CHRIST
(DEEMED TO BE UNIVERSITY)
BENGALURU · INDIA

MDS573A - GEOSPATIAL DATA ANALTYICS

TORONTO CRIME DATA ANALYSIS

by

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Introduction

This report provides an in-depth analysis of crime data from Toronto, focusing on spatial and temporal patterns of various offenses. The dataset encompasses detailed information on criminal incidents, including event identifiers, report dates, occurrence dates, offense types, geographical coordinates, and neighborhood context. Using geospatial and statistical tools, the analysis aims to identify trends and provide actionable insights for urban planning and law enforcement strategies.

1. Objective

This report primarily focuses on:

- Analyzing spatial and temporal distributions of crime incidents in Toronto.
- Identifying patterns and hotspots associated with various offense types.
- Giving insights into targeted intervention, urban planning, and improved public safety.

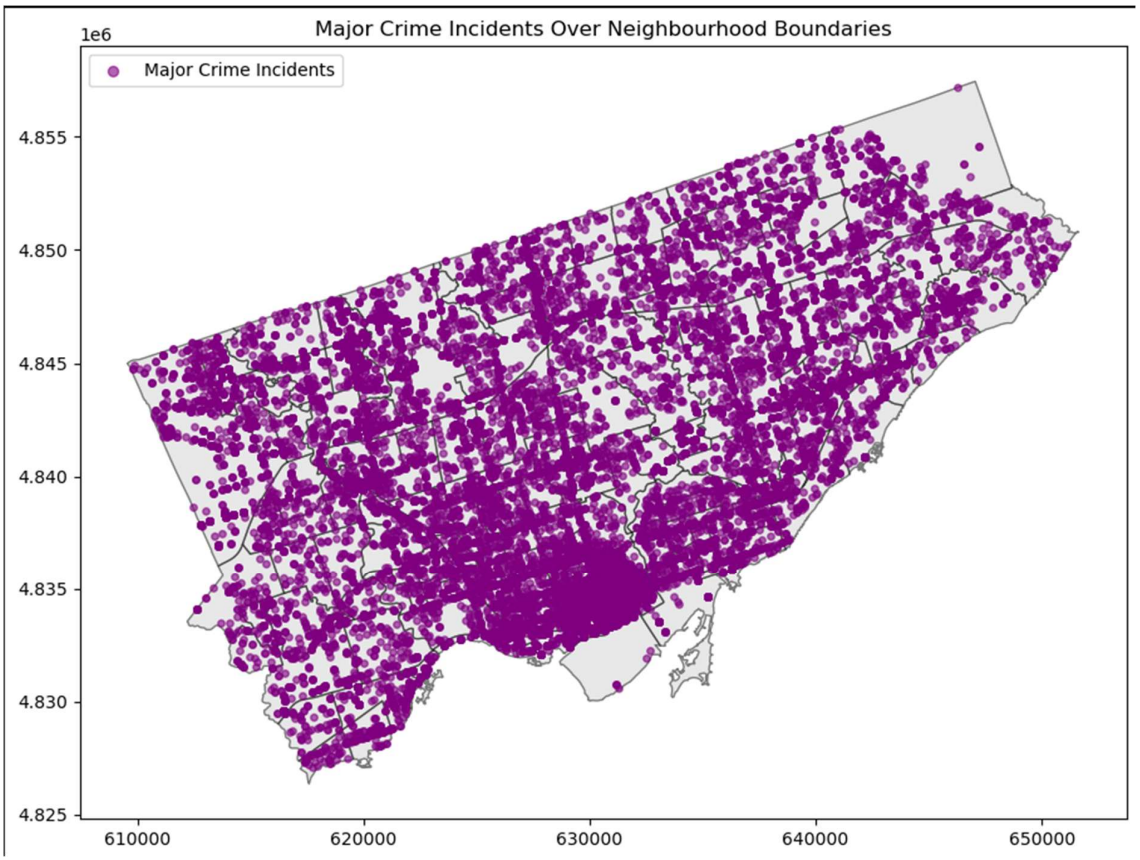
2. Data Overview and Processing

The dataset contains detailed crime information, which includes event IDs, report dates, occurrence dates, offense types, and geographical coordinates. Key processing steps included conversion of the CSV file into a GeoDataFrame using latitude and longitude coordinates for spatial analysis. Neighborhood boundary shapefiles were incorporated to contextualize crime locations. Statistical and geospatial techniques were applied to analyze and visualize patterns effectively.

3. Spatial and Temporal Crime Maps Analysis

Spatial Distribution of Crime

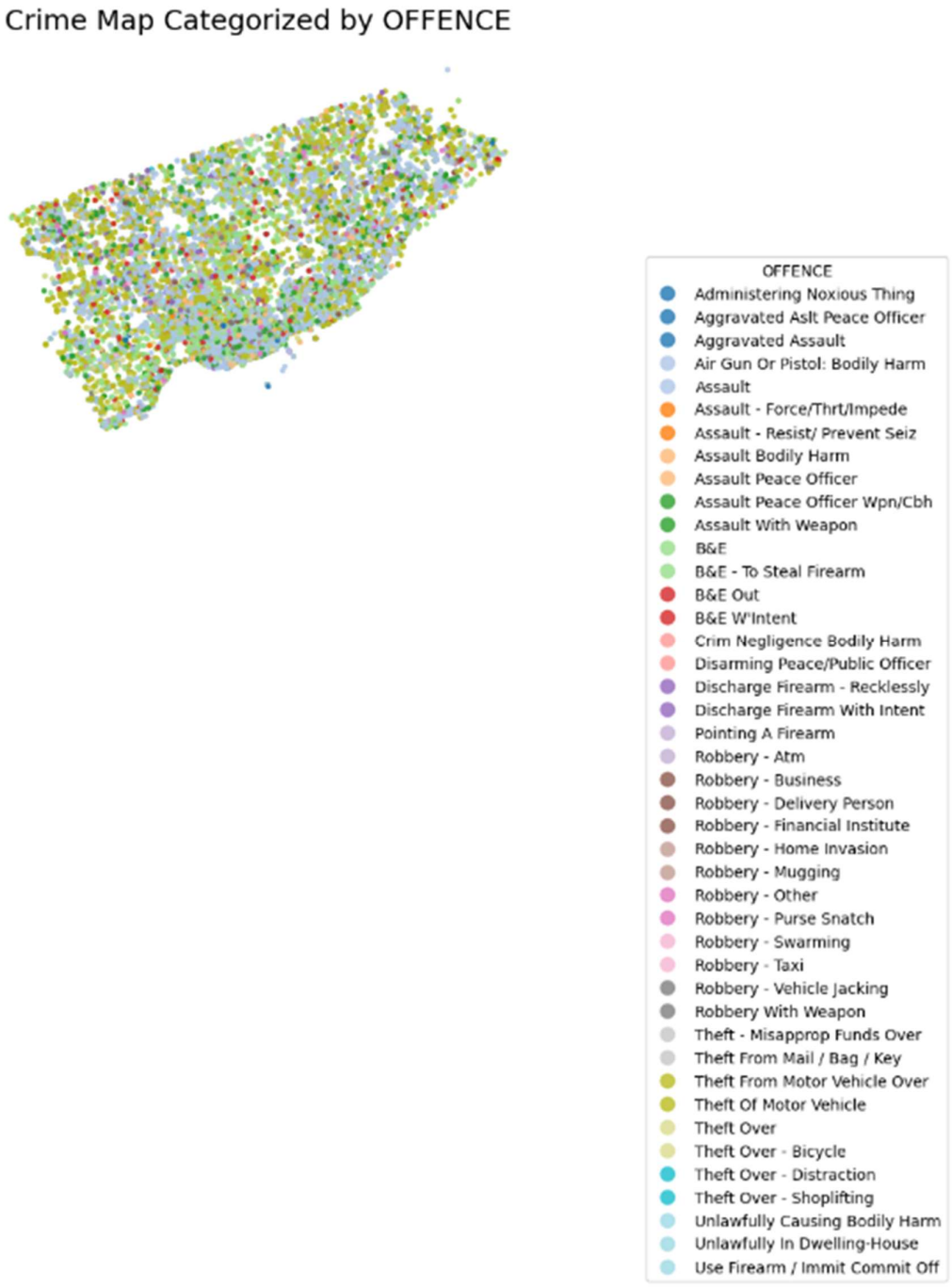
There is a large number of crime incidents spatially distributed in Toronto, and trends are observed. Many are concentrated in the downtown core due to the population density and commercial activity. In suburban areas, there are more dispersed patterns based on socio-economic and demographic differences. Hotspots of localised crime concentrations over large areas exist and require more focused interventions from authorities.



Major Crime Incidents Over Neighbourhood Boundaries

Analysis of Specific Crime Types

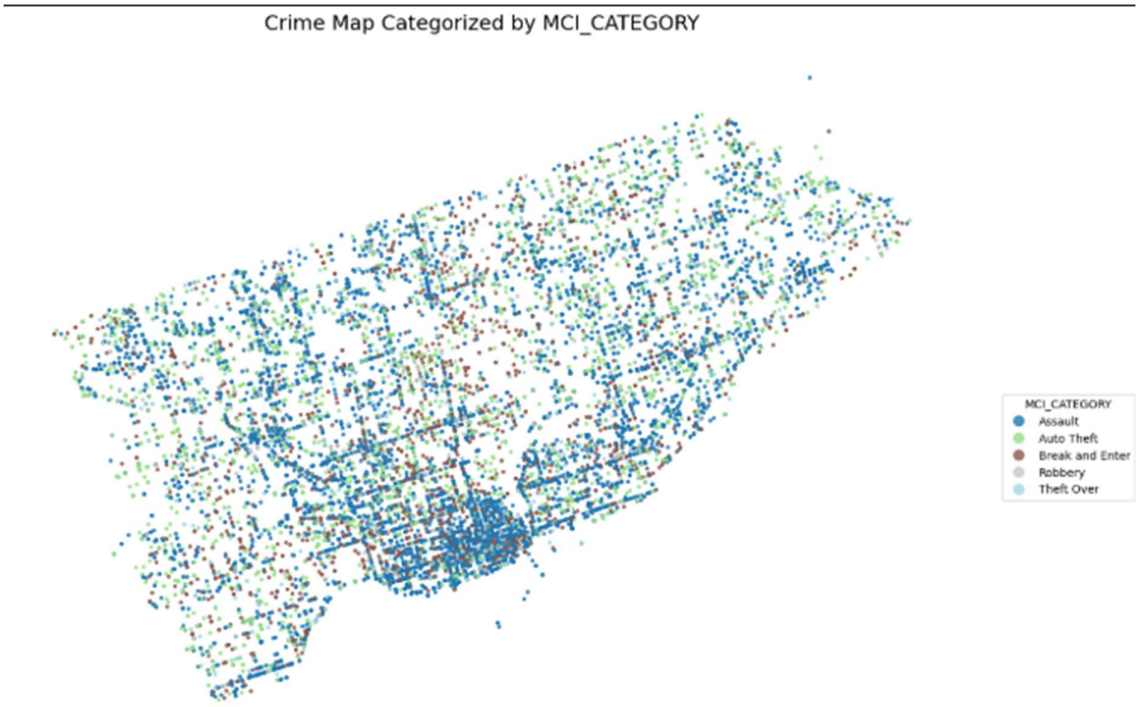
The different crime types found in the analysis include assaults, thefts, robberies, and break-and-enter incidents. All of them present unique spatial patterns. For example, commercial areas have tendencies to group thefts together, while entertainment districts tend to host assaults. These offense-specific hotspots are evidence that crime requires differently focused strategies to deal with its diverse types effectively.



Crime Map Categorized by OFFENSE

MCI Categories

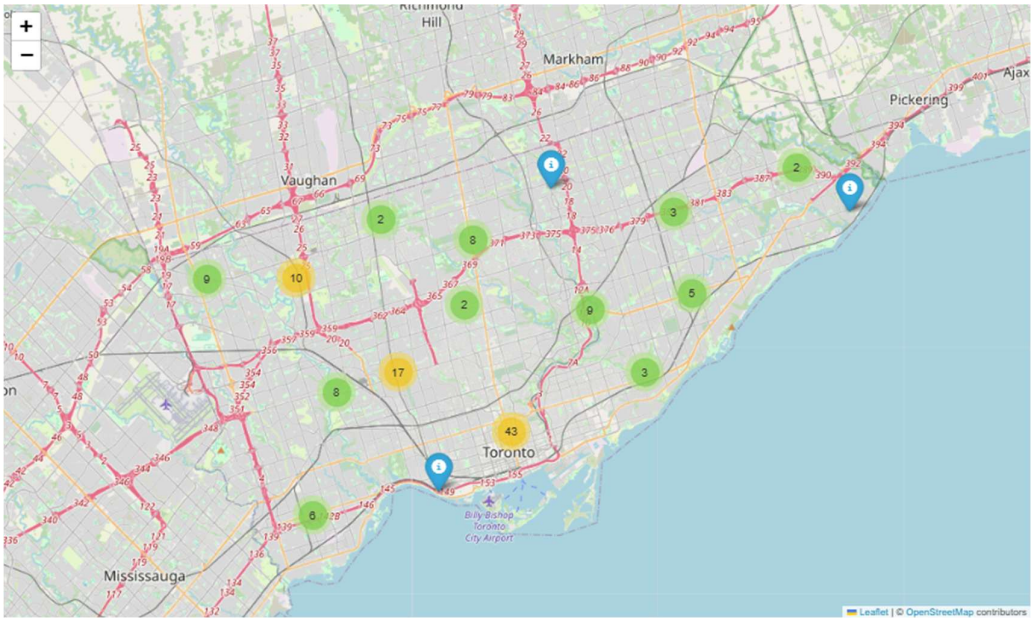
Breaking down the crimes into larger MCI categories such as Assault, Auto Theft, and Robbery provides an even clearer view. These categories have significant spatial differences, which are a good starting point for police to decide where to focus more and put their resources better. Through these categories, the police can target serious crime issues in particular regions.

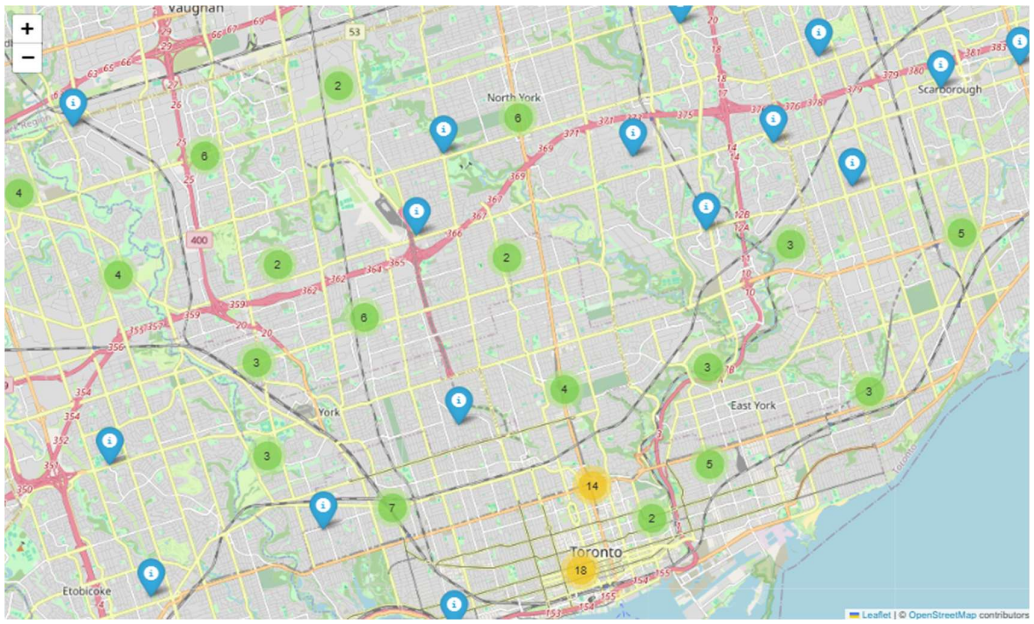


Crime Map Categorized by MCI_CATEGORY

Crime pattern in Toronto

Marker Cluster inclusion allows for a dynamic view of assault density, indicating hotspots relative to geographical features such as landmarks and neighborhoods. This tool allows for further detailed exploration and helps in strategic planning.

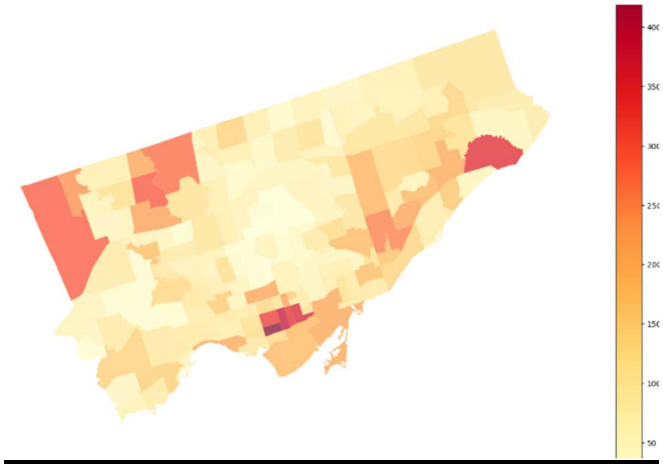




Toronto Assault Map

Analysis of Choropleth Maps

The choropleth map of assaults in Toronto highlights the spatial distribution of assault crimes across various neighborhoods. From the analysis, it can be observed that assaults are often concentrated in entertainment districts, which may indicate a higher likelihood of altercations in busy, social areas.

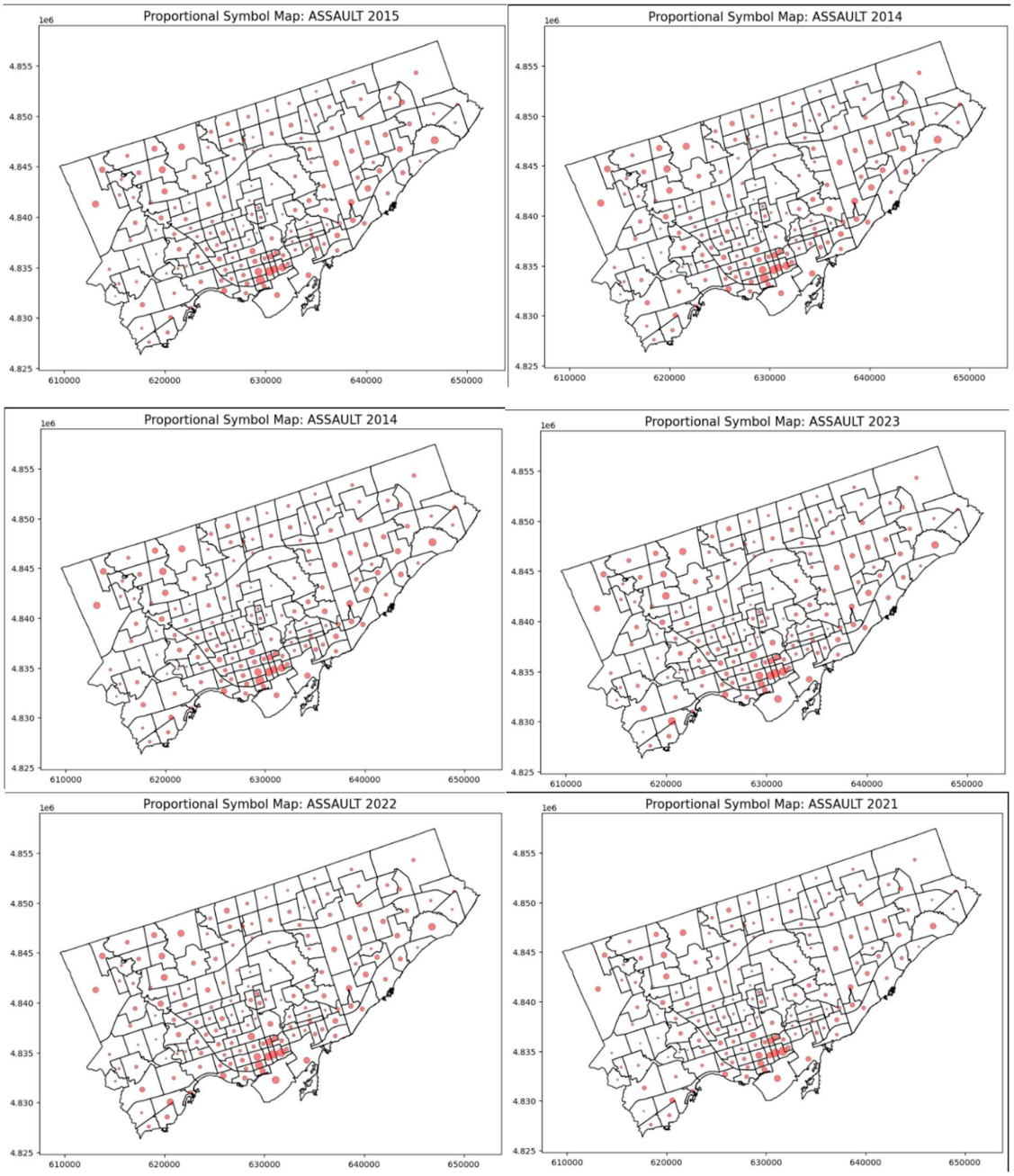


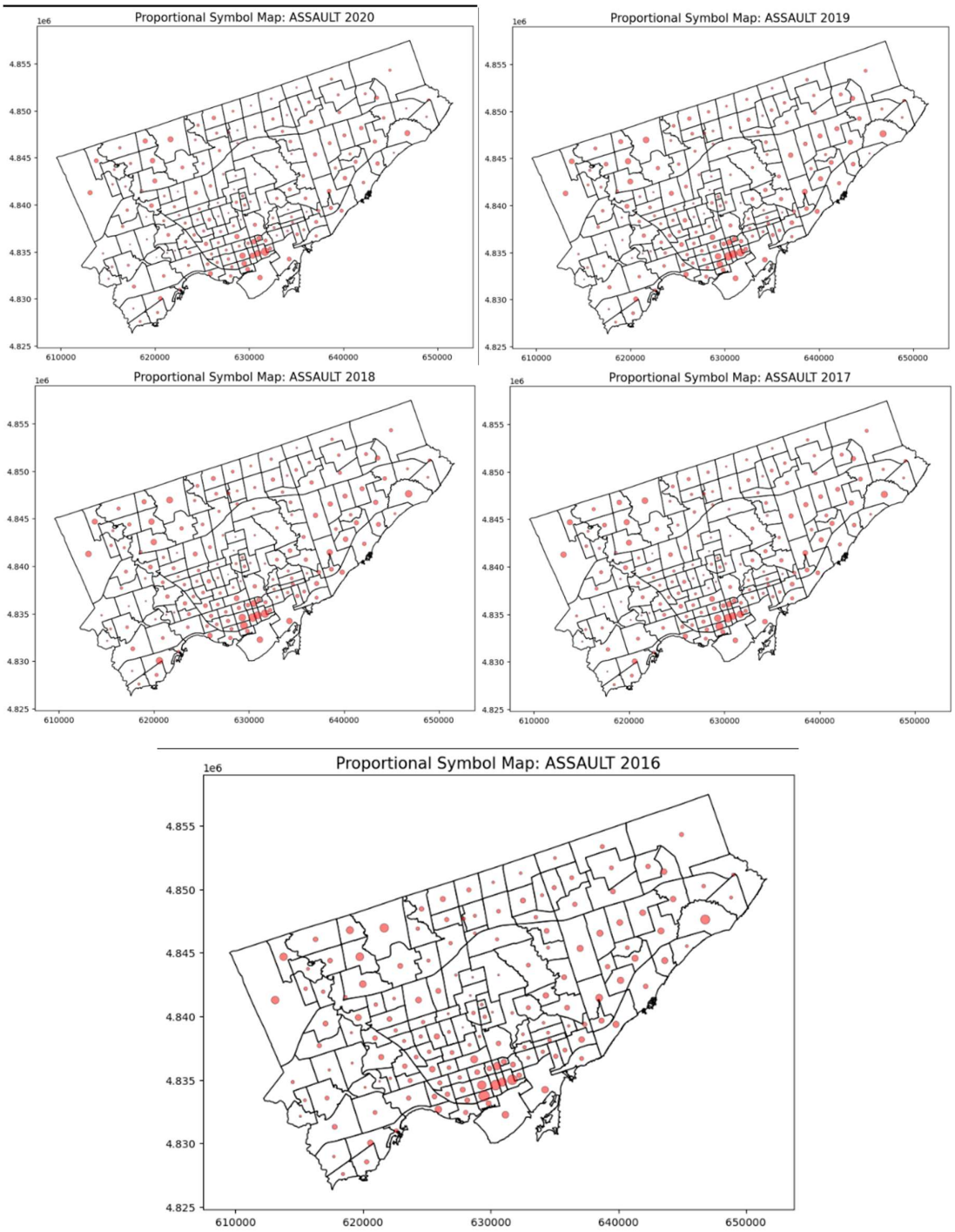
choropleth map of assaults in Toronto

Proportional Symbol Maps

Proportional symbol maps create an easy view of crime volumes by neighborhood. Larger symbols represent more crime counts that make it easy to compare locations in a glance. Trends over time-the

change in symbol size year in and year out-point up neighborhoods that need to keep on the radar or perhaps be celebrated for improvement.



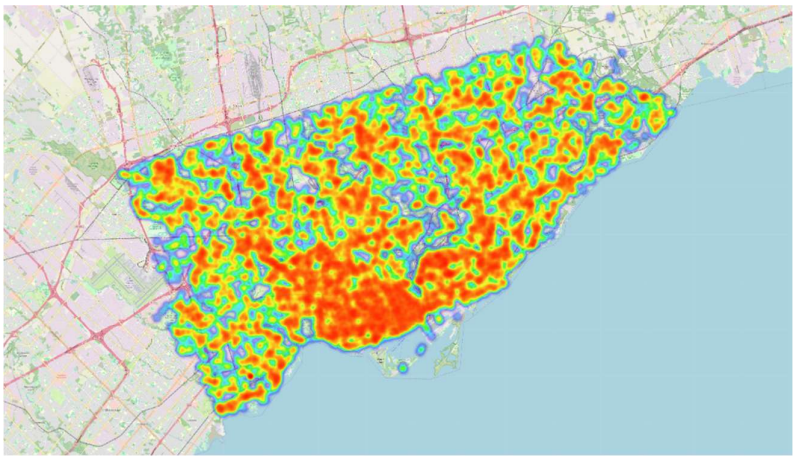


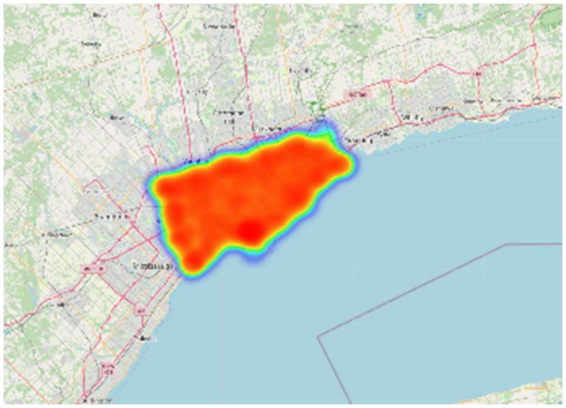
Analysis of Point map

Point map for offenses and MCI categories provide important insights into the crime landscape of Toronto. High crime activity hotspots are mainly located in the central and eastern parts of the city. The heatmaps also indicate environmental correlations, such as proximity to transit hubs and nightlife districts. Temporal variations in these patterns highlight the need to align resource allocation with seasonal and hourly crime trends.

Heatmap

This heat map visualization provides a vivid description of the intensity and concentration of criminal activities across Toronto. Places with darker colors have high crime densities, often coinciding with central and eastern neighborhoods characterized by greater population density, nightlife activity, and public transit hubs. Temporal variations are evident, such that crime density is higher at peak hours in the evening and late at night.





Heatmap of crimes in Toronto

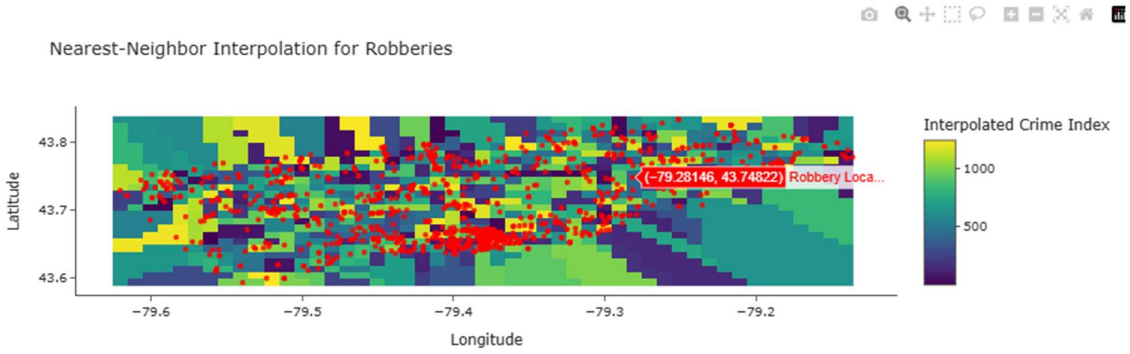
Region-Wise Clusters

The spatial clustering analysis reveals distinct patterns of crime concentrations across Toronto. Central Toronto, with its dense commercial districts and high foot traffic, consistently emerges as a hotspot for various types of crimes, including assaults and robberies. Eastern regions, marked by a mix of residential and industrial areas, also show significant clustering, possibly influenced by socio-economic conditions and proximity to transit hubs. Suburban areas tend to have more dispersed crime patterns, reflecting lower population densities and fewer opportunities for certain types of offenses. These findings emphasize the importance of regional context in understanding crime dynamics and tailoring law enforcement efforts.

Cluster based on the region

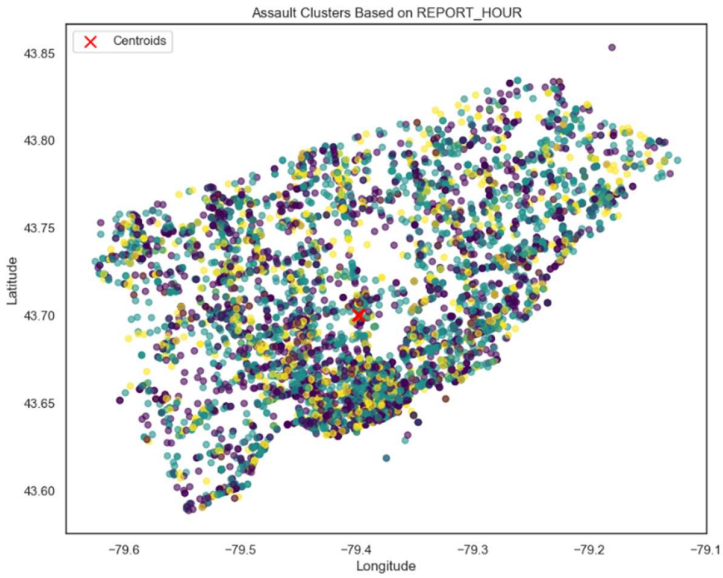
Nearest-Neighbor Interpolation for Robberies

The nearest-neighbor interpolation draws attention to the concentration of robberies in central and eastern Toronto. Nevertheless, the analysis suffers from edge effects, so it is less reliable near the boundaries of the map. The constraint calls for caution when interpreting data at the map's periphery.



Assault Clusters per Hour

Hourly assault clusters identify distinct spatial and temporal patterns in Toronto. Incidents peak between 6 PM and 2 AM, coinciding with nightlife and high social activity in central urban areas, especially around entertainment and transit hubs. Dense evening hour clusters are evident, while early morning hours exhibit sparse distributions, reflecting low activity. Centroids can be used to pinpoint hotspots of high-risk activity for the effective targeting of peak hours and locations by law enforcement.



Distribution of Assault Incidents based on time classes

The temporal distribution of assault incidents shows evident and actionable patterns. The data reflects the fact that assault activity escalates significantly during evening hours and peaks at 10 PM, in line with high social engagement and nightlife activities. This pattern, represented by orange color for evening hours, suggests the influence of alcohol consumption, increased pedestrian movement, and larger crowd gatherings during these times. The 5 AM to 7 AM hours, depicted with blue representing

the morning category, record very few incidents. One reasons behind this could be less activity during these hours by human populations and greater calm. Besides the main patterns identified through afternoon incidents in green, night incidents are also evident in purple. These color-coded insights point out that the risk associated with assault activity can be minimized if law enforcement is strategically deployed during evening and late-night periods.

Hourly Assault Distribution

4. Regression Analysis of Assaults

Regression analysis shows that there is a significant relationship between the hour of the day and assaults, with an R-squared value of 0.650. The positive coefficient indicates that later hours are associated with increased assaults, while the intercept suggests the expected baseline at midnight. These findings reinforce the importance of temporal considerations in crime prevention strategies.

OLS Regression Summary:

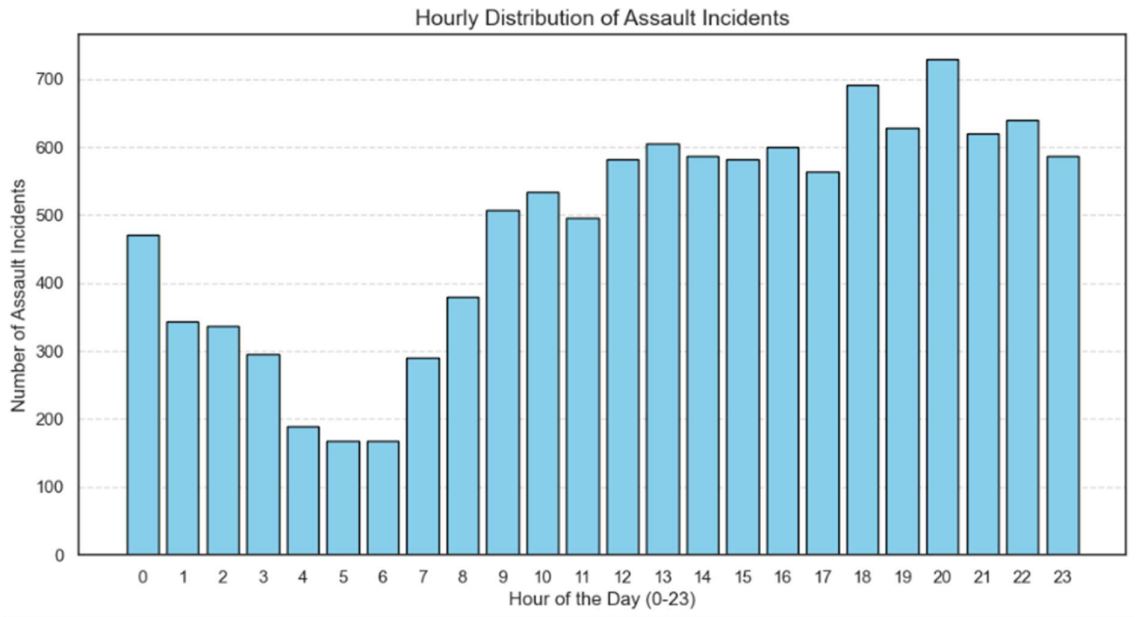
OLS Regression Results

Dep. Variable:	y	R-squared:	0.650
Model:	OLS	Adj. R-squared:	0.634
Method:	Least Squares	F-statistic:	40.80
Date:	Wed, 18 Dec 2024	Prob (F-statistic):	1.99e-06
Time:	19:39:38	Log-Likelihood:	-144.09
No. Observations:	24	AIC:	292.2
Df Residuals:	22	BIC:	294.5
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	261.2200	40.503	6.449	0.000	177.221	345.219
x1	19.2743	3.018	6.387	0.000	13.016	25.532

Omnibus:	1.096	Durbin-Watson:	0.568
Prob(Omnibus):	0.578	Jarque-Bera (JB):	0.714
Skew:	-0.416	Prob(JB):	0.700
Kurtosis:	2.853	Cond. No.	26.1

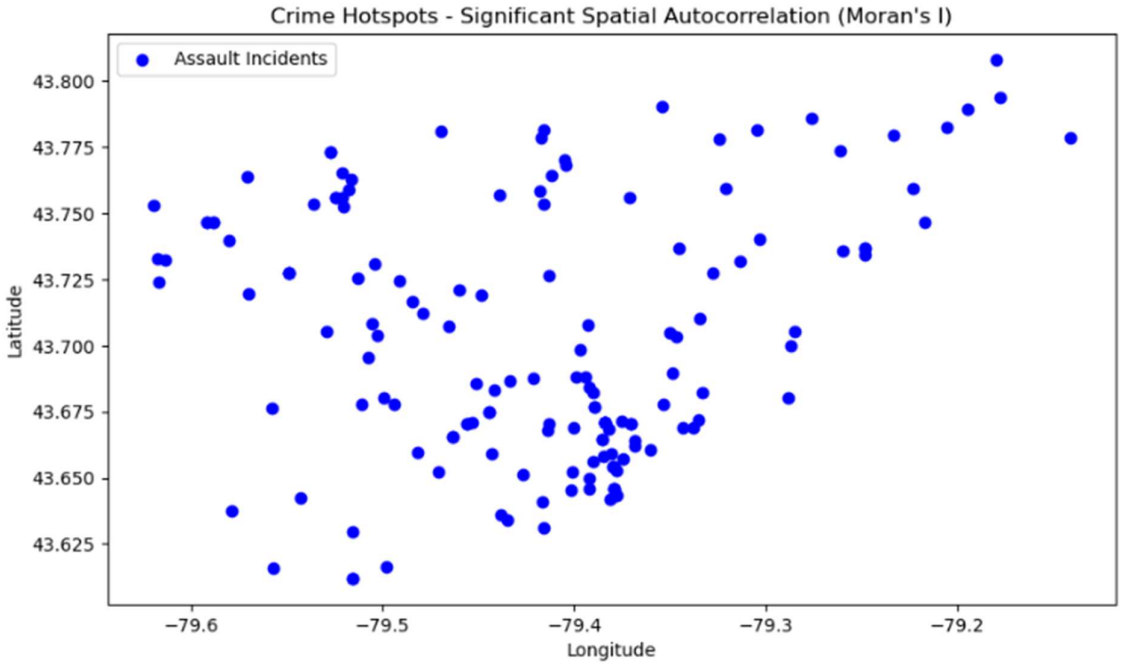
OLS Regression Results



Spatial Autocorrelation Analysis

The Moran's I test confirmed the significance of the clustering of assaults with a p-value of 0.001. It indicates that the assaults are not randomly distributed, but they follow a certain spatial

autocorrelation. This type of clustering calls for specific focus from the urban planners as well as the law enforcement.



Conclusion

The analysis of Toronto crime data reveals clear spatial and temporal patterns, with significant clustering in specific neighborhoods and time periods. These insights can guide targeted policing, improved urban planning, and optimized resource allocation. The findings underscore the need for enhanced policing efforts during peak hours and in identified hotspots. Community engagement and outreach programs can further address underlying socio-economic issues contributing to crime. Environmental factors affecting criminal activity can be addressed through various urban development initiatives, such as improved lighting and redesigning public spaces. Lastly, broadening the analysis to other types of crime and including socio-economic data will contribute to a more complete understanding of the crime dynamics in Toronto.