



Modeling an Intelligent System for Effective Community Policing

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ABSTRACT

The Nigerian Law Enforcement landscape faces myriad challenges ranging from inadequate resources to new crime patterns. In response to these challenges, this paper proposes an intelligent system tailored for effective policing. Drawing from emerging advancements in AI, data analytics, and smart technology, the pro-posed system aims to revolutionize traditional policing approaches by enhancing proactive crime prevention, and efficient resource allocation. The paper adopts the object-oriented methodology. The proposed system would integrate various com-ponents, including predictive analytics and citizen reporting platforms, to create an integrated system for law enforcement agencies. Predictive algorithms analyze historical crime data to identify crime hotspots and predict future incidents, enabling law enforcement agencies to deploy resources strategically. Mobile and web frontends will empower citizens to report crimes, share information, and communicate with law enforcement authorities, fostering collaboration between the police and the community. The effectiveness of the proposed system will be evaluated through pilot implementations in selected regions of Nigeria, demonstrating its potential to reduce crime rates, improve response times, and enhance public trust in law enforcement.

ARTICLE INFO

Article History

Received: August, 2024

Received in revised form: September, 2024

Accepted: October, 2024

Published online: December, 2024

KEYWORDS

Intelligent Crime Management, Crime Profiling, Crime Management, Machine Learning

INTRODUCTION

Recent times have seen the exponential rise in crime within communities globally [1]. Preventing and controlling crime within communities is a collaborative effort within local, regional and cross-national law enforcement agencies. For these collective efforts to be successful there must be a strong relationship between the law enforcement agencies especially the Police, and the communities they serve [2]. Community policing initiatives often involve officers working closely with residents, local organizations, and other stakeholders to identify and address local concerns, improve public safety, and foster trust and cooperation. This approach creates a safer, more resilient community, by involving community members in

policing efforts and tailoring law enforcement activities to meet the unique needs of each neighborhood.

Policing ensures that crimes are reduced to the barest minimum. These crimes include kidnapping, armed robbery, burglary, murder, rape, cult clashes, to mention but few, and a host of technology-driven crimes, that are prevalent globally irrespective of their global social status. The causes of crime globally have been linked to unemployment, poverty, income inequality, hereditary factors, peer influence [3-4]. In this paper, we use Nigeria as a case study to establish the rationale for the need for technology-driven community policing.

Nigeria has an estimated population of 202 million people [5]. The human capacity of the

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Police formation in Nigeria is estimated at 370,000. With this number, it is obvious that when compared to the United Nations policing requirement, Nigeria's policing system is inadequate, and this may be connected to the challenges in containing crimes [6,7]. Given the grave consequences of crime, [3] notes that economic development is inversely proportional to the crime rate, that is, the higher the crime rate the lower the economic prosperity. Due to the rising spate of crime, and insufficient policing technology, law enforcement agencies are considered incompetent [3,8-11].

Technologies such as AI can help provide low-cost and effective tools for policing. However, AI solutions are knowledge-driven hence, knowledge of crime patterns is crucial and attainable if data on crime is stored in a manner that affords easy retrieval, analysis and generation of real-time insights. Unfortunately, majority of the crime-related documentations in Nigeria are scattered and stashed in physical cabinets prone to destruction by rodents, human activity, etc. This study is aimed at identifying the critical elements that will drive the implementation of a cost-effective, flexible smart solution for community policing. The proposed solution will collate, harmonize, store, analyze, segment, profile, visualize, predict crime occurrences, and apportion resources hereby enhancing community policing. It would integrate with the existing policing strategies, to provide crime reports, incident logs, demographic information, and response to public queries. It would leverage the existing system, such as communication networks, and community interest groups, to collect and analyze data in real-time. The system would align with existing policies, procedures, and legal frameworks to ensure compliance with regulations and ethical standards.

RELATED WORKS

AI and ML are potential game changers in the different sectors in the society including crime and justice management [12-46]. [47] stated that Decision Support System (DSS) and data mining techniques could be utilized to support crime management. [48] proposed k-means

clustering for building models against web-based crime. The proposed model yielded 94.75 % accuracy. [49] compared three data mining algorithms: Naïve Bayes, JRip and J48 and tested it on a sample dataset to show their pros and cons. [50] designed and implemented a computerized system targeting the Nigeria Police Force. They adopted the waterfall model; the Hypertext Markup Language (HTML), PHP and MySQL.

The system did not implement any intelligence for predictions and visualization. [51] developed a desktop application for the Police to digitize First Incident Report (FIR), staff records and other registers utilized by Police stations. [52] documented and analyzed the instances of sexual offenses announced at the Metropolitan Lagos State Police Commands from 1999 to 2004. [53] designed a system to strategically detect and control cybercrime. [54] used Geospatial Information System (GIS) as a spatial apparatus to classify crime zones in Katsina Metropolis, Katsina territory of Nigeria, so as to generate a crime database for the region. [55] proposed a methodology that utilized information mining strategies for crime discovery in India.

[56] utilized Natural Language Processing (NLP) strategies to enable agents/officers to deal with huge sum of printed data in an increasingly effective and quicker manner. Its focus was on the execution speed, and ease of use for specialists. [57] examined how text analysis and classification procedures could be utilized to improve e-government, law enforcement officer proficiency and adequacy. [58] proposed a model for crime analysis utilizing the k-means algorithm. They suggested that the paper could be of assistance in finding examples and patterns, making gauges, discovering connections and potential clarifications, mapping criminal systems and in identifying potential suspects. [59] examined crime relocation by recognizing changes in the spatial examples/ dissemination of crime.

METHODOLOGY

The object-oriented methodology (OOM) affords the decomposition and recomposition of any system irrespective of their

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complexity [60] hence, the choice in this study. The tools used are: Visual Studio Code, Apache Spark, Apache Web Server. MySQL Server 8.0, The data was collected from the State Criminal Investigation Department (SCID), Pantl, Yaba, Lagos State, and the Lagos State Police command situated in Ikeja GRA respectively. The datasets were obtained from the Force Statistics and Records Unit of the Department of Research and Development.

The Crime Reporting Process

The actors involved in reporting a criminal event include the victim(s), eyewitnesses, the officer(s) who might have witnessed the crime, and the public relations office. A crime may be reported through the First Incident Report (FIR).

The victim / Eyewitness(s) calls helplines to report criminal activity after it has occurred. The victim/eyewitness(s) may also report a crime at the Station and files report on first arrival. Subsequently, the Patrol officers may visit the crime scene and arrest suspect (where possible), and also summon eyewitness(s) and/or victims to the Station to file a report. Thereafter, the case is then classified as valid or not depending on the content of the report. The next phase is the management of the data arising from the crime event. Here, there are three main actors: records officers, the criminal investigative department (CID), and the investigators. The activities undertaken during this phase are shown in Fig. 1-2.

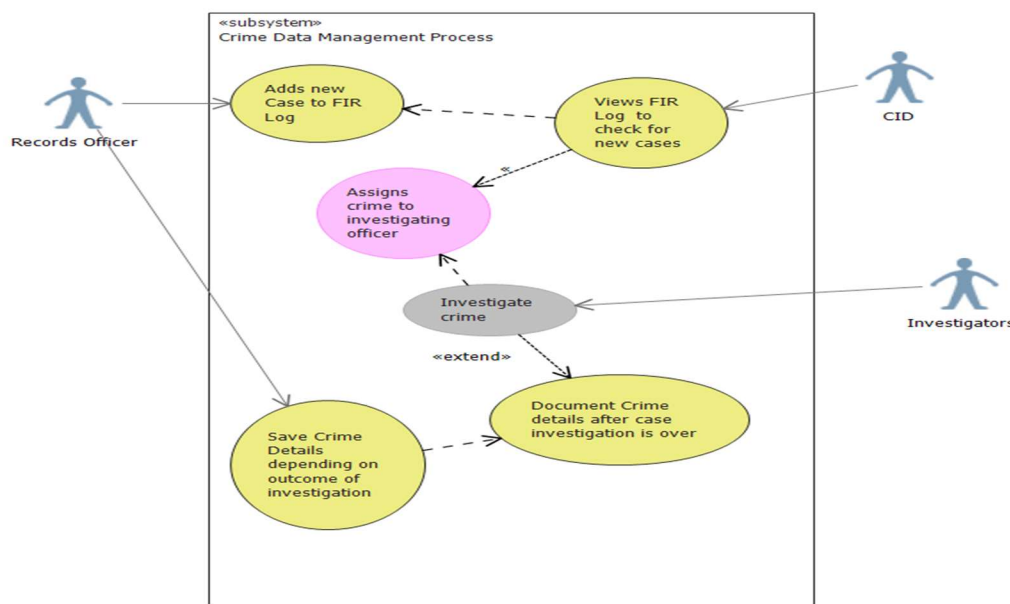


Fig. 1. Use case diagram for the existing crime data management subsystem

In the existing system, a colossal volume of information exists in physical structure which make recovery much troublesome and for all intents and purposes incomprehensible; particularly when it has to do with recovery and study of a huge amount of records. The existing system doesn't oblige information from all subsystems for straightforward recovery and

control thus data extraction and study is largely irksome. Furthermore, paper work constitutes more than 70% of the crime management workflow. Paper files could be stolen or damaged leading to loss of sensitive information, and much time is wasted in trying to transmit information from one department to another, and also, when assigning cases to an investigative officer.

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Intelligent decision making and crime pattern identification is a difficult task.

Analysis of the Proposed System Use Case Analysis

In the proposed system the actors involved in the crime reporting subsystem, would

include the records officer, officers and victim(s) / eyewitness(s). The victim / eyewitness could call the helpline and report a case or go to the station to record a First Incident Report (FIR). Fig. 2 shows the use case diagram of the proposed crime reporting system.

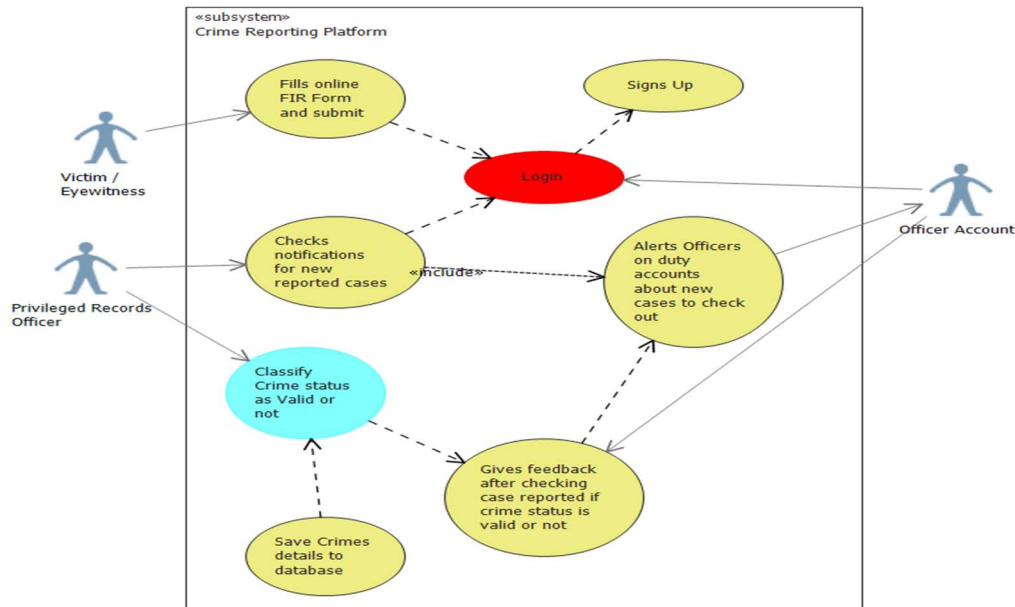


Fig.2. Use case diagram of the proposed crime reporting subsystem

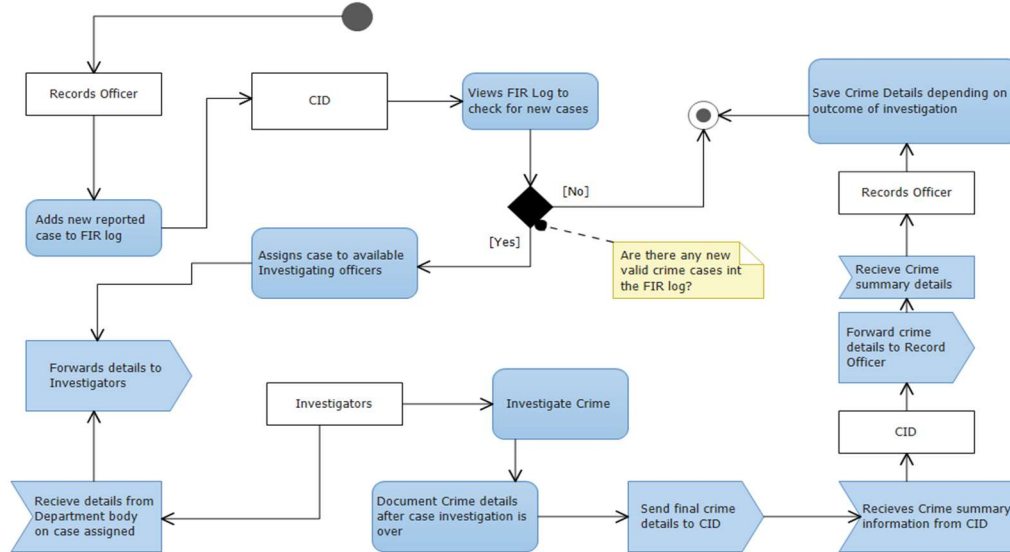


Fig. 3. Activity diagram of the crime data management subsystem

Activity Analysis

Fig. 4 shows the activity diagram for the crime reporting subsystem.

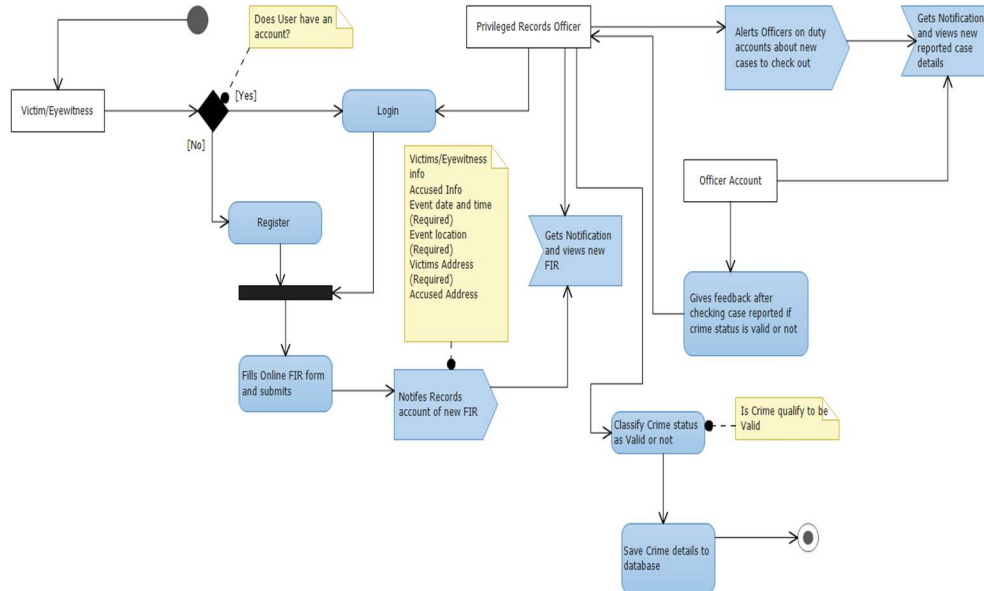


Fig. 4. Activity diagram of the proposed crime reporting subsystem

Crime Dataset and Attributes

The dataset provided information on crime incidents that occurred in Lagos State from

2015 to 2019. It was collected in spreadsheet and converted into a comma separated values (**csv**) format. The dataset contains 11 attributes and are

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presented in Table 1. Table 2 shows the sample dataset from the various area commands with crimes categorized into 30 different classes. Each area represents a cluster of police stations under

a given commander or jurisdiction within the State. The areas are identified formally as Areas A-N.

Table 1. Crime dataset attributes

Attribute	Description
Time and Year	Time and Year crime event took place.
Type of crime	Type of crimes. This is the target label for the data.
Location/Area Command	Name of police command.
Case reported	Number of cases reported from citizens through FIR reports.
Case refused	Number of cases classified as false alarm.
True case	Number of cases classified as true.
Persons arrested or summoned	Number of persons arrested or summoned
Gender	Gender status of accused.
Age group	Group specifying if accused is an adult, youth or underage.
Killed	Number of victims killed during course of criminal event.
G.B.H	Number of victims injured during course of criminal event.

Table 2. Sample of the processed crime dataset for Police Area Commands (Area A-N)

Crime Categories	A	B	C	D	E	F	G	H	J	K	L	M	N
Murder	8	4	7	15	7	5	1	0	0	0	0	4	8
Manslaughter	0	1	0	0	0	0	0	0	0	0	0	0	0
Attempted_Murder	1	1	1	4	2	1	0	0	0	0	0	1	1
Suicide	3	3	5	9	4	1	1	0	0	0	0	2	3
Attempted_Suicide	1	2	3	7	0	2	1	1	0	0	0	2	1
Grievous_Harm_and_Wounding	24	11	97	16	14	80	40	50	3	45	3	19	24
Assaults	0	4		6	0				0		5	0	0
	24	16	17	36	21	22	72	16	2	34	2	31	24
	0	5	6	0	0	0		0	1		3	0	0
Child_Stealing	2	3	3	16	21	2	2	0	0	0	0	4	2
					0								
Slave_Dealing	1	2	3	5	2	1	2	0	0	0	0	2	1
Rape_and_Indecent Assault	10	9	8	27	20	10	3	4	1	2	0	10	10
Kidnapping	6	1	2	1	1	1	1	1	0	1	0	1	6
Unnatural_Offences	5	4	7	14	6	0	0	0	0	0	0	5	5
Armed_Robbery	8	7	7	28	10	8	5	5	1	3	0	10	8
Demanding_With_Menace	1	1	2	5	2	1	0	0	0	0	0	2	1
Theft_And_Other_Stealing	5	20	21	49	34	27	13	12	5	13	6	47	5
		0	2	0	5	0	5	0	0	0	0	0	
Burglary	10	25	37	45	76	20	10	10	4	10	6	50	10
House_Breaking	12	10	16	30	39	8	7	8	2	5	3	25	12

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Crime Categories	A	B	C	D	E	F	G	H	J	K	L	M	N
Store Breaking	2	11	14	35	15	0	4	5	1	2	0	6	2
False_Pretences_Cheating	48	90	90	33	24	98	40	40	2	40	2	14	48
Forgery	3	6	6	39	12	8	3	4	1	2	0	7	3
Receiving_Stolen_Property	2	4	6	22	10	3	3	3	0	0	0	2	2
Unlawful_Possesion	20	18	17	47	45	10	15	15	5	15	1	40	20
Arson	2	2	7	8	5	0	2	1	1	1	0	3	2
Forgery_Of_Currency_Notes	1	2	2	4	2	2	0	0	0	0	0	2	1
Coining_Offences	0	1	0	1	1	0	0	0	0	0	0	0	0
Gambling	30	56	54	15	11	30	20	30	5	15	1	60	30
Breach_of_Public_Peace	12	13	11	27	28	12	80	10	3	60	3	20	12
Prejury	0	2	1	2	1	0	0	0	0	0	0	0	0
Bribery_and_Corruption	0	0	0	0	0	0	0	0	0	0	0	0	0
Escape_From_Lawful_Custody	0	2	3	6	3	0	0	2	0	0	0	3	0

Feature Engineering

Pre-processing was conducted to normalize out-of-range values, unrealistic data combinations, missing values and redundancies. Since crime data comprises of string labeled data, we utilize a string indexer, a feature transformation technique provided by Apache Spark. After the dataset is indexed, it was normalized by scaling in

a way with the end goal that qualities fall within a range between 0.0 to 1.0. The normalization was done with standard deviation and the mean. For standardization, we utilized the Apache Standard Scaler class. Table 3 shows the selected features that was be used for prediction. Nine attributes were selected as shown in Table 3.

Table 3. Selected Features of Dataset

Attribute	Description
Area Command	Name of police command
Offences Against Person	Category 1 of crime
Offences Against Properties	Category 2 of crime
Offences Against Law Act	Category 3 of crime
Grand Total	Frequency of the crime committed in the area
Adults	Frequency of Adults offenders
Under-aged	Frequency of Under-aged Offenders
Gradation of Havoc caused	Measure of havoc done to area.

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No of victims

Number of victims injured during course of criminal event.

Next, we constructed a prediction model. We used the Apache Spark machine learning library. This tool provides a rich facility to easily work with big-data along with machine learning and data mining capabilities. The Naïve Bayes was utilized to predict crime categories. To predict crime occurrence in a city i given a crime dataset containing crime labels, their frequency in a given area, and areas i to n :

1. $P(C_i)$ as the prior probability of crime occurring in city i .
2. $P(A_j|C_i)$ as the conditional probability of crime labeled j occurring in city i .
3. $P(A_j)$ as the probability of crime labeled j occurring overall, regardless of the city.
4. $P(C_i|A_j)$ as the posterior probability of crime occurring in city i given that crime labeled j has occurred.

According to Bayes' theorem, the posterior probability, $P(C_i|A_j)$ can be calculated as:

$$P(C_i|A_j)=P(A_j)P(A_j|C_i) \times P(C_i) \quad (1)$$

To predict the occurrence of a specific crime label j in city or zone i , we compute the posterior probability for each city i and choose the city with the highest posterior probability as the predicted location for the crime occurrence. To integrate the predictive model into the entire application, a machine learning module would be built. Apache Spark alongside its Machine Learning Library MLlib and R gives a rich toolset to AI and data mining, hence, its use in this study. Since crime data has a parcel of printed information it creates enormous irregularities, and blunders when feeding it into the machine learning module.

Architecture of the Proposed System

Fig. 5 is the component model diagram for the proposed crime analysis and prediction solution. The system has the login, the main menu, the service, the database and the crime analysis and prediction components.

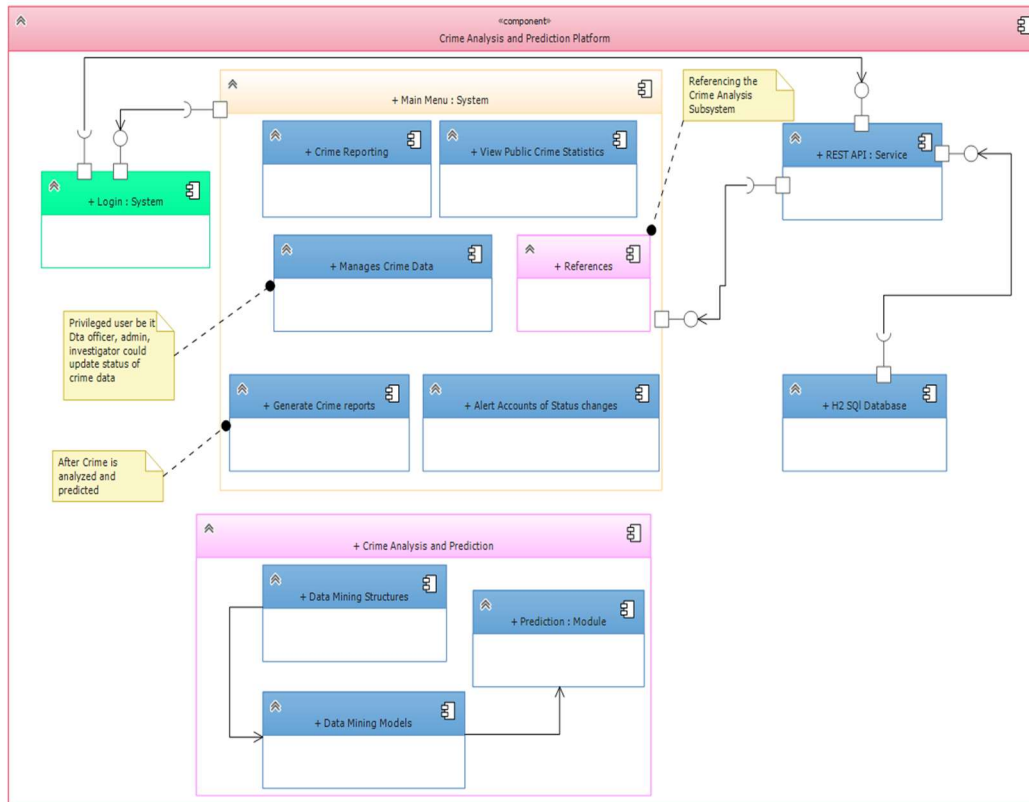


Fig. 5. Component model diagram of the proposed system

DISCUSSION AND CONCLUSION

ICT solutions play crucial roles in the various domains of crime management [61-70]. The essence of this study is to apply advanced technologies to provide effective and efficient solutions for a grossly inadequate policing system that is completely overwhelmed by a large population and rising crime rate. This study is part of an ongoing project that is expected to present the Nigeria Police with a sophisticated tool. In this study, we have detailed the procedures followed to collect requisite data on crime over a period from one of Africa's busiest criminal investigation departments located in Lagos Nigeria. Before the commencement of this study, we conducted a detailed review of the available technologies as well as concluded studies on technology-enhanced policing and crime fighting. We intend to integrate enormous prediction and visualization

abilities into a user-friendly front-end. We presented the analysis specifications by way of use case and activity diagrams. We also specified the interesting features in the dataset that would constitute the prediction parameters. The proposed architecture of the system is presented but the overall interface and database specifications had been left out for convenience. From what has been realized so far we conclude that the deployment of an intelligent system for efficient policing and crime control is feasible and when completed would boost the policing operations in Nigeria and other sub-saharan countries. The complete design specifications, test cases, and system evaluation results from specific policing agencies will be presented in a future paper.

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