Software Development for Crime Management in Nigeria

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Abstract

An onsite observation conducted at Nigerian police stations indicated that criminal records are managed manually in a crime diary or ledger. This technique is prone to time waste in searching criminal records and fire disasters. To address this problem, this study, a web-based Graphical User Interface (GUI) application was designed to aid Nigerian police in capturing criminal records across various Police Stations. This study adopted Object Oriented Analysis and Design (OOAD) approach by employing Unified Modeling Language (UML) tools. In the implementation stage, Mongo Database (Mongo DB) was used at the backend and Python programming language was chosen to design user interface at frontend. The results indicate that user's authentication, criminals' biometric capturing, criminal data entry and criminal information updates were successfully implemented. Besides, a module is also implemented to extract features from the crime database and export extracted crime datasets into Python for further data analytics.

Keywords: Object-Orient Analysis, Mongo DB, Crime, Management, Software Development, Nigerian Police

1.0   Introduction

Effective data management such as that of crime is a basis to production of reliable, accurate and up-to-date information on criminal facts which requires the use of computer machine together with functional database management software. Also, management of exponential growth of data which is the order of the day in almost every field of human endeavours including criminology provides reason for reliable crime database development. Commenting on data management, Martin, Cadiou and Jannès-Ober [1] stressed that the need for management and recovery of data become crucial in these fields, especially, as we live in digital revolution era.   In the opinion of Soler, Ort and Steckel [2], management of data deals with data in scientific views which emphasizes on generated results, analysis and derived conclusion for efficient decision

making. Thus, there is need for proper generation, storage and retrieval of information for effective data management, [3].   In an attempt to produce quality and reliable information through effective data management strategies, Data Management Association - Data Management Body of Knowledge –

Figure 1: Illustration of DAMA-DMBOK2 Guide Knowledge Areas Wheel.
Source: Cupoli, Earley & Henderson [4].

DAMA-DMBOK as reported in Cupoli, Earley & Henderson [4] came up with eleven knowledge areas wheel which must be taken into account while managing any electronic information system in an organization and these are depicted in figure 1.

In order to achieve these 11 conceptualized knowledge areas in data management as proposed by DAMA-DMBOK in [4], data must be properly managed by the database management system (DBMS) software. Describing DBMS, Hoffer, Ramesh and Topi [5] & Elmasri and Navathe [6] pointed out that database refers to an organized set of logically related data and software known as DBMS is used in managing it. Similarly, Gould [7] pinpoints that a database contains group of related tables of data maintained by software, known as database management system DBMS, [8]. This implies that DBMS is a program for accessing, updating and overall management of a computerized database and its structures.

In essence, to develop software in managing criminal information systems, DBMS is used at backend to design database while application interface is deigned at frontend using Python Programming Language. Hence, in the process of software development for crime management, three layers are involved, i.e. application interface, database and DBMS, [3]. The three layers are illustrated in figure 2.

Layer 1: This is DBMS software which is responsible for creating, controlling, manipulating and management of the database in tables form. As it is indicated in figure 2, DBMS is the core software that runs all criminal details table, location of crime table and recorder table. DBMS interprets application user request and sends the response to the interface in a real time.

Layer 2: This layer consists of database (tables) at which all criminal details, crime location and recorder details are stored after being captured or entered from user at the program interface.

Layer 3: This is the third layer where user (police) captures criminal's biometric, criminal details and store these records in the database.
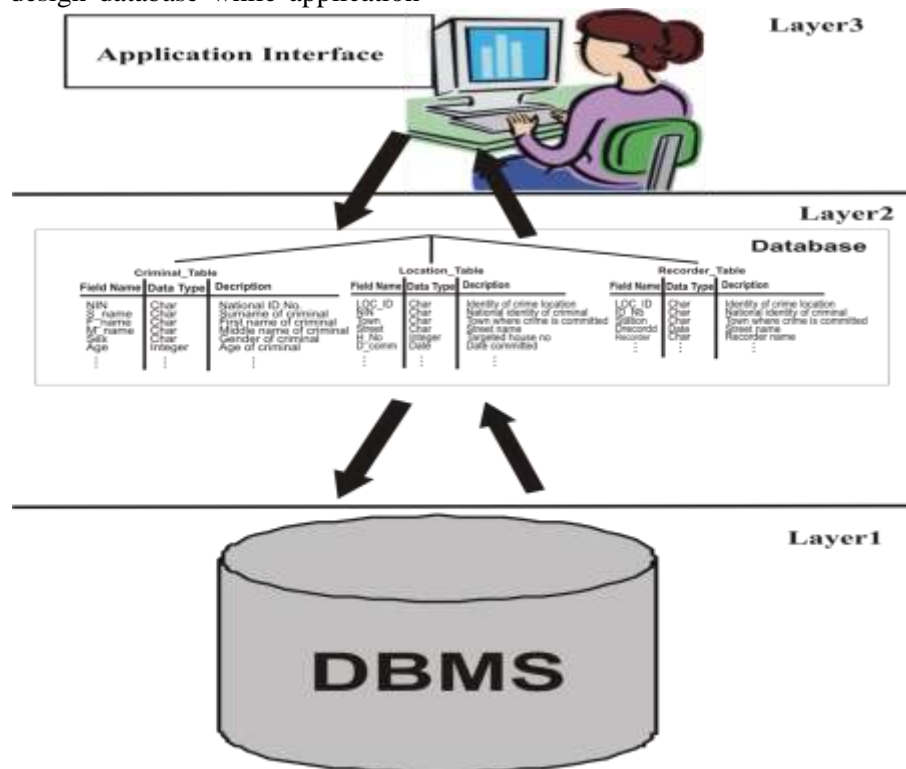

Figure 2: Illustration of interaction between DBMS, Database and Application Interface

Crime is a great threat to societal development, causes under-development and enormous sufferings on business activities and citizens, [9] & [10]. Crime also leads to loss of lives and properties, [11]. In Nigeria today, it is obvious that one type of crime or the other, such as, Boko Haram insurgency, kidnapping, women trafficking, rituals, sexual harassment, to mention but a few are on-going in all six geo-political zones of Nigeria and Governments at all levels are making colossal efforts in reducing crimes to barest minimum through its well established security agencies, especially Nigeria Police Force.

Crimes, according to [12], [13], [14] and [15] have been grouped into different categories and these are personal crimes, property crimes, victimless crimes, white-collar crimes, organized crimes, juvenile delinquency, computer crime and violation of public safety. In order to reduce criminal activities in our society, without mincing words, Federal Government of Nigeria through the 1999 constitution mandates Nigeria Police Force (NPF) to protect lives and property of citizens [16] and at the same time prosecute any offender in a competent court of law and met appropriate sanction on such offender, [17]. The relationship between police, society and crime is illustrated in Figure 3.

Figure 3: The Relationship between Society, Crime and the Nigerian Police Force

2.0   Related Works

The importance of software design in managing criminal information cannot be underestimated across the world and such criminal information system has potentials to assist law enforcement agents to have up-to-date criminal records in their domains as opposed when such records are managed manually. Many researchers have developed software on this aspect. For instance, Dabhere, Kulkarni, Kumbharkar, Chhajed and Tirth [18] designed and implemented a system called "Crime Area Detection and Criminal Data Record" using Information and Communication Technology (ICT) tools and Mwiya, Phiri & Lyoko [19] developed a crime reporting system with the aid of Internet cloud. In these systems, Android application is made available to police during their investigation and at the same time mobile application is also produced for user (crime incident reporter) in order to speed up entire process of apprehending reported criminals on the system. This process, according to [20] and [21] will greatly increase the efficiency of the investigating officers in nabbing down the criminals at the reported location.

Furthermore, Ugwuishiwu, Ugwu and Inyiamah [22] implemented a real-time criminal information system using National Drug Law Enforcement Agency (NDLEA) in Nigeria as a case study. The system consists of three key integrated components; an informant, NDLEA Head Office, branch offices across the country. All related tables in the software are managed by MySQL DBMS at backend while the frontend is a web based user interface that employed the use of Short Message Services (SMS). The informant sends SMS to headquarters with location of drug crime and NDLEA headquarters in turn swift action by deploying officers to the reported locations.

Also, Sharma and Shahnawaz [23] designed Crime Records Management System (CRMS) for Indian police office. The software was employed across police stations in India. Pilot implementation technique was adopted by implementing the software firstly across major cities and towns and then extended to other places which were not covered before. By this, all detective officers in India can access the developed software in order to enhance speedy and accuracy of criminal information in their custody. The criminal database was handled using constructs of SQL at backend and the user interfaces were developed using Microsoft ASP.NET.

Similarly, Ormachea, Haarsma, Davenport and Eagleman [24] developed a criminal record system and used for storing all forms of criminal information in United States of America (USA). The software has capabilities to carry out crime data analyses, such as, query of high-frequency offenders, measuring of policing strategies changes and as well as quantifying of courts order that can help law enforcement agents' decisions making. The database also supports proper means of identifying a criminal who has been tried in different occasions within the same location. The criminal records stored in the software are growing daily and as at year 2014, it contains 22.5 million records covering many countries in USA.

Furthermore, Oludele, Onuiri, Olaore, Sowunmi and Ugo-Ezeaba [25] implemented computer-based real-time Criminal Information Management System (CRIMS) for Nigeria Police Force (NPF). The researchers employed waterfall software development model with design tools, such as, Entity Relationship Diagrams (ERD) and use case diagrams. PHP embedded in Hypertext Markup Language (HTML) was used to implement graphical user interface at frontend, while MySQL was employed in the database design at the backend. The software is an effective program for easy criminal detailing for proper police decision making and in turn improves the police efficiency in terms of criminal records management.

Similarly, software on criminal information management system was developed by Webb [26]. The system was used by Sam Houston State University Police Research Center in Texas. The Record Management System (RMS) was in existence since 1995 and has been operated by fifty-four local law enforcement agencies. The developed software was designed to capture criminal records across various law enforcement agencies and constantly modified to cater for criminal information updates by local police. The software was developed with flexibility in the ease of access and operation by local police in the State of Texas.

Moreover, Canadian Police Know-ledge Network [27] developed real time criminal identification system for Canada with a web-based system known as Criminal Justice Information Management (CJIM), which has an interface that enable police agency users to submit criminal charges and other information electronically in accordance with Canadian rules. The software is users' friendly and in turn provides tips for users on easy navigation on the system. The system also gives rooms for updating of offenders' information and charges.

Furthermore, Shah, Fayaz, Shah, and Shah [28] also designed software for police station in Pakistan to manage and maintain record of police station properly. The developed application software was designed in such a way that data storage and retrieval was made easy when compared with existing system, that is, manually system of data handling. The software was tested using flow of automated testing activities technique. The five stages of automated testing activities were prioritized in testing cases by dividing test cases into different categories; selection of testing tool and environment, coding, simulation, validation and verification. The result indicated that the software is very effective and reliable in operation. The result also showed that the software is portable and criminal information can be updated easily.

Besides, requirements engineering were carried out by [29] on Uganda Police Force Crime Records Management System (CRMS), aiming to significantly improve the entire operations of the functionalities in software by strengthening the relevant processes. The requirements engineering process revolved the four key ingredients of software development; goals and system context definition, elicitation of requirements, system analysis and specification. The project was anchored by the Academic Record Management System (ARMS), Makerere University. The results indicated that the software works perfectly with minimal errors when it was deployed to the sites.

In the same vain, Punjab Police [30] implemented Criminal Record Management System (CRMS) with the target to manage criminal information and identify criminals. The software employed three elements of the criminals; biometrics, physical appearance and

previous criminal history. The database in the software handled digitized fingerprint of criminals and identification of their various crimes. The digitalization of the fingerprints was integrated with all Punjab police units/stations such that a criminal of one location can easily be identified in another location. The software was also embedded with Tenant Registration System and Hotel Eye so that any tenants and guests of hotels having criminal record can be identified in all over Punjab.

A crime prevention framework in Nigeria using computer-based security was carried out by [13] to address community perception on the effectiveness and accept-ability of Closed Circuit Television (CCTV) tool in public places. The study is a survey research and both questionnaire and interviews were used in collecting data for the research. The CCTV captures would-be image of criminal without his/her prior knowledge. The stored images can later be analyzed by crime forensic experts to visualize the criminal trespass into a building, hall, office, etc. It was reported that respondents gave good indicators in supporting the implementation of the tool. This work strictly looked at CCTV camera as a measure for crime prevention in Nigeria.

Adebayo, Onifade, Akinmosin, Yusuf and Dada [32] conducted a research on combating terrorism with biometric authentication using face recognition. Some of known terrorists' images were trained using Principal Component Analysis (PCA) and feature-based technique. For the feature-based technique, some key features, such as, red, green, blue colours of the eyes, the width and height of the eyes together with ratios between them were extracted. Weights for each image based on these features were computed and recorded in the database with the name of each person that owned these features. These feature weights were combined with the weights computed from PCA and were used as the final weight to perform recognition. The system was used to authenticate any immigrant by matching their faces with the faces of the known terrorists in the database. The system was used to

authenticate apprehended terrorists to match faces in the database and if a match is found, it implies the person must be a terrorist and would be arrested and prosecuted by security personnel.

Similarly, Okonkwo and Enem [33] carried out a research on the use of data mining technique in combating criminal activities. The research looked at data mining technique as a tool that can be used in tracking the activities of criminals. Algorithms and techniques, such as, classifications, link analysis, classification, etc. to analyze and scrutinize data were x-rayed in the work. The research positioned that if data mining techniques are imbibed by government with expert ideas, the activities of criminals and terrorists can be curtailed.

Kawai and Samson [34] developed a criminal record information system that can produce criminal information timely when needed by law enforcement authority such as, Nigerian police so as to nib in the bud the criminal activities in a given locality. In the research, Structured System Analysis and Design Methodology (SSADM) were adopted to capture all necessary details from the police, develop and implement the system. The system was implemented using Vb.net programming to develop user interface at frontend and Microsoft structured query language (SQL) server was used at the backend. The modules in the developed software work as expected by the researchers.

Similarly, Cooray and Weerasinghe [35] developed software for crime management to help in solving problems encountered in manual process of handling crime data by police officers in all police stations in Sri Lanka. In the software, mechanism to help police officers for effective and efficient decision-making on crime situation was incorporated. Also, system provided important information on crimes which can be shared among the relevant authorities. The methodology adopted in developing the system is Rational Unified Process (RUP) model. The architecture is made up of Model View Controller (MVC) which was implemented using PHP, Java Script and

Ajax at frontend, while MySQL used for the database at backend.

Lyoko, Phiri and Phiri [36] proposed integration of biometrics into police information management system, purposely to identify police major business processes and develop a web-based software interface to store fingerprint biometric of both criminal and non-criminal citizens into the police's mode of operation. Mixed approaches of qualitative and quantitative data analyses were employed due to the nature of the data required for the research. Both interviews and questionnaires were used to gather information, while Agile Software Develop-ment (ASD) approach was selected for software development. For user's interface, Java Server Pages (JSP) was used, while MySQL database which runs on an Apache Server was utilized for database at backend.

From a critical look at the reviewed articles above, it can be observed that most of the articles provide solutions for effective criminal information management targeting police officers as end users in a press of button with the aid of database technology and programming languages. This eventually eliminates problems encountered when manual technique is applied. Also, in this review, some articles proffer solutions on crime reporting using database technology, geographical positioning system coupled with mobile phones or computing device. Most of software solutions in these articles were implemented outside Nigeria. In view of this, this research is aimed to develop web-based software for crime information management in Nigeria using object-oriented analysis and design approach

and as well provide means for crime datasets features extraction which can be exported in form of Comma Separable Values (CSV) file format that can be further analyzed in a CSV supported programming language, such as Python, R, e.t.c. by a data scientist.

3.0 Methodology

The following tools are required for the development of the software in this study: a computer system with windows operating system, Mongo Database (Mongo DB), Python programming compiler with PyCharm IDE (Integrated Development Environment), webcam and fingerprint machine.

Users interface design was developed using PyCharm IDE after careful study of all appropriate users requirements. All the Python libraries needed to make software functionalities work as expected were imported and embedded during the coding section. At the backend, Mongo DB was used due to its efficiency in handling growing of data exponentially (big data).

Software design methodology adopted in this research was Object-Oriented Analysis and Design (OOAD) approach. As such, Unified Modeling Language (UML) tool, such as, use-case diagram, sequence diagram, class diagram, activity diagram and collaboration diagram were used in analyzing design process.

For the purpose of this study, stages in figure 4 are followed to ensure that an effective web based software for crime inforamtion management system is developed for Nigeria Police Force.
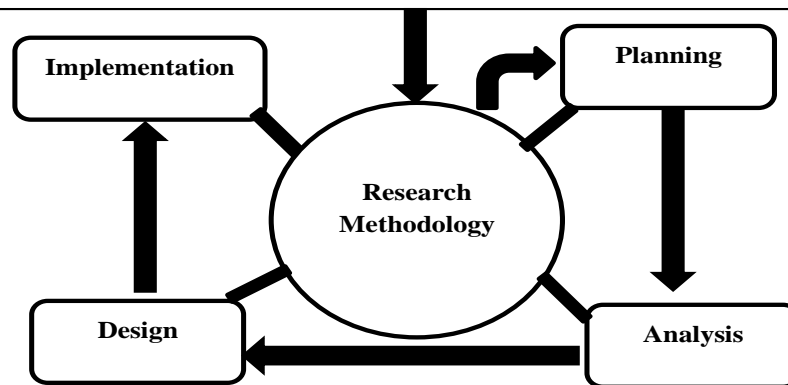
Figure 4: Research Methodology Stages

3.1 Planning: In this stage, requirements analyses were elicitated in terms of the scope of the the study. The users of this system are specified and for the purpsoe of this system, the identified users are the admin., the IGP, CP, police officers and criminologists.

3.2 Analysis Stage: This is a phase where software developers gather necessary information that will make entire system works as it is expected. In this stage, consultations were made which involve all users or their representatives mentioned in the first stage.
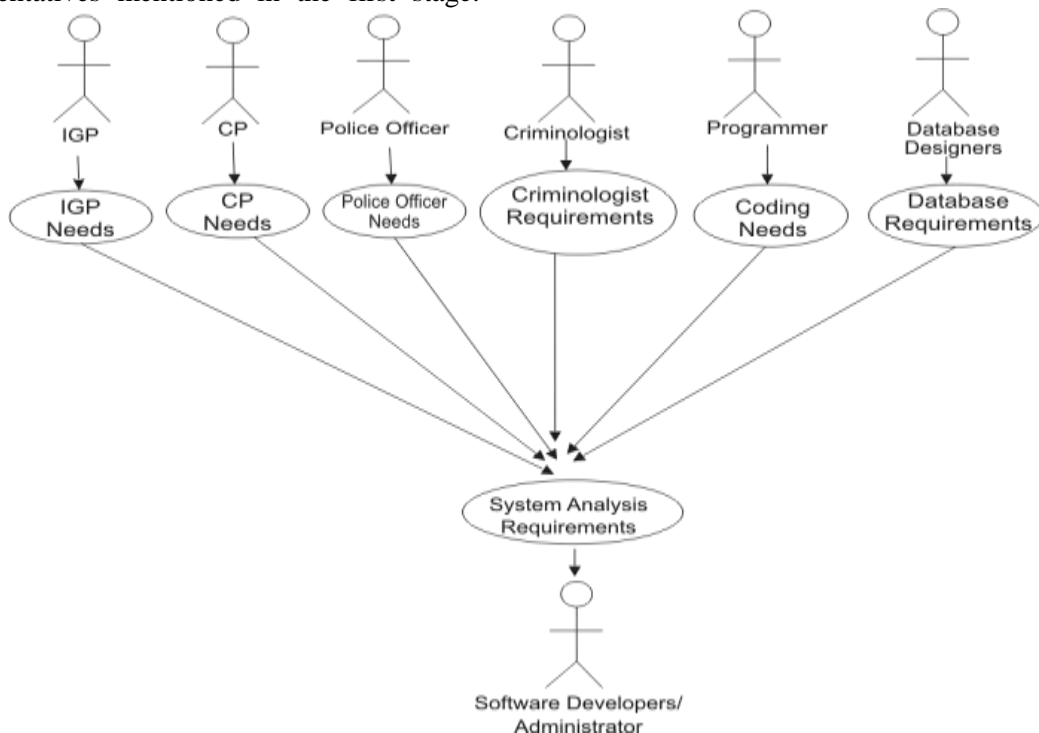
During this phase, information gathering techniques (requirement elicitation), such as, structured and unstructured questionnaires, interviews, onsite observations and document analysis from previous criminal diary/records were collected to aid in the new design. Tools, such as, use-case, activity diagram and sequence diagram were employed to detail the report of the analysis stage. One of the use-case diagrams employed here is shown in Figure 5.

Figure 5: Use-Case Diagram of Analysis Requirements

3.3 Design Stage: This is the actual translation of the needs stated in phase two into modeling and consists of three important aspects of modeling which focused on criminals' requirements, location of crime requirements and crime recorder requirements.

The database employed in this study is Mongo DB. It is a NoSQL database which is schema-less in nature. That is, a document-based data model that can be used in handling big data as a result of the exponential growth. A database has three levels of data modeling; conceptual, physical and logical.

In a nut shell, conceptual data model is the process of developing users' requirements in a high level view and it can be visualized using UML tools, [40], [42] & [43]. However, logical data model is the process of developing logical schema of NoSQL that can be derived from conceptual data model, [41]. It shows the relationship between one class of NoSQL database and the other, [41].

While physical data modeling is all about describing the data structures used for data storage in NoSQL database.

Figure 6 depicts conceptual data model of Mongo DB employed in this study together with the relationship between the classes of attributes stored in the database and Figure 7 illustrates transformation of conceptual data model into physical data model of Mongo DB in the form of document- based data model.
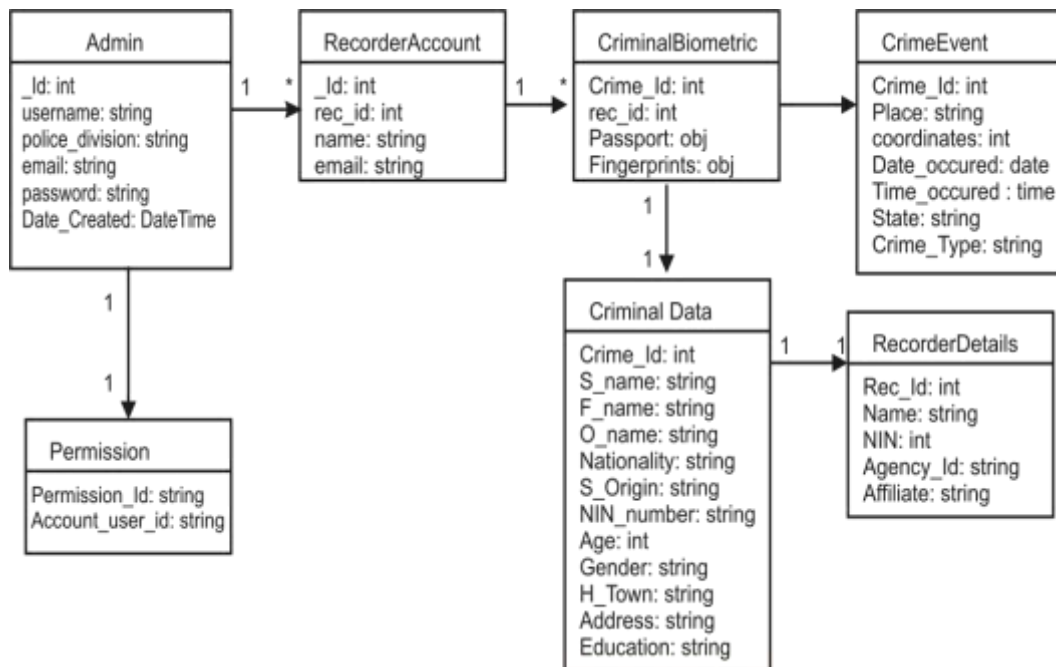
Figure 6: Conceptual Data Model of the employed Mongo DB using UML tool.

```
from mongoengine import *
from .db import db
import datetime

class Admin(db.Document):
    username = StringField(max_length=200, required=True)
    police_division = StringField(required=True)
    email = EmailField(required=True, unique=True)
    password = StringField(required=True)
    created_at = DateTimeField(default=datetime.datetime.utcnow

class RecorderAccount(db.Document):
    rec_id = IntField(required = True)
    name = StringField(max_length=200, required=True)
    email = EmailField(required=True, unique=True)

class CriminalBiometric(db.Document):
    crime_id = IntegerField(required=True)
    Rec_id = IntegerField(required=True)
    photo = StringField(required=True)
    fingerprints =StringField(required=True)

class CriminalData(db.Document):
    s_name = StringField(required=True)
    f_name = StringField(required=True)
    o_name = StringField(required=True)
    nationality = StringField(required=True)
    state = StringField(required=True)
    nin_number = StringField(required=True)
    age = StringField(required=True)
    gender = StringField(required=True)
    h_town = StringField(required=True)
    address = StringField(required=True)
    education = StringField(required=True)

class CrimeEvent(db.Document):
    place = StringField(required=True)
    coordinates = StringField(required=True)
    date_occurred = DateField(required=True)
    time_occurred = TimeField(required=True)
    state = StringField(required=True)
    type_crime = StringField(required=True)

class CrimeEvent(db.Document):
    rec_id = stringField(required = True)
    name = StringField(required=True)
    nin_number = StringField(required=True)
    r_id_number = StringField(required=True)
    affiliate = StringField(required=True)
```

Figure 7: Transformation of Conceptual Data Model into Physical Data Model of

Employed Mango DB

3.4 Implementation: This entails production of software using a particular programming language. In this case, Python was employed in coding. Users interface was developed and shown in section tagged results in this study, while Mongo DB was used for database implementation at the backend. The interface was user-friendly designed. The architectural design of the developed crime information management software is shown in Figure 8.
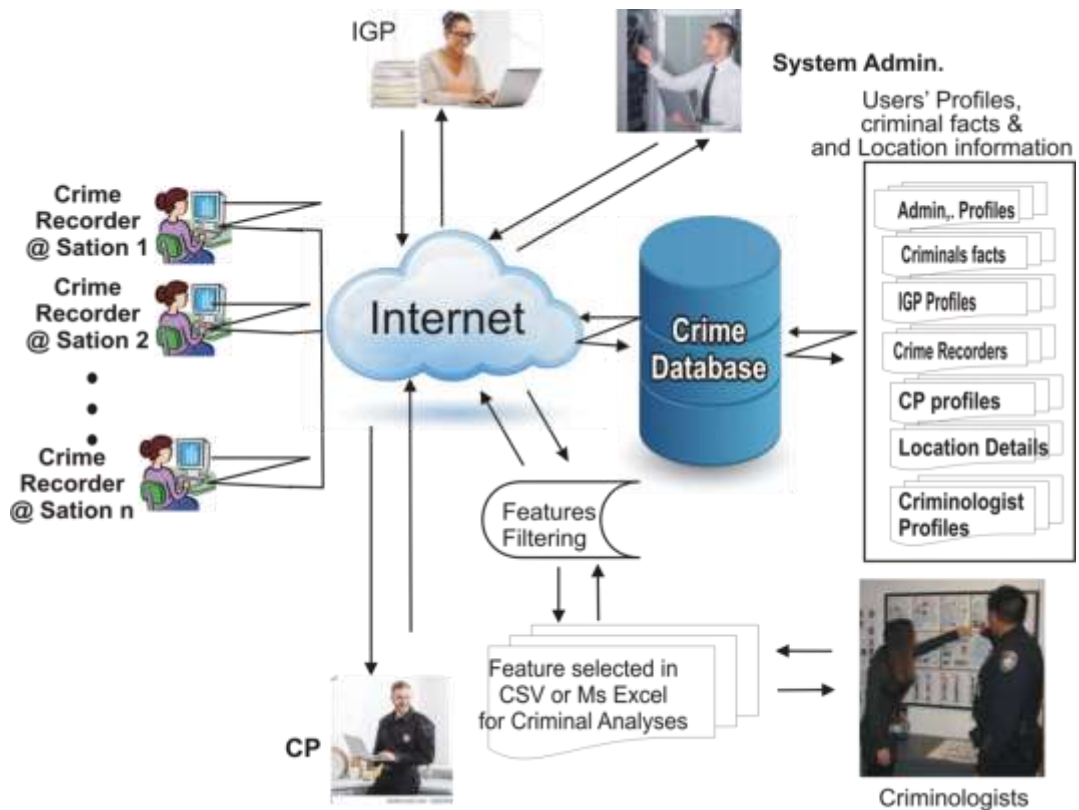
Fig. 8: Architecture of Developed Crime Software

4.0 Results and Discussion

This section presents result of the study and it is in form of the screenshot images that describes the functionalities in the developed crime information management software.

System admin can login and create users who will use the software by entering the email address and password. After signing in, the system displays biometric page where images of criminal and fingerprints can be captured as indicated in Figure 10. Beneath the image / biometric page is three tabs, Configure, Take Snapshot and Save Snapshot.

Figure 9: Authentication Login page for different users

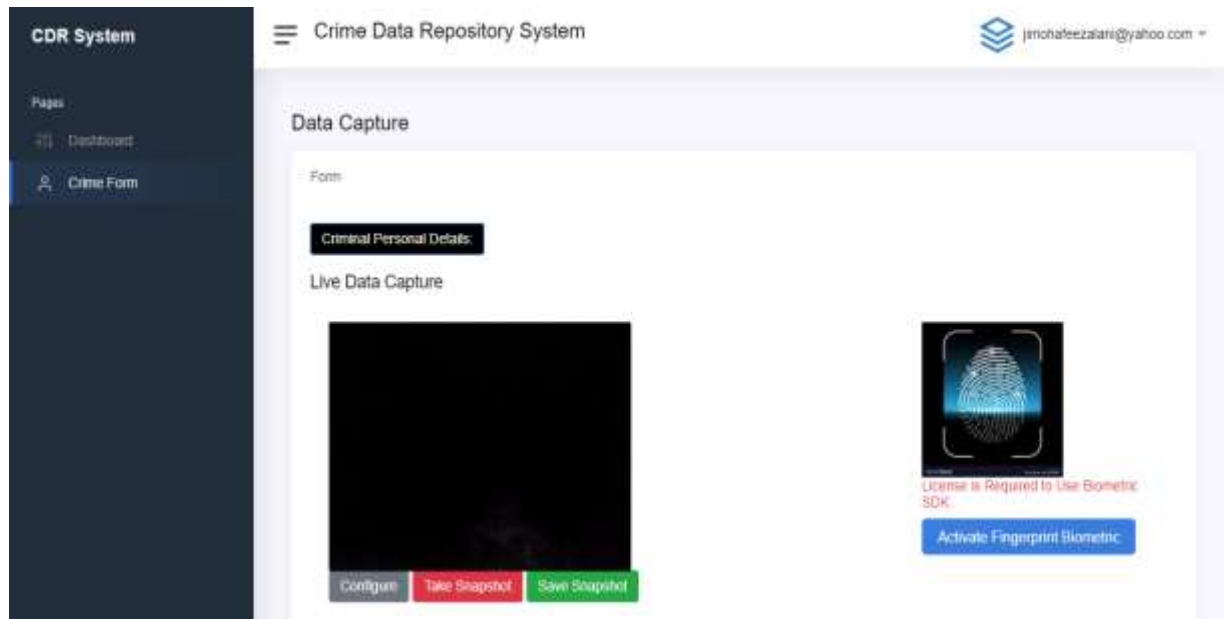The crime recorder then clicks on take snapshot and save snapshot to display the criminal detailing page
.

Figure 10: Biometric Page for capturing image and finger prints of the criminals

Click OK to save the biometric captures after which criminal details can then be entered as shown in figure 11.

Figure 11: Criminal detailing page

After detailing criminal data, the next step is to detail crime events as indicated in Figure 12.

Figure 12: Detailing location of crime event

Having detailed Crime incident, the next step is to capture the detail of recorder as shown in figure 13.

Figure 13: Detailing Crime Recorder profile

At the last page, the recorder clicks on submit button to store all entered information into the database. The software allows recorder to edit any misspelt data item. This is done by navigating to the Dashboard of the software.

Click on Dashboard and click view details of the record to edit in the Criminal Record Table as shown in Figure 14 and then click Update to enable editing as depicted in Figure 15.

Figure 14: Criminal record Table Display page for editing

Clicking on View details generates update page shown in figure 15.

Age	23
Gender	Male
Nationality	Nigerian
Home Town	Lagos
Education Level	Primary
State	Lagos
Home Address	Baraga Estate
Place of Occurrence	Agege
Coordinates	23.6 65.0
Date	05/12/2021
Time	18:45
State of Occurrence	Lagos
Crime Type	Theft
Recorder Name	Cap. Iyiola
Recorder NIN	LA6750
Recorder ID	NPF678
Recorder Affiliate	Agege Area command

Close   Update Record   Delete Record

Figure 15: Criminal record Update page

As shown in Figure 15, three functionalities can be performed, that is, Close, Delete and Update.

- Close is to cancel the display function and return to Criminal Table
- Update permits the recorder to edit wrong entries made.
- Delete is used to remove a record from the Database.

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Apart from these functionalities, filtering can be done by navigating to the top of table and click in Search button and enter actual value of the attribute to filter from the table, as shown in Figure 16. Assuming, we want to Search and filter for "crime type = 'Theft' ". The result of filtered data is shown in Figure 16

Figure 16: Crime Type 'Theft' Filtered from the Database

Lastly, other functionalities such as report generation for all criminal records and filtered data from the database can be exported to Microsoft Excel and saved in form of CSV file supported by Python. Such CSV file can be used in crime analytic for decision making by police officers. Table 1 depicts criminal records stored in the database while Table 2 shows filtered data using search criteria 'Crime Type=Theft'.

4.1   Discussion

In this paper, software for crime management has been developed. Added feature in the software is the opportunity given to export filtered datasets into CSV file format which can later be used for crime data analytic and hence, effective decision making by the police officers. This result is in line with Unegbu and Adenike [37] which affirmed that a record management program should contain timely
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information which executives and managing directors of an organization will use in making decisions. And in today's digital world of competition among many establishments, it is necessary that the manager must have relevant data at hand which can either be used in taking decision ahead of the competition, or by making a better and more informed decision.

Besides, the developed software consists of input controls and validations that enable users create and capture criminal information as well as crime events together with crime recorder details. This embedded feature is in consonance with the view of Biraud [38] which stated that the record management software needs an efficient and systematic control of the data creation, maintenance, use and disposition of records, including the processes for capturing and maintaining evidence of information about business activities and transactions in the form of records

Table 1: Screenshot of Report of Criminal Table contents

NIGERIA POLICE FORCE								
BAUCHI STATE COMMAND HEADQUATERS								
KATAGUM AREA COMMAND								
#	Surname	First Name	Other Name	Gender	Age	Education Level	Crime Type	Place of Occurrence	State
1	Abubakar	Saleh	Muazu	Male	23	Secondary	Theft	Jamaare	Bauchi
2	Abubakar	Dada	Azare	Male	23	Secondary	Car Snatching	Azare	Bauchi
3	Usama	Fatima	Hassan	Female	34	Primary	Theft	Jamaare	Bauchi
4	Abubakar	Musdafa	Kabiru	Female	23	Secondary	Stealing	River Jamaare	Bauchi
5	Dabo	Aminu	Mijiyawa	Male	26	None	Theft	Jamaare	Bauchi
6	Samaila	Musa	Dogojeji	Male	32	Primary	Car Snatching	Jamaare	Bauchi

Table 2: Screenshot of Report of Attribute 'Crime Type' with value = 'Theft'

NIGERIA POLICE FORCE								
BAUCHI STATE COMMAND HEADQUATERS								
KATAGUM AREA COMMAND								
#	Surname	First Name	Other Name	Gender	Age	Education Level	Crime Type	Place of Occurrence	State
1	Abubakar	Saleh	Muazu	Male	23	Secondary	Theft	Jamaare	Bauchi
2	Usama	Fatima	Hassan	Female	34	Primary	Theft	Jamaare	Bauchi
3	Dabo	Aminu	Mijiyawa	Male	26	None	Theft	Jamaare	Bauchi

The developed software in this study is web based application which can be accessed worldwide using any mobile devices (desktop and laptop computer, mobile phone, tablets, etc) and this also aligns with the studies of Mwiya, Phiri and Lyoko [19] that developed a prototype short message services based crime reporting and showed improved results because majority of public make use of mobile devices and as a result, improved management reports due to automation of crime reporting and monitoring.

The software was designed in such a way that records can easily be retrieved, stored, updated and users must be authenticated before accessing it. This functionality is also corroborated by Caravaca [39] who described that records in database are easily retrievable for use, accurate and up-to-date and the users in the organizations must be authenticated before it can be accessed.

4.2 Limitation of this Study

The crime datasets extraction is based on CSV file format, which can only be run on CSV supported programming language. A look at the possibility of incorporating different file formats which can be handled by several programming languages can be further researched on in the future.

5.0 Conclusion

In this study, a software was developed with the aim of solving the problems associated with the manual method of crime reporting and detailing in Nigerian Police Stations. Object-oriented analysis and design methodology was adopted in the design and analysis process. The software is designed to be web based application which can be accessed worldwide by Nigeria Police Force after the user must have been authenticated by the system administrator. Other important feature in the software is the opportunity given to export filtered crime datasets in CSV format which can be used for crime analytics in Python.

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