Application of Spatio-Temporal Analysis in Criminal Incident Recording System

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***Abstract* — Crime has always been a part of people's daily lives, and statistically speaking, the number of crimes has never decreased while continuously increasing. Despite the fact that no one can predict when a crime will occur, this study aims to use spatial and temporal analysis in crime mapping to identify crime patterns and hotspots that will be used by Caloocan Police Substation 03 to determine where and when the police officers should patrol to prevent criminal activity from happening. The researchers have discovered that the police officers find the system useful for keeping their crime data and for establishing their patrolling regions based on the findings of the survey that was done. The findings indicate that using Spatio-Temporal Analysis in a Criminal Incident Recording System can help reduce crime rates in the jurisdiction of Caloocan Police Substation 03.**

***Keywords* — Crimes, Criminal Recording System, Software Engineering, Spatial Element, Spatio-Temporal Analysis.**

I. Introduction

It is hard to have a completely crime-free environment because crime is considered a social phenomenon and is based on how living things interact with one another. However, with the use of technology, authorities particularly police officers, can prevent criminal activities. According to the report of [18], "A significant portion of our population has lost faith in the government's law enforcement organizations due to lack of action by officials on the increasing crime rate." This statement describes how a slow processing of reports causes the justice system to function slowly or not at all. Practically every aspect of one's existence has been affected by the evolution of several technology advancements during the past decade. A number of fields, including crime incident prevention, have benefited from these developments. According to the [20] “Spatio- temporal analysis is used in data analysis when data is collected across both space and time.” With the use of this technique, a phenomenon at a specific place and time can be identified and predicted. The stated method was used in several research to prevent criminal activities. The researchers aim to improve the criminal incident recording system by implementing Spatio-Temporal analysis algorithm in response to technological improvements in computing power and the understanding of how crimes are committed.

II. Project Objectives

A. General Objective

To develop a Criminal Incident Recording System with application of Spatio-Temporal Analysis this can minimize and prevent criminal activities in a specific area inCaloocan City, Manila, Philippines.

B. Specific Objectives

1. To develop a system for recording criminal incidents that uses spatial and temporal analysis in identifying crime patterns and hotspots.
2. To implement crime mapping with applied cluster marker algorithms.
3. To improve the crime recording and analysis system and provide beneficial insights through analyzing its contents, finding patterns and assessing trends.

III. Related Literature and Studies

Findings from related literature have revealed that the application of criminal analysis and crime mapping in criminal incident recording systems is practical and adequate in providing insights and predicting criminal activities. According to [25], “crime mapping” is the software-based combination of visualization and statistical techniques. Crime mapping has become an essential component in crime prevention because it can help identify crime problems and evaluate crime prevention initiatives.

Previous studies of graduate students have indicated that people are becoming increasingly interested in the Spatio-temporal characteristics of data in the age of enormous data. [4] Researchers have hypothesized that creating maps with hotspots is turning into a vital and significant tool for policing. It reveals how it contributes to the growth of understanding and awareness of various urban places, including perhaps why crime may occur there [23].

A similar study by [21] applies Knowledge Discovery to several areas with geospatial significance, particularly a crime department, to follow the patterns of crimes that have occurred using data mining methods.

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The project utilized the KDD approach in processing data, which involves interdisciplinary efforts, including data access and storage, scaling algorithms to enormous data volumes, and analyzing outcomes.

The research, as mentioned above, crime analysis, clustering, and mapping procedures were the foundation and motivation of this project. The study focused on the development of a system for criminal incidents that would display crime clusters, spatial and temporal characteristics and then develop a strategy to address and reduce such concentrations using the Marker Cluster algorithm.

IV. Theoretical Framework

This study is anchored on the hypothesis of routine activity theory (RAT) as seen on Fig.1, which was defined [11] as an approach to examining how the everyday behavior of individuals exposes them to more or less risk of being a victim. The criminologist can identify 'hotspots' where criminal activity is likely to be concentrated by investigating such routine activities [15].

Fig. 1 Routine activity theory model.

The model analyzes individual motivation and guardianship elements relevant to crimes committed in a specific location. RAT was used to identify what data features are needed in order to come up with relevant results and to analyze the final output of the crime map to identify the time and place where crimes frequently occur.

V. Methodology

A. Process Flow

The criminal incident report system as seen on Fig. 2 shows the process flow of the application where users can efficiently generate crime incident reports and view crime records which will be processed using Spatio-Temporal analysis which can be viewed on a crime map that will provide crime information such as crime type, crime location, crime date and time.

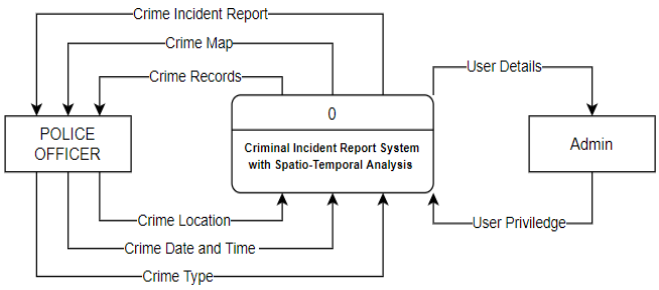

Fig 2. Flow Diagram.

B. User Interfaces

The access screen for user is shown on Fig. 3. The dashboard as seen on Fig. 4 shows the past analysis of cases from 60 days, 1 month, 6 months, and the last 1 to 2 years of the case record. It gives information on the solved cases, cases that are under investigation, the total number of cases, highest cases by crime type, the most dangerous barangay and the time when crime mostly occurs. The Google map is then updated with the cluster marker which can be seen on the crime map of the application as shown on Fig. 5. This is the process of joining close markers to create a single new marker with an additional number, usually the number of pins to represent the density of locations at a particular zoom level. The system also shows the number of crimes per category and its ranking according to volume. The user can examine a chart that displays the number of crimes that have occurred over a certain period of time, together with an analysis of the suspect and victim who were involved in the crime.

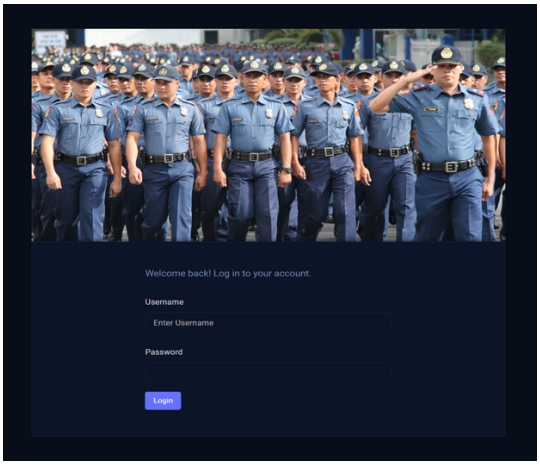

Fig. 3. User log-in screen.

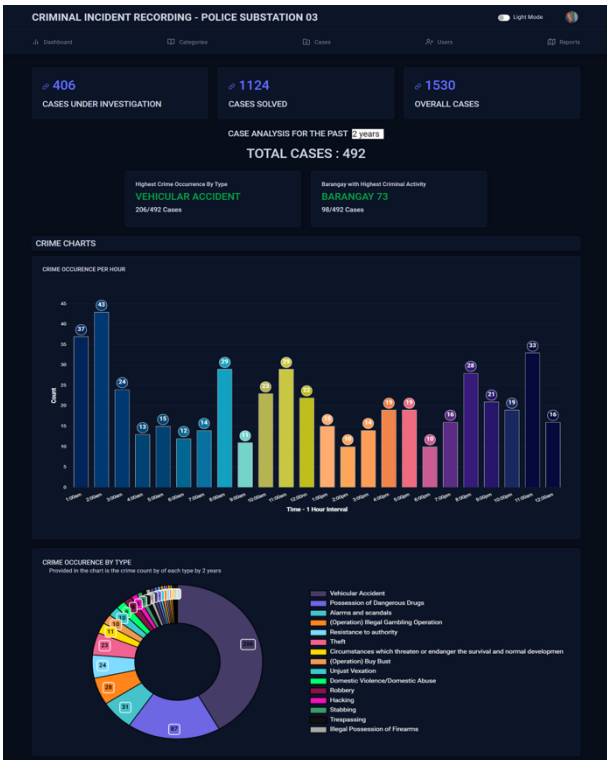

Fig. 4. Dashboard.

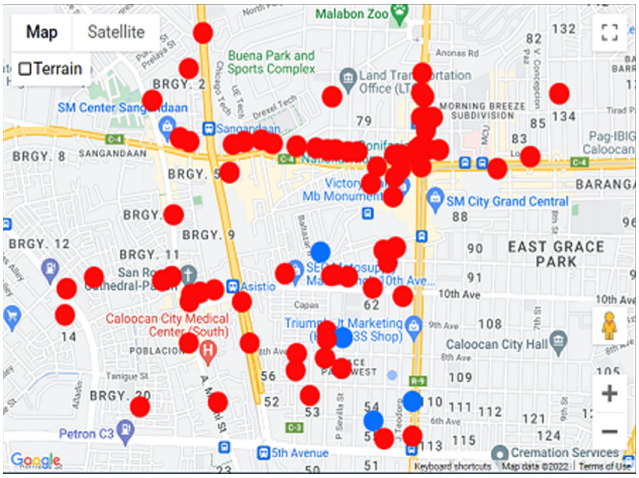

Fig. 5. Crime map.

Crime time graph as seen on Fig. 6 shows the time and place where the majority of the crime happens.

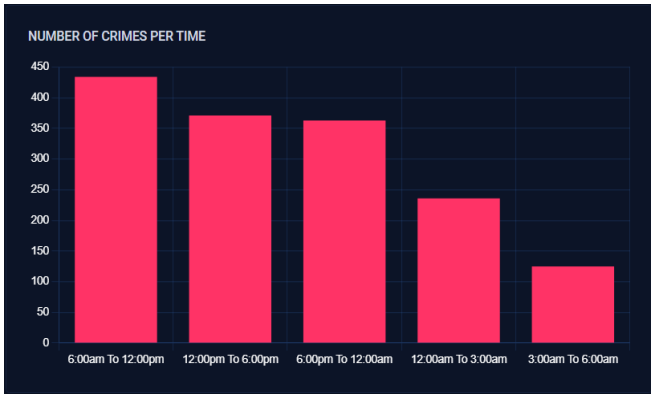

Fig. 6. Crime stat.

C. *Evaluation Method*

The researchers used the purposive sampling technique and the five-point Likert scale weighted mean where 1 is interpreted as “strongly disagree” and 5 is interpreted as “strongly agree”. A total of 19 respondents consisting of police officers, crime investigators and Officer in Charge (OIC) in the police substation were selected as respondents.

The effectiveness of the application was evaluated based on its usability, functionality, portability, maintainability and efficiency.

VI. Results

The Criminal Incident Report System with Spatio-Temporal Analysis is a web application developed specifically for Police Substation 03 Caloocan City to assist law enforcement in allocating resources to improve security and to minimize the crime rate through the detection of crime patterns defining the time and place of the occurrence of crime.

Spatio-temporal analysis was used in the system to generate clearer, more efficient way of analyzing and representing previously exhibited data in pin maps and so as the cluster marker algorithm to identify criminal hotspots.

In terms of system usability, 63% of respondents said the system is user friendly. 68% agree that the application will be used frequently.

Easiness of use results to a 73% while 63% agree that the system is working properly.

In terms of system functionality, 52% agree that data entry is quick and easy. System functionality is rated as satisfactory by 57% of the respondents. Efficiency of the system resulted to a 73% response rate as well as 68% of respondents agreed that the system generate reports in real time and as a result 68% agreed that the system work as planned and required.

In terms of system reliability, 73% of respondents strongly believe that the system has consistent pattern and structure. In each page of the system, 68% agreed that the dashboard page is working as intended and that it shows a comprehensive overview of the crime statistics and 52% agree that the crime map is likewise working well.

In system portability, 63% said that the system can easily be access, 68% find the system is conveniently transferable. 52% agreed that the system can easily be access through the net. 52% of the respondents said that they need instruction in order to access the system and 68% agreed that the system is portable and lightweight.

In terms of system maintainability. 89% of respondents witnessed that the system did not crash during the demonstration and implementation, 68.4% of respondents said that the system does not create any latency.

In terms of system efficiency, 68% of the respondents agreed on this factor. According to 84% of respondents, the system offers quick loading time. 68% respondents rate the system's performance as outstanding, while 84% respondents rate the system's information as properly presented.

VII. Conclusion

The main purpose of this study is to provide a Crime Reporting System that applies Spatio-Temporal Analysis for Police Substation 03 that will improve the crime recording system of the said station. Based on the evaluation conducted, it is said that:

- The system provides a user-friendly interface.
- The dashboard of the system provides case analysis.
- The system is able to provide a summarized report and gives a clustered crime map that shows the pin location/vicinity of the reported crimes.
- The system managed to improve the crime recording and analysis of the criminal incident report system.
- The system can generate real-time and accurate reports.

VIII. Recommendations

The Criminal Incident System for crime hotspots in Caloocan City is still in progress and is open for further improvement or development. Some of the recommendations are as follows:

- Mugshot of suspects can be displayed or included in the system.
- Clicking the pin of a location, the crime cases or records within that specific location can be shown.
- Try to consider implementing the system to crowded areas or with higher crime rates such as cities or urban areas.

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