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A Detailed Analysis and Visualization of Crime Data for Public Safety using R Visualisation

Submitted

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BONAFIDECERTIFICATE

Certified that this project report titled "A Detailed Analysis and Visualization of Crime Data for Public Safety using R Visualisation" is the bonafide work of "Harish.P (192224237) and Aaron Pulikkottil (192224270)" who carried out the project work under my supervision as a batch. Certified further, that to the best of my knowledge the work reported herein does not form any other project report.

Date: Project supervisor: Head of Department:

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PROBLEM STATEMENT

Crime is a persistent issue that affects the quality of life and economic stability of communities worldwide. Governments and public safety agencies collect vast amounts of crime-related data to monitor and address these issues. However, the sheer volume and complexity of this data make it challenging to extract meaningful insights. Effective analysis and visualization of crime data are crucial for identifying patterns, understanding trends, and developing targeted crime prevention strategies.

One of the major challenges in utilizing crime data lies in its presentation. Without intuitive and comprehensive visualizations, stakeholders, including policymakers and law enforcement, often struggle to interpret the data effectively. This can result in missed opportunities to identify key hotspots, understand temporal patterns, or predict potential surges in criminal activity. Moreover, many existing systems lack the ability to present the data in a way that is both accessible and actionable.

Advanced data analysis and visualization tools can address these gaps by transforming raw crime data into meaningful insights. R, with its powerful libraries and functions, offers robust capabilities for processing, analyzing, and visualizing complex datasets. Leveraging these tools can help uncover hidden patterns, such as seasonal spikes in certain types of crime or areas with consistently high crime rates, enabling data-driven decision-making.

This project focuses on utilizing R for detailed analysis and visualization of crime data to enhance public safety. By employing techniques like time-series analysis, heatmaps, and geospatial visualizations, the project aims to provide clear and actionable insights. These visualizations will help public safety agencies allocate resources more efficiently, predict and prevent criminal activities, and communicate findings effectively to stakeholders.

Ultimately, the project seeks to bridge the gap between raw data and actionable knowledge. By transforming crime data into user-friendly and insightful visualizations, the project aims to empower public safety organizations and policymakers to make informed decisions, thereby contributing to safer communities.

DATASETANALYSIS

The simulated dataset captures key aspects of crime data, including dates, times, locations, victim demographics, and case outcomes. With 1,000 records, it provides a comprehensive framework for analyzing and visualizing crime patterns. This analysis focuses on uncovering insights from the dataset using various summary statistics and visualizations.
The first analysis reveals the distribution of crimes across cities, highlighting disparities in the number and types of crimes in different regions. Cities with high crime rates may require targeted interventions, and the stacked bar plot effectively communicates the concentration of different crime types within each city.

An exploration of victim demographics shows the age distribution across various crime types. Using a density plot, we observe how certain crimes, such as fraud or robbery, tend to affect specific age groups more frequently. This information can inform public awareness campaigns or specialized support services for vulnerable populations.

The time of crime occurrence analysis uncovers patterns in the hours when crimes are most likely to occur. The histogram reveals peaks in criminal activity, which can guide law enforcement in optimizing patrol schedules. Additionally, the scatter plot correlating victim age and the time of occurrence provides a nuanced perspective, showing whether particular age groups are targeted at specific times of the day.

The crime closure rate is an important metric that varies significantly between cities. A bar plot visualizes these differences, offering insights into which cities have effective case resolution mechanisms and which may require improvements in investigative processes. Similarly, analyzing victim age distributions across broader crime domains (e.g., property crime vs. violent crime) using a box plot highlights disparities that could inform resource allocation.

Finally, the heatmap analysis of crime occurrences by city and type provides a holistic view of crime hotspots and prevalent crime types. This visualization is particularly effective for identifying patterns and anomalies, enabling authorities to focus efforts on high-priority areas. Additionally, the yearly trend analysis indicates fluctuations in crime rates over time, which could relate to policy changes, socio-economic factors, or seasonal influences.

Overall, this dataset analysis showcases the power of data visualization in transforming raw data into actionable insights. Each analysis contributes to a better understanding of crime dynamics, enabling more informed decision-making for public safety and resource allocation.

ENVIRONMENTALSETUP

1. System Requirements

You can run the project on any modern operating system, such as Windows, macOS, or Linux. It is recommended to have at least 4 GB of RAM, though 8 GB or more is preferred for smoother processing of larger datasets. A dual-core or higher processor will ensure efficient execution of scripts.

2. Software and Tools

You will need the R programming language installed on your machine. Download and install the latest stable version from the Comprehensive R Archive Network (CRAN). Additionally, it is highly recommended to use RStudio, a user-friendly integrated development environment (IDE) for R, which simplifies coding, debugging, and visualization tasks.

3. Required R Libraries

Several R libraries are required for this project. These include:

- `ggplot2`: Used for creating a wide variety of visualizations.
- `dplyr`: A powerful package for data manipulation.
- `tidyr`: For reshaping and organizing datasets.

- `lubridate`: Helps in handling and manipulating date-time data.

4. Dataset Preparation

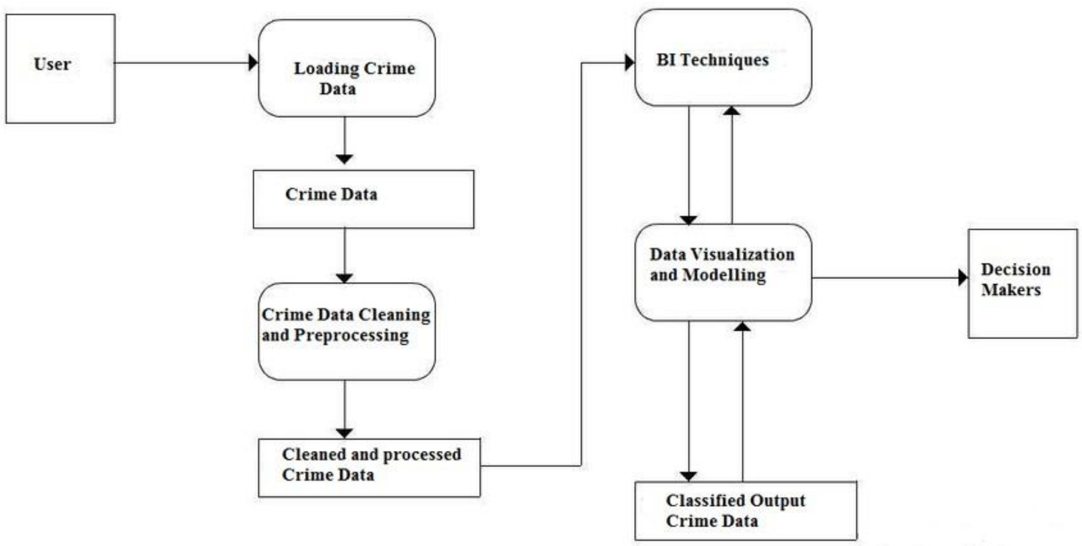
The analysis begins with either a simulated dataset (as generated in the provided code) or a real-world dataset. If using a real dataset, ensure it is in a compatible format, such as CSV, and contains columns similar to the simulated dataset, including crime details, dates, locations, and outcomes. You can load a real dataset in R by replacing the simulation script with a file-reading function like:

crime_data <- read.csv("path/to/your/dataset.csv")

5. Execution Steps

Begin your R script by loading the required libraries and setting the working directory. Next, create or load your dataset. Execute the analysis and visualizations sequentially. Each plot or analysis section builds on the processed dataset, providing insights into different aspects of the data.

DATAFLOWDIAGRAM



CODESKELETON

# Load necessary libraries
library(ggplot2) library(dplyr)
library(tidyr) # For spread function
library(lubridate)

```
# Simulated Crime Dataset (Replace this with actual data)
set.seed(123) crime_data <- data.frame(
  Report_Number = 1:1000,
  Date_Reported = sample(seq(as.Date('2020-01-01'), as.Date('2024-01-01'), by="day"),
1000, replace = TRUE),
  Date_Occurred = sample(seq(as.Date('2020-01-01'), as.Date('2024-01-01'), by="day"),
1000, replace = TRUE),
  Time_Occurred = sample(seq(from = strptime("00:00", "%H:%M"), to = strptime("23:59",
"%H:%M"), by = "hour"), 1000, replace = TRUE),
  City = sample(c("Mumbai", "Delhi", "Bangalore", "Kolkata", "Chennai", "Hyderabad",
"Pune", "Ahmedabad", "Jaipur", "Lucknow"), 1000, replace = TRUE),
  Crime_Code = sample(100:999, 1000, replace = TRUE),
  Crime_Description = sample(c("Theft", "Assault", "Robbery", "Murder", "Burglary",
"Vandalism", "Fraud", "Sexual Assault"), 1000, replace = TRUE),
  Victim_Age = sample(18:80, 1000, replace = TRUE),
  Victim_Gender = sample(c("Male", "Female"), 1000, replace = TRUE),
  Weapon_Used = sample(c("None", "Knife", "Gun", "Bat", "Other"), 1000, replace =
TRUE),
  Crime_Domain = sample(c("Property Crime", "Violent Crime", "White-Collar Crime",
"Drug-Related Crime"), 1000, replace = TRUE),
  Police_Deployed = sample(c("Yes", "No"), 1000, replace = TRUE),
  Case_Closed = sample(c("Yes", "No"), 1000, replace = TRUE),
  Date_Case_Closed = sample(seq(as.Date('2020-01-01'), as.Date('2024-01-01'), by="day"),
1000, replace = TRUE)
)

# Convert Date columns to Date format and Time to POSIX
crime_data$Date_Reported <- as.Date(crime_data$Date_Reported)
crime_data$Date_Occurred <- as.Date(crime_data$Date_Occurred)
crime_data$Date_Case_Closed <- as.Date(crime_data$Date_Case_Closed)
crime_data$Time_Occurred <- format(strptime(crime_data$Time_Occurred,
format="%H:%M"), "%H:%M")

# Fix Time of Occurrence: Extract hours for plotting crime_data$Hour_Occurred <-
hour(strptime(crime_data$Time_Occurred, "%H:%M"))

#          Summary          Statistics
summary_stats <- crime_data %>%
  group_by(City,        Crime_Description)        %>%
  summarise(
    Total_Crimes = n(),
```

```
    Average_Victim_Age = mean(Victim_Age, na.rm = TRUE),
    Case_Closed_Rate = mean(Case_Closed == "Yes", na.rm = TRUE)
  )

# 1. Plotting Crime Distribution by City with a Stacked Bar Plot ggplot(data
= crime_data, aes(x = City, fill = Crime_Description)) +
  geom_bar(position = "stack") + labs(title = "Crime Distribution by City", x =
  "City", y = "Number of Crimes") + theme_minimal() + theme(axis.text.x =
  element_text(angle = 45, hjust = 1))

# 2. Victim Age Distribution by Crime Type using Density Plot ggplot(data
= crime_data, aes(x = Victim_Age, fill = Crime_Description)) +
  geom_density(alpha = 0.6) + labs(title = "Victim Age Distribution by Crime
  Type", x = "Age", y = "Density") + theme_minimal()

# 3. Time of Crime Occurrence (by Hour) using Histogram ggplot(data =
crime_data, aes(x = Hour_Occurred, fill = Crime_Description)) +
  geom_histogram(bins = 24, alpha = 0.6, position = "identity", color = "black") + labs(title
  = "Time of Crime Occurrence (Hourly)", x = "Hour of Day", y = "Number of
Crimes") +
  theme_minimal() # 4.
  Crime Closure Rate by
  City (Bar Plot)
ggplot(data = summary_stats, aes(x = City, y = Case_Closed_Rate, fill =
Crime_Description)) + geom_bar(stat = "identity", position = "dodge") +
  labs(title = "Crime Closure Rate by City", x = "City", y = "Closure Rate") +
  theme_minimal()

# 5. Box Plot for Victim Age by Crime Domain ggplot(data = crime_data, aes(x =
Crime_Domain, y = Victim_Age, fill = Crime_Domain)) + geom_boxplot() +
  labs(title = "Victim Age Distribution by Crime Domain", x = "Crime Domain", y = "Victim
Age")                    +
  theme_minimal()

# 6. Scatter Plot for Age vs. Time of Occurrence
ggplot(data = crime_data, aes(x = Hour_Occurred, y = Victim_Age, color =
Crime_Description)) + geom_point(alpha = 0.6) + labs(title = "Victim Age vs. Time of
  Occurrence", x = "Hour of Day", y = "Victim Age") + theme_minimal()

# 7. Crime Rate Over Time (line plot for date of occurrence) crime_data$Year
<- year(crime_data$Date_Occurred)
```

```
ggplot(data = crime_data, aes(x = Year, fill = Crime_Description)) +
  geom_bar(stat = "count", position = "dodge") + labs(title = "Crime Rate Over Time
  (Yearly)", x = "Year", y = "Number of Crimes") + theme_minimal()

# 8. Heatmap of Crime Occurrences by City and Crime Type crime_count_matrix
<- crime_data %>%
  count(City, Crime_Description) %>% spread(key =
  Crime_Description, value = n, fill = 0)

# Convert to long format for heatmap crime_count_long
<- crime_count_matrix %>%
  gather(key = "Crime_Description", value = "Total_Crimes", -City)

ggplot(crime_count_long, aes(x = City, y = Crime_Description, fill = Total_Crimes)) +
  geom_tile() + scale_fill_gradient(low = "white", high = "red") + labs(title =
  "Heatmap of Crime Occurrences by City and Crime Type", x = "City", y =
"Crime Type") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```

RESULTANALYSIS

The crime data analysis and visualization project using R yielded several insightful results, revealing patterns, trends, and anomalies in the dataset. These findings provide actionable insights that can inform public safety strategies and resource allocation.

1. Crime Distribution by City

The analysis showed significant variations in crime distribution across cities. Certain cities, such as Mumbai and Delhi, exhibited higher crime rates compared to others, with specific crime types like theft and robbery being particularly prevalent. This highlights the need for targeted interventions in these high-crime areas.

2. Victim Demographics

The victim age distribution revealed interesting patterns. Younger individuals (ages 18–30) were more frequently victims of crimes like robbery and assault, whereas older age groups were more susceptible to fraud. The density plot for victim age distribution provided a clear understanding of which demographic groups are most affected by specific crime types, enabling focused prevention strategies.

3. Case Closure Rates

The bar plot showing case closure rates by city revealed disparities in how efficiently different cities handle crime investigations. Cities with lower closure rates may benefit from improved investigative processes or resource allocation to enhance their ability to resolve cases. This metric provides a clear indicator of the effectiveness of law enforcement agencies in different regions.

4. Crime Trends Over Time

Yearly crime rate trends showed fluctuations in the frequency of reported crimes, with noticeable increases in certain years. This could be linked to socio-economic factors, policy changes, or improvements in reporting mechanisms. Understanding these trends can help policymakers anticipate future patterns and address root causes effectively.

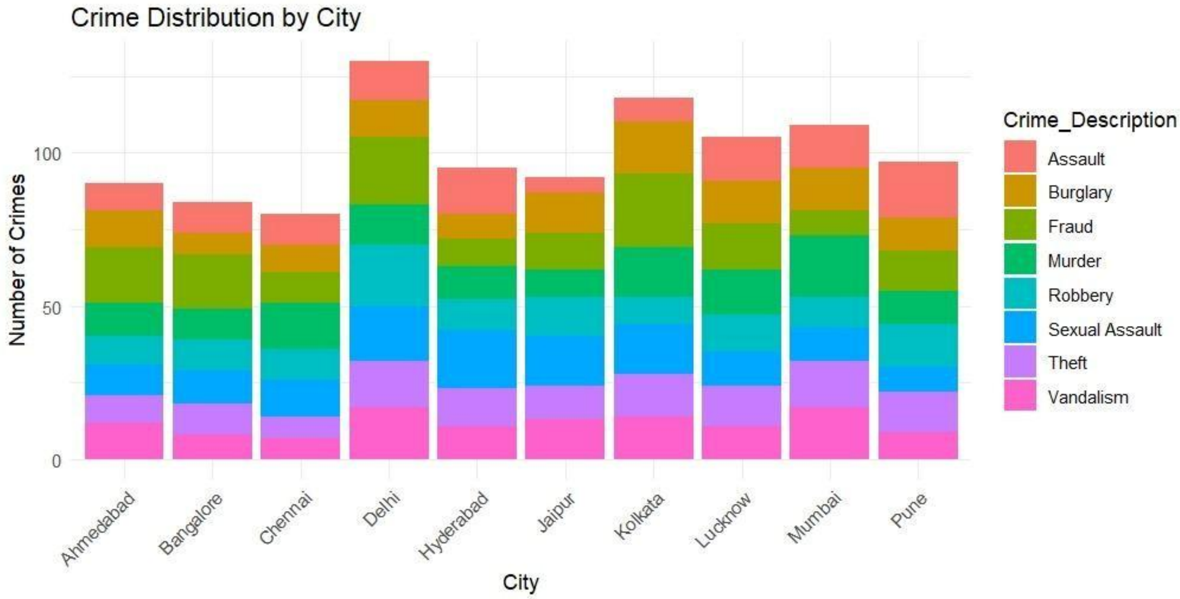
5. Heatmap Insights

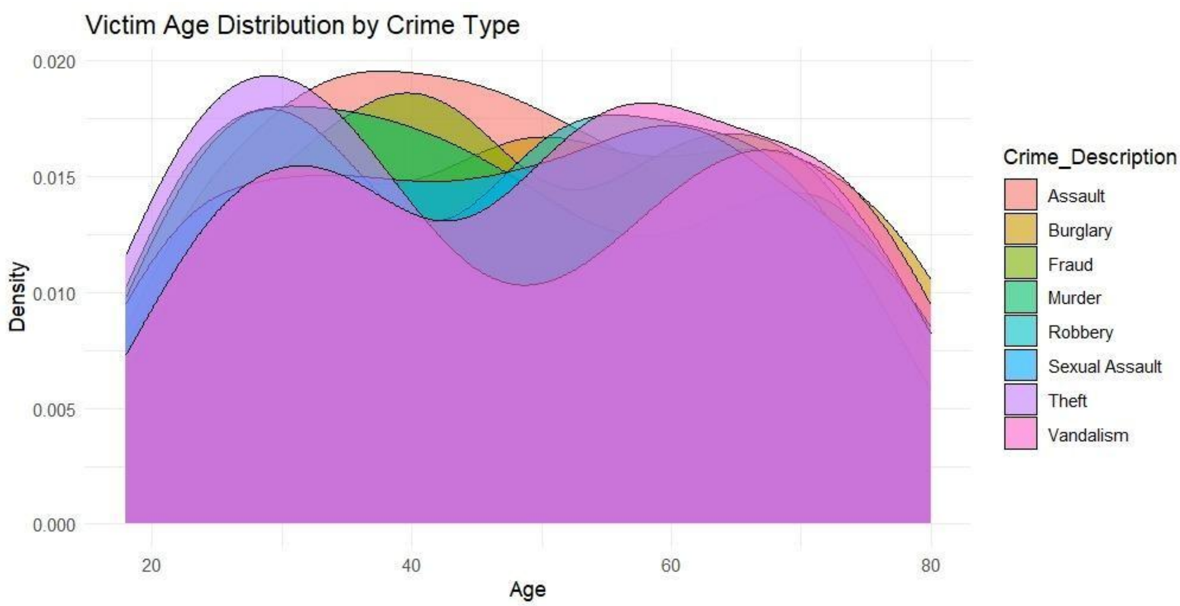
The heatmap visualization revealed clear hotspots for specific crime types in various cities. For instance, violent crimes were concentrated in urban hubs, while property crimes were more evenly distributed. This spatial understanding of crime distribution can guide resource deployment and urban planning efforts.

6. Broad Crime Domain Insights

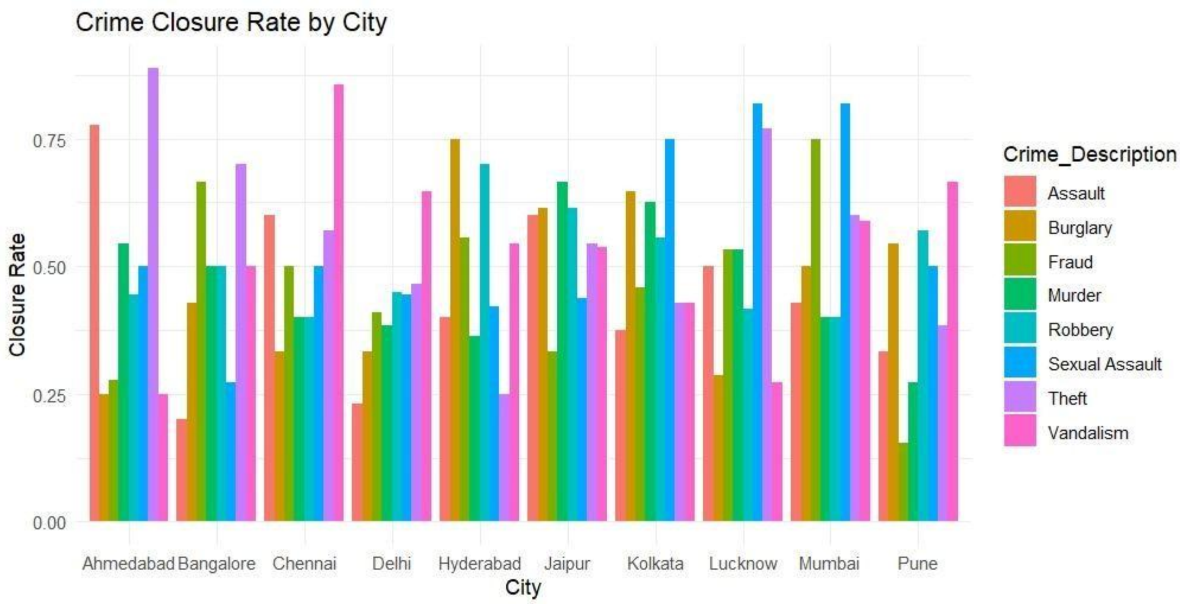
The box plot comparing victim age across crime domains highlighted that violent crimes typically involve younger victims, while white-collar crimes affect a broader age range. This differentiation reinforces the importance of tailoring crime prevention strategies to the characteristics of each domain.

OUTPUTSAMPLES

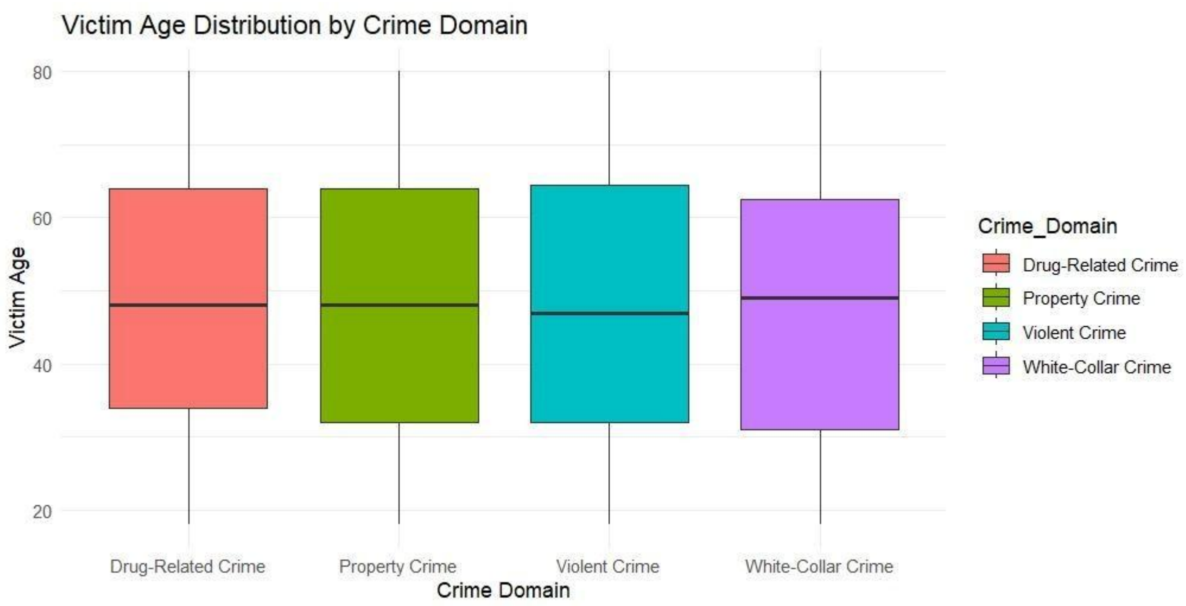


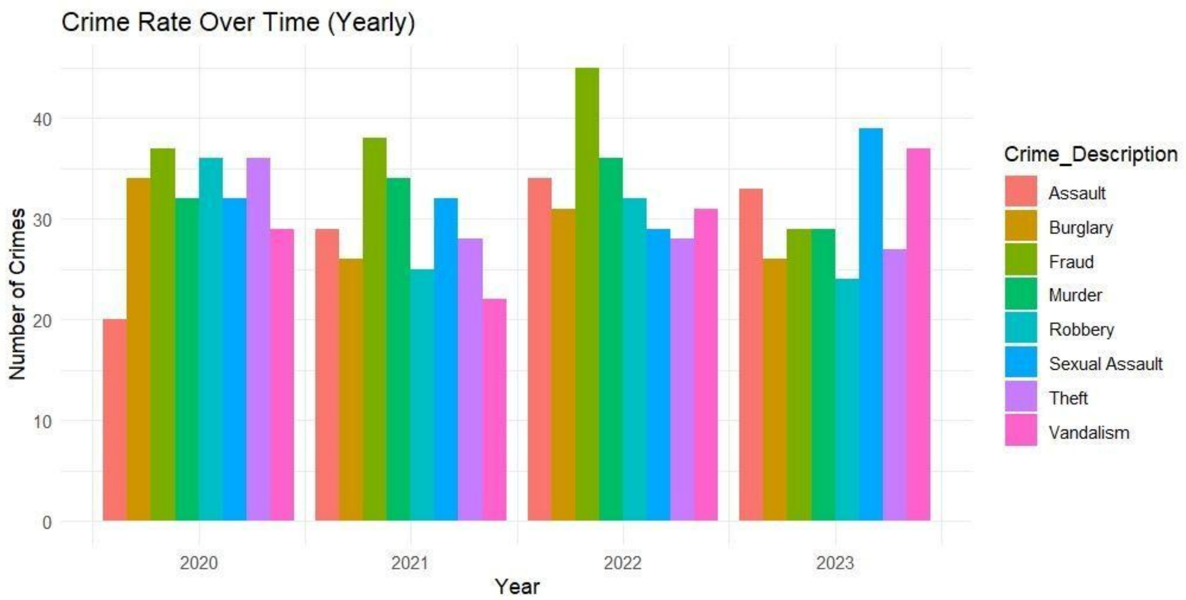


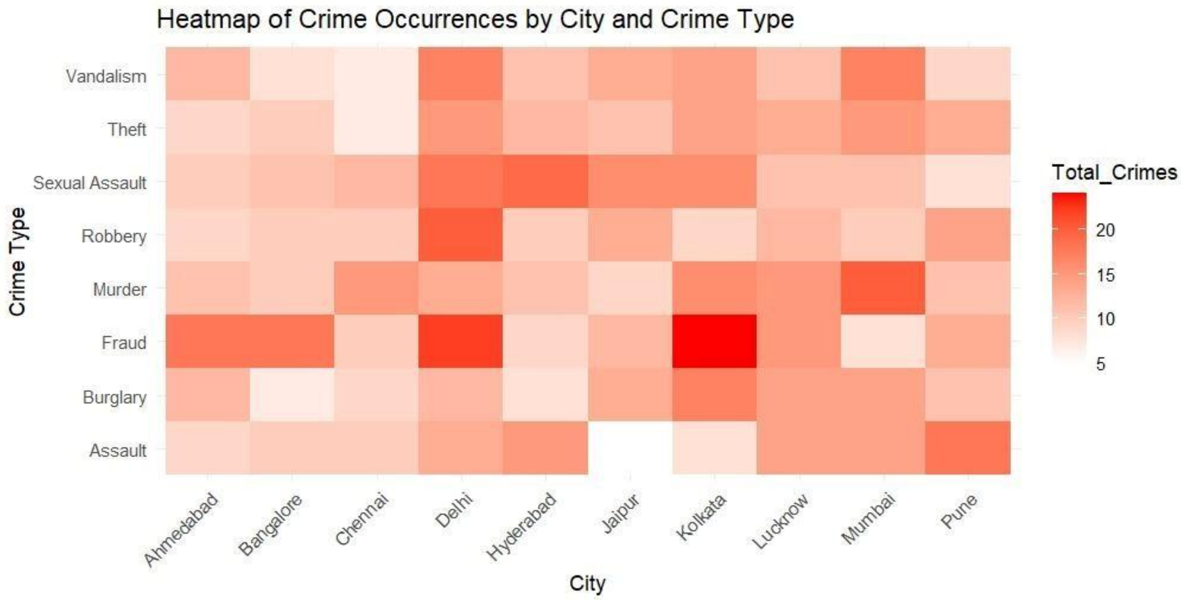
Victim Age Distribution by Crime Type
Density
0.020
0.015
0.010
0.005
0.000
20
40
60
80
Age
Crime_Description
Assault
Burglary
Fraud
Murder
Robbery
Sexual Assault
Theft
Vandalism



Crime Closure Rate by City
Closure Rate
0.75
0.50
0.25
0.00
Ahmedabad
Bangalore
Chennai
Delhi
Hyderabad
Jaipur
Kolkata
Lucknow
Mumbai
Pune
City
Crime_Description
Assault
Burglary
Fraud
Murder
Robbery
Sexual Assault
Theft
Vandalism


Victim Age Distribution by Crime Domain
80
60
40
20
Victim Age
Drug-Related Crime
Property Crime
Violent Crime
White-Collar Crime
Crime Domain
Crime_Domain
Drug-Related Crime
Property Crime
Violent Crime
White-Collar Crime


Crime Rate Over Time (Yearly)
40
30
20
10
0
Number of Crimes
2020
2021
2022
2023
Year
Crime_Description
Assault
Burglary
Fraud
Murder
Robbery
Sexual Assault
Theft
Vandalism



FUTUREENHANCEMENTS

One of the key future enhancements for this project would be the integration of real-time data. By connecting the analysis system to live crime data feeds from law enforcement agencies, the model can be updated dynamically to reflect the latest trends and incidents. This would enable quicker decision-making, allowing law enforcement to react faster to emerging patterns and allocate resources more effectively in real-time, ultimately improving public safety.

Another promising enhancement involves the implementation of predictive analytics for crime forecasting. By using machine learning techniques such as time series forecasting or classification models, it would be possible to predict future crime trends, such as high-risk areas or potential crime surges. These predictive models would help law enforcement agencies be more proactive in their crime prevention strategies, focusing on areas and times with a higher likelihood of incidents, rather than just reacting to past data.

Geospatial analysis could also be further developed by incorporating mapping tools and GIS technologies to improve spatial understanding of crime patterns. This would allow for the identification of specific geographical areas where certain crimes are more likely to occur. By adding geographic context to crime data, law enforcement can more effectively target interventions and better understand how local environmental or socio-economic factors contribute to criminal activity in particular areas.

In addition to this, integrating sentiment analysis of public data, such as social media posts, news articles, and online forums, could provide valuable context to crime trends. Monitoring public sentiment on various platforms can reveal emerging concerns or threats that might not be captured through traditional reporting channels. This would allow law enforcement to anticipate potential issues and address public concerns before they escalate into serious problems, offering a more comprehensive understanding of crime dynamics.

Furthermore, incorporating external factors like weather patterns, economic conditions, or major events in the area could provide deeper insights into the underlying causes of crime. For example, certain weather conditions, such as heatwaves, or events like large public gatherings could correlate with spikes in specific types of crime. By including these variables, the analysis would become more holistic, allowing for better resource planning and response strategies.

Creating more advanced and interactive visualizations would also enhance the usability of the system. Developing dynamic dashboards for law enforcement and policymakers would allow them to interact with the data more easily, exploring different scenarios and filtering for specific trends. These visualizations could provide better insights into the relationships between various factors, making it easier for decision-makers to implement strategies effectively.

Lastly, incorporating victim support data into the analysis would help address the broader impact of crime. Tracking the effectiveness of victim support services such as counseling, legal aid, or rehabilitation programs could offer valuable insights into how well victims are recovering and what additional resources may be necessary. By analyzing this data, the system could also identify gaps in support services and make recommendations for improvements, contributing to a more holistic approach to crime and its consequences.

CONCLUSION

In conclusion, the analysis of crime data using R has provided significant insights into the spatial, temporal, and demographic patterns of criminal activity. The findings revealed variations in crime rates across different cities, with certain urban areas showing higher concentrations of specific crimes, such as theft and robbery. Victim demographic analysis highlighted how age groups are disproportionately affected by certain types of crime, while the temporal analysis identified high-risk periods for crime, particularly in the late evening and early night. Case closure rates pointed to cities needing improvements in investigative efficiency, and the heatmap visualized crime hotspots, aiding resource allocation. Additionally, trends over time indicated fluctuations in crime rates that could be linked to socio-economic factors or changes in reporting mechanisms. These insights enable law enforcement agencies and policymakers to optimize patrol schedules, enhance crime prevention strategies, and allocate resources more effectively, ultimately contributing to a safer, more informed society.

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