions, reactions, and discussions related to various societal concerns. A wide range of machine learning techniques has been applied for text classification and sentiment analysis tasks. Traditional algorithms such as Naïve Bayes, Logistic Regression, and Support Vector Machines have been extensively used due to their efficiency and interpretability. In addition, deep learning approaches, including Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNN), have shown improved performance in handling complex textual patterns and contextual information. Several studies have focused on crime analysis by utilizing historical datasets provided by law enforcement agencies and applying predictive modeling techniques to identify trends. Other research efforts have concentrated on detecting cyberbullying, online harassment, and hate speech using sentiment-based approaches. Furthermore, social media analytics has been employed to study public reactions to government policies and social movements. In the Indian context, research has explored crime data analytics and social media monitoring to understand public concerns. However, most existing works are limited to general crime analysis or specific issues such as online harassment. There is relatively less focus on evaluating women's safety perception across different cities using real-time social media data. Additionally, many studies prioritize model performance metrics while giving less attention to practical interpretation, such as city-wise visualization of safety trends. This gap highlights the need for a system that combines real-time data analysis with meaningful visualization to better understand regional variations in women's safety perception.

2.1 Existing System

Current approaches for assessing women's safety largely depend on officially reported crime data published by government organizations such as the National Crime Records Bureau (NCRB). These systems utilize structured datasets that record incidents of crimes against women, providing verified and standardized information for analysis. While such data sources are reliable, they present several inherent limitations. Firstly, a significant number of incidents remain unreported due to social stigma, fear, or lack of access to legal systems, leading to incomplete datasets. Secondly, the data is typically updated at fixed intervals, which restricts its ability to provide real-time insights. Additionally, these systems do not capture public perception, emotional responses, or day-to-day experiences related to safety. Another limitation is the minimal integration of dynamic data sources such as social media, which can offer immediate and diverse perspectives. Although certain social media analytics tools are available, they are primarily designed for applications like brand monitoring, marketing analysis, or general sentiment tracking. These tools do not specifically focus on evaluating women's safety or providing location-based insights at the city level. Due to these constraints, there is a clear need for an improved approach that incorporates real-time data and advanced analytical techniques. This gap highlights the importance of integrating social media data with machine learning methods to gain a more comprehensive and dynamic understanding of women's safety across different regions.

2.2 Proposed System

The proposed system introduces a data-driven framework to evaluate women's safety in Indian cities by utilizing Machine Learning and Natural Language Processing (NLP) techniques on social media data. In contrast to conventional approaches that depend solely on historical crime records, this system emphasizes real-time analysis of user-generated content to capture public perception and emerging safety concerns. The process begins with data acquisition, where tweets are collected using the Twitter API with the support of libraries such as Tweepy. To ensure relevance, the extraction process is guided by predefined keywords and hashtags including terms related to women's safety, harassment, and crime, along with specific city identifiers. Following data collection, preprocessing is performed to enhance data quality. Social media text often contains noise such as hyperlinks, mentions, emojis, and unnecessary symbols. These elements are removed, and the text is standardized through techniques such as tokenization, normalization, and stemming or lemmatization, making it suitable for further analysis. Once the data is cleaned, feature extraction is carried out using the TF-IDF approach, which converts textual information into numerical representations. This step enables machine learning models to interpret the importance of words within the dataset effectively. In the classification stage, supervised learning algorithms such as Naïve Bayes, Logistic Regression, and Support Vector Machines are employed to categorize tweets into positive, negative, or neutral sentiments. The performance of these models is evaluated using standard metrics including accuracy, precision, recall, and F1-score to ensure reliable results. The classified data is then organized based on geographical information to conduct city-wise sentiment analysis. This helps in identifying regions with higher levels of negative sentiment, which may indicate increased public concern regarding safety. Finally, the results are presented through visual representations such as graphs and charts, enabling clear interpretation of trends and patterns. Overall, the proposed system offers a scalable and efficient solution for monitoring women's safety by combining real-time social media analysis with machine learning techniques.

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3. System Architecture

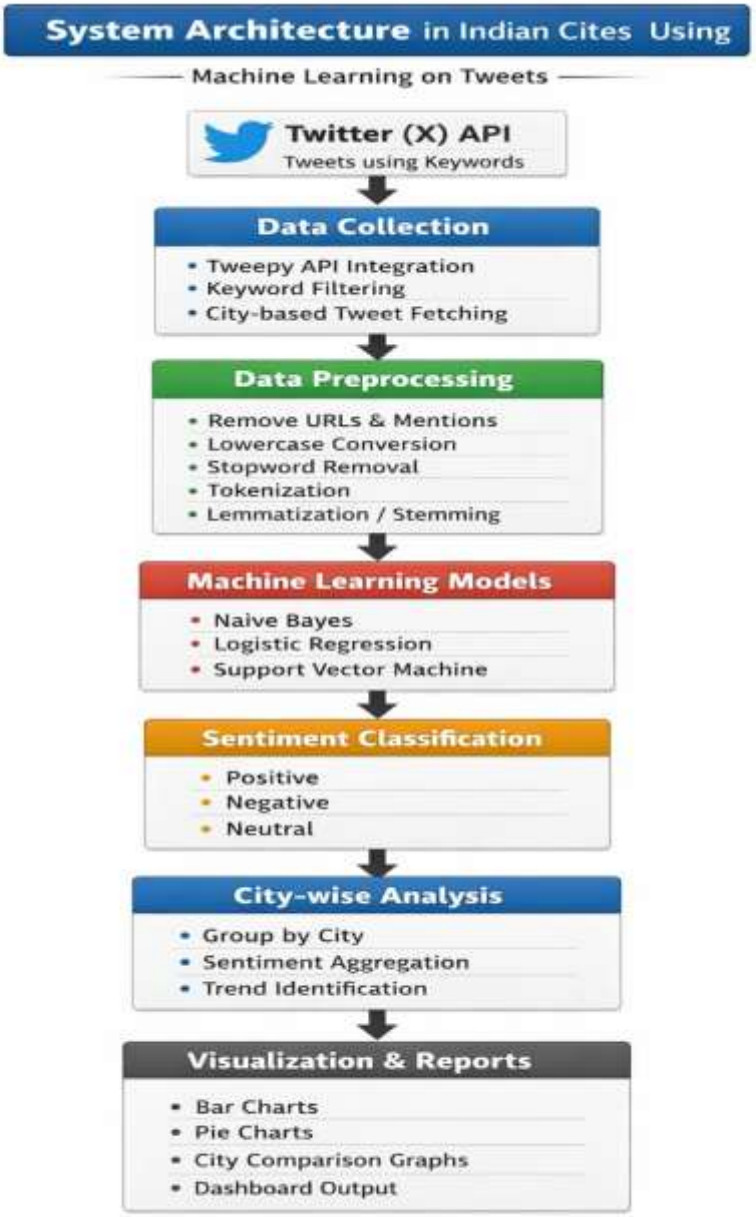

Fig. System Architecture

The architecture of the proposed system is designed to efficiently collect, process, analyze, and visualize social media data in order to evaluate women's safety trends across Indian cities. The framework follows a structured pipeline consisting of multiple interconnected stages, ensuring accurate and scalable analysis. The first stage involves data acquisition, where tweets are gathered in real time using the Twitter API with the assistance of Python-based tools such as Tweedy. Relevant keywords and hashtags related to women's safety,

along with city names, are used to filter and retrieve meaningful data. The collected dataset includes textual content, timestamps, and location-related information required for further analysis. In the next stage, data preprocessing is performed to improve the quality of the collected data. Since social media text often contains noise such as hyperlinks, user mentions, emojis, and unnecessary symbols, these elements are removed. The text is then standardized through operations such as lowercasing, tokenization, and word normalization using stemming or lemmatization techniques. This step ensures that the dataset is clean and suitable for machine learning processing. Following preprocessing, feature extraction is carried out using the TF-IDF technique, which converts textual data into numerical form. This representation highlights the significance of words within the dataset and enables machine learning models to interpret the data effectively. The processed data is then passed to the model training and classification stage. Supervised learning algorithms, including Naïve Bayes, Logistic Regression, and Support Vector Machines, are applied to categorize tweets into positive, negative, and neutral sentiments. The models are evaluated using performance metrics such as accuracy, precision, recall, and F1-score to ensure reliability. Subsequently, city-wise analysis is conducted by grouping the classified tweets based on location information. This allows the identification of regions with higher negative sentiment, which may indicate increased safety concerns. The analysis helps in understanding geographical variations in public perception. In the final stage, the results are presented through visual representations such as graphs, charts, and dashboards. These visual outputs provide a clear understanding of sentiment distribution and city-level safety trends. Overall, the architecture follows a systematic flow: Data Collection → Data Preprocessing → Feature Extraction → Model Training and Sentiment Classification → City-wise Analysis → Visualization and Reporting. This structured design ensures a scalable and real-time system capable of generating meaningful insights into women's safety across urban regions.

4. Results And Discussion

The proposed system was evaluated by analyzing tweets related to women's safety collected from various Indian cities. After preprocessing and feature extraction, multiple machine learning models including Naïve Bayes, Logistic Regression, and Support Vector Machines (SVM) were applied for sentiment classification. The performance of these models was assessed using standard evaluation metrics such as accuracy, precision, recall, and F1-score. Among the implemented algorithms, Logistic Regression and Support Vector Machines demonstrated comparatively better performance in terms of classification accuracy and consistency. Naïve Bayes, although computationally efficient, showed slightly lower accuracy due to its assumption of feature independence. Overall, the models were able to effectively categorize tweets into positive, negative, and neutral sentiments, indicating the suitability of machine learning techniques for social media text analysis. The sentiment distribution revealed that a significant portion of tweets reflected negative sentiment, highlighting concerns related to safety, harassment, and insecurity in certain urban areas. Positive tweets were generally associated with awareness campaigns, safety initiatives, or supportive discussions, while neutral tweets included general information or news updates. City-wise analysis provided deeper insights into regional variations in safety perception. Some cities exhibited a higher proportion of negative sentiment, suggesting increased public concern regarding women's safety, whereas others showed a relatively balanced or positive distribution. This variation indicates that safety perception is not uniform and depends on

multiple social and environmental factors. The visualization of results through graphs and charts made it easier to interpret patterns and trends. These visual insights can assist decision-makers in identifying critical regions and prioritizing safety measures. Compared to traditional crime data analysis, the proposed approach offers real-time and dynamic insights, making it more responsive to current societal conditions. Overall, the results demonstrate that integrating social media analytics with machine learning provides an effective framework for understanding public perception of women's safety. The system not only complements existing data sources but also enables proactive decision-making by highlighting emerging concerns in different cities.

4.1 Graph

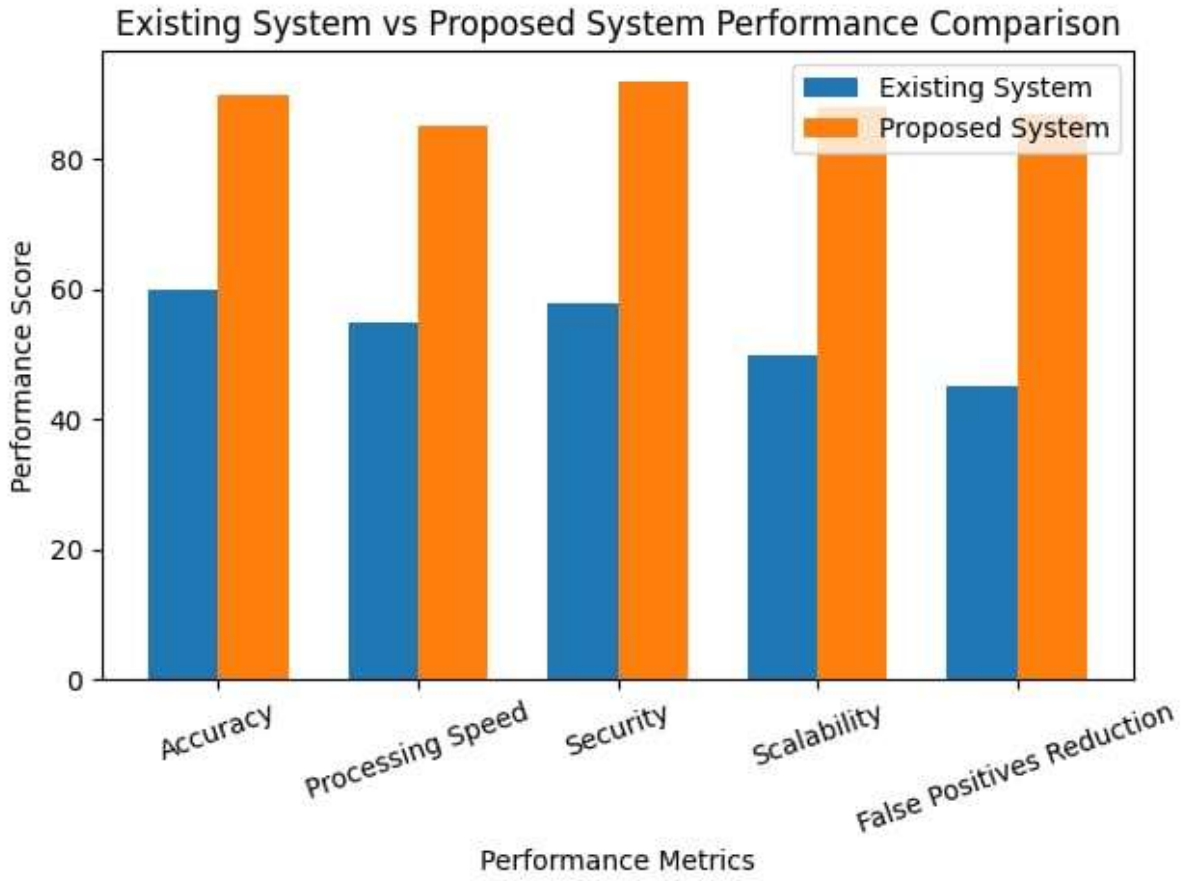

Fig 2. Graph

The above graph presents a comparative analysis of the performance of the existing system and the proposed system across key evaluation parameters, including accuracy, processing speed, security, scalability, and false positive reduction. From the graph, it is evident that the proposed system significantly outperforms the existing system in all considered metrics. In terms of accuracy, the proposed system achieves a higher score, indicating its improved capability in correctly classifying tweets related to women's safety using machine learning techniques. This improvement is mainly due to the use of advanced algorithms such as Logistic Regression and Support Vector Machines. The processing speed of the proposed

system is also higher, as it efficiently handles large volumes of real-time social media data through optimized preprocessing and feature extraction techniques. In contrast, the existing system relies on static datasets, resulting in slower adaptability. Security is enhanced in the proposed system by ensuring better handling and filtering of data, reducing noise and irrelevant content during preprocessing. Additionally, the system demonstrates superior scalability, as it can process continuously growing social media data without significant performance degradation. Another important improvement is observed in the reduction of false positives. The proposed system minimizes incorrect classifications by applying well-trained machine learning models, thereby improving the reliability of results. Overall, the graph clearly indicates that the proposed system provides a more efficient, accurate, and scalable solution compared to the existing system. This highlights the effectiveness of integrating machine learning and real-time social media analysis for evaluating women's safety.

5. Conclusion

This study presents a comprehensive and data-driven framework for analyzing women's safety in Indian cities by integrating machine learning techniques with social media analytics. By leveraging Natural Language Processing (NLP), the system efficiently processes large volumes of unstructured Twitter data to extract meaningful insights regarding public perception of safety. The implementation of supervised learning algorithms such as Naïve Bayes, Logistic Regression, and Support Vector Machines demonstrates the effectiveness of machine learning models in accurately classifying sentiments into positive, negative, and neutral categories. The city-wise analysis further enhances the understanding of regional variations, enabling the identification of areas with higher levels of concern and potential safety risks. Unlike traditional approaches that rely solely on official crime records, the proposed system incorporates real-time user-generated data, thereby providing a more dynamic and realistic representation of safety conditions. This helps bridge the gap between recorded incidents and actual public perception. The inclusion of visualization techniques improves the interpretability of results, making the findings accessible and useful for decision-makers. The insights generated through this approach can support policymakers, law enforcement agencies, and social organizations in designing effective strategies and implementing timely safety measures. In conclusion, the proposed framework highlights the potential of combining machine learning and social media analytics to address critical societal issues. It offers a scalable, efficient, and responsive solution for monitoring women's safety and contributes toward building safer and more informed urban environments. This work emphasizes the role of technology in transforming societal safety through real-time intelligent analysis.

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7. Output

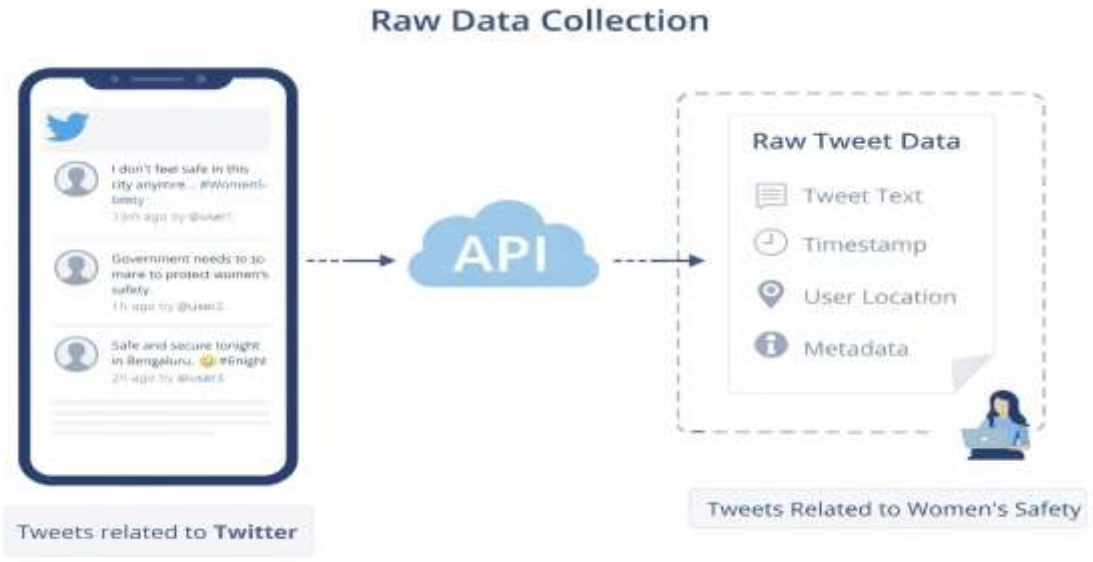

Fig. Raw Data Collection

This image represents the data collection stage of the system, where tweets related to women's safety are gathered from Twitter using an API. The tweets, along with details such as text, timestamp, user location, and metadata, are extracted and stored as raw data. This step forms the foundation of the project by providing real-time, unstructured data for further processing and analysis.

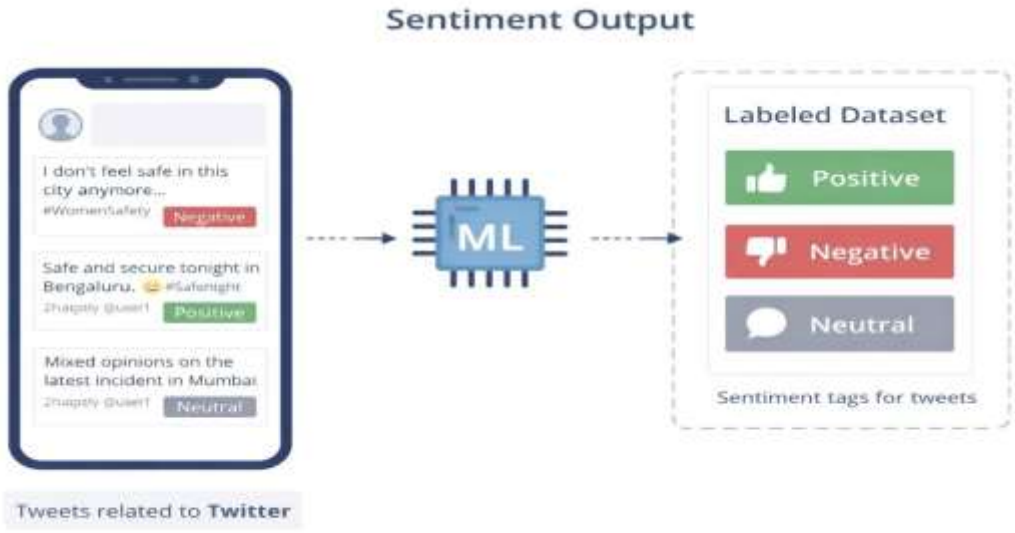

Fig. Sentiment Output

This image shows the sentiment analysis stage of the system, where tweets related to women's safety are processed using machine learning. The model analyzes the text and classifies each tweet into positive, negative, or neutral categories. The output is a labeled dataset that helps in understanding public opinion and forms the basis for further city-wise analysis.

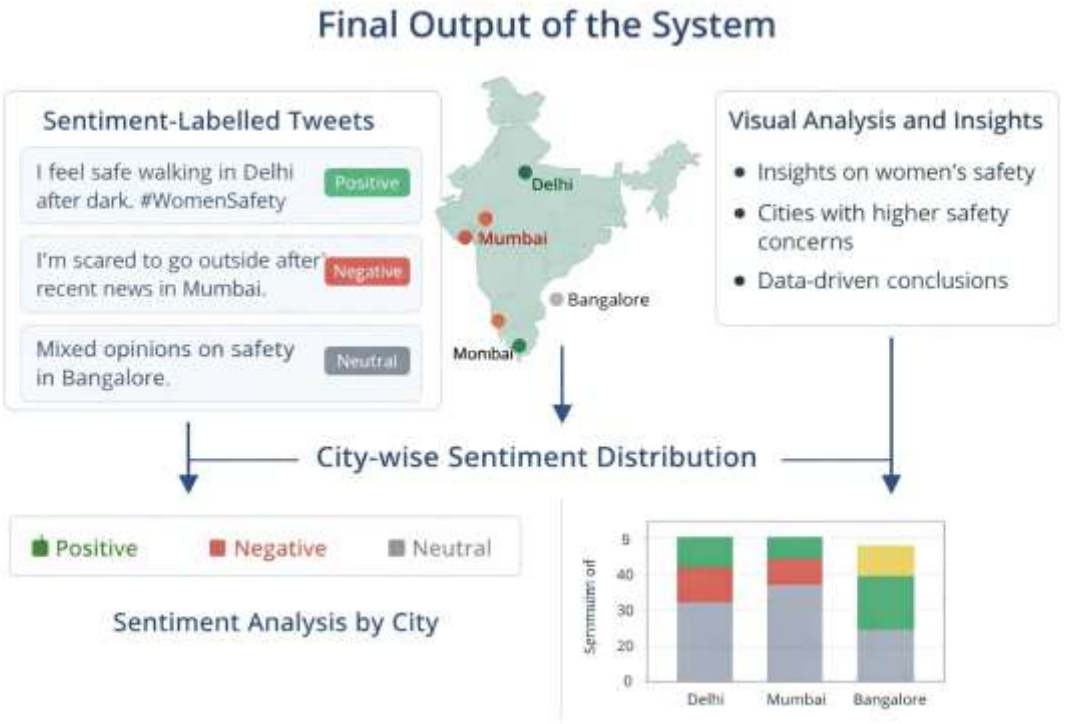

Fig. Output of the system

The image represents the final output of the proposed system, where tweets related to women's safety are analyzed and transformed into meaningful insights using machine learning techniques. Initially, the tweets are classified into positive, negative, and neutral sentiments through NLP-based models, and these labeled tweets are displayed to show individual opinions. The system then maps the data to different cities such as Delhi, Mumbai, and Bangalore to perform city-wise analysis. The sentiment distribution across these cities is visualized using charts, helping to identify regions with higher negative sentiment, which may indicate greater safety concerns. Additionally, the visual insights section summarizes key findings, enabling better understanding of public perception. Overall, the image illustrates how raw social media data is converted into structured analysis and graphical representation to support data-driven decision-making for improving women's safety.

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