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Predicting recidivism among inmates population using Artificial Intelligent (AI) techniques: A case study of Kenya prisons department

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A RESEARCH SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF MSC COMPUTER SCIENCE

Declaration

This project is my original work and to the best of my knowledge this research work has not been submitted for any other award in any University

Judy W. Gikaru: ______________________________ Date: ________________

(P58/76338/2012)

This project report has been submitted in partial fulfillment of the requirement of the Master of Science Degree in Computer Science of the University of Nairobi with my approval as the University supervisor

Dr. C. Chepken: ______________________________ Date: ________________

School of Computing and Informatics

Abstract

Currently in the Kenya prisons department there is no defined way of checking the rate of recidivism among the prison inmates population. The officers rely only on manual tallying of prisoners during admission which is not efficient. With the increase use of computerized systems in the department there is need to implement those that can help in rehabilitation and reformation. In this research Artificial intelligent techniques that is decision tree, neural networks and bayesnets are used to check on the rate of recidivism in the inmate's population. This is illustrated by the development of the Recidivism Prediction System (RPS) prototype, using the WEKA tool and the python GUI application, which play a major role in risk assessment of the inmates by checking their rate of recidivism. Currently congestion in the prisons institutions is a major challenge to the management, since the resources provided doesn't match up the need on the ground. Using the RPS prototype the department management can be able to visualize various patterns on recidivism from predicted result and most importantly show the prisoners likely rate of recidivism. Assisting the users in the decision making process, as rehabilitation and reformation is not just about incarnation but also include Community Service Order and parole.

The RPS prototype is important to the users as it can be used to predict recidivism rate and plan on various programs on rehabilitation and reformation to introduce or not. As from the prototype results the prediction outcome vary from one instance to another, where those with value above TWICE are of higher recidivism risk compared to those with ONCE and below. The prediction results is also compared with other attributes and displayed for better understanding.

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List of Abbreviations

ANN- Artificial Neural Networks

API – Application Programming Interface

CART – Classification & Regression Tree

CART – Classification and Regression Tree

CRISP-DM- Cross Industry Standard Process for Data Mining

CT- Classification Tree

DA- Discriminate Analysis

DM - Data Mining

DM- Data mining

FSOM – Fuzzy Self Organizing Map

ICT- Information Communication Technology

LR- Logistic Regression

NN- Neural Networks

ORMS – Offenders Record Management System

PMML – Predictive Model Markup Language

RPM- Recidivism Prediction Model

SEMMA- Sample Explore Modify Model and Assess

SKU – Store Keeping Units

SOM – Self Organizing Map

CSV- Comma Separated Values

ARFF- Attribute-Related File Format

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CHAPTER ONE

1.0 Introduction

1.1 Background

The Kenya prison department is a correctional service which is mandated by the constitution the responsibility of safe custody of both convicted and un-convicted prisoners. It has a total of 108 penal institutions countrywide and a total of 109,629 convicted prisoners this is as at 2014 which is a 41.6 percentage increase from 77,405 in 2013. For the previously convicted population in 2014 was 24,927 a 8.8 percentage increase from 22,910 in 2013 (KNBS, 2014). The population increase of the prisoners has resulted in congestion in most penal institutions mostly due to the fact that the infrastructure growth does not match that of the population among other factors. Therefore, there is the need for a system to help manage the population of inmates in the penal institutions to complement the existing methods.

The Recidivism Prediction System is to help the Kenya Prison department in its operations to study the cases of a person being released and the chances of being convicted again. For example the system could aid in the adoption of a policy based on the prevention of recidivism, adequate release planning and referrals to community based services among others. The risk levels of a person's chance of committing another crime after release will be helpful to the department in decision making on scenarios of labor allocation, Compulsory Supervision Order and parole among others.

Details of the prisoner like age, gender, offence committed, area of residence, education background and employment among others are fetched from the ORMS (Offenders Record Management System) which is maintained by Kenya Prison Department and used as variables in predictions on a prisoner's history of arrest.

The results will help the department meet its core functions effectively, and ensure public safety and effective rehabilitation of the offenders. With the rise in the number of the convicted persons in the penal institutions, there is need to increase the budget allocation among other resources for the persons to be effectively rehabilitated. By prediction of recidivism and its risk level of the inmates the department can segment those who need incarnation and those that can be sent on community supervision order among others depending on their level of risk to the society.

Recidivism is the act of a person repeating an undesirable behavior after they have either experienced negative consequences of that behavior, or have been treated or trained to extinguish that behavior. It is also used to refer to the percentage of former prisoners who are rearrested for a similar offense (Hensil J., 2008).

Recidivism is one of the most fundamental concepts in criminal justice. It refers to a person's relapse into criminal behavior, often after receiving sanctions or undergoing intervention for a previous crime. Recidivism is the most common outcome (dependent) variable in all of criminal justice research and the rate determines the success or failure of a correctional system (O'Connor, 2013).

A research by (Gray, Birks, Allard, Ogilvie, Stewart and Lewis,2008) states that risk assessment procedures occupy a central role in the Criminal Justice System decision making process and typically involve a prediction about the likelihood that an individual will re-offend.

Use of data mining techniques like decision trees and neural networks has proved to have the potential of improving prediction accuracy of risk assessment compared with the traditional statistical techniques like the regression model, because with model efficiency prediction results will be of great significance to the public safety and offender rehabilitation.

A study by (Howard, 2000) states that Canadian criminal justice system relies heavily on prediction of risk though inherently error prone, due to the fact that there are no ‘laws ‘of behavior that can be applied to a set of circumstances to determine the behavioral outcome that will follow. Criminal behavior in particular is motivated and supported by an unquantifiable number of factors; therefore to assess an individual’s as ‘high risk’ is not to say that he/she will definitely recidivate. Despite its shortcomings, risk assessment can to a certain extent, differentiate offenders who pose a significant risk for re-offending in the future from those who are likely to refrain from committing future offenses.

The Recidivism Prediction System prototype for this research is developed using the WEKA software package for its full functionality as it includes API, Database system support, visualization, PMML support, statistical capabilities among others. More so WEKA is highly robust for a variety of users irrespective of their knowledge level in data mining and the fact that it's readily available as its open source. Together with a Front end application for better and easier visualization of the predicted results to help the management in decision making.

1.2 Problem statement

Currently Kenya Prison Department is the correctional service provider in Kenya with a number of mandates among them being containment and safe custody of inmates, rehabilitation and reformation of prisoners, facilitation and administration of justice among others. As from 2010 to 2014 the inmate's number in Kenya prisons varied between 56,051 and 109,629 and for the recidivism during the same duration range between 12,949 and 30,547 (KNBS, 2014). Therefore there is the need to have a number of ways to check recidivism. One of them will be a system to check recidivism among the inmate population which would be more accurate and efficient. By predicting the level of risk of an offender re-offending to help in determining whether an offender can be sent on various programs like parole and community service order among others, thus helping in dealing with the congestion in various prisons institutions countrywide.

The system will solely provide the Kenya Prisons Department management with more insightful information to aid in decision-making process of the day-to-day running of the department operations.

This is especially with the convicted prisoners who sole responsibility lays with the Kenya prison department until they have completed their sentence.

Currently there is no existing system in place to predict recidivism in the prison department. What exists is the use of manual and some features from the ORMS which are not specific, nor are they efficient and effective.

1.3 General Objectives

The purpose of this project was to develop a RPS (Recidivism Prediction System) prototype using Artificial Intelligent (AI) techniques to check recidivism among the inmate's population with an aim to help the prison department management in decision making.

1.3.1 Specific objectives

1. To identify and analyze the variables used in predicting recidivism in the prison inmates population
2. To identify a data mining technique suitable to predict recidivism in the prison inmates population
3. To develop a prototype application using an identified data mining technique
4. To test and validate the prototype

1.4 Research questions

1. Which is the suitable technique to use to predict recidivism in the Kenya prison population?
2. What variables in the provided dataset that most determine the probability of recidivism in the Kenya prison population?
3. How can data mining techniques be used in recidivism prediction?

1.5 Justification

Kenya Prison Department, being a Government agency, is guided by the current Kenya Vision 2030 project which puts much emphasis on technology development by using Information Technology. This is to make work easier and manageable as there is a tremendous increase in data volume. On security one of the goals includes installation of effective ICT infrastructure in all security agencies which can be achieved by a crime prevention strategy, by use of ICT (Government of Kenya, 2007).

The System will assist the department run its operations effectively considering the increase in population and the resources allocated which may not be enough and most importantly be able to utilize other modes of rehabilitation apart from confinement of prisoners. As a result the prisoner is rehabilitated and reformed to be able to re-integrate back to the society.

To the society the system will be helpful as there will be a reduction in resources used to cater for the prisoners while confined as the population is bound to decrease.

1.6 Significance of the research to Kenya Prison Department

It will provide knowledge to help the department management in decision making this is especially in adoption of various policies like on Compulsory Supervision Orders (Cap. 90, Rev 2009), parole, and pardon (Power of Mercy Act 2012 part III section 47 1 (a)) among others.

Also provide a foundation for studying the prisoner's criminal careers and may provide insight into effective reentry programs.

1.7 Limitation and assumptions

The Recidivism Prediction System takes into consideration all offenders even the life and death sentenced with the assumption that at some point there are those that appeal and are released or sentence reduce.

The system will not take into consideration of the pretrial detainees/remands prisoners as despite them being confined in the prisons their release is determined by the courts and there is the likely of the person not being sentenced as the case is ongoing.

1.8 Project scope

This project was based on selected number of prisons within the Kenya Prison department they include Nairobi medium prison, Nairobi west prison and Langata women prison. Why the stated prison considering that there around 108 prisons country wide, due to their proximity and data availability and the time given to conduct the research is limited.

The system is intended for the management team in the department; the commissioner General of Prisons, directors and the officers in charge heading the prisons countrywide.

CHAPTER TWO

2. Literature review

2.1 Introduction

In this section various techniques used in data mining for prediction are discussed and previous work which has been done on the subject.

Data mining technology has been used in various fields like business, games, science & engineering, medical among others with the goal to extract information from a data set and transform it into an understandable structure for further use. The technology has shown to be a powerful and effective methodology to help business users facilitate intelligent decision support. In particular it enables criminal investigators to explore criminal acts quickly and efficiently (Li, Kuo and Tsai, 2010).

Data mining process is best thought of as a set of nested loops rather than a straight line. The steps do have natural order, but it is not necessary or even describes to completely finish with one before moving on to the next. The tasks involved in data mining include: classification, estimation, prediction, affinity grouping and clustering (Berry, Linoff, 2010 pg 44).

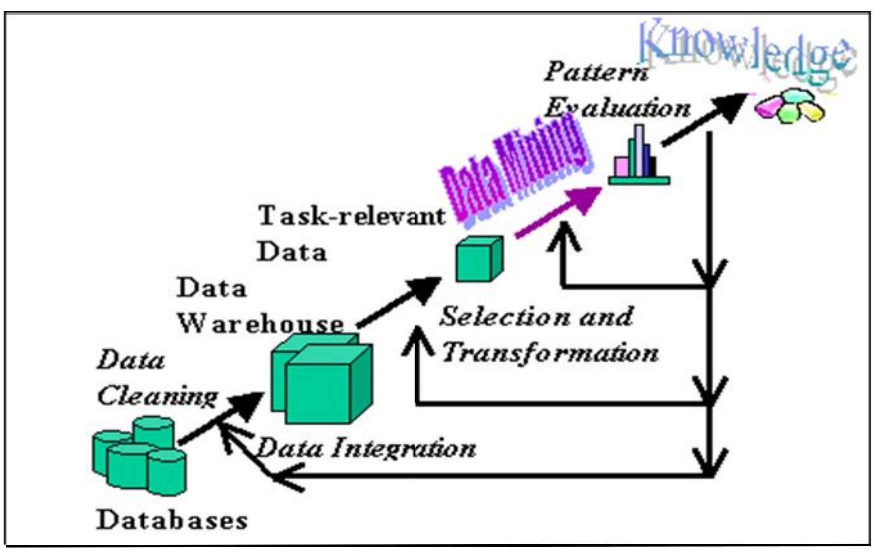


Fig 1: Data mining steps (Zaiane, 1999)

Various studies have been undertaken on recidivism especially on the risk assessment at different angle; that is female recidivism, male sexual offender's recidivism, juvenile's recidivism among others using various methods like anamnestic, clinical, and actuarial. Anamnestic (recollection) methods use historical data to determine the future actions of an individual. Clinical methods involve the human judgment of professionals such as probation officers and psychologists to make risk assessments. Actuarial methods use quantitative analyses of individual characteristics to determine risk. Both clinical and actuarial methods are commonly used today, but studies have shown that the actuarial risk prediction consistently outperforms the results of clinical risk prediction this is as stated by Gettredson &Moriarity, (2006) cited by Harris, menus, Obradovic, Izenman, Gruwald, Lockwood, Jupin and Chisholm, (2012).

The actuarial methods are more efficient as research findings consistently indicate that decision-making based on actuarial risk assessment tools is more accurate, valid and reliable than clinical decision-making this is by Ægisdottir, White, Spengler et al., 2006; Dawes et al., 1989; Gambrill & Shlonsky, 2000; Grove, Zald, Lebow, Snitz, & Nelson, 2000; Hanson, 2005 as cited by Gray, Birks, Allard, Ogilvie, Stewart and Lewis, 2008).

2.2 Importance of risk assessment

The risk assessment on the likelihood of re-offending in the justice system is highlighted by broad range of processes that require assessment and given its role in improving public safety and offender rehabilitation. The processes that require risk assessment includes; bail, sentencing, prisoner classification, parole, the case management and supervision of community based orders and the provision of effective treatment (Silver & Miller, 2002; Gottfredson & Moriarty, 2006). This is because any improvement in the ability to accurately assess risk would improve the efficiency of criminal justice decision making. Risk assessment provides a useful tool for the attainment of public safety by enabling the identification of offenders who pose an elevated risk of recidivism who require greater supervision. Consistent with the principles of best-practice for offender rehabilitation, risk assessments can also be used to target interventions, with high-risk offenders receiving intensive interventions and low-risk offenders receiving either none or minimal interventions (Andrews et al., 2006; Gray et al.,2008).

2.3 Overview of data mining techniques and related work

Data mining is the process of identifying interesting patterns from large database. It is best described as an iterative and exploratory process achieved through either automated or manual methods. The two primary roles of data mining are prediction, which involves the use of variables to predict unknown future events or values of a given outcome and description involving the identification of patterns that describe the data in a meaningful manner (Gray et al., 2008).

Data mining involves using a range of techniques which are stated in various approaches like statistical, mathematical algorithms, database oriented and machine learning among others to examine potential relationships in data sets and are often used to form predictive models of either continuous or categorical variables.

According to Gray et al., (2008), some of the more common data mining methods include neural networks, decision trees, support vector machines and algorithms for mining association rules. The algorithms can be classified according to the various distinction like; methods used to discover predictive relationships for categorical variables (i.e.: classification methods), methods used to discover predictive relationships for numeric variables and methods of association rule discovery.

2.3.1 Nearest neighbor

This is among the oldest technique used in data mining. It has similarity with clustering as its essence is that in order to predict what a prediction value is in one record look for records with similar predictor values in the historical database and use the prediction value from the record that it “nearest” to the unclassified record.

It is among the easiest to use and understand because they work in a way similar to the way that people think, by detecting closely matching examples (Berson, Smith, & Threarling, 2000).

2.3.2 Clustering

Clustering is the methods which like records are grouped together. This is done to give the end user a high level view of what is going on in the database. Mostly applied in the business area of marketing where it’s believed to give one a bird eye view of the business happenings.

The main difference between the two techniques that is clustering and nearest neighbor being one is called unsupervised learning technique and the other supervised respectively. Where the unsupervised learning techniques has no particular reason for the creation of models the way there is for supervised that are trying to perform prediction (Berson et al., 2000).

2.3.3 Rule induction

It is one of the major forms of data mining and perhaps most common of knowledge discovery in unsupervised learning systems as when applied to a database its helpful in that it can allow possible patterns which are systematically pulled from data and added accuracy and significance. The retrieval of all possible interesting patterns in the database is a strength in the sense that it leaves no stone unturned but also a weakness as users can easily become overwhelmed with such a large number of rules that it's difficult to look through all of them.

Mostly is used on databases with either fields of high cardinality or many columns of binary fields like from the retail shops that is supermarket basket data from store scanners that contains individual product names and quantities and may contain tens of thousands of different items with different items with different packaging that create hundreds of thousands of SKU identifiers (Berson et al., 2000).

According to Li et al., (2010), the framework of intelligent decision support model based on a fuzzy self organizing map network to detect and analyze crime trend patterns from temporarily crime activity data. It also incorporates rule extraction algorithm to uncover hidden casual effect knowledge and reveal the shift around effect. It is intended to identify crime trend pattern for different criminal activities, conduct temporal rule extraction to uncover their shift around effect and provide a reference for experts when analyzing the different types of crimes. The FSOM model is used to discover crime pattern which combine the features of SOM networks and fuzzy logic in dealing with clustering, visualization and linguistic information processing. The rule extraction algorithm is used to find the hidden casual effects between different temporal linguistic crime data that can help police management understand more clearly the criminal acts. Thus providing actionable information for the police management to make better use of its duty deployment and help criminal experts to develop and implement more effective law enforcement policies and crime control programs.

2.3.4 Bayesian Methods

Bayesian approaches are a fundamentally important DM technique. Given the probability distribution, Bayes classifier can probably achieve the optimal result. Bayesian method is based on the probability theory. One limitation that the Bayesian approaches cannot cross is the need of the probability estimation from the training dataset. It is noticeable that in some situations, such as the decision is clearly based on certain criteria, or the dataset has high degree of randomality, the Bayesian approaches will not be a good choice.

According to Blattenberger, Fowles and Krantz, (2010) where they use various Bayesian statistical methods the Bayesian model averaging, extreme bounds analysis and classification &regression tree. This is to explore criminological, sociological and economic factors to predict parolees' returns to prison by comparing their results to provide useful public policy guides. The results from the extreme bounds analysis and Bayesian model analysis may differ from those of the classification and regression tree in that they are based on traditional Bayesian linear specifications within the context of a normal gamma conjugate framework. The Bayesian CART model does not necessarily lead to terminal tree nodes that have high degree of homogeneity. Using extreme bounds analysis one is able to determine the variables associated with a higher risk of recidivism by showing variation of variables how they affect the results that is recidivism from economic to the number of incarnations prior to conviction despite lack of clear policy prescription from the number of prior incarnations and age of the parolee. But there is the short run solution that could reduce the total cost of crime that is development of policies aimed at enhancing the opportunities for parolees to gain employment.

2.3.5 Neural networks

A neural network is a form of statistical method that may be used to construct dynamic models of interactions among variables for the purposes of regression and classification (Paik, 2000). Neural networks are generally composed of a collection of elementary processing units interconnected by weighted connections or "relationships" of a particular strength (Gray et al.,2008). Neural networks can be used for both regression of a numeric dependent variable and classification of a categorical dependent variable.

Research by Palocsay, Wang, & Brookshire, (2000) uses neural networks models to predict criminal recidivism by splitting an offender population into two groups: non-recidivists and eventual recidivists. The results suggested that the NN models obtained significantly higher predictive accuracy in offender's classification as recidivists and non recidivists compared to logistic regression models. As prediction accuracy heavily depends on the scope of network topology, such as the number of hidden layers and nodes in each layer, the training methodologies used and node activation functions (Gray et al., 2008).

The Artificial Neural Networks (ANN) compared with other computational function, process information in parallel rather than as with conventional computing where each task is broken down into discreet subtasks and processed sequentially. By use of a cost function it's able to process complex and non linear information as it's a mathematical computation system.

The advantages of using ANN includes:

- It can be applied to incomplete, fragmented data sets.
- It can understand and analyse incomplete, nonlinear data, the sort of data produced by human behaviour ,data that linear processors (conventional computers) cannot.
- They are arguably fairer, as they recognise numerous pathways towards an end goal, and do not focus on traditional stereotypes.
- They learn from existing data, they allow for "local" validation and prediction studies that would be costly and less effective using traditional methods.

ANN has been used extensively in prediction of behavior for example the Research from the USA has looked into predicting juvenile recidivism. Traditional methods of identifying the factors that separate repeat and non-repeat offenders had accounted for 20% of the variance in recidivism. While the ANN was trained using part of a data set (120) and tested on the remaining 46. The predictability rate rose to 74% for the test population. This represents a significant increase in the ability to predict human behaviour (Booth, 2007).

2.3.6 Decision trees

Decision trees are tree-shaped structures that represent decision sets. These decisions generate rules, which then are used to classify data. Decision trees are the favored technique for building understandable models. Auditors can use them to assess, for example, whether the organization is using an appropriate cost-effective marketing strategy that is based on the assigned value of the customer, such as profit (Silltow, 2006).

Rosenfield & lewis (2005) application of a CART approach to violence risk assessment using a sample of 204 stalking offenders. The model prediction accuracy was found to be high compared to logistic regression models and relative simplicity of its application in clinical practice compared to logistic regression models (Gray et al, 2008).

Example of an application of the decision tree is the random forest modeling used by Richard Berk working with NIJ - funded researchers Geoffrey Barnesand Jordan Hyatt (2013) to build the risk prediction tool for Philadelphia's Adult Probation and Parole Department. Which can be described as hundreds of individual decision trees, where data are organized using a technique called "classification and regression trees." The computer then runs an algorithm that selects predictors at random and repeats and repeats this process to build several hundred trees which then allow the randomly selected predictors to average themselves into a single outcome. In the case of the Philadelphia tool, this outcome was assignment to one of three risk categories (high, Moderate or low) for probation-super vision purposes.

The random forest model prediction tool, allows agencies to base their personnel and policy decisions on a scientifically proven method. A tool like the one developed in Philadelphia provides an opportunity to advance the capabilities of the criminal justice system to protect communities, particularly for jurisdictions with large probation populations that must be managed with fewer dollars. This has helped probation officials manage cases more efficiently, and allowed concentration of resources where most needed (Ritter, 2013).

2.4 Data mining tools for prediction

There are various tools available that have been developed for various usage example we have Waikato Environment for Knowledge Analysis (WEKA), Rapidminer, Knostanz Information Miner (KNIME), Clementine among others. They provide a set of methods and algorithms that help in better utilization of data information available to users; that is data analysis, cluster analysis, genetic algorithms, nearest neighbor, data visualization, regression analysis, decision trees, predictive analytics, text mining among others (Wahbeh,, Al-Radaideh, Al-Kabi, and Al-Shawakfa 2008).

2.4.1 WEKA

It contains a collection of visualization tools and algorithms for data analysis and predictive modeling together with graphical user interface for easy access to this functionality. It supports several standard data mining tasks like data processing, clustering, classification, regression, visualization and feature selection. WEKA capabilities include; API, database system support, visualization capabilities, PMML support and statistical analysis capabilities (Witten, frank,& Hall, 2011).

2.4.2 KNIME

KNIME is an open source data analytics, reporting and integration platform, as it integrates various components for machine learning and data mining through its modular data pipelining concept. Mostly has been used in pharmaceutical research, customer data analysis, business intelligence and financial data analysis (Tiwaria, Abhishek, Sekhar, and Arvind K.T.,2007).

Its capabilities includes; API, database system support, visualization, statistical analysis capabilities among others (Kavoc, 2012).

2.4.3 Rapid Miner

Comparing it with the above tools rapid miner has full API support, which makes it possible to access a wide variety of functionality and support. It capabilities are same like for WEKA and KNIME but the variation comes in on users using it as using rapid miner an advanced user will be able to achieve more functions compared to less advanced user (Kavoc, 2012).

2.4.4 Orange

It is similar with the other data mining tools mentioned above on functions that can be performed. Though for one to achieve full functionality additional add-ons, widgets have to be obtained and added to the program as it's a library of objects and routines written in C++. Thus may have some effect on the software's functionality and performance. It has no additional functionality that seems relevant for the end user, as it's quite basic in its performance and operations (Kavoc, 2012).

2.5 Summary of Literature Review Findings

The Neural networks and Decision tree techniques have great potential to assist in improving the predictive accuracy of decision-making processes and instruments aimed at assessing and predicting the risk of recidivism in criminal justice settings. From various researches conducted the techniques display high level of predictive accuracy over traditional statistical methods. As with their efficiency thus more improved and efficient criminal justice decision making and they are more intuitively appealing to professionals in criminal justice practice (Gray et al., 2008)**.**

Research by Yang, Liu and Coid, (2010) which compares the traditional models, verses the data mining models accuracy measures on various scenarios. This includes overall accuracy a combination of sensitivity and specificity. The traditional methods LR and DA are more robust and controllable though limiting with number of categories involved while CT models are flexible, comparable and not restricted to large data sets with inter-correlated variables involving small effects though less plausible in risk assessment practice. When developing a model they can be manipulated technically to achieve a rather high predictive accuracy, thus resulting to poor performance in other external samples or very low accuracy in prediction of the outcome category that is relatively small.

For Neural networks it is favorable for scenarios where there are many parameters (variables) as it has the greatest flexibility to reflect complex relationships between inputs and outputs of the data. Though may be restricted by various issues like parameters change, sample size, misclassification error which may result to poor performance on an external sample. A change in parameter often causes a change in model performance in terms of predictive accuracy, having in mind that those parameters are interrelated. NN is preferred where there are large variables or target population with better homogeneity.

Neural networks and decision trees are the methods widely adopted mostly due to their prevalence in the field of data mining and proven ability to form models across a wide range of application areas. More so with advancement of data mining the two methods have proved to be most versatile and accurate techniques available. Also compared with other techniques, they are well established for adoption in criminological data (Gray et al, 2008).

Decision tree models produce a tree of decisions based on the values of the independent variables which is used to assess the predicted outcome. With its transparency helps analyst determine the exact structure of the model and how independent variables are used to arrive at its prediction. The decision trees internal workings are binary compared to the networks which are continuous. As each point of the decision tree model decision process is a discrete decision tree point. The tree slices the independent variable space into regions of different predictions.

Considering the various data mining tools as discussed earlier in the literature review section that is Rapid miner, KNIME, WEKA, Orange and jHep which most are freely available for use, and no single machine learning scheme is appropriate to all data mining problems as stated by Kavoc, 2012. Thus a tool like WEKA through its workbench provides a collection of state of the art machine learning algorithms and data preprocessing tools. It includes virtually all algorithms in data mining thus its diverse functionality characteristic, so one can quickly try out existing methods on new datasets in flexible ways. It also provides extensive support for the whole process of experimental data mining, including preparing the input data, evaluating learning schemes statistically and visualizing the input data and the results of learning (Witten, Frank, & Hall, 2011 pg 404-406).

Considering WEKA full range of API and PMML capabilities it allow importation of files from a variety of database formats thus if the RPM is to be implemented countrywide; in all prison stations the database types which may vary will not be a problem. More so the robust nature of the WEKA software on provision of various interfaces that is explorer, knowledge flow and experimental. The explorer interface is easy to navigate data and results, knowledge interface allow the user to connect various functions together in order to perform data mining functions and experimental interface allows one to compare results of more than one dataset. Therefore, it can be used by a variety of users in various setups with different levels of skills in data mining (Kavoc, 2012).

Therefore, for this project WEKA was appropriate as it could be used on existing dataset of the prisoners and analyze its output to learn more about the prisoners recidivism and also use learned models to generate predictions on new instances example to predict the prisoners likely to re-offend or apply several different learners and compare their performances to choose one for prediction. The risk factors variables for the RPS include: age, sex, socioeconomic status and unemployment. More so due to the fact that WEKA can be fed data using a file and output to a file too, thus applicable for a small scope meant for checking viability of its implementation; the development of a prototype on RPS. Due to WEKA limitation on visualization properties we have incorporated a GUI application where the prediction results are displayed using graphs and summarized into report to assist the users in decision making.

The GUI application was developed using python programming language as it’s a widely general purpose high level programming language, and supports multiple programming paradigms that is object oriented, functional or procedural styles. Therefore it is used to display the prediction results from the WEKA tool into a format that the end users can easily understand to allow easy and insightful decision making process.

CHAPTER THREE

3. Methodology

3.1 Introduction

This chapter presents the research process with details on key aspects on research methodology such as design, data, procedure and analysis which are important for a successful research activity.

It also states why specific methodology and tools were used to come up with the conclusion in line with the research area. As in data mining there are various methodologies and no standard one for applying. Thus several vendors have created their own proprietary methodologies where the approaches are strongly correlated with the design of their own software packages and solutions. The popular methodologies include Sample Explore Modify Model and Assess (SEMMA) and Cross Industry Standard Process for Data Mining (CRISP-DM). SEMMA may contain essentials elements of data mining project that is statistical, modeling and data manipulation but it lacks some fundamental parts of any information systems project like analysis, design and implementation phase. While CRISP-DM comprises of six (6) phases which are not rigid and they include; business understanding, data understanding, data preparation, modeling, evaluation and deployment much emphasis is on data which must be divided into training and validation sets. But it is limiting as techniques are selected according to data available only and not on organization goals and requirements, though it's a good approach to the general process, therefore considered for the development of the RPS for this project (Rohanizadeha, Moghadama, 2009).

Overview of CRISP-DM methodology

The methodology describes the activities as shown in the Figure 2, that are done to develop a data mining project. Every activity is composed of tasks. For every task, generated outputs and needed inputs are detailed. CRISP-DM comes up to resolve the problems that existed in data mining project developments.

The main objectives include ;ensurealing quality of data mining projects results, reducing skills required for data mining, capturing experience for reuse, general purpose (i.e., widely stable across varying applications), robust (i.e., insensitive to changes in the environment), tool and technique independent and tools supportable(Presutti, 1999).

CRISP-DM is the most commonly used methodology for developing data mining projects.

Though it has the limitation that it just defines what to do and not how to do. Another inconviniences is that CRISP-DM does not include project management activities such as quality management or change management.

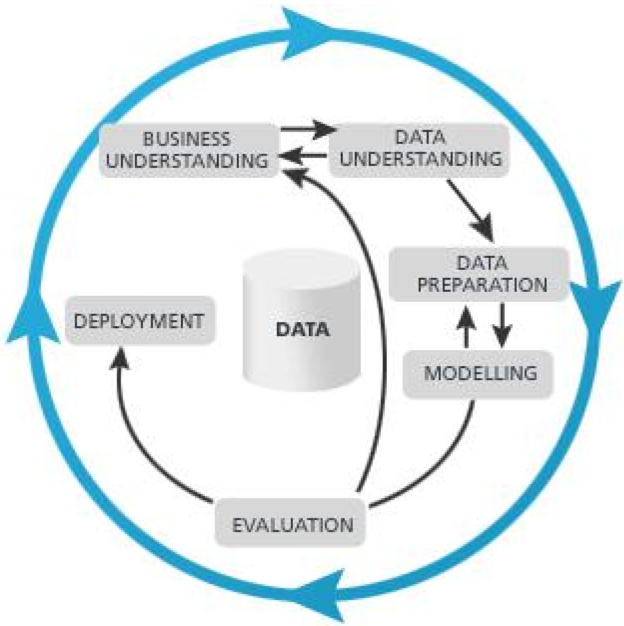


Fig 2 CRISP-DM (Rahim,. 2014)

3.2 Research analysis and design

Using the CRISP-DM methodology in the research enabled a better understanding of the data from the Offenders Record Management System (ORMS) by analyzing it using Ms Excel and WEKA tool for the pattern and prediction on occurrence of re-offending of an already convicted prisoner. It involved:

3.2.1 Requirements Analysis

Understanding Recidivism

As stated by various researches like Howell, 2003 and Omboto, 2010 a number of factors like education, vocational training, counseling, farming skills and financial support are sought to affect the recidivism in prisons from a social perspective. And according to Haseltine and day, 2011, prisoners with higher level of education found it difficult to stay in prison and tried their best to move out of prison, as education is enlightening and equips the prisoners with positive attitude and outlook of life which enables them to overcome crime and other high risk behaviors (Hoffman, 2004 and Chappel, 2002). With this we were able to narrow down to the most likely attributes that can be used to determine a prisoner's likely hood of re-offending.

With the range of factors which are thought to affect recidivism from different research work which has been done it was a guide for the attributes (variables) to be used for the RPS. Though no clear cut line on how it can be prevented or reduced the RPS can be used with the existing measures to help in minimizing the congestion in the prisons institutions and ensuring that the prisoners are rehabilitated.

Considering the prisons department mandates which include; containment and safe custody of inmates, rehabilitation and reformation of prisoners, facilitation of administration of justice among others. Prediction of recidivism in the department would be much helpful in measuring whether the various activities on rehabilitation that are in place are helpful in meeting the mandates especially rehabilitation and reformation of prisoners. And more so give a guide line on the various policies to be implemented for efficient and effective service delivery.

The data mining goals being to:

- Extract recidivism patterns by analyzing of the dataset from the ORMS of the three stations
- Prediction of recidivism based on the existing data and anticipation of recidivism rate using data mining techniques

This is with an aim of helping in the current state of congestion in the various prison institutions.

Architecture design

This represent a conceptual design of the recidivism prediction system (RPS) based on the various subsystems that were interlinked. By showing how the various processes of the systems are interacting from data inputs, data cleaning, artificial intelligent using WEKA, input and output file, decision support systems and the decision makers.

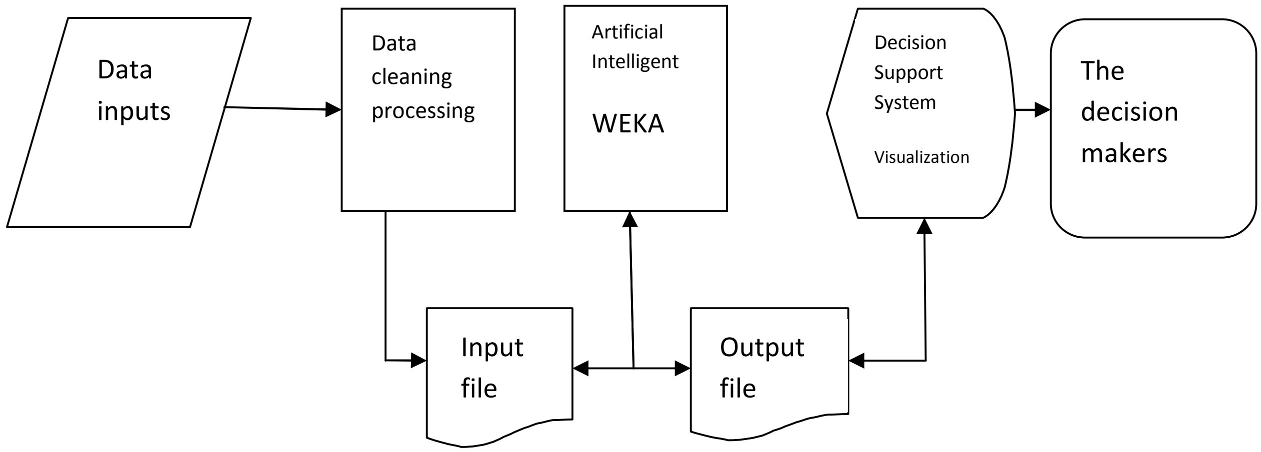


Fig 3: The architecture design of the prototype

3.2.2 Data collection and analysis

As stated from the previous phase the already known factors that affect recidivism act as a guide to the attributes (variables) to be used in the RPS. They include date of sentence, age, religion, region, occupation, education, marital status and previous conviction as the target dataset.

The data collected of the ORMS database from the three stations that are Langata women, Nairobi west and Nairobi medium existed in SQL format therefore had to be extracted to meet the intended need.

To manage the collection of data from the three stations, it involved acquiring permission letter from the prisons Headquarter. This was during the initial stage of the research when writing the proposal.

Due to the state of the databases at the station level which had a lot of incomplete fields which would have posed as an error during prediction, there was need to extract a target dataset file from the SQL files collected from the three prison stations.

Thus the use of Comma Separated Values (CSV) and Attribute-Related File Format (ARFF) file which can be feed into the WEKA tool.

The methods used for data collection in this research work included: visiting of site (secondary data) and interview conducted during the testing period to check the viability of the prototype to the users.

The data collection process

At this stage for the researcher to collect the initial data, it involved visiting the site and interacting with the Offenders Record Management System (ORMS) of the station in question. Being that all of the three stations were using the same database My SQL the process involved was the same. This is illustrated by the following steps:

Steps:

a) Using Mysql admin window to assess the database, which showed the databases operational and for this case the interest was on the Inmates database
b) Import the inmates database sql file
c) Save in a portable memory (flush disk) for later use, as the sizes of the files was manageable; with a size between 500mb and 1000mb.

The **Figure 4** shows a sample of the collected data from one of the station extracted into a Ms excel format

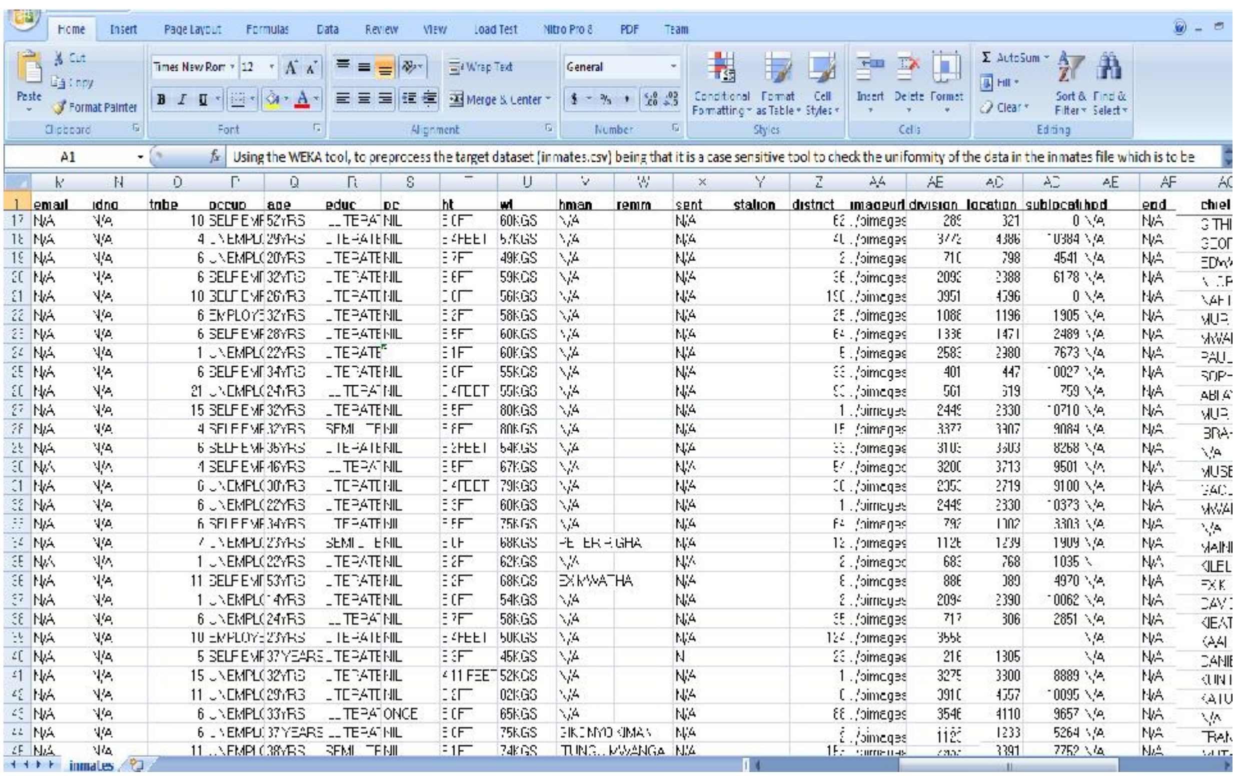


Figure 4: The raw data from the ORMS

Steps for extracting the data:

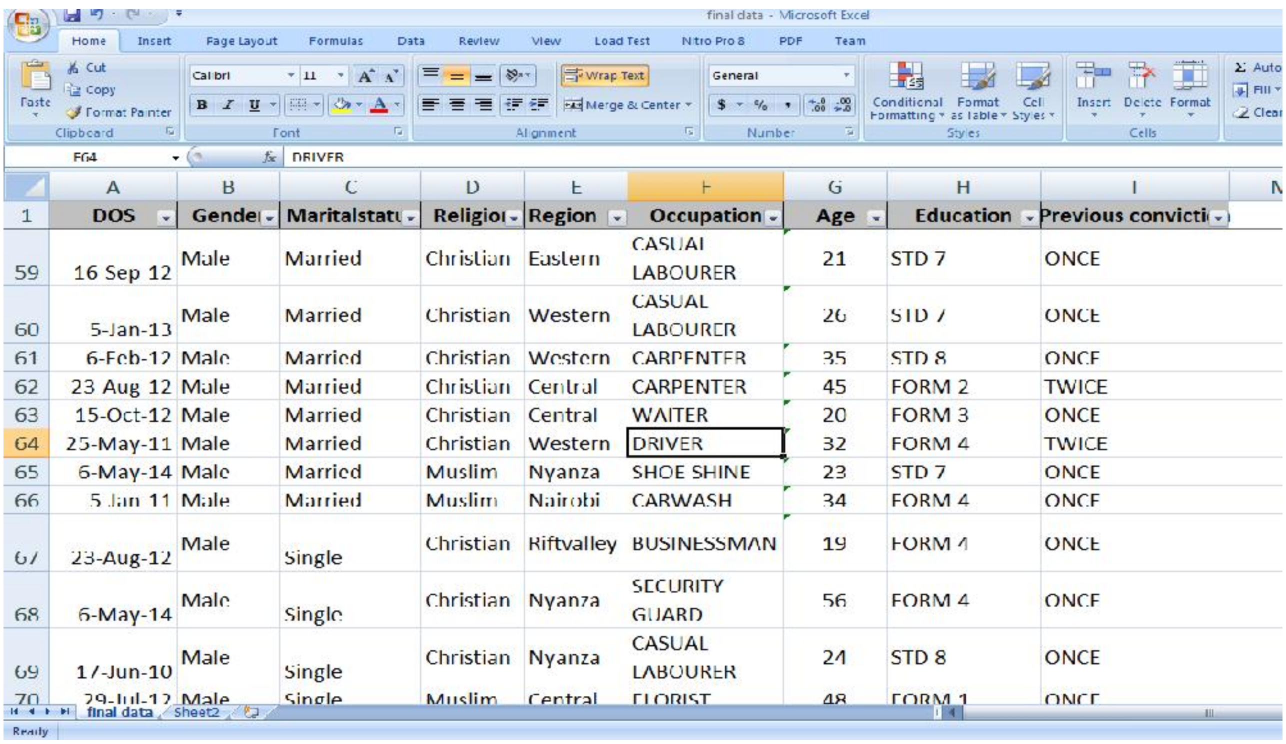
At this stage the data saved in the flush disk from the station was extracted to a format that could be input to the WEKA tool. The steps undertaken for extraction are as follows:

i. Using ODBC application interface was able to transfer the SQL data from the three stations from MYSQL platform to MS Access

ii. Then from the MS Access database exported the inmates table to MS Excel

iii. Using Ms Excel cleaned the data using the filter option; this involves removing blank spaces and non-uniformed data among others.

The **Figure 5** shows a sample of the cleaned data displayed using Ms excel



	DOS	Gender	Maritalstatu	Religion	Region	Occupation	Age	Education	Previous convicti
59	16 Sep 12	Male	Married	Christian	Eastern	CASUAL LABOURER	21	STD 7	ONCE
60	5-Jan-13	Male	Married	Christian	Western	CASUAL LABOURER	26	STD 7	ONCE
61	6-Feb-12	Male	Married	Christian	Western	CARPENTER	35	STD 8	ONCE
62	23 Aug 12	Male	Married	Christian	Central	CARPENTER	45	FORM 2	TWICE
63	15-Oct-12	Male	Married	Christian	Central	WAITER	20	FORM 3	ONCE
64	25-May-11	Male	Married	Christian	Western	DRIVER	32	FORM 4	TWICE
65	6-May-14	Male	Married	Muslim	Nyanza	SHOE SHINE	23	STD 7	ONCE
66	5 Jan 11	Male	Married	Muslim	Nairobi	CARWASH	34	FORM 4	ONCE
67	23-Aug-12	Male	Single	Christian	Riftvalley	BUSINESSMAN	19	FORM 4	ONCE
68	6-May-14	Male	Single	Christian	Nyanza	SECURITY GUARD	56	FORM 4	ONCE
69	17-Jun-10	Male	Single	Christian	Nyanza	CASUAL LABOURER	24	STD 8	ONCE
70	29-Jul-12	Male	Single	Muslim	Central	FLORIST	48	FORM 1	ONCE

Figure 5: The processed data to be loaded to WEKA

iv. Picked the nine (9) attributes the date of sentence, age, religion, region, occupation, education, marital status and previous conviction as the target dataset to a separate workbook

v. Then converted the Excel file containing the target dataset to a CSV format for easy use in the WEKA tool, when saving it.

The interview

The interview mode of data collection was used to check the prototypes viability to the end users need on recidivism at the testing stage. This is after the RPS prototype was developed.

Involved two types of interviews the personal interview and telephone interview; this is because of the time available for research and the availability of the end users due to their tight schedules at work.

The questions for the interview included:

1. The level of automation of prisoners records in the department, whether it's efficient enough to enable service delivery.
2. Whether there is any advantage in automation of prison activities; example the use of the RPS?
3. Considering the rate of recidivism in prisons, would the RPS be of help in the day to day running of the department.
4. Whether he/she could advocate for the RPS implementation in the department

3.2.3 Data preparation

The collected data from various stations is diverse and due to the fact that the ORMS is still in its initial state of implementation in the department thus there were missing values, inconsistence data and not useful data. Thus data preprocessing was inevitable as it's a process that consists of data cleaning, data integration and data transformation, with intent to reduce some noises, incomplete and inconsistent data.

Using the WEKA tool, to preprocess the target dataset (inmates.csv) being that it is a case sensitive tool to check the uniformity of the data in the inmates file which is to be used in the system for prediction.

This is to enhance the quality of the output from the system.

The preprocessing includes the following tasks:

i. **Data cleaning:** fill in missing values, smooth noisy data, identify or remove outliers, and resolve inconsistencies (there are many modest proposals for filling missing values).

Different preprocessing techniques were used to get clean data, these include:

- Removing outliers, some of the data in the inmate's (inmates.csv) datasets represent outliers and cannot be included in the analysis algorithms and techniques, so these data records were deleted from the, set.
- Filling missing data,

ii. **Data integration:** using multiple databases, data cubes, or files (since our data are collected from various stations, the data are integrated to build uniform datasets).

iii. **Data transformation:** normalization and aggregation

There was no much normalization involved as all attributes were a determining factor for the end result on recidivism rate.

iv. **Data reduction:** reducing the volume but producing the same or similar analytical results (Omitting entire records because they have more than three missing values so the filling will cause noisy).

v. **Data discreetisation:** part of data reduction, replacing numerical attributes with nominal ones

For easy interaction the value for the number of convicted times was changed from numeric to alphabetic for easy interaction

Therefore out of the 2000 instances collected from the three (3) stations, after preprocessing process there was 624 instances that could be used in the WEKA tool.

CHAPTER FOUR

4.0 Prototype development

4.1 Introduction

In this section the process of developing the prototype using both WEKA tool for prediction and the Python GUI to assist the end user in accessing the relevant data through better visualization is detailed.

The WEKA tool use the data inmates file to predict on the rate of a person who had been earlier convicted being convicted again, using a number of algorithms like the; BayesNets, J48 and multilayerperceptron. The result from all algorithms is compared to see that with a high level of accuracy among others. Providing a platform to compare practically the algorithms (techniques in data mining) those with the highest level of accuracy, thus helping in the identification of the optimal results to assist the users in the decision making.

The output from the WEKA tool is then input to the Python GUI application for better visualization into reports and graphs. This is to give the end users a better view of predicted results.

4.2 Prototype development Process

In this section it includes detailed illustration on how during development of the prototype the researcher interacted with both the WEKA tool and the Python GUI application to the accomplishment of the third objective stated earlier.

4.2.1 WEKA Tool

This involves the comparison of results from various models built using different algorithms (techniques) with an essence of identifying that with the highest prediction rate on recidivism.

BayesNets

A Bayesian classifier is a program which predicts a class value given a set of attributes.

Using the Bayes rule where C is a class value and the attributes are A_1, A_2……A_n

$$P(C|A_1, A_2 ... A_n) = \frac{(\prod_{i=1}^{n} P(A_i \mid C))P(C)}{P(A_1, A_2 ... A_n)}$$

For each known class value,

1. Calculate probabilities for each attribute, conditional on the class value.
2. Use the product rule to obtain a joint conditional probability for the attributes.
3. Use Bayes rule to derive conditional probabilities for the class variable.

Once this has been done for all class values, output the class with the highest probability.

The Figure 6 shows the results from the BayesNets algorithm run using the percentage split test option. It comprise of four columns the instance, actual value, predicted and error prediction. Whereby like for instance 1 to 4 the predicted class is 2 whose value is ONCE and that of instance 5 predicted classes is 1 but value is TWICE with a probability that instance 5 actually belongs to class 1 is estimated at 0.693.

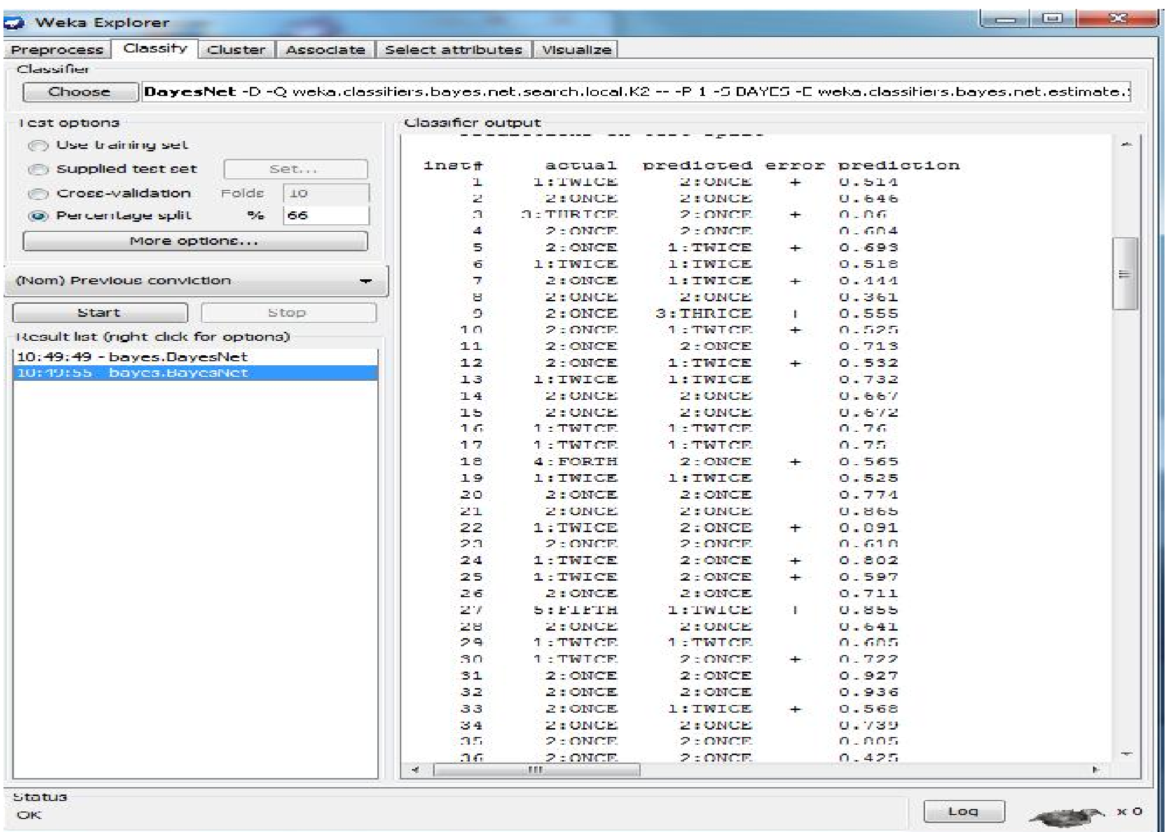


Fig 6: Prediction result of BayesNet

While the Figure 7 shows the confusion matrix which shows the class proper placing and the percentage level of accuracy (correctly classified instances) of the same test option.

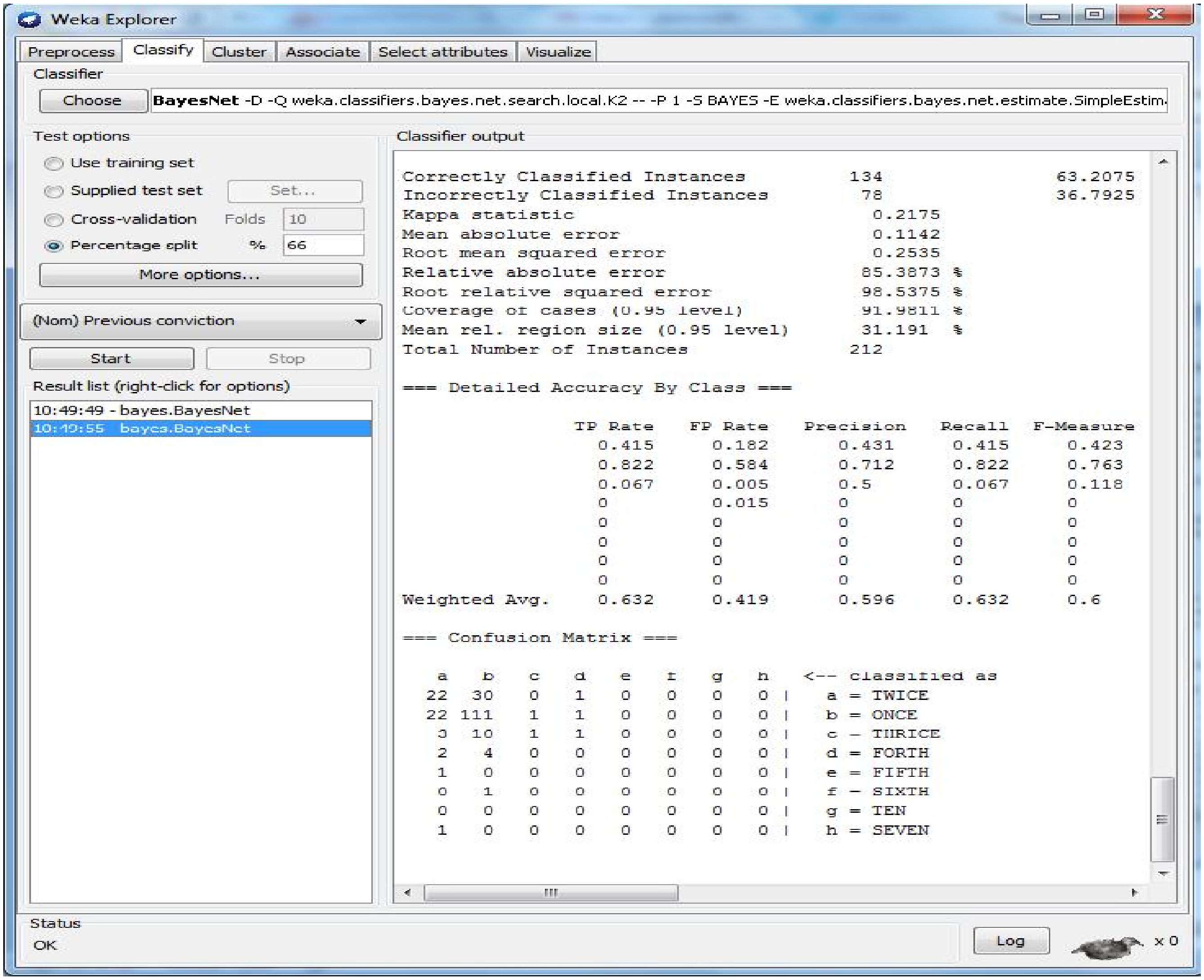


Fig 7: Second part of prediction results of BayesNet

J48

At this section the researcher illustrate the use of the J48 algorithm (decision tree) whose accuracy level may not vary much with the previous results but has much difference on the error prediction. This is shown in the figure 8 below where the prediction result is different in that most of them are predicted for class 2 whose value is ONCE and the probability is constant compared to that of Bayesnet which valid with some as high as 0.972.

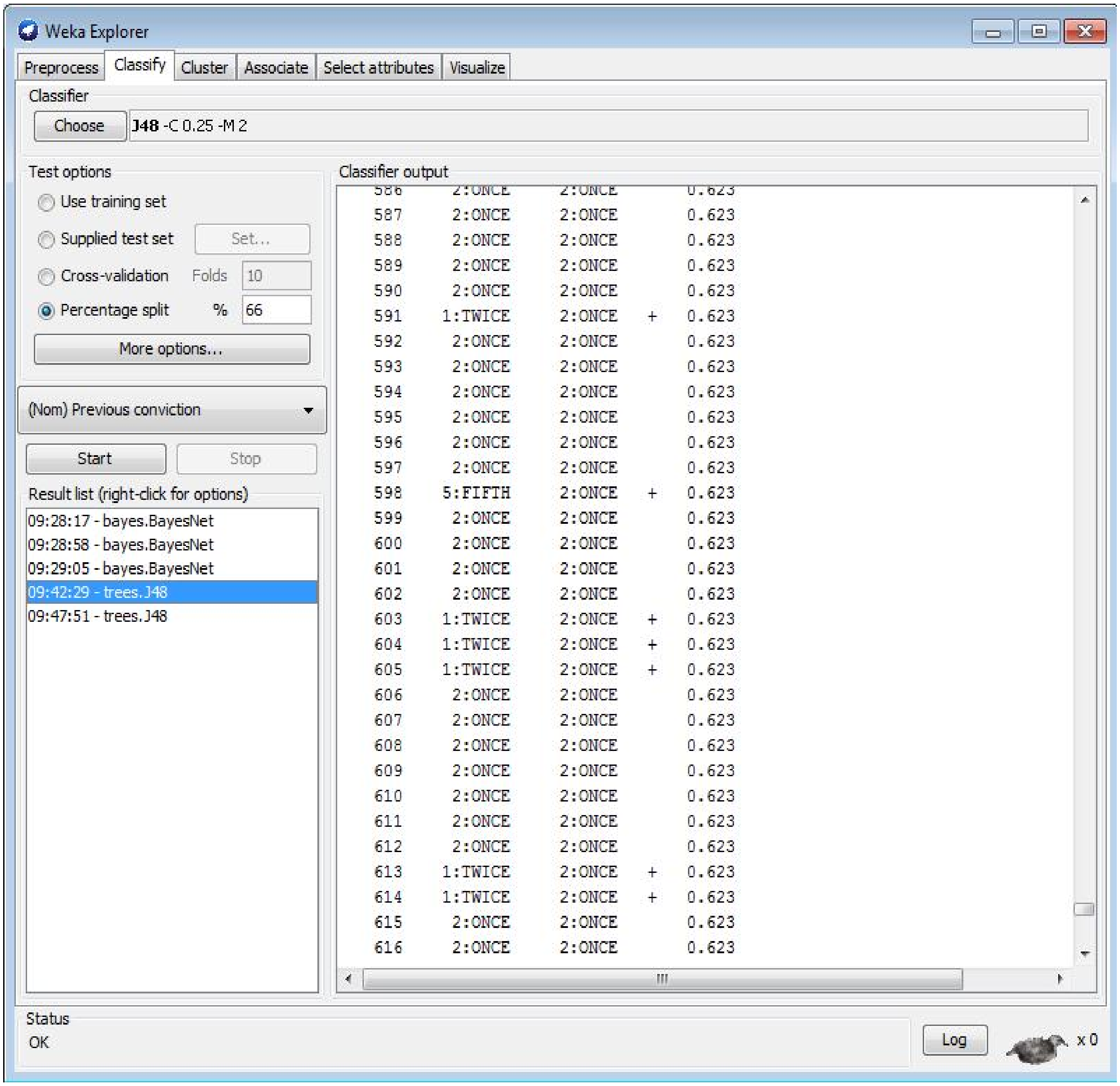


Fig 8: Prediction results using Decision tree (J48)

The Figure 9 shows the decision tree confusion matrix and the correctness of instances that have been well classified.

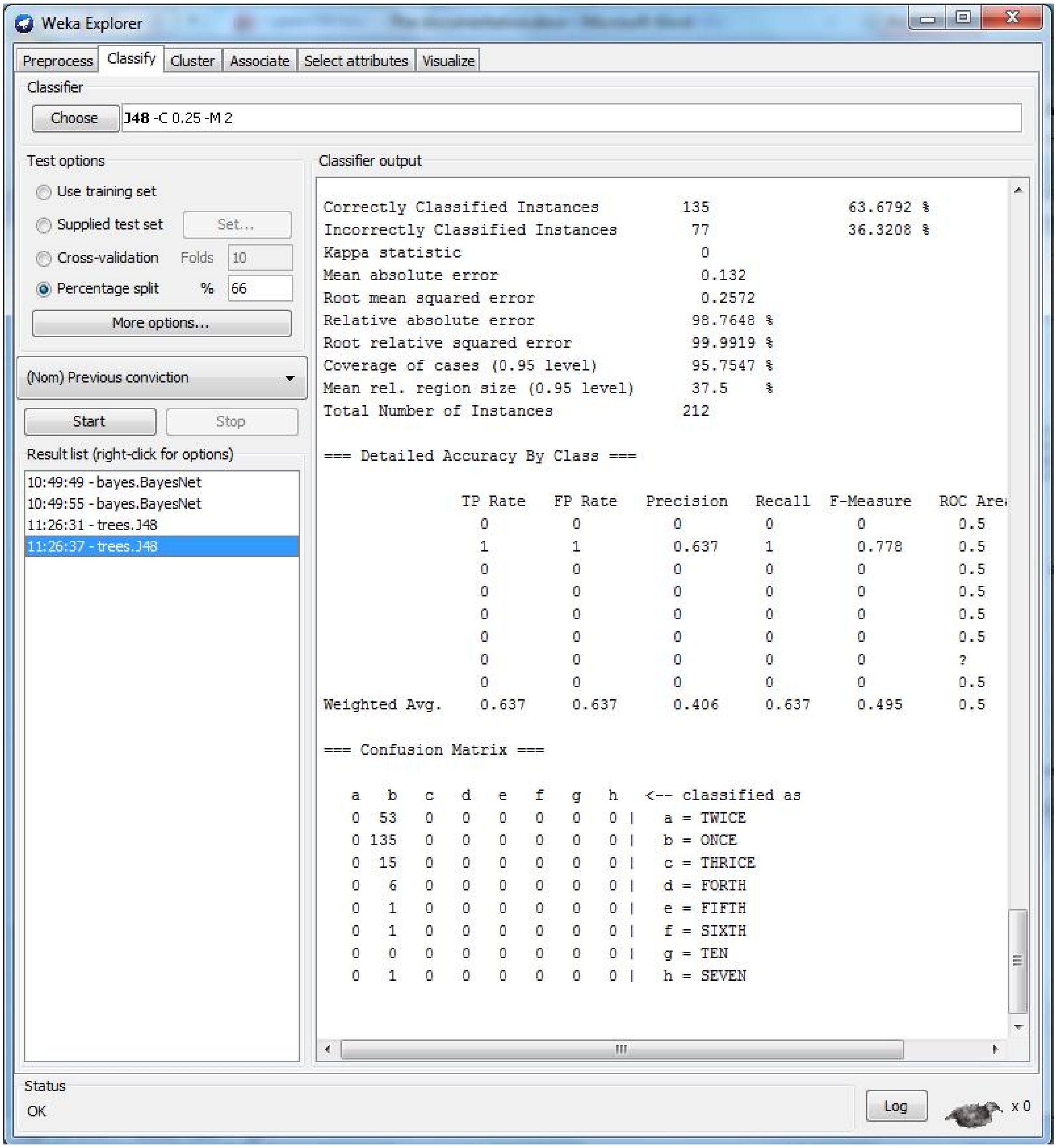
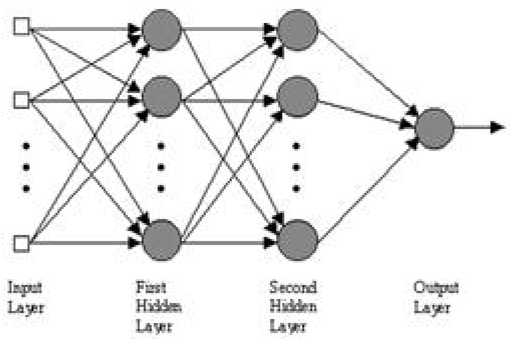


Fig 9: Second part of the J48 prediction results

Multilayerperceptron

In this section the researcher illustrates the result from the multilayerperceptron, which is the most common neural network model, also known as supervised network as it requires a desired output in order to learn. Its goal is to create a model that correctly maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown.

A graphical representation of an MLP is shown below:



(Mu-sigma,2014)

Fig 10: Graphical representation of MLP

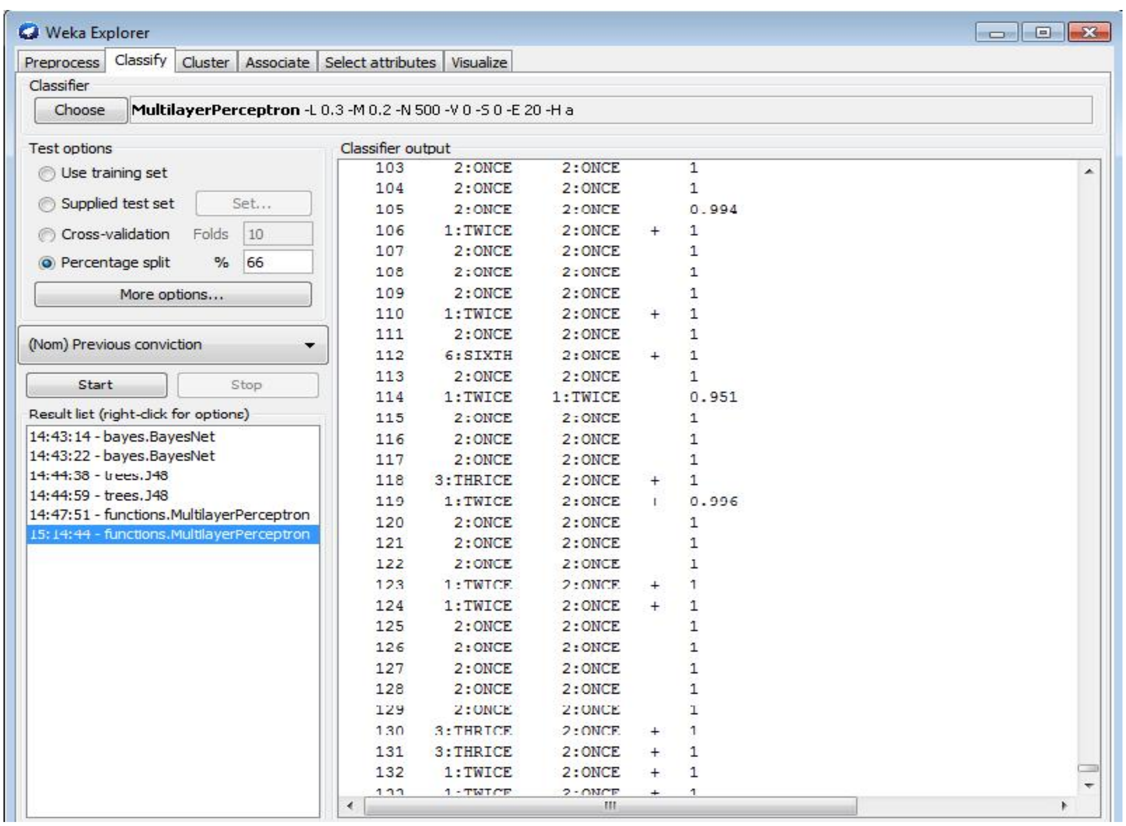


Fig 11: Prediction of the results of multilayerperceptron

The figure 11 shows the multilayer-perceptron prediction results the predicted value and the value it’s estimated at.

Compared from the rest of the algorithms i.e. the BayesNets and J48 the Multilayer-perceptron has a high accuracy level and the probability of the predicted class being in the said predicted class is high, showing that the Neural Network is a better option as a data mining technique.

As it learn using an algorithm called back-propagation, where the input data is repeatedly presented to the neural network with each presentation the output of the NN is compared to the desired output and an error is computed.

As shown in the Figure 12.

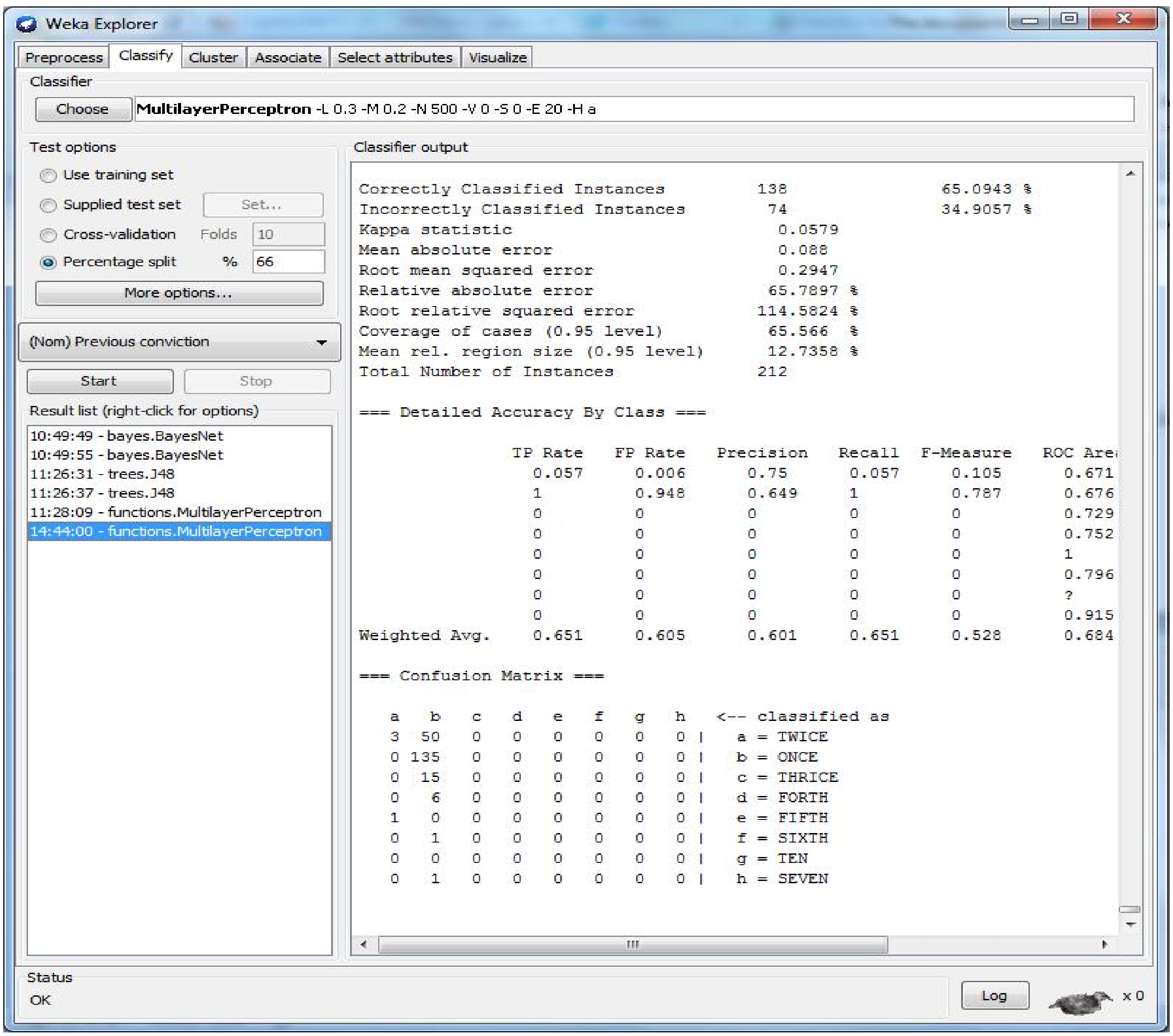


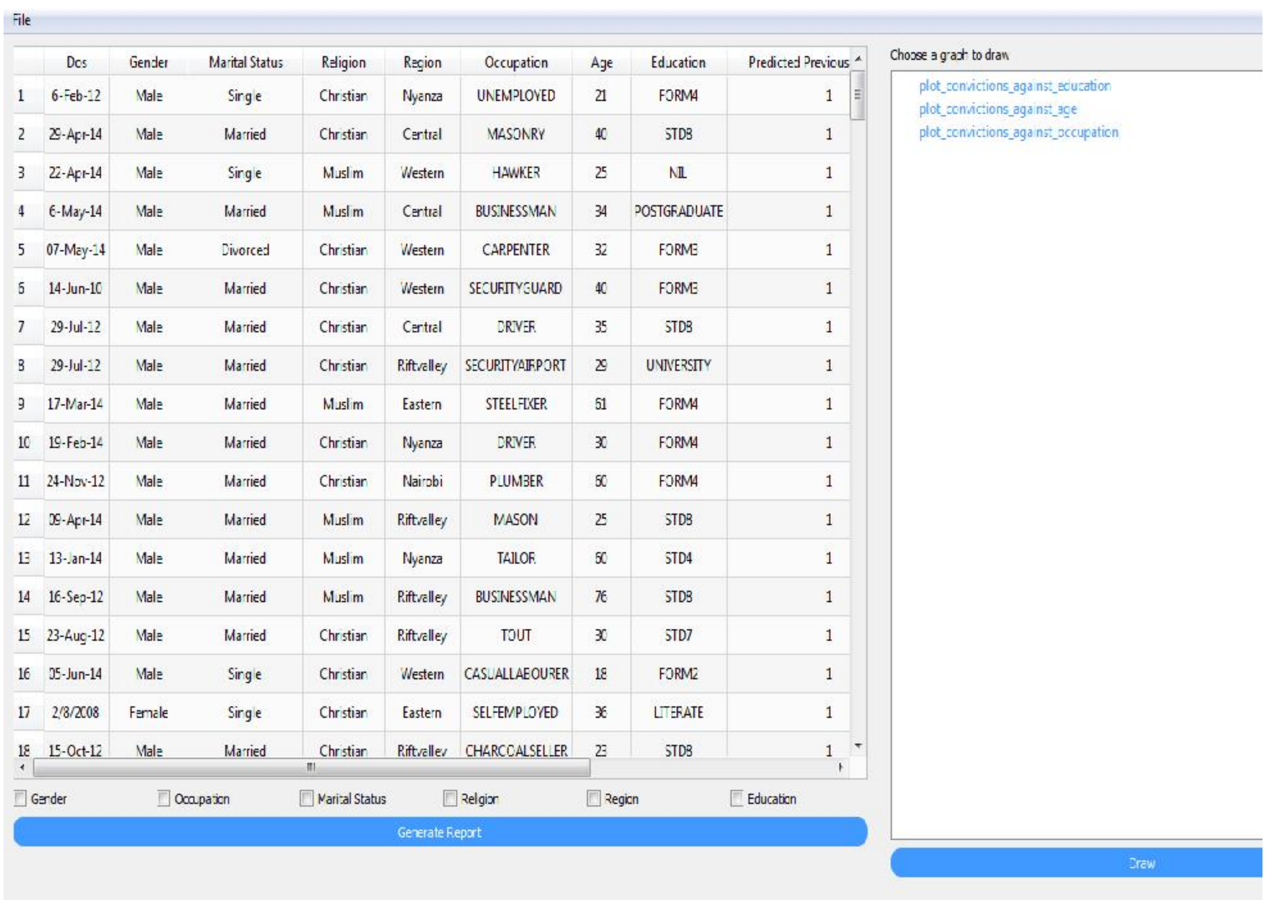
Fig 12: Results of the Multilayerperceptron

The figure 12 shows the confusion matrix of the multilayer-perceptron, the correctness of instances that have been well classified.

4.2.2 The Graphical User Interface application

At this section there is the detailed illustration of how the researcher developed the Python GUI application for the project. This is to help in better and clear visualization of the predicted results by use of reports and graphs.

Its developed using the python software which is a widely used general purpose high level programming language and features includes a dynamic type system, automatic memory management and a large comprehensive standard library. More on the need of the python GUI being used is in the summary part of the literature review part of this report.



	Dos	Gender	Marital Status	Religion	Region	Occupation	Age	Education	Predicted Previous
1	6-Feb-12	Male	Single	Christian	Nyanza	UNEMPLOYED	21	FORM4	1
2	29-Apr-14	Male	Married	Christian	Central	MASONRY	40	STD8	1
3	22-Apr-14	Male	Single	Muslim	Western	HAWKER	25	NIL	1
4	6-May-14	Male	Married	Muslim	Central	BUSINESSMAN	34	POSTGRADUATE	1
5	07-May-14	Male	Divorced	Christian	Western	CARPENTER	32	FORM3	1
6	14-Jun-10	Male	Married	Christian	Western	SECURITYGUARD	40	FORM3	1
7	29-Jul-12	Male	Married	Christian	Central	DRIVER	35	STD8	1
8	29-Jul-12	Male	Married	Christian	Riftvalley	SECURITYAIRPORT	29	UNIVERSITY	1
9	17-Mar-14	Male	Married	Muslim	Eastern	STEELFIXER	61	FORM4	1
10	19-Feb-14	Male	Married	Christian	Nyanza	DRIVER	30	FORM4	1
11	24-Nov-12	Male	Married	Christian	Nairobi	PLUMBER	60	FORM4	1
12	09-Apr-14	Male	Married	Muslim	Riftvalley	MASON	25	STD8	1
13	13-Jan-14	Male	Married	Muslim	Nyanza	TAILOR	60	STD4	1
14	16-Sep-12	Male	Married	Muslim	Riftvalley	BUSINESSMAN	76	STD8	1
15	23-Aug-12	Male	Married	Christian	Riftvalley	TOUT	30	STD7	1
16	05-Jun-14	Male	Single	Christian	Western	CASUALLABOURER	18	FORM2	1
17	2/8/2008	Female	Single	Christian	Eastern	SELFEMPLOYED	36	LITERATE	1
18	15-Oct-12	Male	Married	Christian	Riftvalley	CHARCOALSELLER	23	STD8	1

Fig 13: Report generated by the GUI application

The Figure 13 shows the actual GUI application interface where we have the report part and the graphs, where the nine attributes are shown of the instances. In this case the figure 13 is a report of all the attributes and some instances from the predicted result. From the report the user can opt to fetch specific data, for instance the female or male, occupation, marital status, religion and education.

Functionalities

1. Input of predicted results from WEKA
    - Predict on recidivism rate
2. Decision support function
    - Visualization of prediction on graphs to the users

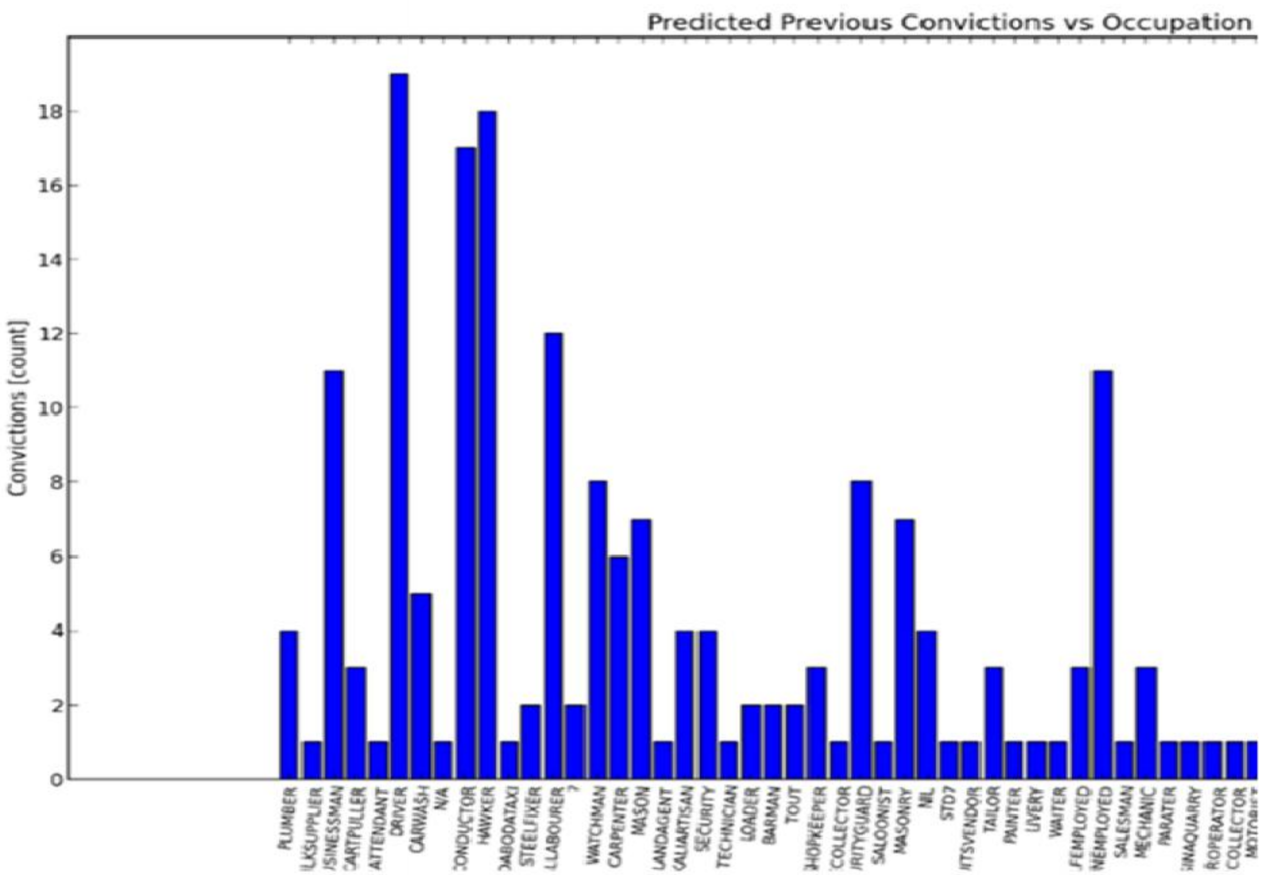
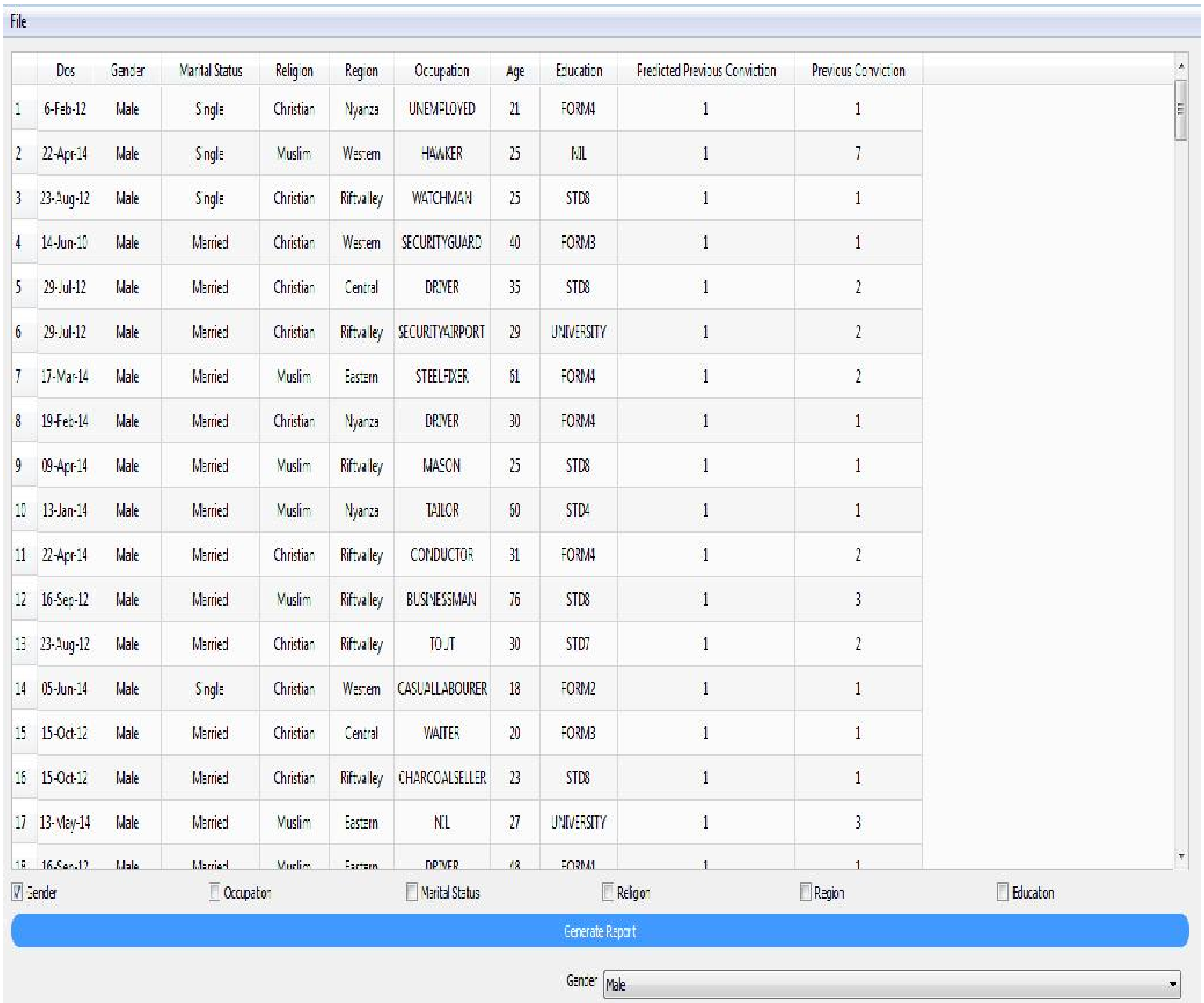


Fig 14: Graph on previous conviction prediction and occupation

The Figure 14 shows a graph from the application which shows the rate of recidivism against various occupations, where the driver and hawker are the likely persons to be reconvicted.

- Report generation



	Dos	Gender	Marital Status	Religion	Region	Occupation	Age	Education	Predicted Previous Conviction	Previous Conviction
1	6-Feb-12	Male	Single	Christian	Nyanza	UNEMPLOYED	21	FORM4	1	1
2	22-Apr-14	Male	Single	Muslim	Western	HAWKER	25	NIL	1	7
3	23-Aug-12	Male	Single	Christian	Riftvalley	WATCHMAN	25	STD8	1	1
4	14-Jun-10	Male	Married	Christian	Western	SECURITYGUARD	40	FORM3	1	1
5	29-Jul-12	Male	Married	Christian	Central	DRIVER	35	STD8	1	2
6	29-Jul-12	Male	Married	Christian	Riftvalley	SECURITYAIRPORT	29	UNIVERSITY	1	2
7	17-Mar-14	Male	Married	Muslim	Eastern	STEELFIXER	61	FORM4	1	2
8	19-Feb-14	Male	Married	Christian	Nyanza	DRIVER	30	FORM4	1	1
9	09-Apr-14	Male	Married	Muslim	Riftvalley	MASON	25	STD8	1	1
10	13-Jan-14	Male	Married	Muslim	Nyanza	TAILOR	60	STD4	1	1
11	22-Apr-14	Male	Married	Christian	Riftvalley	CONDUCTOR	31	FORM4	1	2
12	16-Sep-12	Male	Married	Muslim	Riftvalley	BUSINESSMAN	76	STD8	1	3
13	23-Aug-12	Male	Married	Christian	Riftvalley	TOUT	30	STD7	1	2
14	05-Jun-14	Male	Single	Christian	Western	CASUALLABOURER	18	FORM2	1	1
15	15-Oct-12	Male	Married	Christian	Central	WAITER	20	FORM3	1	1
16	15-Oct-12	Male	Married	Christian	Riftvalley	CHARCOALSELLER	23	STD8	1	1
17	13-May-14	Male	Married	Muslim	Eastern	NIL	27	UNIVERSITY	1	3
18	16-Sep-12	Male	Married	Muslim	Eastern	DRIVER	48	FORM4	1	1

Fig 15: Report of male convicts on rate of recidivism

The Figure 15 shows a report sample of the male convicted persons and other attributes.

CHAPTER FIVE

5. Results

5.1 Introduction

In this section, the results obtained from the developed prototype are described. The purpose is to establish if the prototype met the functional requirements of the system and if the results can be relied on to make a decision on various management issues on prisoner's rehabilitation. This is on the viable rehabilitation programs to be used on a prisoner be it incarnation, parole, community service among others.

Table 1: Tabulation results from the WEKA algorithms

	Test options	**Training set**	**Percentage split**
	Algorithms	**Correctly classified instances**	
1	**BayesNet**	76%	63%
2	**J48**	62%	63%
3	**Multilayerperceptron**	62%	65%

The table 1 shows the variation on various algorithms accuracy level done using different methods; the training data and the percentage split, whereby the results from the ANN (multilayerperceptron) are more reliable since it has a higher accuracy level compared to the other techniques used i.e. the BayesNets and J48.

Where the prediction value is TWICE and ONCE, thus for those with a higher value from twice and above are considered of high risk so they can be proposed to be treated in special way to avoid their chance of being convicted again after release, or introduction of various programs that will help cub the chances of the convicted prisoners being convicted again.

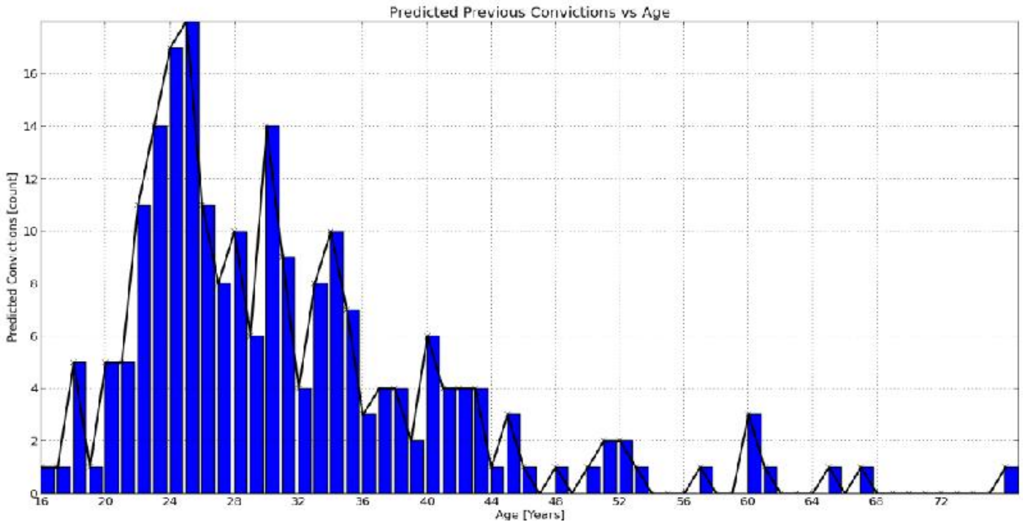


Fig 16: Graphical representation on Age and previous conviction prediction

Figure 16 shows a graph on result of the predicted values visualized that can assist the user in various decisions as far as recidivism is concerned, where the rate of recidivism is compared with the age. From the graph there is the age group which is more prone to recidivism than other, the age between 23 and 32.

The RPS assist in strategic recidivism analysis as it is concerned with long term problems and planning for long term projects, by allowing examination of long term increase or decrease in recidivism.

Also include administrative analysis focus by providing summary data, statistics and general trend information to the prison management.

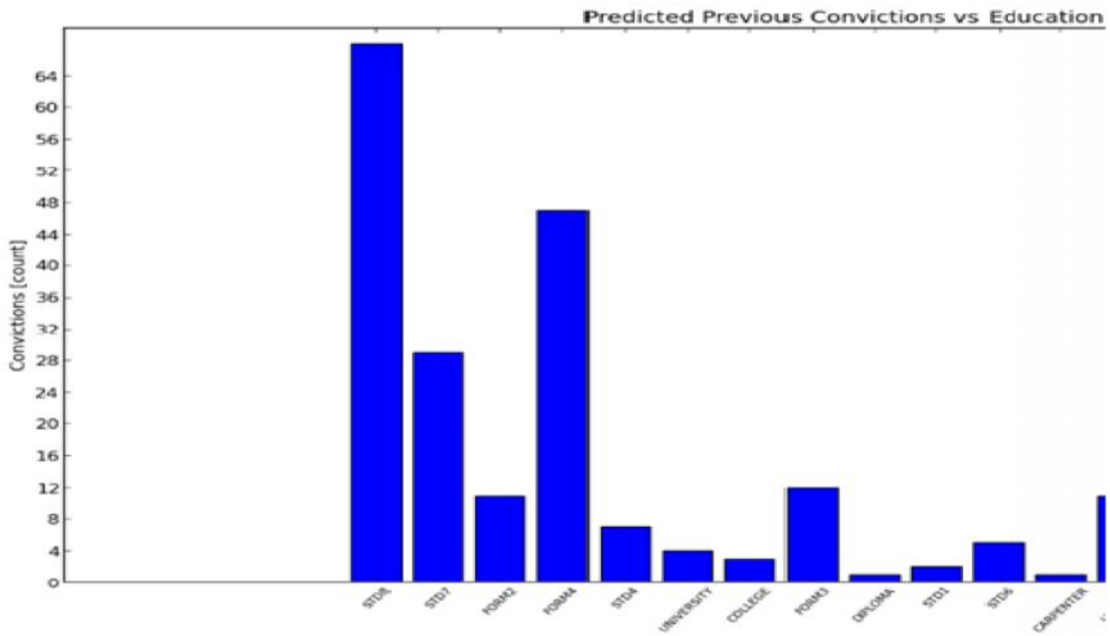


Figure 17: Graphical representation on level of education and previous conviction prediction

From the graph in figure 17 the user of the system can be able to tell the level of education of those with a high risk of recidivism.

As assessing recidivism through analysis helps in prevention efforts, because prevention will cost less, compared to the cost incurred when there is high population in the prison institutions especially due to high rate of recidivism.

5.2 System Evaluation

Considering the results from the algorithms, of all the instances there is a prediction of a prisoner being convicted again. As observed there are those whose chances are once or twice, depending on other attributes of that specific instance.

5.3 System testing

In this section the objective was to verify that the system had the functionalities required to monitor recidivism in the prisoner's population. How well the two applications interface and give an end result which can be used by the prison management in decision making.

This is from the reports and the graphs generated or displayed when running. Some of the reports and graphs include:

- Figure 15 report of male convicts on rate of recidivism
- Figure 16 Graph representation age and previous conviction prediction
- Figure 17 Graph representation level of education and previous conviction prediction

5.3.1 User acceptance testing

This formed the final stage of testing the developed RPS prototype. The officers working in the three (3) stations; langata women, Nairobi west and Nairobi medium prisons at the data entry point of prisoners' records and release of prisoners were given access to use the prototype. The main objective being to check if the user expectations were met by the prototype developed.

In order to ensure proper testing of the prototype, the researcher interviewed a number of officers from the three stations; Nairobi west prison, Nairobi medium and Langata women. The officer's interviewed were senior, middle and junior officers in the institution. Those interviewed were eight officers at least two from the three stations that data had been corrected from and one officer based at the prison headquarters.

Out of the eight officers interviewed six of them were positive towards the use of the prototype as a tool to help in the rehabilitation and reformation in the department. This is because it provides the knowledge to the users on determining the recidivism rate of a new prisoner who has just been brought from court by comparing his or her details provided with the prototype existing predictions.

Summary on the interview results

From the interview conducted, the officers from the various stations in the KPS agreed that recidivism truly exist in the department. The various modes/programs for rehabilitation and reformation of the prisoners include:

- Vocational training
- Professional courses
- Formal learning
- Counseling

- Chaplaincy
- Sports and recreation
- Offender development
- Case management
- Volunteer and placement

Though it was noted that the level of automation in the department is generally poor, but if systems like RPS were implemented they would be of great help in the listed programs on rehabilitation.

The benefits of the RPS to the department from the interview result:

a) The system would be of much help to the department if used together with the existing measures due to the sensitivity of the issue; the convicted person, as a person whose chance of reconviction is once can be considered for other rehabilitation programs like parole or community service after serving his sentence for a while among other factors.
b) Allow development of other programs that would be of help to control the rate of recidivism in the department

Challenges encountered from the interview result

a) Being a new technology in the department enough training is needed to show how well the RPS is relevant to the needs of the department on recidivism

Thus it meets the intended goal of a recidivism pattern and the prediction rate which were the goals during the initial phase on recidivism understanding.

CHAPTER SIX

6. Conclusion, Recommendation and Future Works

6.1 Conclusion

The prison department has a large volume of data especially on prisoners that if it was well stored and data mined it would be of much assistance to the prison department management, as illustrated by the development of the operational prototype on the RPS.

The big data within the department has not adequately been used for analysis and predicting of future trends to aid in decision making process. There is no prediction in place if any they only rely on numbers especially on recidivism and projected future numbers which is not realistic.

The effective knowledge discovery techniques and tools of data mining in the modern world are important in the building of intelligent analysis and prediction systems from the big data in various industries. Data mining and prediction tools like WEKA used in this research and the prototype building have proved to be very efficient in prediction from the big data available in the department on recidivism.

The objectives set earlier at the introduction of the project, have been realized as follows:

a) To identify and analyze the variables to be used to predict recidivism in the prison inmates population.

From the existing knowledge on recidivism illustrated in the literature review during the research the objective was achieved. By the identification of the risk factors which are factors that if prisoner posses will have a higher rate to be reconvicted. This includes occupation, age, level of education and marital status.

b) To identify a data mining technique suitable to predict recidivism in the prison inmates population.

This is also realized from the existing knowledge in the literature review, where various techniques have been used in the criminal justice system to check recidivism among other areas.

The most common techniques being; Bayesian, neural networks, rule induction and decision tree whose accuracy levels vary depending on the area applied.

c) To develop a prototype application using an identified data mining technique

Using the WEKA tool which comprises of a number of algorithms (techniques) it's used to predict the rate of recidivism. The results from the algorithms (Bayesnets, J48 and multiperceptron) are compared for that with best accuracy level. Whose results are displayed using the python developed application in the form of reports and graphs in the 5^{th} chapter on results.

d) To test and validate the prototype

After the prototype development the end users from the prison department get to interact with it during the testing phase, and from their response the system is found viable to the needs on the ground. As illustrated in the system testing section in the 5^{th} chapter.

e) To display existing recidivism patterns using the prototype application

Using the python application there is a better visualization of the prediction results from the WEKA tool by use of graphs and reports, which are crucial in the decision making process.

The prototype is therefore a useful piece of invention that prison department management can use to predict recidivism rate and plan on various programs to introduce or not. The only limitation of the system is that it can only help the prison management in decision making but not replace the management.

6.2 Recommendation

The efficiency of the prototype depends largely on availability of accurate data from all the prisons institutions in the country. My recommendation to the prison department is to implement proper and full automation of the prisoner's records using the Offender Records Management System (ORMS). To enhance the functioning of prediction systems built from the data.

This will aid in advancement of the system to enable it to include more specific cases on recidivism at a larger scale.

This prototype has been built using python and data feed using file in CSV and AARF format while WEKA is implemented using Java platform. Thus predicted results could not seamlessly accessed by the python GUI and had to be uploaded manually, reducing the flexibility of scenarios that the user can try within the prototype outside WEKA in case such data has not been uploaded.

Therefore it's recommended that the system in future be built in java to aid a seamless integration of WEKA with the system.

6.3 recommendations for future work

This project confined the research to only three (3) prisons within the prison department and it can be expanded to other prisons within the country. More so it can also be implemented in other justice administration bodies like the Police, Probation Department and Judiciary.

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Appendices

Appendix A – Interview Questions

1**. Full Name (optional):** **2. Name of Prison** **3. Position held**	
Question 1. Does recidivism exist in Kenya Prison service?	☐ Yes ☐ No
Question 2: What are the various modes of rehabilitation and reformation of the prisoners within Kenya prison Service? a) b) c) d)	
Question 3: What is the level of automation within the Kenya Prisons service on prisoner's records?	☐ Poor ☐ Average ☐ Good
Question 4: Would the RPS system be of help in rehabilitation and reformation of prisoners?	☐ Yes ☐ No
Question 5: In your opinion what should be taken into consideration of the final system for better performance. ……… ………	

Appendix B– Sample code

```
'''
Plot graphs
'''
import os
import re
from csv import DictReader
from collections import OrderedDict

from pylab import *

PATH = os.path.join(os.path.dirname(__file__), 'data_.csv')


class DataRow(object):
    '''
    Represents a single row(instance) of data
    '''
    def __init__(self):
        self.dos = None
        self.DOS = 0

        self.gender = None
        self.GENDER = 1

        self.marital_status = None
        self.MARITAL_STATUS = 2

        self.religion = None
        self.RELIGION = 3

        self.region = None
        self.REGION = 4

        self.occupation = None
        self.OCCUPATION = 5

        self.age = None
        self.AGE = 6

        self.education = None
        self.EDUCATION = 7

        self.predicted_previous_conviction = None
        self.PREDICTED_PREVIOUS_CONVICTION = 8

        self.previous_conviction = None
```

```
        self.PREVIOUS_CONVICTION = 9

    def __getitem__(self, key):
        return getattr(self, key)

    def __setitem__(self, key, value):
        return setattr(self, key, value)

    def is_equal(self, **kwargs):
        '''
        If the passed kwargs match the datarow values
        '''
        for key, value in kwargs.items():
            slugified_key = slugify(key)
            if not hasattr(self, slugified_key):
                return False
            if not getattr(self, slugified_key) == value:
                return False
        return True


class Data(object):
    def __init__(self, f_path):
        self.f = open(f_path, 'rb')
        self.reader = DictReader(self.f)
        self.fieldnames = self.reader.fieldnames
        self.x = 'predicted_previous_conviction'
        self.set_data()

    def yield_rows(self, return_object=False):
        '''
        Returns the rows in the file
        '''
        self.f.seek(0)
        for row in self.reader:
            if return_object:
                obj = DataRow()
                [setattr(obj, slugify(key), row[key])
                 for key in row]
                yield obj
            else:
                yield row

    def set_data(self):
        '''
        Sets the data
        '''
        enum = enumerate(self.yield_rows(True))
```

```
    self.data = []
    for i, data in enum:
        self.data.append(data)
    self.data = self.data[1:]

def map_age_count(self, data):
    '''
    Returns the count of ages
    '''
    field = 'age'

    # Get the min and max ages
    min_age = 0
    max_age = 0
    ages = []
    for row in data:
        ages.append(int(row[field]))
    min_age = min(ages)
    max_age = max(ages)

    # Get the age map
    age_map = OrderedDict()
    for age in range(min_age, max_age + 1):
        age_map[age] = 0
    for row in data:
        try:
            age_map[int(row[field])] += int(row[self.x])
        except TypeError as e:
            print e

    return age_map

def plot_convictions_against_age(self, data):
    '''
    A graph of convictions against age
    '''
    graph = self.map_age_count(data)
    # Use one figure
    figure(0, figsize=(15, 10))
    hold(True)
    # Set grid
    grid(True)
    # Set the grid parameters
    yticks(arange(min(graph.values()), max(graph.values()), 2))
    xticks(arange(min(graph.keys()), max(graph.keys()), 4))
    # Set the labels
    xlabel('Age [Years]')
    ylabel('Predicted Convictions [count]')
```

```
        # Title
        title('Predicted Previous Convictions vs Age')
        # Plot the graph
        plot(graph.keys(), graph.values(), 'x-', color='#000000', lw=2)
        # bar graph
        bar(
            graph.keys(),
            graph.values()
        )
        # Show the graph
        show()

    def map_occupation_count(self, data):
        '''
        A mapping of occupations and convictions of each occupation
        '''
        name = 'occupation'

        occupations = set()
        occup_map = OrderedDict()
        for row in data:
            if row[name] not in occupations:
                occup_map[row[name]] = 0
            occupations.add(row[name])

        # Get the occupation mapping
        for row in data:
            occup_map[row[name]] += int(row[self.x])

        # Return the map
        return occup_map

    def plot_convictions_against_occupation(self, data):
        '''
        A graph of convictions against occupations
        '''
        try:
            graph = self.map_occupation_count(data)
            # Use figure 0
            figure(0, figsize=(15, 10))
            # plot the bars
            bar(arange(0, len(graph)), graph.values(), align='center', width=.8)
            # Set the labels
            xticks(arange(0, len(graph)), graph.keys(), rotation=85, fontsize=9)
            yticks(arange(0, max(graph.values()), 2))
            # grid
            grid(False)
            # title
```

```
        title('Predicted Previous Convictions vs Occupation')
        # labels
        xlabel('Occupation')
        ylabel('Convictions [count]')
        # show
        show()
    except Exception as e:
        print e


def map_education_count(self, data):
    '''
    Education mapping
    '''
    name = 'education'

    educations = set()
    edu_map = OrderedDict()
    for row in data:
        if row[name] not in educations:
            edu_map[row[name]] = 0
        educations.add(row[name])

    # Get the occupation mapping
    for row in data:
        edu_map[row[name]] += int(row[self.x])

    # Return the map
    return edu_map


def plot_convictions_against_education(self, data):
    '''
    A graph of convictions against education
    '''
    try:
        graph = self.map_education_count(data)
        # Use figure 0
        figure(0, figsize=(15, 10))
        # plot the bars
        bar(arange(0, len(graph)), graph.values(), align='center', width=.8)
        # Set the labels
        xticks(arange(0, len(graph)), graph.keys(), rotation=50, fontsize=8)
        yticks(arange(0, max(graph.values()), 4))
        # grid
        grid(False)
        # title
        title('Predicted Previous Convictions vs Education')
```

```
        # labels
        xlabel('Education')
        ylabel('Convictions [count]')
        # show
        show()
      except Exception as e:
        print e


def slugify(string_value):
   '''
   Slugifies a string
   '''
   return string_value.lower().replace(' ', '_')


def wordify(slug):
   '''
   Undos slufigy
   '''
       return re.sub('_+', ' ', slug).title()
```