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MODELING OF VEHICLE ACCIDENT PREVENTION AND CONTROL SYSTEM USING MACHINE LEARNING TECHNIQUE

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Abstract

This paper presents the modeling of vehicle accident prevention and control system using machine learning technique. The study revealed from literatures that solution has not been obtained for this problem considering tricycle vehicles which has evolved recently as the major means of transport in Nigeria. This problem was addressed using Feed Forward Neural Network (FFNN), rule based and data collected from the ministry of transportation. The FFNN was used to develop the tricycle detection model, while the rule based was used to develop the accident detection and control system using the tricycle detection model and safe distance standard between vehicles according to the Federal Road Safety Corp (FRSC) which is not less than 1.3meters. The model was implemented with Simulink platform and then evaluated. The result of the accident detection model was evaluated with Means Square Error (MSE), Receiver Operator Characteristics (ROC) curve and confusion matrix. The MSE 3.0512e-10, accuracy is 98.1% and ROC is 0.9807. The model was compared with other sophisticated accident detection and control model and the result showed that the new system has a percentage improvement of 5.1%.

Keywords: Vehicle; Accident; Neural Network; Tricycle; Receiver Operator Characteristic

1. INTRODUCTION

Today in Nigeria, the major problem has remained insecurity which has affected all part of the country. In many occasions, these insurgents move using motorcycles which are coincidentally a major means of transport in both the rural and urban areas. Having tried, various solutions to combat this problem with no avail, the government simply bans motorcycles as a means of transport in many areas today. However, this decision has affected numerous innocent citizens which equally employed these machines as a means of transport to move people from one place to another.

To this end, many of these citizens have turn to the tricycles as an alternative transport means and as a result, these means of transportation has dominated both the local and high ways. But unfortunately, in the country, there is no standard, regulation, or administrative provision made to ensure that drivers of these tricycles are qualified and fit for driving, thus resulting to both the fit and unfit to have access to the system and drive.

Overtime, (Rossi et al. (2015); Qianyin et al. (2015); Cui et al. (2011); Mehboob et al. (2016); Wu and Wang (2017); Chen et al. (2017) and Kim et al. (2015)) presented studies that addressed vehicle accident prevention. However, there are still gaps and limitation to their success. The major problem over the years is still virtually on daily basis, there are events of accident involving other vehicles and tricycles.

In the conventional accident detection and control system developed, solution was never considered for tricycles and this has remained problem. This research proposes to address these issues using machine learning technique.

2. METHODOLOGY

The methodology used is the simulation method, while the software design methodology used is the agile model. The method employed are data collection from the ministry of transportation, Enugu state Nigeria, data extraction, modeling of the inter-vehicle classification algorithm, modeling of the accident prevention and control system, and then implementation with high level programming language.

2.1 Data collection

Data of tricycles were collected from the federal ministry of transportation. The sample size of data collected is 21,300 samples of tricycles and was stored in the system image repository to create the training dataset. The samples of the data collected were presented in the figure 1;

Figure 1: Samples of data collection

2.2 Data extraction

Having collected the data in image format, it was converted into statistical features using the Histogram of Feature Gradient. The reason this feature extraction technique was adopted was due to its ability to correctly extract the rich features in an image and then convert into statistical equivalent for training purpose (Saxe and Berlin, 2015).

3. MODELING OF THE INTER-VEHICLE COLLISION DETECTION MODEL

To develop the inter-vehicle collision detection model, Feed Forward Neural Network (FFNN) was adopted from Nancy et al. (2020) and then used to develop the classification model. The model of the FFNN was presented using the figure 2;

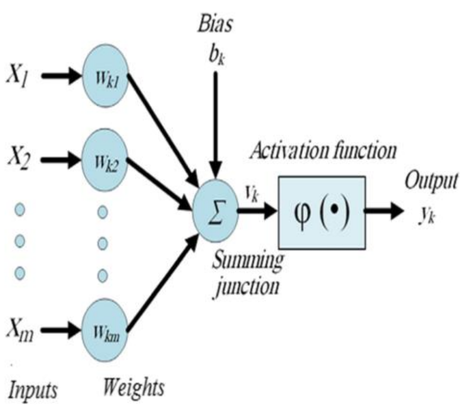

Figure 2: Architectural model of the FNN

The figure 2 presented a simple model of FFNN where x is he input neurons, w is the weights, b is the bias function, v_k is the summation function, φ is the activation unction an y_k is the output function. This FFNN was loaded with the data collected to configure the new FFNN as shown in the figure 3;

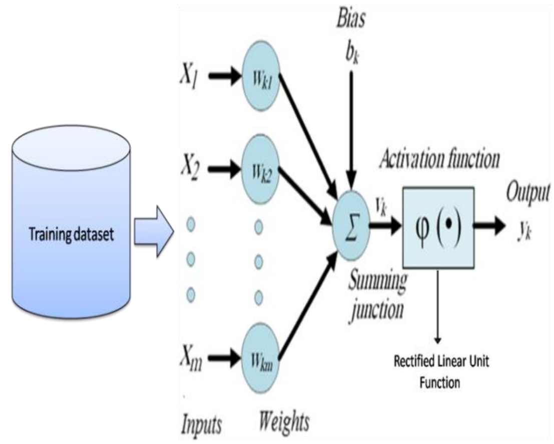

Figure 3: The system configuration of the FFNN with training data

The FFNN model was loaded with the training dataset to configure the FFNN for training using back propagation algorithm as shown in the figure 4;

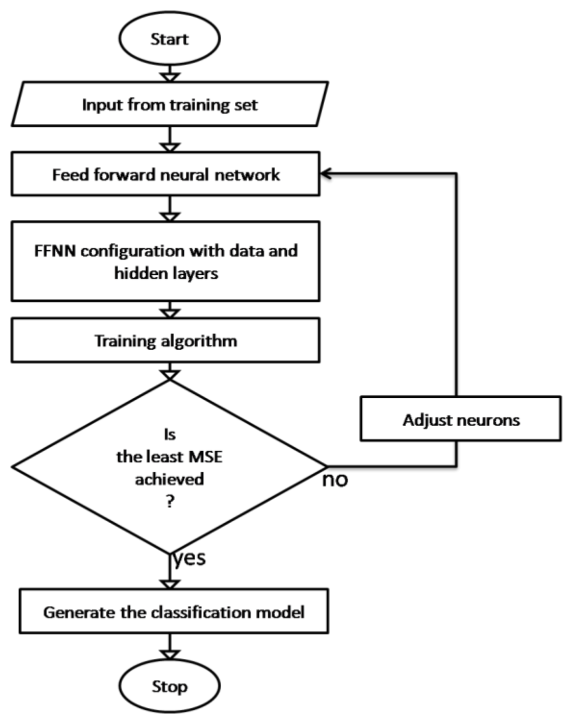

Figure 4: flowchart of the classification model with FFNN

The figure 4 presented the model of the classification system developed with the data collection and FFNN. This classification model was used to develop the inter-vehicle collision detection model as shown in the flowchart of figure 5;

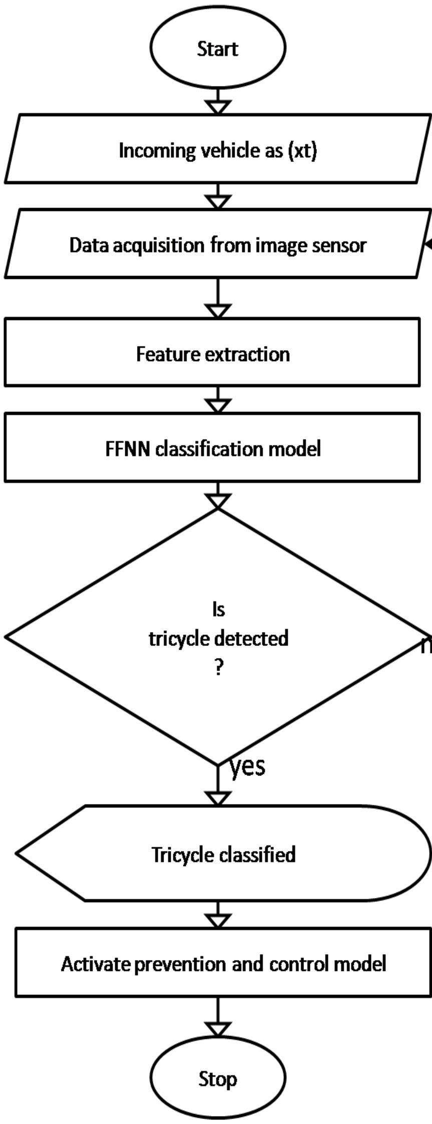

Figure 5: Flowchart of inter-vehicle collision detection model

3.1 Modeling of the accident prevention and control model

The model was developed using rule-based optimization approach based on the incoming from proximity sensor and then classified output from the model in figure 5 to develop a flowchart which showed the workflow for the prevention of accident.

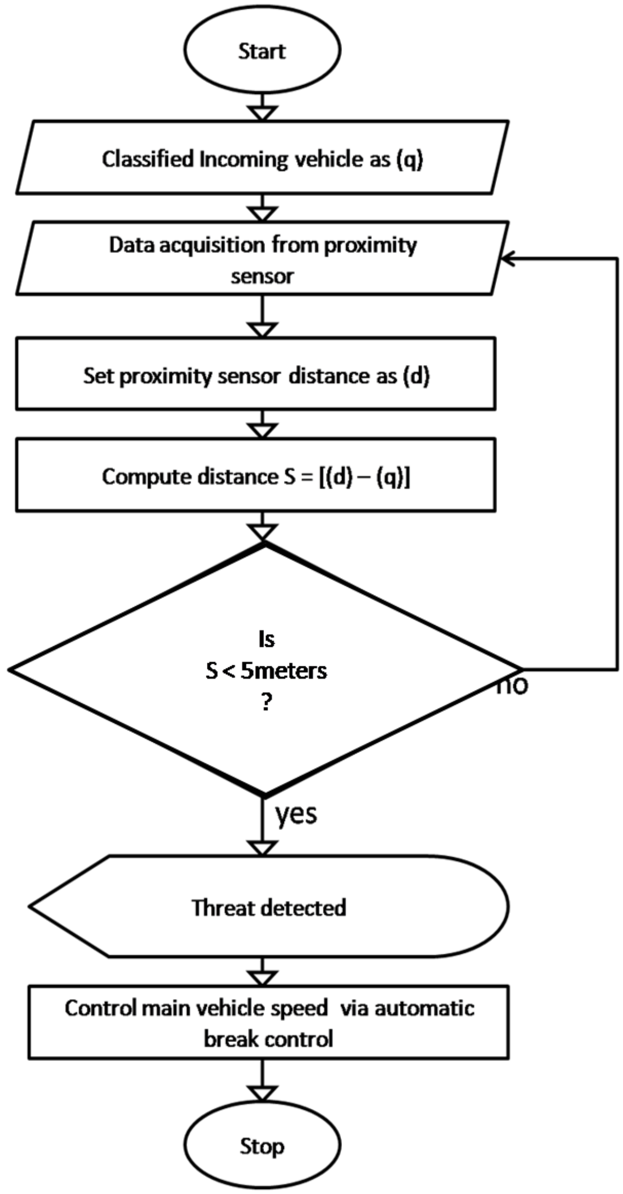

Figure 6: The accident prevention and control flowchart

The figure 6 presented the flowchart used in modeling the accident prevention and control system. The complete system flowchart which showed the workflow of the entire system operation was presented in the figure 7.

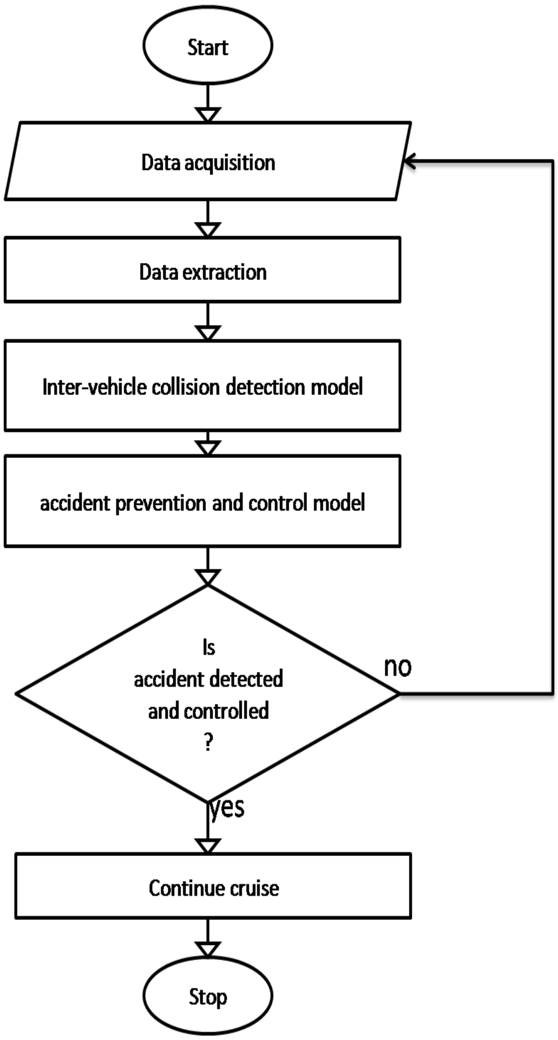

Figure 7: The complete system flow chart

The figure 7 presented the work flow of the complete accident prevention and control system developed with machine learning. From the flowchart in figure 7, the image sensor was used to capture incoming vehicles on the road and extracted using the histogram extraction technique into the collision detection model in figure 4 and tricycle was detected from the vehicle, the distance was determined using the accident prevention and control model in figure 5 to compute the distance from the main vehicle and if it do not satisfy the 5meter inter-vehicle standard specified by the Nigerian road safety commission, then the automatic brake control system was sued to control the main vehicle speed to prevent the accident.

4. SYSTEM IMPLEMENTATION

The models were implemented using image acquisition toolbox, data acquisition toolbox, machine learning and statistics toolbox, neural network toolbox and Simulink. The data acquisition and image acquisition toolbox were used to drive the data capturing process. The statistics toolbox was configured with the feature extraction techniques adopted. The neural network toolbox was configured with the accident prevention and control system developed. These toolboxes were used to implement the new system in Simulink environment and the performance evaluated.

5. RESULTS AND DISCUSSION

The performance of the inter vehicle collision detection system was evaluated using MSE, ROC curve and confusion matrix. The MSE was sued to show the error which occurred during the training process. The ROC was used to show how the model trained was able to detect potential accident and then Confusion matrix was used to measure the accuracy of correct accident detection. The figure 8 presented the result of the MSE performance.

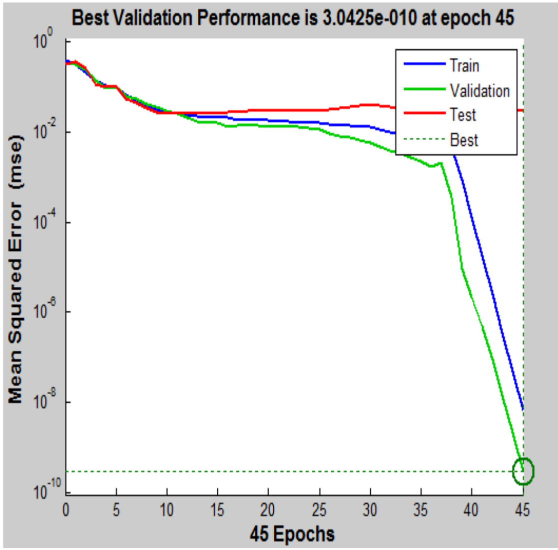

Figure 8: MSE result

The figure 8 presented the performance of the accident detection model developed with the FFNN. The result showed the performance of the neurons trained with the data collected. In the result the aim was to achieve a least MSE value of equal or approximately zero. This implied that the neurons learnt the features of the data with no overshot or tolerable error. From the result achieved, the MSE is 3.0425e-10 after epoch 45 which is good. The implication of the result showed that the training error achieved with the neurons was tolerable and showed that the neurons correctly learn the features they were trained with after 45 respective iteration epochs. The next result presented the performance of the ROC which was used to study the Correct Classification (TP), False Classification (FP), False Negative (FN) and True Negative (TN) rate of the accident detection model. The result was presented in the figure 9;

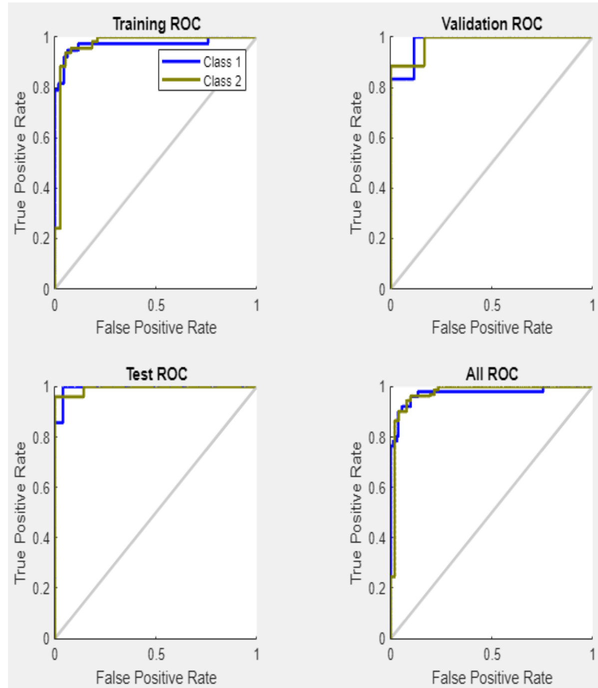

Figure 9: ROC analysis

The figure 9 presented the ROC of the training, test and validation of the accident detection model. The aim of this result was to achieve ROC value approximately or equal to one, which implied good accident detection performance. The overall ROC was achieved from the average of the training, test and validation set as 0.9831. The implication of the result showed that the neurons correctly learn the data and was able to detect accident correctly. To measure the detection accuracy of the model, the confusion matrix was used as in figure 10;

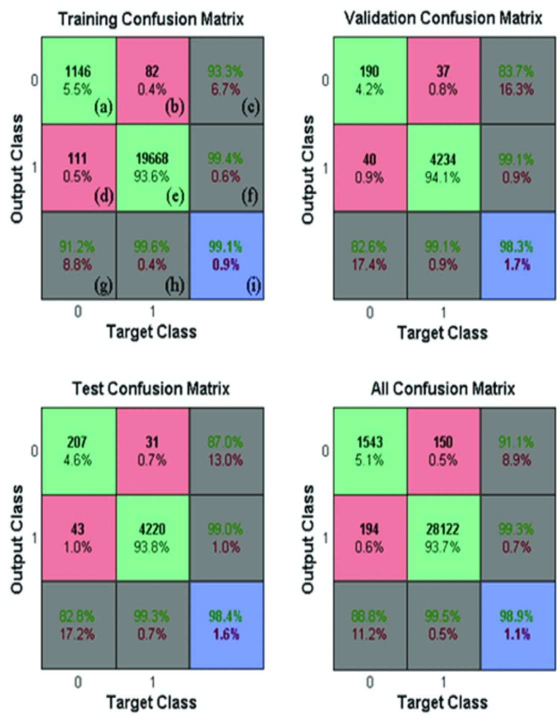

Figure 10: Confusion matrix

The figure 10 presented the confusion matrix used to evaluate the accuracy of the accident detection system. The result showed how the model developed was able to correctly detect incoming tricycle which poses threat to the main vehicle and correctly control to prevent accident. The results accident prevention accuracy was measured here and the result overall is 98.9%. The implication of the result showed that the system was able to correctly detect potential accident on the road and control.

5.1 Results of the accident prevention and control system

Having tested, analyzed and validated the result of the models developed for accident prevention and control model developed, it was used to develop an accident control system and evaluated as shown in the figure 11;

Figure 11: Results of system integration with two vehicles

The figure 11 presented the system integration result of the developed model for accident prevention and control. The result showed how the image sensor was able to capture the vehicle and classify as tricycle using the classification model, the proximity sensor was used to detect the distance of the vehicle from the main vehicle and then when it is less then 5m from the main vehicle, the sleep was controlled.

From the result it was observed that the accident detection model was able to classify one of the two tricycle distance as less than 5m in the front of the main vehicle, during translation and the speed was controlled. The next result presented anther system evaluation as in figure 12;

Figure 12: Result of the system testing with one threat vehicle

The figure 12 presented where the accident detection and control system was able to detect a tricycle which was 2.3meters in front of the main vehicle and then control to prevent accident. The next result presented the performance of the in another driver scenario and it was observed that potential accidents were detected and then controlled as shown in the figure 13;

Figure 13: The result of the system integration.

6. CONCLUSION

Many works have developed accident detection and control system, but solution was never modeled which considered tricycles as a major cause of accident, even though it has dominated the means of transport and logistics in many developing countries. This study has successfully collected the data and develops a model which was used to the detection of incoming tricycle which can cause accident to the main vehicle. The detection output was identified by the control model developed with rule based which used the FRSC standard for safe vehicle distance on high way to make control decision and prevent accident. The result when tested and validated showed that the accident detection accuracy is 98.1; MSE is 3.0512e-10 and ROC is 0.9807. When compared with other model trained with similar data type, the result showed that the FFNN developed was better and more accurate with a percentage improvement of 5.1%.

7. AUTHORS DECLARATION

The authors declare no conflict of interest in this manuscript.

8. AUTHORS CONTRIBUTION

All authors contributed in the development of this research and agreed, it should be published.

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None

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