On the Development of a Deep Learning Model for Profiling and Predicting Traffic Offenders: OOADM Approach

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Abstract
Monitoring of traffic offenders in developing countries has a lot of challenges including; lack of proper authentication of vehicles and users, lack of substantive traffic system that suits the management of traffic offenders' profile in both rural and urban areas, lack of predictable modules to forecast the tendency of an offender to cause accident in the future, poor means of communication between traffic agencies and vehicle users, poor traffic offence awareness for vehicle users and lack of a dependable traffic offenders profile database. Therefore, this thesis is providing a solution by development of a deep learning model for profiling and predicting traffic offenders focuses on developing a traffic offenders profiling and prediction system using deep learning algorithm to predict the likelihood of an offence to be committed by a road user. The proposed system developed a model that will profile traffic offenders in both urban and rural settings, create a traffic offender's database that will interact with existing national databases to authenticate traffic offenders, provides a module that will predict the likelihood of a road user to commit severe traffic blunder in the future and provide intelligent information necessary for timely action by law enforcement agencies. The system designs was implemented using a web-system developed with PHP, MySQL and JavaScript. The System Design followed the OODM methodology for componentization of the system modules giving room for coupling, decoupling, modification, encapsulation and reuse, as well as easy maintainability. Unified Modeling Language was extensively used to simplify the explanation of the system modules. The software performance was tested using accuracy of traffic offender prediction and Confusion Matrix was adopted for the thesis. For the purpose of this thesis, dataset was collected from data-world (https://data.world/healthdatany/qutr-irdf) and the data is an excel sheet dataset for Traffic offenders. The result obtained from the new system developed shows 95% accuracy of the deep learning technique for predict the likelihood of a road user to commit traffic blunder in the future.

Keywords: *OOADM, Database, deep learning, authentication of vehicles*

Introduction

Profiling of offenders is an important tool used by traffic agencies in solving traffic problems [1]. Profiling saves traffic agents time on the investigation of offences by providing detailed demography of an offender and the past traffic offence antecedents [2]. [3] describes profiling as an educated attempt to provide specific information about certain types of suspects. Profiling has helped law enforcement with the application of behavioral forensic science over the years in solving crimes problems by creating psychological profiles of criminals [4]. Road traffic offences/offenders profiling should be able to give descriptive details of an offender, offence committed and rate the number of occurrences of an offence, and exact identification of vehicle used to commit the offence at a given time and location. In developing and under-developed economies where most people violate protocol and are criminally minded, most traffic offenders appear to be anonymous and it is difficult to profile such offenders. It is necessary for every vehicle user to be authenticated during registration and licensing to use the road to ensure that anonymity of vehicle users is discouraged. This is achievable by creating a synergy between traffic registration systems with a dependable national identity database to ensure that a registered vehicle owner is genuine and authentic. Traffic systems in operations are designed to operate in urban areas where there are supporting amenities such as light, availability of online features and mobile coverage. Traffic has extended from the cities to the rural areas leading to loss of lives and properties. There is every need to develop a traffic system that will support rural settings as well. In profiling traffic offenders and offences, inputs are gotten from various traffic points both in the urban and rural areas. It is therefore necessary that a profiling system should support both urban and rural traffic systems [5]. Building and deploying traffic offence and offender systems will not be enough to effectively aid in the curtailing of traffic challenges. The system should be able to communicate with traffic agents and pass information to guide the agents on how to effectively manage traffic challenges [6]. A good traffic offender's profiling system should be able to predict risky drivers by automatically forecasting offences, the sequence of occurrence of such offences. This will enable traffic agents to tag a driver reckless status a not road user, then take the necessary actions to apprehend such a driver. Traffic profiling systems should not just be a database of traffic offenders and offences. Rather the system should be able to communicate offenders to remind them of their traffic rating from time to time. The system should be able to communicate with traffic agents and the vehicle users on current trends in traffic managements. This will inform the duo and create proper traffic awareness.

In recent times, deep learning techniques have been vastly used in modelling and monitoring complex applications. Deep Learning has also shown outstanding performances in many fields including crime profiling, by providing useful descriptive and predictive information. The main advantage of Deep learning methods is their ability to create models that may be integrated into the decision-making process. To achieve the set target of this thesis, data mining and deep learning-based methods will be developed to aid in promoting effective and efficient traffic offender's profiling and prediction. The new system framework allows road traffic agents to profile a road user and predict the possibility of committing traffic offence in nearest future. In the developing countries, traffic agencies while trying to discharge their duties end up causing more harm by chasing offenders thereby leading to their doom. Corrupt road traffic officers also exploit motorists in the course of discharging their official duties. Moreover, a critical look at some of the existing systems shows lack of proper channel of road traffic awareness which makes it difficult for road

users to get acquainted with traffic rules and regulations. There are no polite and convenient means of communicating with road traffic offenders in the developing countries. Traffic systems deployed in developing countries lack adequate authentication of road users, no efficient and effective profiling system of offenders and offences, as such, traffic agents cannot generate instant traffic history of an offender. In the same way vehicles are tagged "not road worthy", regular traffic offenders should be tagged likewise and further denied access to the use of the road. This is not possible in the developing countries because there is no traffic system deployed that can peruse through traffic offenders and offence profile in order to predict the likelihood of an offender being denied the privilege of using the road for traffic safety or present comprehensive information about an offender for traffic agent's decision. The following is a list of the summarized traffic challenges in developing countries that are addressed by this paper: Lack of Proper authentication of vehicles and users, Lack of substantive traffic system that suits the management of traffic offenders' profile in both rural and urban areas, Lack of predictable modules to forecast the tendency of an offender to cause accident in the future, Poor means of communication between traffic agencies and vehicle users, Poor traffic offence awareness for vehicle users in developing countries, Lack of a dependable traffic offenders profile database. The aim of this paper is to develop a deep learning model for profiling and predicting traffic offenders. The following are the objectives of the research.

1) To build a System that will profile traffic offenders in both urban and rural settings.
2) Create a Traffic offender's database that will interact with existing national databases to authenticate traffic offenders.
3) Provides a module that will predict the likelihood of a road user to commit severe traffic blunder in the future using deep learning and provide intelligent information necessary for timely action by law enforcement agencies.
4) Create and Integrate SMS based Traffic awareness module that handles traffic offences communication between traffic agents and offenders.

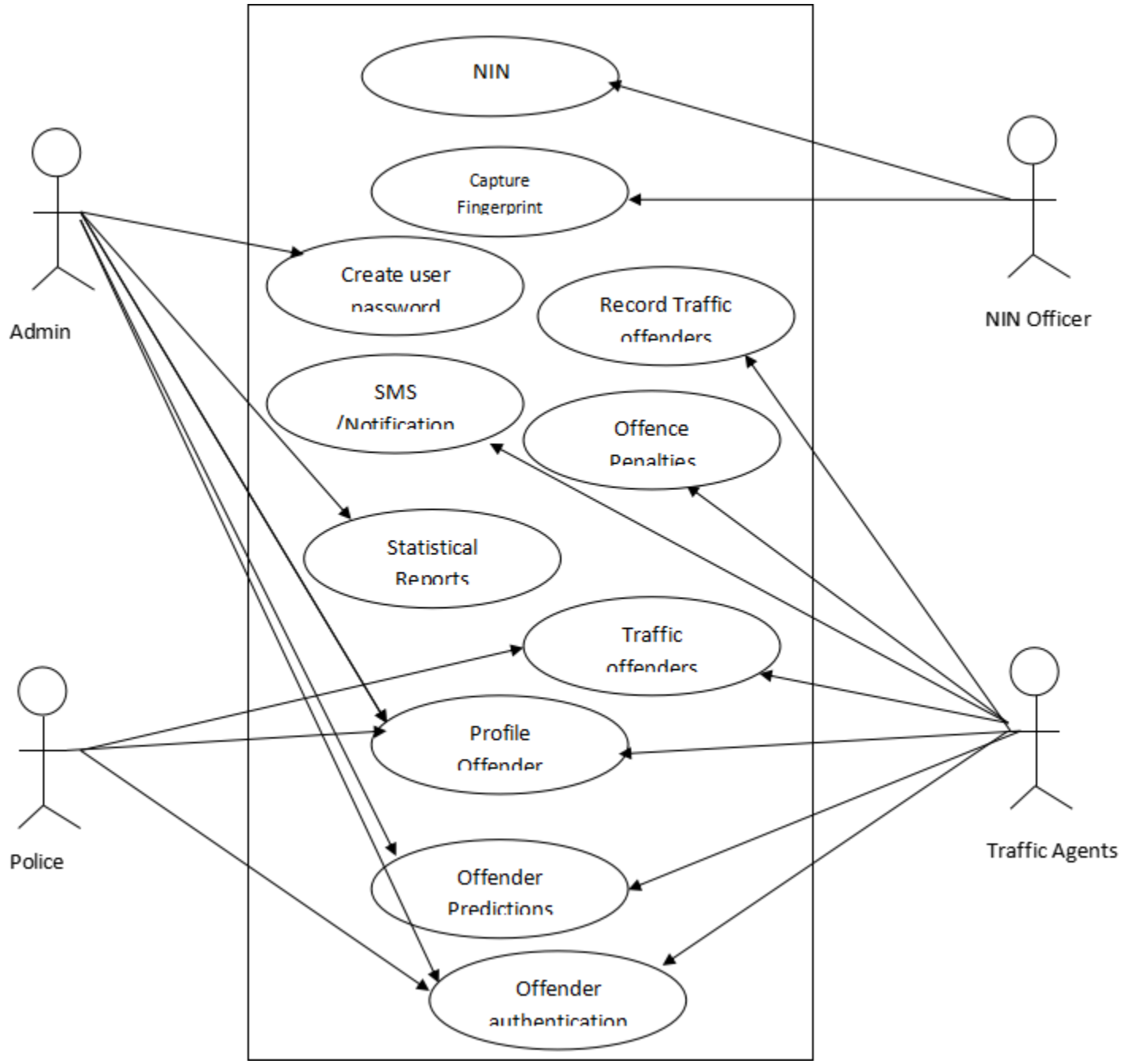
Review of Related works

Traffic system is an organized plan and procedure with the intention to solving traffic related problems in society. [7] noted that when the numbers of people increase, so also the number of vehicles increase thereby leading to several traffic issues which may result to accident and even loss of lives. This is so because, it is easy for vehicles to be added to the existing system naturally as the population of the people in any given area increases, but the possibility to expand traffic infrastructure especially roads to accommodate the influx of cars promptly cannot be guaranteed. As a result of this increase, the volume of cars in a small road can trigger traffic problems. Apart from accident caused by traffic jam, there are dark areas which are naturally prone to accidents [7]. They further inform that in the western world, the dark area problem of traffic is minimize due to advance follow up and provision of needed infrastructures to curtail the incidents and that this is not so in the developing and under-developed countries. [8] noted that with the provision of social indicators such as security, well-being and economy, urban trips increase thereby resulting to traffic congestion. The consequence of traffic jam and congestion is a global issue that raises so much concern. To overcome or reduce traffic challenges universally, policies, control measures

and systems are developed continuously to tackle traffic jam and congestion. In the developing countries, adequate attention or provision have not been given with respect to traffic control. This is responsible for the frequent and daily occurrence of road accidents in the various parts of Nigeria. especially in the cities. There is the need to come up a wholistic system that will manage traffic jam and congestion to reduce the rate of road accidents and loss of lives. Taking Nigeria as a case study, while the developing societies are planning on how to plant systems to help control traffic problems, Nigeria has deplorable roads which are not only causing traffic jam and congestion, but vehicles damage as well. One of the major factors considered in traffic control is good roads. Traffic systems are mounted on good roads to control speed, interjection and unethical traffic habits and practice. In the situation where the roads are narrow and bad, deploying a traffic system on such roads is unreasonable and a waste of resources because it will have no effect on traffic control. However, in a situation like Nigeria, the best traffic system that may be more effective is to control road user habit on the use of road. This can be done by developing a profiling traffic offenders' system which will help traffic agents to bring to book offender, educate them on the road traffics and punish those who perpetually violate traffic rules. Traffic system could be manual or automatic depending on the type of traffic problem it is designed to solve and the level of technology available at the movement.

Object Oriented Analysis and Design Methodology (OOADM) Approach

Use Case Diagram



The use case diagram depicts all the actors in the development of a traffic offenders profiling and prediction system using deep learning algorithm to predict the likelihood of an offence to be committed by a road user and how they interact with the system.

Figure 1: Use Case Diagram

The user requirements describe functions that are performed by the users on the system. The users of the proposed system are categorized into four levels namely Admin, traffic agent, NIN officer and Police.

Sequence Diagram

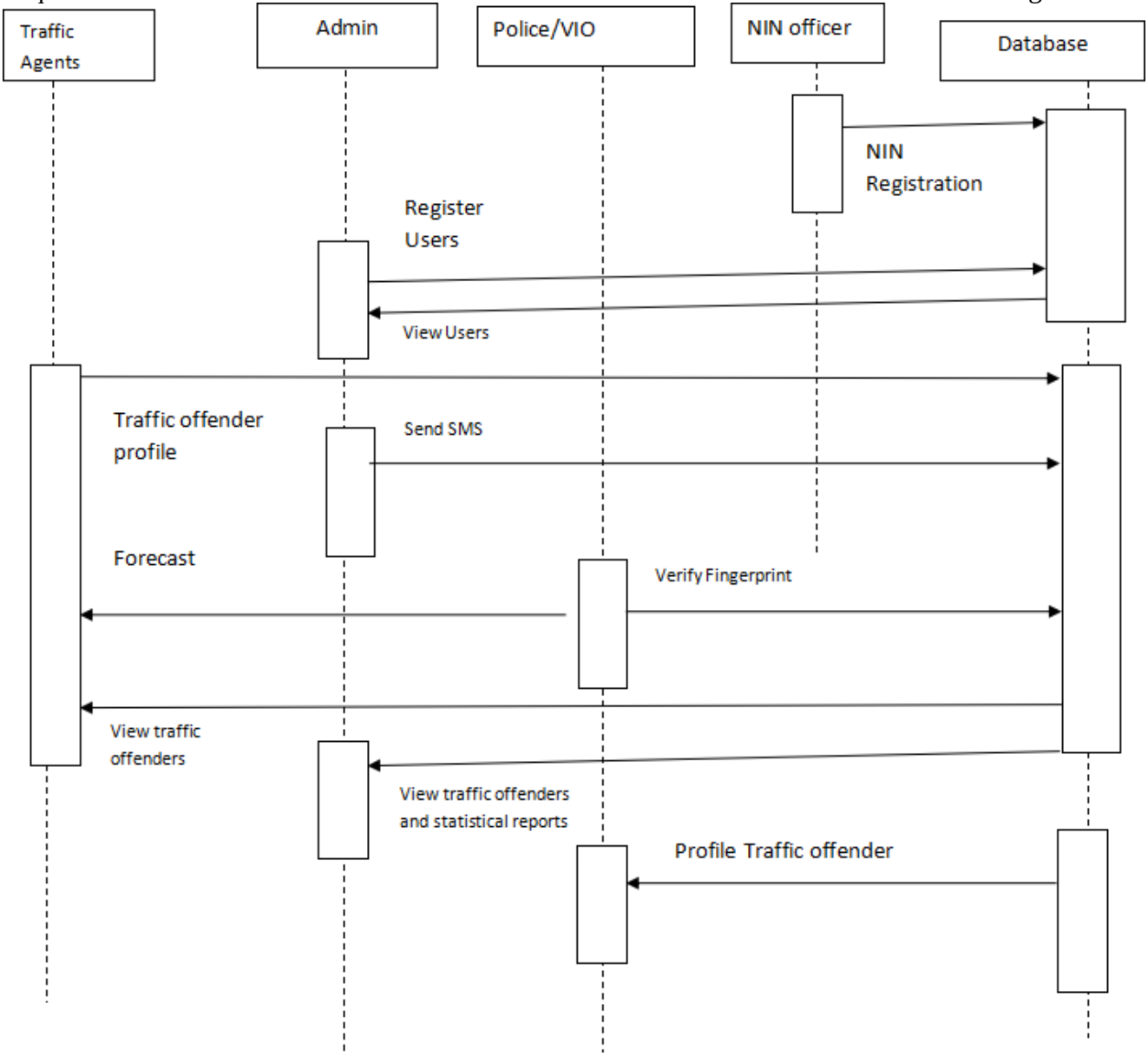


Figure 2: **Sequence Diagram**

Figure 2 shows the sequence diagram of the proposed system and it depicts how objects interact with one another and in what order. It depicts the objects and classes involved in the scenario.

ACTIVITY DIAGRAM

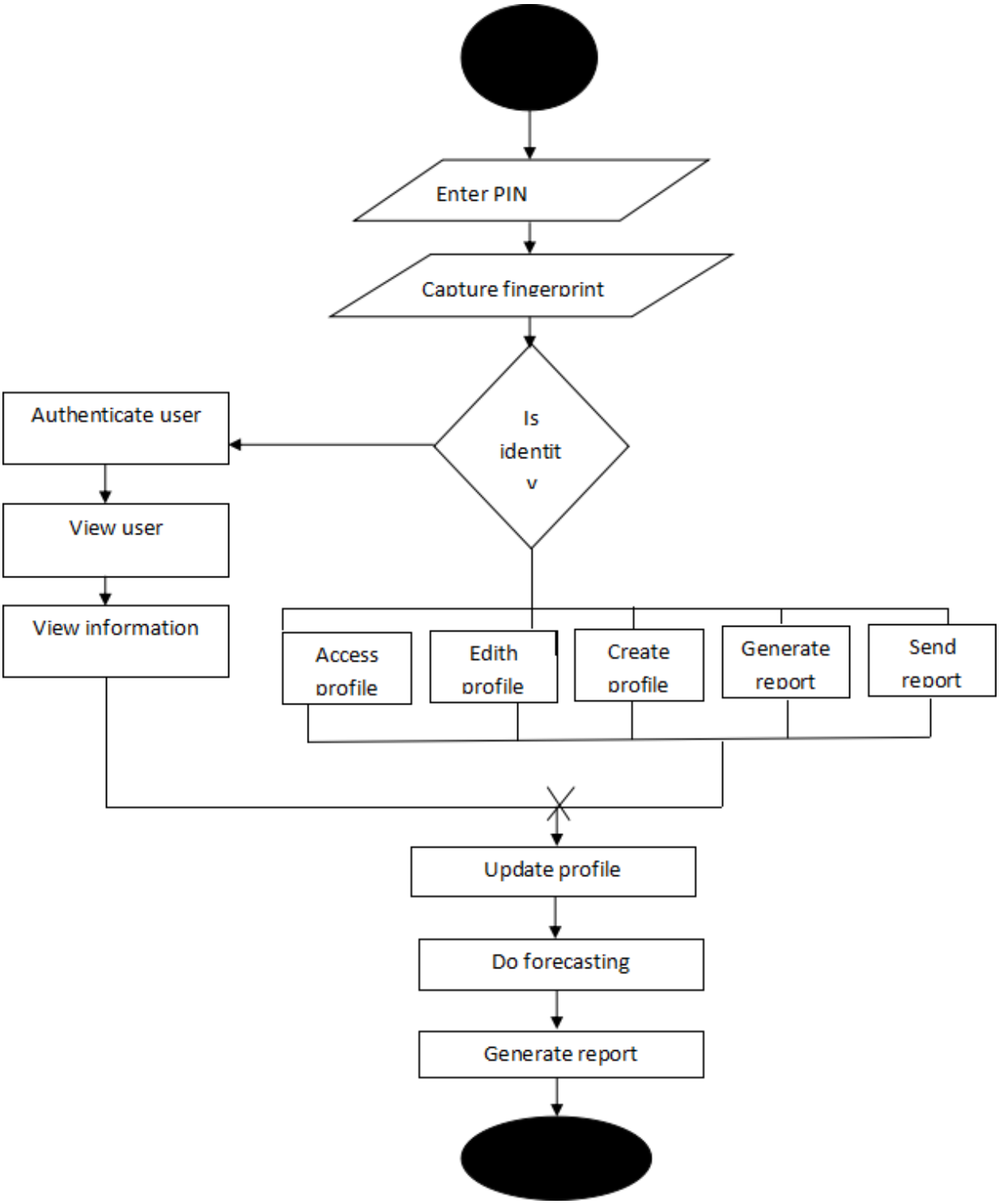


Figure 3: **Activity Diagram**

Algorithm

The algorithm for the proposed model is Long Short-Term Memory Networks (LSTMs) and it is a deep learning algorithm. LSTMs retain information over time. They are useful in time-series prediction because they remember previous inputs. The algorithm developed is as follows.

Start
Algorithm to set up the Traffic Rules dataset
Enter the traffic offence
Enter the code, point and penalty
Create a dataset
Store in database
Stop
Algorithm for Fingerprint Capture
Start
Place the finger on the fingerprint machine
Create the fingerprint template
Store the fingerprint on the database
Stop
Algorithm for Fingerprint verification

Place the finger on the fingerprint machine
Capture the fingerprint template
Query the fingerprint db
Match the fingerprint captured with the one in the database
Is similar case found?
If yes search for then display the bio data of the offender
stop
Algorithm for traffic offender profiling
Call Fingerprint verification algorithm
filter the offender record from NIN database
Enter the traffic offence committed
Search for matching case for the penalty and point
Store the traffic offender profile on the offender database
Stop
Traffic Offender Forecast algorithm
Enter the traffic offender NIN
Call Long Short-Term Memory Networks (LSTMs) (deep learning algorithm)
Is the offences found?
Extract the results that matched the data found
Display the search results
stop
Deep learning algorithm
First, LSTMs forget irrelevant parts of the previous state
Next, LSTMs selectively update the cell-state values
Finally, LSTMs output of certain parts of the cell state

Stop

System Flowchart

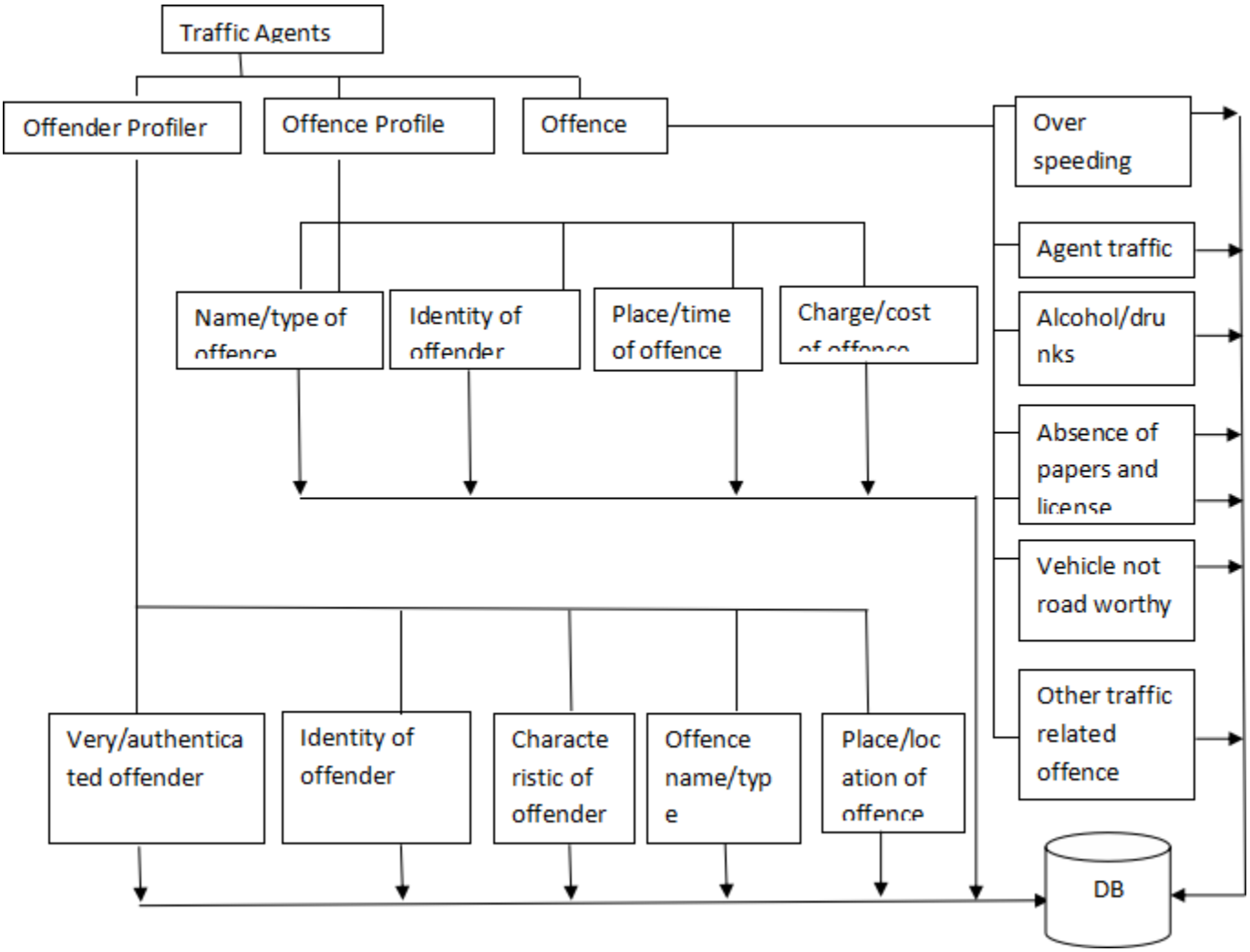


Figure 4: System Flowchart of the proposed system

The system flowchart (figure 4) shows how the various program flows. The agent login with his identity to access, view the offender's offence profile; verify/authenticate offenders; create traffic awareness, post offenders/offence details profile create/update profile and trial offenders. Monitor offenders/offenses reports as they arrive and view and act according to automated traffic reports generated by the system.

UML Class Diagram

The object model represented in UML with class diagrams, describe the structure of the proposed system of traffic offender profiling system, in terms of objects, attribute, associations, and operations. The class diagram for the proposed system describes the system in terms of classes, attributes, operations, and their associations as shown in Figure 5. In UML, classes and objects are depicted by boxes composed of three compartments. The top compartment displays the name of the class or object. The center compartment displays its attributes, and the bottom compartment displays its operations.

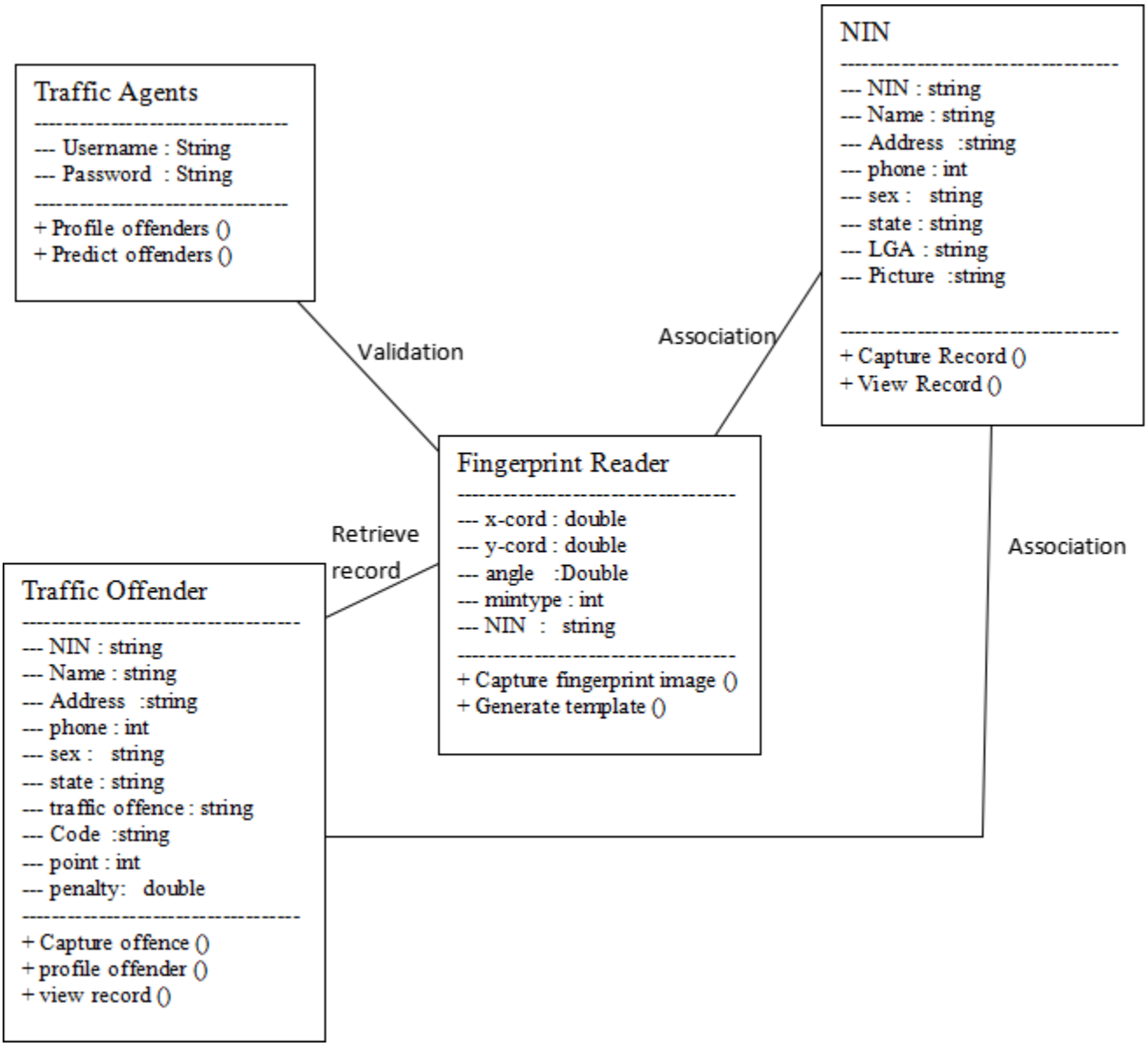


Figure 5: UML Class Diagram

Confusion matrix applied to test dataset of predict the possibility of committing further traffic offences

		Observed	
		True	**False**
Predicted	**True**	18	0
	False	1	1

Table 1 shows that out of 20 different predictions was carried out using deep learning technique; 18 results are True Positive and returned the needed intelligent information necessary for timely action by law enforcement agencies correctly, 0 predictions returned forecast that is not accurate, 1 predictions was unable to return a particular prediction result from the data set. Finally, 1 False was detected where there was no traffic offence. A model of performance metrics can be derived from the confusion matrix as show in equation 4.1, which show the level of accuracy of the deep learning technique for predict the likelihood of a road user to commit traffic blunder in the future.

Substituting the values we have

AC = (18+1) / (18+0+1+1)

AC = 0.95 i.e. 95% accuracy of the deep learning technique for predict the likelihood of a road user to commit traffic blunder in the future.

Summary

The development of a deep learning model for profiling and predicting traffic offenders as implemented in this thesis produced a profiling and prediction System using deep learning algorithm to predict the likelihood of an offence to be committed by a road user. The system developed authenticates the user through validation of their username and password. It also identifies the traffic offenders through verifying their NIN or fingerprint. The system developed integrates the NIN database to the traffic offender profiling modules by linking the user's personal details as contained in the NIN database to the traffic offences committed by the traffic offender. The model developed is very unique and presents a very high level security system for accessing data stored in the database. The traffic offender profiling system developed in this system has various modules that perform different functions like:

1. Register all the traffic offences and their penalty.
2. Record traffic offenders caught in the act of disobeying traffic rules.
3. Profile traffic offenders and display all the previous traffic offences committed by the offender.
4. Predict the probability that a traffic offender will commit another traffic offence in the nearest feature.

5. Verify the traffic offender's bio data and link it to the traffic offence committed by the offender using fingerprint.
6. Send SMS to road users on traffic awareness / traffic offender's penalty reminder, and also post offender's penalty payment record

The system developed was tested and was able to achieve 95% accuracy of the probability of deep learning technique used to predict the likelihood of a road user committing traffic offence in the future.

References

[1]. Ibe, P. (2012). Racial misuse of "Criminal Profiling" By Law Enforcement: Intention and Implications. African Journal of Criminology and Justice Studies (AJCJS), 6 (1), 177-196.

[2]. Groeger, J. A. (2016). Youthfulness, inexperience, and sleep loss: the problems young drivers face and those they pose for us. Injury Prevention, 12 (Supplement 1), 19-24.

[3]. Houck, M. M. & Siegel, B. D. (2006). Fundamental of Foreign Science, Sam Diego, C. A. Elseview Limited

[4]. Saini, J. et al (2017). Android App Based Vehicle Tracking using GPS and GSM. International Journal of Scientific & Technology Research, 6 (9), 53-58.

[5]. Shahgholian, M, &Gharavian, D (2018). Advance Traffic Management System: An Overview and Development Strategy. Information accessed from D-Gharavian @ Sub.ac.ir on 16/4/21.

[6]. Onah, C. K. (2017). Design and Implementation of Traffic Offence Tracking System. Unpublished B.Sc. Project submitted to Department of Computer Science. Godfrey Okoyo University.

[7]. Irshad, A.S. et al (2013). Classification of traffic System in Intelligent Transportation System (ITS). Modern Traffic and Transportation Engineering Research (MTTER), 2 (4), 1-10.

[8]. Jadhav, U. V. et al (2015). Proposed e-payment System using Biometrics. International Journal of Computer Science and Information Technology (IJCSIT), 6 (6), 4957-4960.

[9]. Manimathu, P. &Ngartnam, R. (2011). A Real-Time Biometric System for person Authentication using Rebidded Processor. A paper presented in the 3rd National Conference in Signal Processing, Communication and ULSI, Anna University of Technology, Coimbatore, 132-135