ACADEMIC
World Academic Union

ISSN 1746-7659, England, UK
Journal of Information and Computing Science
Vol. 12, No. 1, 2017, *pp*. 033-040

Accident predictive system in Benue State using artificial neural network

A. Amuche[1], B.M. Esiefarienrhe[1], and I. Agaji[1]
[1]*Federal University of Agriculture, Makurdi, Benue State, Nigeria.*
(Received November 10, 2016, accepted December 20, 2016)

Abstract. Road Traffic Accident (RTA) cause serious threat to human life worldwide. Nigeria is not left out in this menace and in fact is ranked as one of the countries with a high number of RTA cases. This is alarming and a preventive measure is to be taken to avoid or reduce RTAs in the country. In this work, a system is developed to predict road accidents in Benue state using Artificial Neural Network (ANN) model. The road characteristics as well as environmental factors are used as parameters. Data of RTA from 2008 to 2014 was collected from the Federal Road safety Commission for predictions. The predictions will help policy makers as well as Federal Road Safety Commission to put in place measures to prevent occurrence of RTAs. The underlying database that store the RTA data was created using MYSQL relational database. The software was written using JAVA programming language and neuroph for the predictions.

Keywords: Artificial Neural Network; Neuroph; Road Traffic Accident.

1. Introduction

There are several means of transportation such as air, land, sea etc., but the most commonly used in Nigeria is the land (road). The invention of these means of transportation has gone a long way in aiding humansin the daily performance of their duties. In as much as road transport has various advantages, it is the most prone to accidents and the highest causes of death. According to [1] road traffic accidents are increasing with rapid pace and presently one of the major causes of sudden deaths in Nigeria. In the year 2012, not less than 4,260 people were killed in road accidents across the country and a total of 20,752 people also sustained various degrees of injuries from different crashes indicating an average of 56 people being injured in road accidents daily of which 432 deaths occurred in Benue [2].

In order to ensure a safe, efficiently and effectively road transportation system, there is need to collect, store, analyse road traffic data so as to monitor the state of road traffic accidents in Benue state and to predict the likelihood of road traffic accident occurrence. This will require the formulation and development a predictive model that can use both past and present data for forecasting accidence occurrence. Thus, the model will allow stakeholders to influence positively key elements responsible for accidence occurrence in a decision support system.

This paper focuses on developing a road accident predictive system for Benue state as a function of road characteristics and to evaluate the application of neural network model for predicting road accidents in the state. The paper is organized as follows: Section 2 gives a brief literature review of application of ANN to road accident prediction. Section 3 focus on the research Methodology used in this work and section 4 shows the results and discussions. The paper is concluded in section 5 with a brief overview of all that has been done.

2. Literature Review

Extensive research has been carried out in the prediction of traffic accidents in both developed and developing countries using various statistical techniques. Some of these techniques include regression, Poisson distribution, binomial distribution, Bayesian theory and neural networks.

One of the statistical techniques frequently used is the regression analysis.

Reference [3] developed a general accident prediction model for rural toll road sections in Indonesia. This model considered the relationship between accident frequencies, traffic flows, various roadway geometric and environment characteristics. Several other models were developed using negative binomial regression model. The resulting general accident prediction model showed that accidents at rural toll road sections were positively correlated with annual average daily traffic and the number of horizontal curvature. The limitation to this model was that the model negatively correlated with the lane width.

Reference [4] developed relationships between traffic casualties and traffic characteristics, road characteristics and socio-demographic characteristics using both non-spatial Negative Binomial models and spatial Bayesian hierarchical models using area or ward (census track) level data. The Bayesian hierarchical models developed indicate that casualties increase with traffic flow, and households with no cars and total employment are statistically significant variables in all the models.

The numerous variables and complex relationships between the characteristics of the various traffic elements require analytical techniques other than traditional. However, the use of ordinary linear regression models is no longer in use.

A recent approach to analyze these relationships is the Artificial Neural Networks (ANN) which has been proposed and employed successfully by many scientists as an alternative to the conventional regression approach in forecasting time series pertaining to complex atmospheric and environmental phenomena. According to [5] neural network have been applied to develop complex software for road traffic management, accident prediction models, and crash estimation models etc. Neural networks are a wide class of flexible nonlinear regression and discriminate models, data reduction models, and nonlinear dynamical systems. Research by [6] shows the advantage of ANN over conventional programming. This is due to its capability to provide solutions to non-algorithmic problems and can learn how to deal with the new and unexpected situations by the help of past experience. Neural networks are able to relate input with output, allow large number of variables and are error tolerant. A neuron has many inputs and one output. The neuron basically consist of inputs (like synapses), which are multiplied by weights (strength of the respective signals), and then computed by a mathematical function which determines the activation of the neuron. Another function (which may be the identity)computes the output of the artificial neuron (sometimes in dependence of a certain threshold). ANNs combine artificial neurons in order to process information. The weights in a neural network are the most important factor in determining its function.

Neural networks are the simple clustering of artificial neurons by creating layers and interconnections as shown in figure 1.

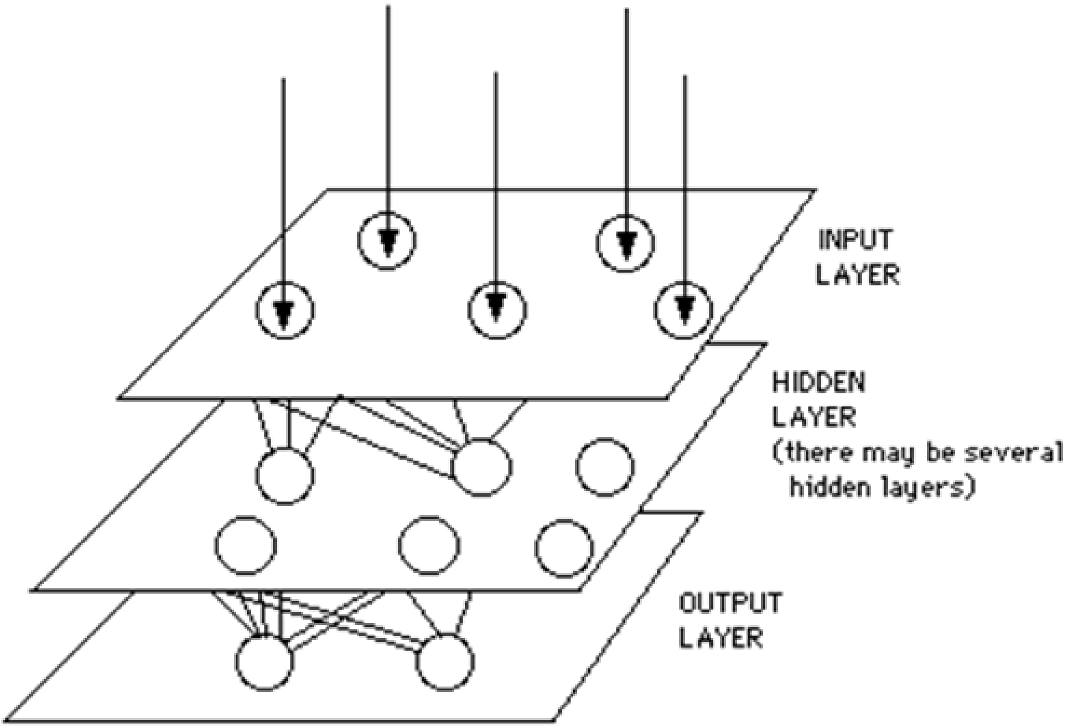

Fig.1. Layers of an Artificial Neural Network
(source: http://www.psych.utoronto.ca/users/reingold/courses/ai/cache/neural3.html)

Many studies on accident analysis, prevention and road safety etc have proved that road traffic accident are affected by lots of factors which are not always linear. Traffic accidents includes uncertainty and the studies already done cannot process pure explicit data.

In a work by [7], Artificial Neural Network was applied for predicting the road accidents in Delhi and was compared with linear and non-linear regression methods. According to results, a linear regression model was used to predict the number of accidents in Delhi for a year. The percentage Error obtained was 29.42%. The neural network was found to be fairly accurate compared to the linear regression method. The least error observed was as low as 0.479%. The root mean square error of neural network was much lower than the results obtained from Linear and Non-Linear regression models applied to the system. it was concluded that artificial neural networks are better for accident prediction than linear and non-linear regression and is considered for this research work.

3. Methodology

The ANN Road Traffic Accident Predictive System network was designed using a Multilayer Perceptron (MLP). MLP is a feedforward neural network with one or more layers between input and output layer. The back propagation algorithm is used to create and train a neural network to predict the number of accidents that will occur in Benue State and whether the accidents will be Fatal (ftl), serious (ser), or minor (mnr) in any given year. Also, the neural network will be able to determine the number of persons killed (pkd), and number of persons injured (pij).

The proposed feed-forward neural network architecture for road accident prediction is shown in figure 2.

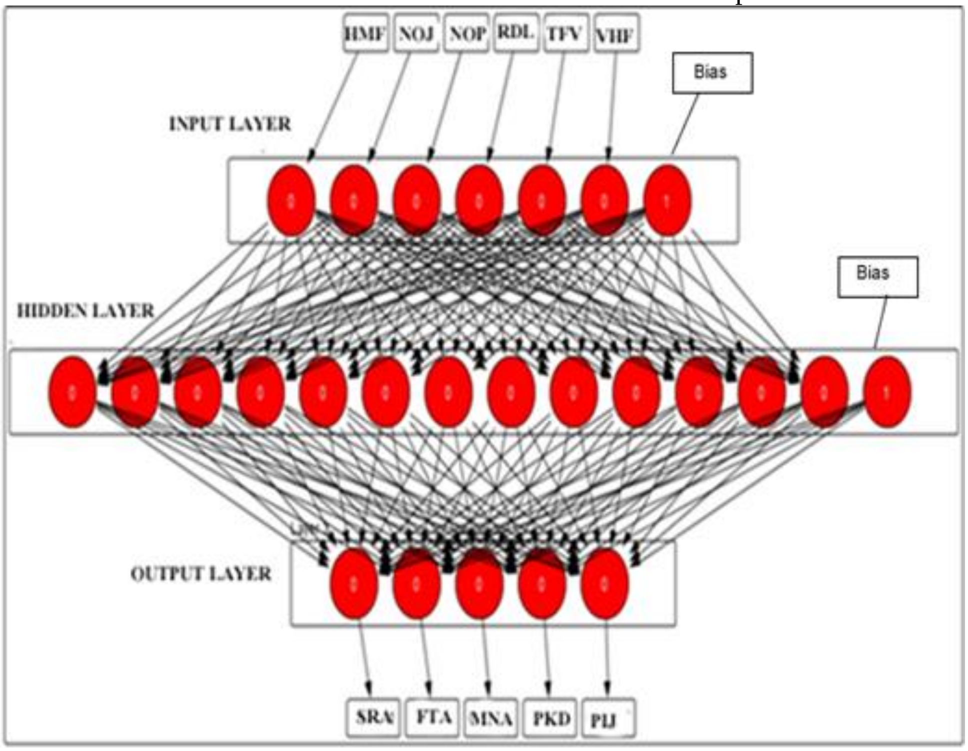

Fig.2. Layers of an Artificial Neural Network

The neural network contains six (6) input attributes alongside a bias and 5 output variables to the network. The input variables include:

Human factors that cause or likely cause accidents (HMF), Vehicular Factors (VHF), Number of Road Junctions (NOJ), Number of Pot Holes (NOP), Road length (RDL), and Traffic volume (TFV). The output variables include:

Fatal Accidents (FTA), Serious Accidents (SRA), Minor Accidents (MNA), Persons Killed (PKD) and Persons Injured (PIJ).

The network has one hidden layer sandwiched between input and output. The number of neurons in the hidden layer is given by (2n+1) where n is the number of input neurons. Also, an extra neuron is added as the bias. The bias neuron is necessary for an effective performance of the network and helps prevent errors in cases of zero input data. The bias affects the initial level of squashing in the sigmoid function which results the desired non- linearity. A total of fourteen (14) neurons were used in the hidden layer of the neural network.

3.1. Back propagation algorithm

According to [7], let $x_1, x_2, x_3, ..., x_7$ be the input to the neural network where x_1= Year; x_2= number of potholes; x_3= number of junctions; x_4= length of route; x_5= traffic volume; x_6= number of accidents caused by vehicle factors; x_7= number of accidents caused by human factors. The values to variables $x_1, x_2, x_3, ..., x_7$ is seen in Appendix A. The weights to which these inputs are multiplied are $w_1, w_2, w_3, ..., w_7$ is chosen by the network.

Let I = the number of nodes in input layer = 6; J= the number of nodes in hidden layer=14; K = number of nodes in output layer =5, since back propagation uses the gradient descent method, we calculated the derivative of the squared error function with respect to the weights of the network. Assuming one output neuron, the squared error function is:

$$E = \frac{1}{2}\sum_{k=1}^{k}(Ok\text{-}Tk)^2 .$$

Where E is the squared error; O_k is the target output for a training sample; T_k is the actual output of the output neuron. The activation function σ is in general non-linear and differentiable. Here, we use the sigmoid function,

$$\sigma(x) = \frac{1}{1\text{-}e^{-\lambda x}}$$

The back propagation algorithm aims to minimize the error with respect to the weight $\frac{dE}{dWijk}$.

Thus, for output layer we have:

$$\frac{dE}{dWjk} = (Oj)\delta k \text{where} \delta k = Ok(1\text{-}Ok)\ (Ok\text{-}tk)$$

And the hidden layer is

$$\frac{dE}{dWij} = Oi\delta j \text{where} \delta j = Oj(1\text{-}Oj \sum_{k \epsilon K} \delta k Wjk$$

3.2. Training and Testing of the Network

The data in Appendix A was used as the training data while the data in appendix B was used for the testing of the network after training. The interface shown in figure 3 is used to configure the network. The expected error of 0.01 is used. Other variables such as the number of expected hidden neuron, the learning rate of the network and momentum is also provided and used alongside the input for the training.

These values are tweaked until we get a minimal error rate in less iteration. As shown in table 1, when the number of hidden neuron was set to 16, a learning rate of 0.9, a momentum of 0.9 and expected error of 0.01, an error rate of 0.009 was obtained in 24 epoch (iterations).

The desired output from the test is shown along with the test output in table 2.

4. Results and discussion

The main focus of this research is to predict the numbers of road accidents that will occur each year. That is, given any year, the system is capable of predicting the number of accidents that will occur in Benue state. In order to predict, a year for prediction is selected. The predictions for year 2016 and 2017 are shown in figures 6 and 7 respectively. It shows the predicted figure of the number of people injured, number of people killed, fatal and minor accident.

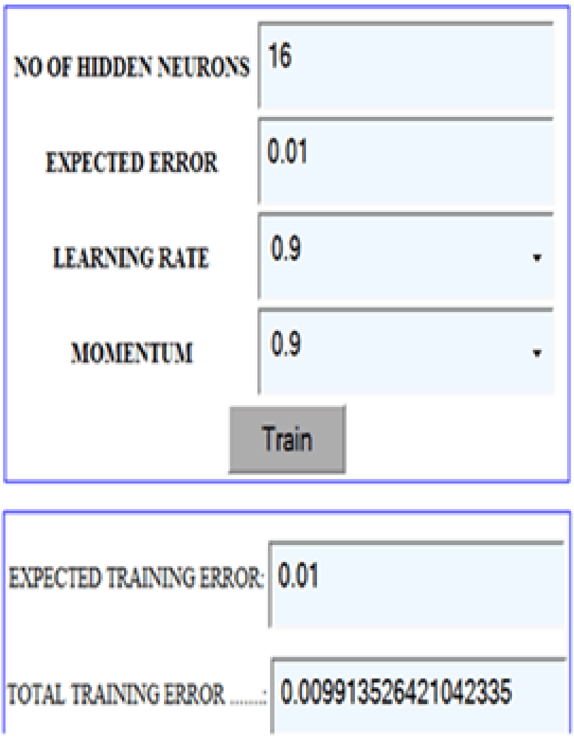

Fig.3. Layers of an Artificial Neural Network

Table 1. Number of Epoch and Expected Error in Training

EPOCH	TRAINING ERROR
1	0.408
2	0.359
3	0.183
4	0.161
5	0.127
6	0.116
7	0.070
8	0.073
9	0.043
10	0.037
11	0.025
12	0.020
13	0.019
14	0.019
15	0.014
16	0.020
17	0.019
18	0.017
19	0.021
20	0.017
21	0.014
22	0.021
23	0.014
24	0.009

Table 2. Output of the Test

YEAR	DESIRED OUTPUT				TEST OUTPUT			
	NO OF INJURED	**NO OF KILLED**	**NO OF FATAL**	**NO OF MINOR**	**NO OF INJURED**	**NO OF KILLED**	**NO OF FATAL**	**NO OF MINOR**
2008	577	98	59	29	541	88	55	31
2009	734	165	53	55	735	175	54	53
2010	673	151	56	49	625	178	58	46
2011	739	187	87	23	772	171	86	24
2012	1205	432	90	50	1262	384	92	59
2013	1400	232	111	54	1315	275	106	50
2014	865	157	40	5	889	129	45	7

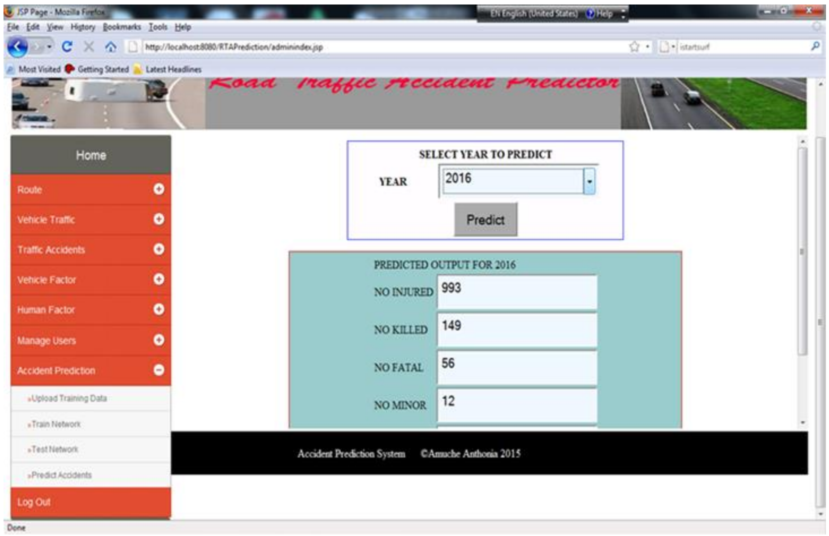

Fig.4. RTA prediction for year 2016

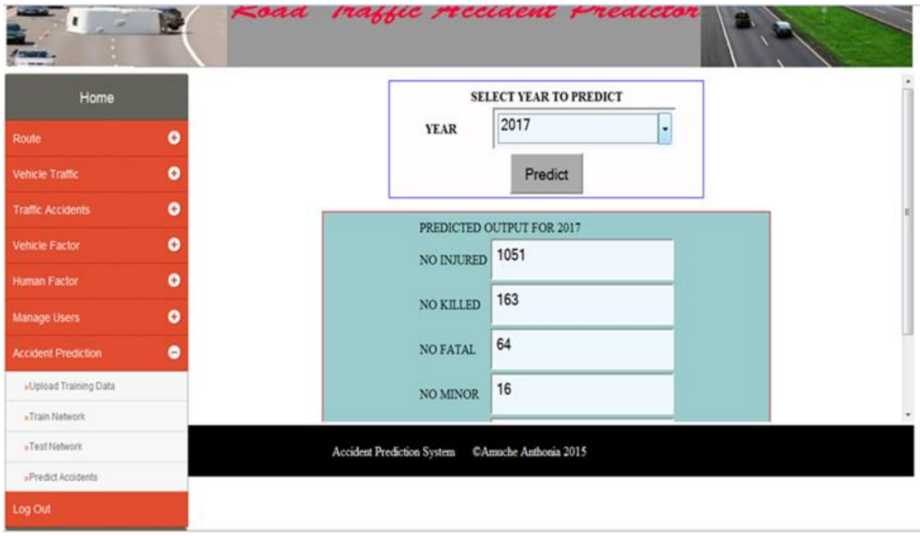

Fig.5. RTA prediction for year 2017

The artificial neural network was used to develop the predictive system for road accident in Benue using a number of inputs namely: average road length, traffic volume, junctions, potholes, human factors and vehicular factors. The artificial neural network model was able to achieve this by using the feed forward-back propagation algorithm. In training the network, a number of parameters were needed such as the number of expected neurons, expected error, learning rate and momentum. A learning rate of 0.01 was chosen for the system. The values of the variables were altered until the expected error is obtained with a small number of epoch.

The number of hidden neuron was set to 15 (which cannot be less than twice the input), with a learning rate of 0.9 and momentum of 0.5. This gave 160 epoch with an approximated expected error of =0.0098. It was noticed that the number of epoch was large. The network was tweaked a number of times. With a hidden layer of 16 neurons, 0.9 leaning rate and momentum of 0.9, the expected error = 0.0099 was achieved in just 24 epoch which is closed to the expected error of 0.01. This showed that the higher the learning rate, the less the epoch and a better performance of network are obtained.

The dataset for 3 years (2012 to 2014) was used to test the network. The significant error of the desired output and tested output was 0.01.

4.1. Evaluating of the prediction ANN model

The coefficients of determination (R^2), mean square error (MSE), and the root mean square error (RMSE) are the main criteria that are used to evaluate the performance of ANN model.

The correlation ratio R^2 is used to measure the closeness of fit. A perfect fit would result in $R\approx 1$very good fit near 1, and a poor fit would be near 0 [8].

In [8], ANN was applied in predicting traffic accident for highway accident prediction in Turkey with a R^2 value of 0.982452 and small dataset.

This ANN model used for RTA prediction in this research had a correlation ratio and R^2 are 0.99912 and 0.9824, respectively with a large dataset of 8,376 accident data collected. This shows that the ANN model is supportive and efficient with predictions for large dataset.

4.2. Validation of the predicted results

This study has so far been able to develop a predictive system for road accident in Benue state of Nigeria using ANN model. The system showed efficiency in predicting road accident in Benue state. Out of a total of 8376 accident data (total accident that occurred within 6 years) collected from the FRSC, Benue State Command, the number of predicted data after testing was 8305 which is proportional to an accuracy of 99.15%. This shows that Artificial Neural Network is an efficient model for prediction. Out of the 8376 data that were provided, 6193 were number of people injured, 1422 were number of people killed, 496 were number of fatal accidents and 265 were number of minor accidents. The Artificial Neural Network predicted 100% each for number of injured and number of fatal accident respectively as a true positive with values of 1 for each incident. Out of 1422 data of number of people killed the ANN model predicted 1400 representing 98.45% of the actual data. Out of 265 data provided for minor accident, the network predicted 270 which represent 98.8% accuracy. The values obtained using the ANN model shows the effectiveness and efficiency of the system in terms of the value of accuracy, error rate and performance evaluation criteria.

5. Conclusion

This research presents a system for predicting road traffic accident in Benue state, Nigeria using ANN model. The neuroph network was used to create a predictive system and data used was obtained from FRSC, Benue Command. The data collected included number of vehicle that plied the routes in Benue, the number of yearly accidents from 2008 to 2014. The back propagation algorithm was used to train the network. The network had six inputs which were Human factors that cause or likely cause accidents , Vehicular Factors, Number of Road Junctions, Number of Pot Holes, Road length, and Traffic volume, and five outputs namely Fatal Accidents, Serious Accidents, Minor Accidents, Persons Killed and Persons Injured.

The system with the inbuilt predictive model was developed using JAVA, MySQL relational database and neuroph network for neural networks.

This research describes the development of road traffic accident predictive system alongside an information system for accidents within the state. Road traffic accidents are prevalent on Nigeria roads. It was gathered during this research that the major variables causing road accidents in the state are high alcohol usage, high speed, poor vehicle maintenance, mechanical failure, high number of potholes, small road carriage widths.

From the analysis in this work, the ANN model showed an accuracy of 99.15% indicating that the model is effective for road accident prediction. Artificial Neural Network model may be used for future predictions on road traffic accidents given information collected on the route, road condition, characteristics and vehicles involved.

The data in Appendix A was used as the training data while the data in appendix B was used for the testing of the network after training. The interface shown in Figure 3 is used to configure the network. The expected error of 0.01 is used. Other variables such as the number of expected hidden neuron, the learning rate of the network and momentum is also provided and used alongside the input for the training.

6. References

[1] J. Ohakwe, I.S. Iwueze, and D. Chikezie. Analysis of Road Traffic Accidents in Nigeria. A case study of Obinze/Nekede/Iheagwa Road in Imo State, South eastern, Nigeria. Asian journal of Applied Sciences. 4:166-175, 2011.

[2] N. Ibeh. Road Accidents killed average 11 Nigerians each day of 2012. Premium Times Newspaper. http://m.premiumtimesng.com/news/116530-road-accidents-killed-11nigerians-each-day-of-2012-frcs.html.(2015).

[3] K. Aine, P.U. Dwi and H. Sri. *Development of accident prediction model for rural toll roads sections.* Proceedings of the Eastern Asia Society for Transportation Studies. 9 (2013).

[4] M.A. Quddus. Modeling area-wide count outcomes with spatial correlation and Heterogeneity: An *analysis of London crash data*. Accident Analysis and Prevention. 40:1486-1497.

[5] S.J Khair, A. Muaath, and H.F. Gammoh. Prediction of Road Traffic Accidents in Jordan *using Artificial Neural Network (ANN)*. Journal of Traffic and Logistics Engineering 2(2). (2014).

[6] F.N. Ogwuleka, M. Sanjay, C.O. Toochukwu, and L. Fernandez-Sanz. An Artificial Neural Network Model for Road Accident Prediction: A Case Study of a Developing Country. 11(5):177-197(2014).

[7] S. Sushant. Prediction of Road Accidents in Delhi using Back Propagation Neural Network *Model*. International Journal of Computer Science & Engineering. 5(6)(2014).

[8] Y. Muhammed, t. Ahmet **.** An Artificial Neural Network Model for Highway Accident Prediction: A Case Study Of Erzurum, Turkey. Promet – Traffic & Transportation. 27(3): 217- 225(2015).