Assessing the Level of Crime Incidence in the Municipality of Silang Cavite Using Monte Carlo Algorithm

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ABSTRACT

Silang Cavite is one of the 24 local government units of the province of Cavite, Philippines. It is subdivided into 64 barangays, and it relies on agriculture as its principal source of income. Based on the record of the Cavite government in 2020, Silang got the highest crime index in the 5th district of Cavite. In response to this pressing issue, the researcher came up with the idea to develop a system that can assess the crime incidence in the municipality of Silang using the Monte Carlo algorithm. The system was developed with the aid of the Systems Development Cycle (SDLC) model. The Monte Carlo algorithm demonstrated a substantial improvement in crime mapping, it provided more nuanced insights into the types or categories of crimes expected in different areas through geofencing. The crime incidence was presented using Google Maps and Bing satellites. Descriptive and developmental research methods were used in conducting the study. As part of the developmental method, the acceptability of the system was tested using the ISO/IEC 25010:2011 standard. The acceptability of the system was evaluated by 38 participants. Purposive sampling was used in the selection of the participants. The evaluation outlines eight characteristics for assessing software quality. Based on these criteria, the system was rated as "Excellent" indicating that it meets high standards of performance, reliability, and user satisfaction. This evaluation underscores the system's effectiveness in addressing the crime assessment needs of Silang, contributing to improved public safety and informed decision-making in the Municipality.

Keywords: Crime Incidence, Desktop Application, Algorithm

INTRODUCTION

Cavite is in the Cavite, Laguna, Batangas, Rizal, and Quezon (CALABARZON) regions. The province is located to the south of Batangas; to the east is Laguna Province; to the northeast is Manila; and to the west is the Philippine Sea (PhilGIS, 2019). There are twenty-four Local Government Units (LGU) in Cavite, one of which is Silang, Cavite (DILG, 2019). Silang is subdivided into 64 barangays, and the primary source of livelihood is agriculture (Loyola, 2019).

The crime volume in Cavite based on the report of Cavite.gov.ph (2020) had increased from 7,286 in 2019 to 15, 986 in 2020, of which 1,194 are index crimes and 6,773 are non-index crimes, and 8,019 are traffic crimes. In the province of Cavite, crime volume was continuously increasing from 2012 to 2017. It has reached its peak in 2017, which increased by 83.24% from 2016. However, it decreased by 56.08% in 2018. The largest increase was in 2008 and 2009, which rose by 544.95%. From 2019 to 2020, the total volume increased 681 representing 9.35%. Index crimes posted a decrease of 172 or 12.59% from 2019-2020. On the other hand, non-index crimes increased by 853, or 14.41%.

Silang, a municipality located in the 5th district of Cavite, had the highest index of crimes in the district, taking 61 (57%), and had the highest non-index crimes with 369 (47%), contributing to the crime volume in the district to 430 accumulated crimes which took 48% of the crime volume in the district. Carmona has 168 or 19% and General Mariano Alvarez has 293 or 33% of the crime volume. The crime incidence in Silang is increasing and an assessment of the crime incidence could be done; to obtain a solution to minimize it, if cannot be eliminated.

The purpose of the study is to develop a system that will analyze crime incidence using a Crime Incidence Mapping System. The system will use analytical techniques to assess and visualize crime patterns. By integrating the Monte Carlo algorithm with geographic mapping technologies, this system aims to enhance the understanding of crime incidence.

Applying Monte Carlo Algorithm, a resource-restricted algorithm in which answers are taken through probability, could be used to support this study. This algorithm simulates the other systems' behavior by applying statistics to acquire results. (Techopedia, 2019).

The researcher aims to design and implement a system that will assess the level of crime incidence in the Municipality of Silang, Cavite. Specifically, this study aims to develop a comprehensive crime incidence mapping system. To utilize the Monte Carlo algorithm to show crime patterns to assist law enforcement in their strategic planning, resource allocation, and crime prevention initiatives.

The system runs in a client-server technology interlinking the personal computers and server. C#, Google Maps, Bing Satellites, and Monte Carlo algorithm were used to come up with the developed system. The crime incidence could be plotted using different colors as a representation of the crimes that occurred in the different areas of Silang. The system covers only the municipality of Silang, Cavite.

The system development was guided using the Systems Development Life Cycle (SDLC) model in coming up with the solution based on the objectives of the study. The acceptability of the system will be assessed using the ISO/IEC 25010:2011 standard using the eight (8) characteristics; however, only applicable sub-characteristics were chosen to assess the system.

Other aspects aside from the above-mentioned are not covered by this study.

LITERATURE REVIEW

A crime is any omission or act that violates the regulations and law and results in punishment (FreeAdvise, 2019). It is an illegal activity or action in which someone can be punishable by the law (Collins, 2019). Crimes cannot be controlled, and high occurrences of crimes are usually experienced in different parts of the Philippines. Usually, most of the crimes happened in the highly urbanized and populated areas in the country (Cavite.gov.ph, 2020). A constant study about the occurrences of crimes in different areas of the Philippines is needed to come up with a solution that could help in minimizing the crime incidents. Crime research is very much reliant on data that is generally recorded by different criminal justice agencies (Ludwig et al., 2015).

Rubio et al. (2018) conducted a study about the identification of crime hotspots in the CAMANAVA area. The study uses a graphical information system (GIS) in identifying the crimes all over the cities, applying the Marker-Clusterer clustering algorithm. This also uses temporal and spatial analysis in clustering the occurrence of crime focused on areas in each period, and the outcome provides recommendations for the crime hotspots. The researchers observed nine (9) types of crimes, such as murder, homicide, car/motor-napping, rape, physical injuries, theft, robbery, drug-related incidents, and vehicular accidents. The final output of the system was a developed software that could map and cluster the crime that could help in providing solutions in producing hotspots where the crime happened.

Crime mapping and information analysis were improved all over the years. This started by using pins in the maps to visualize crime incidences and applying various techniques and algorithms to visualize, investigate, and describe the illegal activities' occurrence (KIani et al., 2015).

Pawale et al. (2017) conducted a study on crime hotspot detection and prediction. The approach used was the geostatistical technique, wherein the research used GIS and digital maps to monitor the occurrence of crimes in different areas. The study also resulted in understanding the crime occurrences and identifying the crime rate in different locations.

In the study of Zou et al. (2017), the hotspot and monitoring of crime were presented. The study used three different approaches such as video analysis, crime mapping, and crime prediction. The crime indicator events used the statistical distribution of semantic concepts in video analysis. The neuro-fuzzy method was used in crime prediction for the modelling of indicator events. The kernel density estimation was used in crime mapping to detect the hotspots of the crime. Simulation of the approach was done using data set in violent scene detection (VSD). Results showed that the model had a generalizing capability and could be used for creating reliable predictions. The developed framework was feasible and can be used for a huge place early warning system.

A report in the Caribbean which is part of IDB Technical Note presented a compilation of data from multiple sources to provide a diagnosis of the characteristics, sizes, and changing nature of Trinidad and Tobago's problem. The report consists of a different survey of crimes preventions, suppression policies, projects adopted by the government, non-government and private sectors, and programs. The data and information gathered served as inputs in doing more effective ways to produce studies about crimes (Seepersad, 2016).

Wang, Zengli & Liu, Xuejun (2017) defined hotspots in their study as referring to numerous crime incidents grouped in a small space-time range. The near-repeat phenomenon allows to create a contagion-like pattern for every victimization encountered. The results of the tests in the experiment demonstrated that hotspots always form. The conclusion reveals that a system can provide detailed analysis pattern of criminals which becomes the advancement of the previous studies and results.

The Monte Carlo algorithm is within the subset of computational algorithms that uses the repeated random sampling process to create the unknown parameter's numerical estimations. This produces complex models using many random variables and is used in assessing risks' impact. This could be applied in a wide range and shared the commonality to solving deterministic problems by relying on random number generation (Pease, 2018). It is a computerized mathematical technique for decision-making and quantitative analysis that allows individuals to account for risk. This leads people to choose different outcomes and the probability of choosing a possible course of action (Palisade, 2019).

Dinca et al., (2019) introduced the Effective Geometry - Monte Carlo simulation algorithm to modify the geometry of a receiver. The approach for a 1D toy model was motivated and applied the results to a spherical absorbing receiver. The study shows the impulse response of the receiver in applying EC-MC simulation which can be precisely simulated. Eftelioglu et al. (2016) conducted a study applying Monte Carlo algorithm simulation trials. The algorithm was applied in the study focused on crime hot spot detection to focus on police enforcement deployment and this algorithm was used in predicting the serial criminal's potential residence.

Wang et al. (2017) used Monte Carlo Algorithm in determining the hotspots of criminals victimizing people in an area. This was used to develop the cell value expected distribution to identify if the cell values are larger than what can be expected with adequate probability. Every iteration of the Monte Carlo simulation provides a randomly distributed group of points in the same number of data sets.

Marchant et al. (2018) conducted a study about the application of machine learning to crime using spatial demographics. The main objective is to provide a probabilistic approach to modeling a crime that shows and presents the uncertainties in the prediction of different offences including other uncertainties that surround the model parameter. The Markov chain Monte Carlo (MCMC) was used for interference analysis.

METHODS

The study employed descriptive and developmental research methodologies to achieve its objective. The descriptive method was used in conducting surveys, interviews and archival research to gather data. The developmental type of research was also used to come up with a system that could assess the crime incidence in the Municipality of Silang, Cavite. It has been developmental since the final design and system of assessing the crime incidence were created. Moreover, as part of the developmental method, the acceptability of the system was tested with the formulated questionnaire using the ISO/IEC 25010:2011 standard.

The design and development of the system were created with the aid of tools and methodology to obtain the desired outcomes as based in the given objectives. A model or tool provides phase-by-phase or step-by-step activities that will lead to obtaining the desired solution. In this study, the researcher used System Development Life Cycle (SDLC). It aims to produce high-quality software that could lead to customer satisfaction. This is used in building software with high-quality and accuracy. It comprises of detailed plans to build, plan and maintain a software (Guru99, 2019). The following shows the SDLC Model:

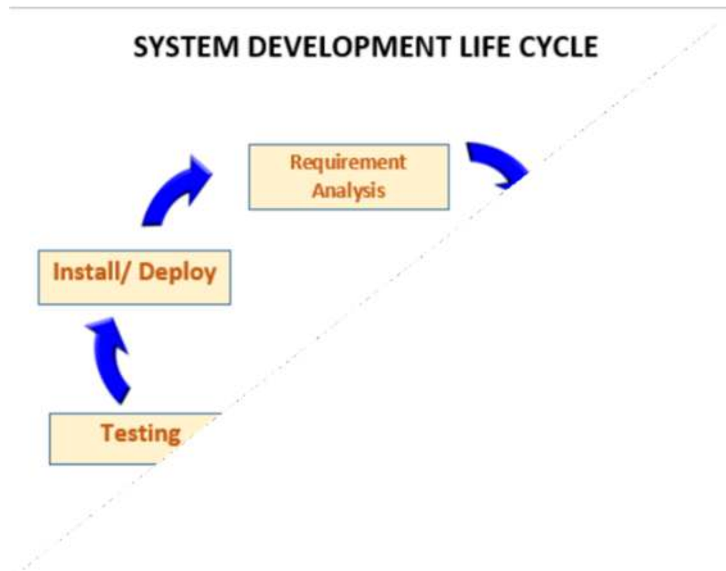

Figure 1: System Development Life Cycle

SDLC, for the development of the system, was used to examine the development from requirement analysis, feasibility study, design, coding, testing, installation, and deployment.

Requirement Analysis is the first stage of SDLC. In this stage the researcher conducted interviews and surveys to gather data. Reading of articles and related journals from the internet was conducted to seek more information and to grasp a deeper understanding of the study and system development requirements. The timeline for the development of the system was also done in this phase.

Upon the completion of the requirement analysis, the definition and documentation of software were the next step. It involved the identification of software requirements necessary in the development of the system focused on crime incidence. It also considered the evaluation of five (5) feasibility check types namely economic, legal, operation feasibility, technical, and schedule.

In the design phase, the system design together with the software design was plotted based on the requirements specifications. The design of how to show the results of the Monte Carlo simulations will be presented are considered. This includes maps showing the crime hotspots, trend graphs, and statistical summaries. High-level design and low-level design documents were also developed in this phase. High-level design means that the brief description of each module was specified, and the outline of functionality was already prepared. Interdependencies and interface relationships between modules were already prepared in this phase together with the database tables along with the key elements. Architecture diagrams were already completed in this phase along with the details of the technology to be used and applied. In low-level design, the functional logic, databases, details of interface, the dependency issues of database, list of error messages and the complete input and output of every module are prepared.

In the coding phase, the coding of programs based on the design was conducted. The researcher used C# to integrate Google Maps, Bing Satellites and Monte Carlo algorithm. The tasks in the development of the system were divided into modules or units. During this phase, Monte Carlo algorithms were considered to simulate and model the systems by generating random samples and analyzing their outcomes. This ensures that the code of the system was based on the plan and developed sequences. Debugging was also conducted in this phase.

Once the software was done, several tests were conducted starting from unit testing until the system was deployed to the server for implementation. The functionality of the system was evaluated in this phase and the system evaluation was done using the questionnaire focused on ISO 25010:2011 standard.

In the Installation/Deployment phase, the system was guaranteed free from bugs, and this time, the final deployment was conducted. The system was finally deployed to the server and ready for implementation and use. This time the level of crimes was found to be easy to identify in the system including the graphical representations of the crime incidences all over Silang, Cavite.

Maintenance covered only the provision of a user's manual on how the system will work even after the deployment.

The ISO/IEC 25010:2011 standard was used to serve as a guide in this study. ISO/IEC 25012 contains a model for data quality that is complementary to this model. The scope of the models excludes purely functional properties, but it does include functional suitability. The scope of application of the quality models includes supporting specification and evaluation of software and software-intensive computer systems from different perspectives by those associated with their acquisition, requirements, development, use, evaluation, support, maintenance, quality assurance and control, and audit. The models can, for example, be used by developers, acquirers, quality assurance and control staff, and independent evaluators, particularly those responsible for specifying and evaluating software product quality. Activities during product development that can benefit from the use of the quality models include: identifying software and system requirements; validating the comprehensiveness of a requirements' definition; identifying software and system design objectives; identifying software and system testing objectives; identifying quality control criteria as part of quality assurance; identifying acceptance criteria for a software product and/or software-intensive computer system; establishing measures of quality characteristics in support of these activities. (Organisation Internationale de Normalisation, 2011).

This model consists of different constituents such as suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability, which is the ISO/IEC 2510:2011. The standard consists of subcomponents as shown above.

In the evaluation of the acceptability of the system, not all sub-characteristics were used. Only applicable sub-characteristics were applied to evaluate the system. In Functionality, functional completeness and functional correctness were used. In Performance Efficiency, only time behavior was used in the evaluation. Coexistence and interoperability were used in the Compatibility characteristics. In Usability, appropriateness, learnability, operability, and user interface aesthetics were used. In Security, only confidentiality, integrity, and authenticity were used. Modularity, modifiability, and testability were used in Maintainability and lastly, portability, adaptability, and installability were applied.

The attributes were captured during the series of tests done by the participants. A questionnaire to test suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability was used to determine the acceptability of the system. This is adapted to the questionnaire of Balba (2018). The questionnaire is a 5-point Likert-type instrument that ranges from 1 to 5 as shown below:

Numerical Rating	Equivalent
5	Excellent
4	Very Good
3	Good
2	Poor
1	Very Poor

Table 1: Likert Scale

The statistical tool that was used in the interpretation of data was the arithmetic mean. The arithmetic mean is the sum of all the members of the list divided by the number of items in the list. Number of items refers to the number of respondents who evaluated the system. In this study, the arithmetic mean was used to get the result of the sub-characteristics. Taking the mean will evaluate if each sub-characteristic obtains the level of acceptance of the system taking into consideration the Likert Scale as presented in Table 1.

Formula:

$$A = \frac{1}{n} * \sum_{i=1}^{n} x_i$$

Where:

A = average (or arithmetic mean)

n = the number of terms (e.g., the number of items or numbers being averaged)

x1 = the value of each individual item in the list of numbers being averaged

The arithmetic mean is also called "Average" that usually used for most scientific experiments. Each of eight (8) characteristics with respect to the sub-characteristics mean was calculated to form a "composite mean". Composite mean is the arithmetic mean of the parts or several parts of elements (English Oxford. Living Dictionaries, 2019). After taking the arithmetic mean of each characteristic, the general weighted mean was calculated which is composed of the average arithmetic mean of all composite means to acquire the final evaluation of the system.

The numerical rating of the Likert Scale was shown in Table 1 and its descriptive scale was used in measuring the evaluation result. This is the instrument used to interpret the output of the evaluation and has a scale of 1 to 5, 5 is the highest, and 1 is the lowest.

The acceptability of the system was evaluated by 10 employees who worked for at least 3 years in the municipal hall of Silang, Cavite, 10 employees in the crime divisions who worked for at least 5 years, and 15 policemen who are assigned in the Silang area for at least 2 years and 3 IT experts with at least 10 years of experience in IT industries. Purposive sampling was used in the selection of participants.

The flowchart below shows the flow of the entire system. It starts from the identification of crimes including the locations, type of crimes, etc. Through the database, crime data could be searched, and profiles could be displayed through the dashboard. Additional crime incidence could be added to the system and could be deleted if necessary. All the details about the crime as specified in the objectives are represented by the system in the dashboard.

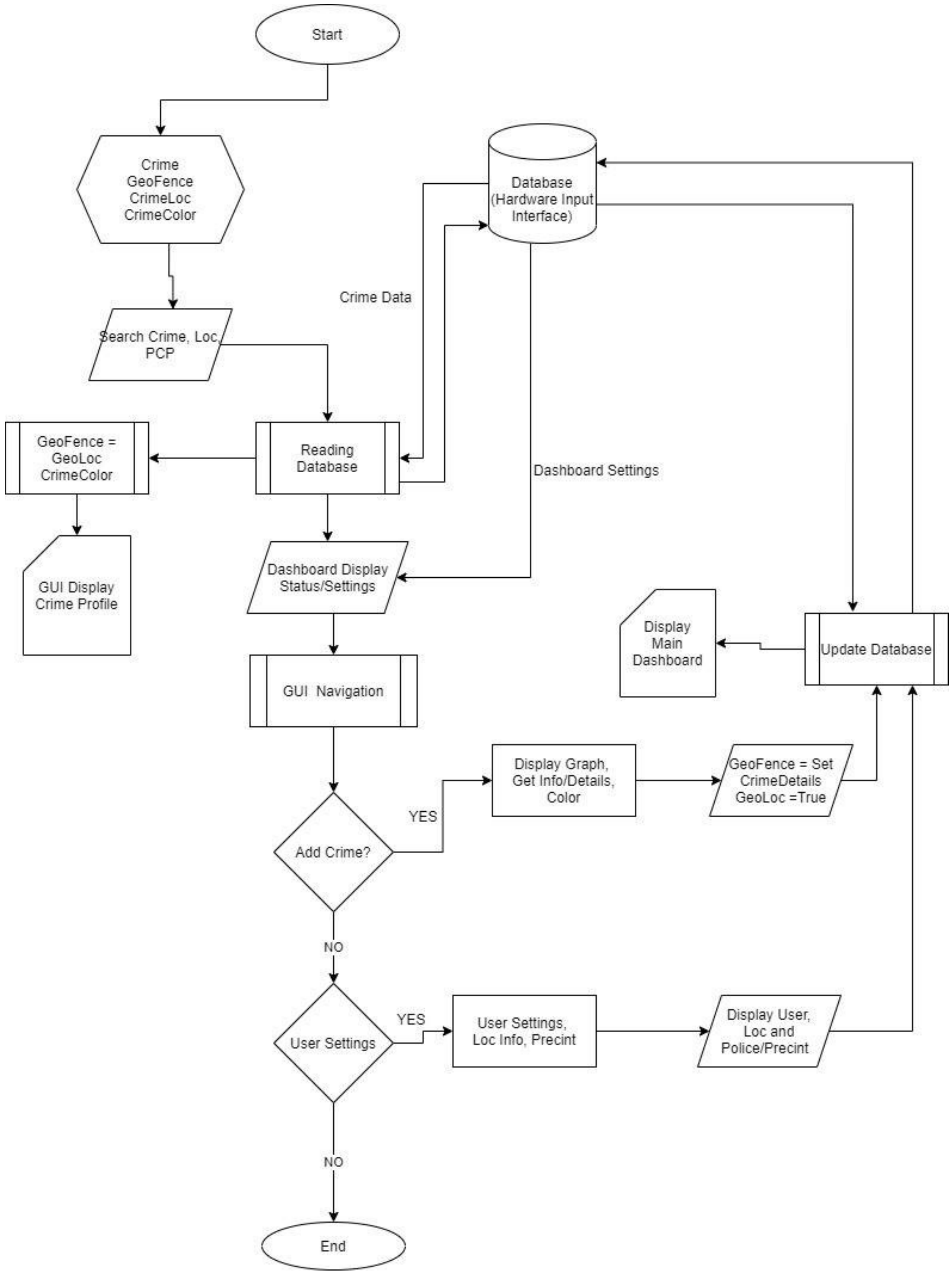

Figure 2: System Flowchart

The acceptability of the system was evaluated by the selected municipal employees, staffs in the crime division, policemen and IT experts as presented in the participants of the study. A formulated questionnaire was used in the evaluation of the eight (8) characteristics of the ISO/IEC 25010:2011 standard.

RESULTS AND DISCUSSION

The acceptability of the system was evaluated by the selected municipal employees, staffs in the crime division, policemen and IT experts as presented in the participants of the study. A formulated questionnaire was used in the evaluation of the eight (8) characteristics of ISO/IEC 25010:2011 standard.

The results of the acceptability tests were presented as follows:

Table 2
Results of Evaluation of Users Acceptability of the Prototype Based on
ISO/IEC 25010:2011 **A: Functional Suitability**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
A. Functional Suitability			
	1. Functional Completeness	4.50	Excellent
	2. Functional Correctness	4.53	Excellent
	3. Functional Appropriateness	4.50	Excellent
Overall Mean		**4.51**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Table 2 shows an excellent rating. This implies that the system satisfies the necessary criteria for completeness, correctness, and appropriateness, meaning that it effectively fulfills all specified requirements, it operates accurately, and is well-suited to the intended purpose.

Table 3
Results of Evaluation of Users Acceptability of the Prototype Based on
ISO/IEC 25010:2011 **B: Performance Efficiency**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
B. Performance Efficiency			
	1. Time Behavior	4.55	Excellent
	2. Resource Utilization	4.51	Excellent
	3. Capacity	4.53	Excellent
Overall Mean		**4.53**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

The result of the performance efficiency test is 4.53 or Excellent which means the system passed the performance efficiency focused on time behavior, resource behavior, and capacity. This also implies that the system promptly addresses the users' requests and maximizes the overall system efficiency.

Table 4
Results of Evaluation of Users Acceptability of the Prototype Based on
ISO/IEC 25010:2011 **C: Performance Efficiency**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
C. Compatibility			
	1. Co-existence	4.62	Excellent
	2. Interoperability	4.40	Very Good
Overall Mean		**4.51**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Compatibility test results to 4.51 or Excellent. This means that the system can exchange information with other systems, and it does perform its required functions. It works along with Application Programming Interface (API). It also means that the system passed the coexistence and interoperability test as shown in Table 4.

Table 5
Results of Evaluation of Users Acceptability of the Prototype Based on
ISO/IEC 25010:2011 **D: Usability**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
D. Usability			
	1. Appropriateness Recognition	4.35	Very Good
	2. Learnability	4.78	Excellent
	3. Operability	4.55	Excellent
	4. User Error Protection	4.50	Excellent
	5. User Interface Aesthetics	4.50	Excellent
Overall Mean		**4.55**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Usability test results to mean of 4.55 or Excellent. This means that the system can easily be understood by the users. This indicates that the system can be used by the users without much effort with the help of the easy to read and understand manual of operation.

Table 6
Results of Evaluation of Users Acceptability of the Prototype Based on
ISO/IEC 25010:2011 **E: Reliability**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
E. Reliability			
	1. Maturity	4.60	Excellent
	2. Availability	4.50	Excellent
	3. Fault Tolerance	4.45	Very Good
	4. Recoverability	4.55	Excellent
Overall Mean		**4.53**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Table 6 shows that the system passed the maturity test where faults has been eliminated. Data are available when needed and it has capability to recover or resume after failure is encountered.

Table 7
Results of Evaluation of Users Acceptability of the Prototype Based on ISO/IEC 25010:2011 **F: Security**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
F. Security			
	1. Confidentiality	4.50	Excellent
	2. Integrity	4.50	Excellent
	3. Non-repudiation	4.56	Excellent
	4. Accountability	4.65	Excellent
	5. Authenticity	4.45	Excellent
Overall Mean		**4.53**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Table 7 shows that the evaluation result is excellent which means that the system was tested secured and has passed the test focused on integrity, confidentiality, nonrepudiation, accountability, and authenticity.

Table 8
Results of Evaluation of Users Acceptability of the Prototype Based on ISO/IEC 25010:2011 **G: Maintainability**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
G. Maintainability			
	1. Modularity	4.55	Excellent
	2. Reusability	4.53	Excellent
	3. Analyzability	4.62	Excellent
	4. Modifiability	4.65	Excellent

	5. Testability	4.60	Excellent
Overall Mean		**4.59**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

Maintainability results to 4.59 or Excellent. This means that the designed system can analyze and diagnose the fault easily. This also shows that the system is stable and can easily be modified and tested.

Table 9
Results of Evaluation of Users Acceptability of the Prototype Based on ISO/IEC 25010:2011 **H: Portability**

Indicators			
Characteristics	**Sub-Characteristics**	**Mean**	**Descriptive Interpretation**
H. Portability			
	1. Adaptability	4.54	Excellent
	2. Installability	4.65	Excellent
Overall Mean		**4.60**	**Excellent**

Legend: *Very Poor =1.00-1.49; Poor =1.50-2.49; Good=2.50-3.49; Very Good =3.50-4.49; Excellent =4.50-5.00*

The portability test results in a mean of 4.60 or Excellent. This means that the system can be moved to another environment that it can be installed easily.

Table 10
Summary of the Results of Evaluation of Primary Users for the Acceptability of the System based on ISO/IEC 25010:2011 standard.

INDICATORS	
Characteristics	**Composite Mean Survey**
A. Functionality	4.51
B. Performance Efficiency	4.53
C. Compatibility	4.51
D. Usability	4.55
E. Reliability	4.53

F. Security	4.53
G. Maintainabilty	4.59
H. Portability	4.60
General Arithmetic Mean	**4.54**

Table 10 shows the summary of the evaluation. Findings suggest that the system can be utilized due to its excellent evaluation across all criteria of User Acceptability of the System based on ISO/IEC 25010:2011 standard.

Table 11

Summary of the Results of Monte Carlo Algorithm Simulation.

Crime	Number of Incidences (Historical Data)	Number of Hotspot Locations (Before Monte Carlo)	Number of Hotspot Locations (Using Monte Carlo)
Robbery	90	10	6
Theft	150	7	5
Vandalism	80	9	5
Physical Injury	100	12	8
Rape	50	5	2
Carnapping	100	8	5

Table 11 shows the summary of the simulation trials. The third column represents the initial hotspots identified based on raw data analysis or simple clustering methods. In the fourth column it shows lesser identified hotspots after applying the Monte Carlo algorithm, implying that the hotspots are refined resulting to potentially fewer but more accurate hotspots, which focuses on areas with higher probabilities of future crime occurrences based on historical patterns.

This result confirms previous studies of Braga et al. (2019), it revealed that hotspot policing is associated with small but meaningful reductions in crime at locations where criminal activities are most concentrated. It suggests that focusing police efforts at high activity crime places is more likely to produce a diffusion of crime prevention benefits into areas adjacent to targeted hot spots than crime displacement.

CONCLUSION

This study successfully developed a crime incidence mapping system for the Municipality of Silang, Cavite, using the Monte Carlo algorithm to simulate and analyze crime patterns. The system provides a visual representation of crime hotspots through integration with Google Maps and Bing Satellites, offering law enforcement a powerful tool for decision-making and resource allocation. The evaluation of the system using ISO/IEC 25010:2011 standards demonstrated its effectiveness, with the system receiving an "Excellent" rating across key parameters such as functionality, performance efficiency, usability, and security.

The Monte Carlo algorithm proved to be an asset in predicting crime hotspots, allowing for a probabilistic approach to crime assessment. This enables law enforcement agencies to plan more effectively by understanding where crimes are likely to occur, thereby improving public safety and facilitating data-driven crime prevention strategies. The system has the potential to significantly enhance the ability of local authorities to respond to crime trends in a timely and efficient manner.

RECOMMENDATION

This study recommends focusing on refining the algorithm's parameters and integrating additional variables, such as socioeconomic factors, to further improve the accuracy and applicability of crime forecasting models. The research should expand its development by integrating real-time crime reporting tools.

While the current system is limited to Silang, Cavite, it is recommended that the scope of the system be extended to cover the entire province of Cavite. By expanding its geographical coverage, the system could provide more comprehensive insights into crime trends across a broader area, benefiting a larger population.

Furthermore, to increase accessibility and scalability, it is recommended to convert the system into a web-based application. This would allow law enforcement officers on the ground, to access the system easily and use it in real-time.

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