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EFFECTIVE IMPLEMENTATION OF VEHICULAR ACCIDENT DETECTION AND PREVENTION USING MACHINE LEARNING TECHNIQUE

by

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ABSTRACT

This paper analyzes the use of rule-based integrated machine learning technique to model inter-vehicular accident prevention and control system. It has been noted that tricycle road movements are the major cause of road accident, even though they have dominated the means of transportation and logistics in many developing countries, especially in Nigeria. To solve this problem of road accident, data of tricycles were collected from the Anambra State Ministry of Transport, Awka; and then trained with machine learning algorithm to generate the accident detection model. The rule-based optimization was developed from the information collected from the Federal Road Safety Corp (FRSC) on the standard of inter vehicle distance and then used to develop the control model. The model was implemented with Simulink and evaluated. The result when tested and validated showed that the accident detection accuracy is 98.1%; Mean Square Error (MSE) is 3.0512e-10 and ROC is 0.9807. When compared with other models trained with similar data type, the result showed that the Feed Forward Neural Network (FFNN) developed was better and more accurate with a percentage improvement of 5.1%.

KEYWORDS/PHRASES: Rule-base, model, machine learning, tricycle, neural network, algorithm.

I. INTRODUCTION

1.1 Background of Study

In recent years, the number of road accident increase has raised great concerns across the globe and presents a major challenge for road traffic administrators. If serious solution is not proposed, by the year 2025 road accident will be the third major cause of human mortality rate, putting road safety ahead of HIV/AIDS, malaria, and other acts of violence (Maninder and Amrit, 2014). Various methods have been identified as the solution to this canker, which include: establishment of driving lesson schools and licensing, road safety rules and regulations, implementation of automatic brake systems, cruise control system, among others. However, despite the success, the rate at which accident happens keep increasing even more.

This problem has recently gained research attention with various techniques proposed already to solve the problem. Wu and Wang (2017) proposed the use of intelligent vehicle detection and tracking system, but the success is limited by the data structure which did not consider all classes of vehicles like the tri cycles machines for instance.

Chen et al. (2017) presented vehicle detection system using building regional covariance descriptors. The limitation of the result is accuracy of 92% which can be increased. Kim et al. (2015) used histogram of oriented gradient for on road vehicle detection, however the technique lacked common sense of the problem in question and has to be improved with artificial intelligence.

Other approaches already used were: polynomial expansion based on motion estimation technique, local scale invariant feature technique, speed up robust feature, feature matching and Kalman filter technique, among others (Ferneback, 2003; Mantripragada et al., 2014; Baye et al., 2016). However, despite the successes, these techniques are not reliable enough for autonomous accident prevention system. Nevertheless, artificial intelligence (A.I) technique has been singled out to produce better result compared to other approaches.

Artificial intelligence is a machine intelligence which mimics human behavior. This is usually achieved using some techniques like machine learning (ML). The ML is a series of mathematical algorithms used to make decisions based on the training dataset used. Today there are various ML algorithms, ranging from support vector machine, K nearest neighbor, clustering technique, artificial neural network (ANN), among others. All have their advantages and disadvantages; however, the ANN performs best for image classification problems like the case study and is therefore proposed in this research to be used for training the problem under study and then makes correct and intelligent decision. This system will then be integrated in autonomous vehicles as an accident prevention system, with high level of efficiency and system reliability.

II. LITERATURE REVIEW

2.1 Overview of Accident Detection and Control System (ADCS)

Accident Detection and Control System (ADCS) are intended to proactively prevent vehicles from colliding with each other or other objects. The ADCS collects data from the environment, extracts the data, and analyzes the information extracted to predict dangers like accident in traffic. These systems are developed in other to offer assistance for drivers to ensure reliability of driving process and protection of lives and properties of passengers using road transport. The system also created driver situation awareness through the provision of alert, traffic situation or state of other vehicles suspected to cause collusion (Arul and George, 2012).

The ADCS avoids accidents by alerting the driver to a potential danger which is predicted using automatic actions provided by the inter vehicle communication (IVC) data processing and then apply control using emergency braking or steering. One example of ADCS is the Adaptive Cruise Control (ACC) system that uses radar sensors to collect data of vehicles within the environment based on feedback light reflection from the sensor and make decisions which ensures safe distance is maintained between vehicles. This data collected can be further process using other techniques like artificial intelligence, controller area network, image processing, among other techniques to activate intelligent control measures using active accident control system like automatic brake control, automatic stir control or passive control systems like seat belts and air bags (Cesar et al., 2018). In general, the ADCS can be classified into two main classes which are the information delivery systems and the automatic control systems as discussed below:

i. Information delivery systems

This are input transducers which collects data from the environment about the dynamics of other vehicles based on their speed, traffic and analyze the result to make predictions of future event possibilities like collision and present to the driver or control system for proactive or active decision. In the information delivery system; this input is usually incorporated with intelligent systems which enable the accurate data collection analysis. This uses the data to train, compare, learn and make decision to predict future time series events and possibilities of danger before notifying the control system for prevention (Cesar et al., 201).

ii. Automatic control systems

The automatic control systems are the driver assistance system incorporated in vehicles to help control dangers. These control systems are actuators such as stirring and brakes, aim at providing more support to the driver by employing automatic action on the part of the vehicle, when they receive signal from the prediction system (Chippendadale et al., 2014).

2.2 Human Vision for Accident Detection and Control

According to the World report on Vision (WRV, 2019), the sensors for the sense of vision are the eyes. Vision works without direct contact. Vision allows the simultaneous viewing of a large spatial field. It is the only sense that allows simultaneous perception and thus gives a global view of an environment. The eye perceives image in two dimensions. It is possible to recreate a 3D image and thus gain information on distances and depth by integrating information on vergence and disparity from both eyes, but also on occlusion, shades, light, and gradients of color, texture, size and information (Noorishta and Akheela, 2019).

Vision excels in different fields. Among them are perception of space, landmarks, directions, distances, orientation and speed of moving objects. Vision has the greatest spatial resolution of all senses and is best adapted for coordinating movements in space and for avoiding obstacle. Finally, it is also well adapted for recognizing shape and material of objects (Chippandel et al., 2014).

Human vision is the process of discovering what is present in the world and where it is by looking. The human visual system can be regarded as consisting of two parts. The eyes act as image receptors which capture light and convert it into signals which are then transmitted to image processing centers in the brain. These centers process the signals received from the eyes and build an internal "picture" of the scene being viewed. Processing by the brain consists of partly of simple image processing and partly of higher functions which build and manipulate an internal model of the outside world. This has been the bases for operation of various systems developed like the case study "vehicles" and driving (Girshieck et al. 2014).

However, effective driving requires more than the intelligence to pilot a vehicle based on sight alone as the human vision can be easily affected due to stress leading to drowsy symptoms like sleep among others. It requires environmental awareness of other moving vehicles also on the same road, while simultaneously changing the dynamics of the piloted vehicle based on their translational dynamics. This might look simple in paper here, but in practical is very challenging and little mistake in this process have results to loss of uncountable number of lives, crashes, injuries, properties among other (Noorishta and Akheela, 2019).

Today, looking at the rate at which vehicles flood the highways and the increased number of accident cases recorded each day in various parts of the world, it is inevitable that human vision alone is not enough for complete cruise control safety.

2.3 Technologies for Accident Detection and Control

Overtime many research areas such as sensors, transport, kinematics, information systems, positioning, computer vision, artificial intelligence and communication networks have contributed to the development of efficient ADCS. From the background of the study, it was observed that they all have their limitations and contribution to knowledge (Arul et al., 2012). However, it was observed that the use of sensors, computer vision, and vehicle communication approach offers the best results so far and has gained more research attention compared to other counterparts. This section therefore singles out these technologies to overview them as presented below:

2.3.1 Sensors

Since the ultimate goal of accident detection and control systems is to keep vehicles from colliding with each other or objects, vehicles are equipped with transducers which collect data from the environment and convert to signal the vehicle interpreted and makes decisions. These transducers are various types of sensors which operate based on various principles of physics and mathematical laws (Obst et al., 2014).

The most used is the photonic sensor which operated based on the principle of light reflection around and obstacles on the path of propagation. Standard radar systems use sensors that send narrow microwave beams of light which are reflected by objects and received back by the radar system. Based on this information, the relative position and speed of other objects can be determined. Lidar systems use light beams for the same purpose (Noorishta and Akheela, 2019).

The major limitation associated with sensor systems is their local perception. This is due to the fact that sensor systems usually require a line of sight (LOS) for focus and object detection. They cannot detect distant or hidden objects outside their LOS and therefore may not be able to provide information about more complex traffic situations. Several other problems arise with the utilization of sensor systems their lack of addictiveness to environmental factors like weather situations like rain, high temperature, fog, humidity among other atmospheric conditions. These parameters can also affect the quality of data collection and as a result affect the prediction accuracy (De Pont et al., 2016).

Cost and response time is another major issue which limits the application of sensors as a tool for ADCS. The response time of most sensors (i.e the time between data localization and

collection) in most cases is too much a delay time and unacceptable as ADCS.
This is because it takes just 3 seconds of concentration loss by driver for accident to occur and in a case where an ADCS cannot make decisions within this time frame; then it is unreliable (Noorishta and Akheela, 2019). The issue of cost is another main challenge with sensor system. They are too expensive, a common man cannot purchase and integrate it on vehicle for safety reasons. These are some of the parameters which hindered the effective application of this technology.

2.3.2 Computer Vision

Computer vision is an interdisciplinary field that deals with how computers can be made for gaining high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do. Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions (Reinhard Klette, 2014).

Computer vision is an interdisciplinary field that deals with how computers can be made for gaining high-level understanding from digital images or videos. It is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding." As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images (Reinhard Klette, 2014). The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision (CV) systems (Noorishta and Akheela, 2019).
Today these systems (CV) have been used for accident detection and prediction system via approaches like intelligent lane detection system, drowsy driver detection systems, and pedestrian detection system, among others. In these applications, stereo cameras are employed for data collection while image processing techniques like segmentation, edge detection, among others were used for the data analysis and result classification. The main issue of this CV as an accident detection and control system is that the system depends on sensors like camera for data collection, however the same fate suffered by the sensors due to factors like poor weather condition, cost, and line of sight also affects this technique as a safety system.

2.4 Methods of Accident Detection and Monitoring

This section will discuss some of the major based technique employed in the conventional systems for the detection and control of accident driving.

a. Fuzzy Logic Image Analysis Method

In this system a camera is installed on the dashboard of the vehicle for capturing consecutive facial images of the driver in real time, then the data collected is processed based on a C++ developed algorithm using image processing technique to calculate the positions of the facial features like the eyes and the eyelid closure duration based on the images taken. Finally fuzzy logic algorithm is employed to detect the alertness of the driver by measuring both the blinding duration and the blinding frequency and then warn the driver accordingly. This technique despite the success has delay time issues which have to be improved in further studies.

b. Images Processing Based Method

An Image Processing based method uses the driver's face images for processing so that one can identify its states. This method employs approaches like segmentation, feature extraction and similarity measured for processing and predicting driver's performance from ground truth image. Image processing is classified under three groups for accident detection which are briefly discussed below as;

i. Eye Blinking-Based Technique

This technique measures eye blinking rate and eye closure duration to detect the drowsiness state of the driver. This is because eye blinking and gaze between the eyelids are different from normal situations when compared to when the driver is feeling drowsy. In this system the position of iris and eye states are monitored through time to estimate the rate of eye blinking frequency and eye closure duration (Artem et al., 2015). This image processing technique uses a remotely placed camera to acquire video as the image data, then computer vision techniques are then applied to sequentially localize face, eyes and eyelids positions to measure ratio of closure, and then use the data to predict is a driver is sleeping or not (Amol et al., (2016). However, despite the success of this technique, most times it gives false alarm and hence not very reliable today.

ii. Template Matching Technique

This technique has the template data representing when the driver's eyes are opened or closed. Hence whenever the eyes of the driver are closed for a long time, the system will trigger an alarm. It is also capable of learn and fetch the open and closed eye templates of a driver. This method is simple and easy to implement because templates of both open and closed eye states as shown in figure 2.4 are available for the system to access at any time needed (Jayanthi and Bommy, 2014).

iii. Yawning Based Technique

One of the known symptoms of fatigue is Yawn. The yawn is associated with a large vertical mouth opening due to hunger or fatigue. Opening the mouth widely is larger in yawning compared to speaking. One can easily detect or identify yawning using face tracking and also mouth tracking by computer vision. In Behnoosh et al (2016), they detect yawning based on opening rate of mouth and the number of changes in the mouth contour area, then the data collected is classified and uses to predict the drowsy nature of drivers. This success is more reliable compared to the eye blinking technique; however, it also gives some degree of false alarm which need improvement in further studies.

iv. Machine Learning Systems for Detecting Driver Drowsiness

This method employs statistical technique based on some sets of intelligent algorithms like deep learning, neural network, and support vector machine, reinforcement learning among others to train and predict future time series behavior of driver in real time. The method reveals significant associations between computer visions based facial expression, head roll, coupling head roll, steering motion and fatigue beyond eye blinks. In machine learning technique, a training dataset is mined using various statistical A.I algorithms under supervised and unsupervised learning respectively to learn and predict drowsiness in real time. This technique has been employed in various works like (Gwak et al, 2018 and Metin, 2018) to train and predict drowsiness in future time series drowsy model and have produced some of the best results today compare to other technique, however despite the success, they have problem of delay training time and this delay have therefore affected the real time effectiveness.

v. EEG Based Method

This method employs electrode designed helmet worn by the driver to detect and monitor the brain behavior via physiological measures. The drowsy detection and monitoring model is designed using the independent component analysis (ICA) and power spectrum to determine the degree of fatigue in the driver from two captured ECG datasets one for drowsy and the other normal drive scene, using an NT-9200 instrument. The ICA was sued to analyze the multi-channel ECG signals, to remove ocular electric and power frequency interferences. Experimental results showed that this method can be used to determine the drowsiness degree of EEG signal accurately and effectually, even though the helmet device used for the process is not very comfortable for drivers and as a result have hindered the application globally (Maninder and Amrit, 2014).

2.5 Machine Learning

Machine Learning (ML) is a computer science discipline and an artificial intelligence (AL) branch that uses statistical techniques to develop the ability of a computer to learn from data without explicit programming. This learning can be accomplished by gradually improving the performance of the system on a particular task by recognizing patterns, making predictions and decisions based on data, and constructing models from sample inputs (Mohammed et al., 2019).

2.5.1 Types of Machine Learning

Even though there are many other algorithms, ML can be grouped into three broad learning tasks, namely supervised learning, unsupervised learning and reinforcement learning as explained in fig. 1 below (Mehta, 2019).

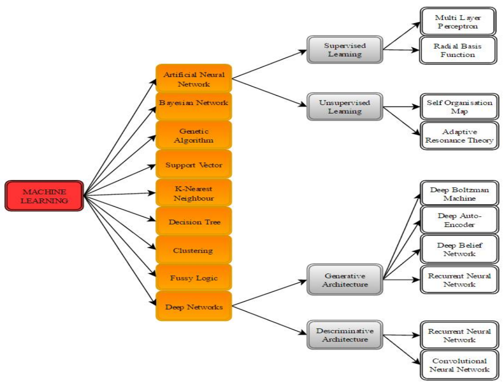

Fig. 1: Types of Machine Learning

a. Supervised Machine Learning

Supervised machine learning, shown in fig. 2, trains itself on a labeled data set. That is, the data is labeled with information that the machine learning model is being built to determine and that may even be classified in ways the model is supposed to classify data. For example, a computer vision model designed to identify purebred German shepherd dogs might be trained on a data set of various labeled dog images (Mehta, 2019).

Supervised machine learning requires less training data than other machine learning methods and makes training easier because the results of the model can be compared to actual labeled results. But, properly labeled data is expensive to prepare, and there's the danger of over-fitting, or creating a model so closely tied and biased to the training data that it doesn't handle variations in new data accurately (Mehta, 2019).

In this type of learning technique, you provide a dataset of different types of shapes which includes square, rectangle, triangle, and Polygon. Now the first step is that we need to train the model for each shape. The desired output in this case is knowing and recognizing the various shapes. The program learns from this data, and next time, it will be able to identify each shape on its own. The machine is already trained on all types of shapes, and when it finds a new shape, it classifies the shape on the bases of a number of sides, and predicts the output.

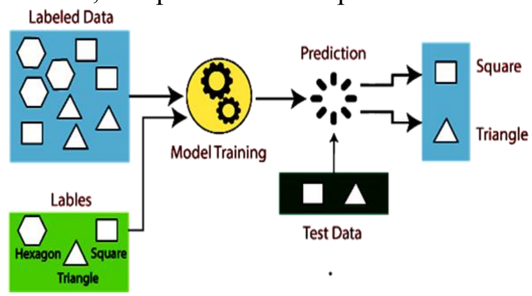

Fig. 2: Supervised Learning

b. Unsupervised Machine Learning

According to (Russel and Norvig, 2019) unsupervised machine learning ingests unlabeled data, lots of it, and uses algorithms to extract meaningful features needed to label, sort, and classify the data in real-time, without human intervention. That means the training dataset doesn't have well defined relationships and patterns laid out for program to learn. Unsupervised learning is less about automating decisions and predictions, and more about identifying patterns and relationships in data that humans would miss. Take spam detection, for example, people generate more email than a team of data scientists could ever hope to label or classify in their lifetimes. An unsupervised learning algorithm can analyze huge volumes of emails and uncover the features and patterns that indicate spam.

In this type of learning technique, the raw data is represented with a selection of fruit. The algorithm finds structure in the data (it notices there are some apples, some bananas, and some oddly shaped oranges). It processes this information and clusters these into groups to be classified. The output is shown in fig. 3 as sorted fruits in neatly defined groups: one for apples, one for bananas, and one for the oranges.

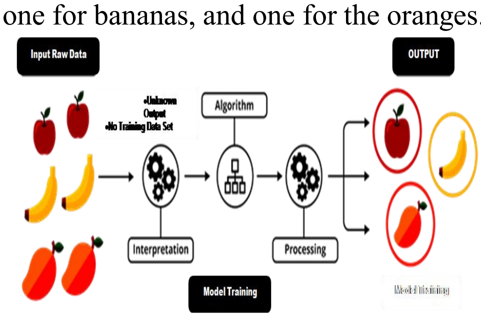

Fig. 3: Unsupervised Learning

c. Reinforcement Machine Learning

Reinforcement machine learning is a behavioral machine learning model that is similar to supervised learning, but the algorithm isn't trained using sample data. This model learns as it goes by using trial and error. A sequence of successful outcomes will be reinforced to develop the best recommendation or policy for a given problem. It is learning what to do, given a situation and a set of possible actions to choose from, in order to maximize a reward. The learner, which we will call agent, is not told what to do; he must discover this by himself through interacting with the environment. The goal is to choose its actions in such a way that the cumulative reward is maximized. So, choosing the best reward now might not be the best decision, in the long run. That is greedy approaches might not be optimal (Russel and Norvig, 2019).

Reinforcement learning is an approach where an agent learns how to behave in an environment by performing actions and seeing the results. Reinforcement learning is connected to applications for which the algorithm must make decisions and the decisions bear consequences. The goal is defined by maximization of expected cumulative reward.

d. Semi-Supervised Learning

Semi-supervised learning, shown in fig. 4, offers a happy medium between supervised and unsupervised learning. During training, it uses a smaller labeled data set to guide classification and feature extraction from a larger, unlabeled data set. Semi-supervised learning can solve the problem of having not enough labeled data (or not being able to afford to label enough data) to train a supervised learning algorithm. This type of learning can again be used with methods such as classification, regression, and prediction (Russel and Norvig, 2019).

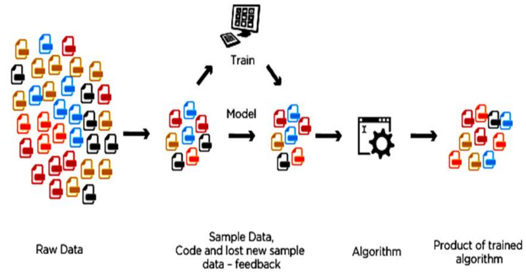

Fig. 4: Semi-Supervised Learning

The goal of a semi-supervised learning model is to make effective use of all of the available data, not just the labeled data like in supervised learning. Making effective use of unlabelled data may require the use of or inspiration from unsupervised methods such as clustering and density estimation. Once groups or patterns are discovered, supervised methods or ideas from supervised learning may be used to label the unlabeled examples or apply labels to unlabeled representations later used for prediction. It is common for many real-world supervised learning problems to be examples of semi-supervised learning problems given the expense or computational cost for labeling examples. For example, classifying photographs requires a dataset of photographs that have already been labeled by human operators (Russel and Norvig, 2019). Many problems from the fields of computer vision (image data), natural language processing (text data), and automatic speech recognition (audio data) fall into this category and cannot be easily addressed using standard supervised learning methods.

2.6 Artificial Neural Networks (ANN)

The field of neural networks is a subarea of machine learning. The human brain has about 100 billion nerve cells. We humans owe our intelligence and our ability to learn various motor and intellectual capabilities to the brain's complex relays and adaptivity. For many centuries biologists, psychologists, and doctors have tried to understand how the brain functions. Around 1900 came the revolutionary realization that these tiny physical building blocks of the brain, the nerve cells and their connections are responsible for awareness, associations, thoughts, consciousness, and the ability to learn. Human brain is one of the best 'machines' we know for learning and solving problems. Within the machine learning fields, there is an area often referred to as brain-inspired computation. The brain-inspired technique is indeed inspired by how our human brain works. It is believed that the main computational element of our brain is neuron. The complex connected network of neurons forms the basis of all the decisions made based on the various information gathered. This is exactly what Artificial Neural Network technique does (Sharma, 2018).

An artificial neural network is a system of hardware or software that is patterned after the workings of neurons in the human brain and nervous system. Artificial neural networks are a variety of deep learning technology which comes under the broad domain of Artificial Intelligence (Mehta, 2019). However, the tools used for modeling, namely mathematics, programming languages, and digital computers have very little in common with the human brain. With artificial neural networks, the approach is different. Starting from knowledge about the function of natural neural networks, we attempt to model, simulate, and even reconstruct them in hardware.

2.6.1 Applications of Neural Networks

There are countless applications for neural networks in all areas of industry, especially for deep learning. Pattern recognition in all of its forms is a very important area, whether analysis of photos to recognize people or faces, recognition of fish swarms in sonar readings, recognition and classification of military vehicles in radar scans, or any number of other applications. Neural networks can also be trained to recognize spoken language and hand written text (Sharma, 2018).

Neural networks are not only used for recognizing objects and scenes. They can be trained to control self-driving cars or robots based on sensor data, as well as for heuristically controlling search in backgammon and chess computers. For quite some time, neural networks, in addition to statistical methods, have been used successfully to forecast stock prices and to judge the creditworthiness of bank customers. Speed trading of international financial transactions would be impossible without the help of smart and fast neural networks that autonomously decide about buying or selling (Sharma, 2018).

2.6.2 Types of Neural Networks

Different types of neural networks use different principles in determining their own rules. There are many types of artificial neural networks, each with its unique strengths. A few of the different types of ANNs and their applications are discussed below (Sharma, 2020):

i. Feed Forward Neural Network

This is one of the simplest types of artificial neural networks. In a feed forward neural network, the data passes through the different input nodes till it reaches the output node. In other words, data moves in only one direction from the first tier onwards until it reaches the output node. This is also known as a front propagated wave, which is usually achieved by using a classifying activation function. Unlike in more complex types of neural networks, there is no back propagation and data move in one direction only. A feed forward neural network may have a single layer or it may have hidden layers. In a feed forward neural network, the sum of the products of the inputs and their weights are calculated. This is then fed to the output (Sharma, 2018).

Feed forward neural networks are used in technologies like face recognition and computer vision. This is because the target classes in these applications are hard to classify. A simple feed forward neural network is equipped to deal with data which contains a lot of noise. Feed forward neural networks are relatively simple to maintain.

ii. Radial Basis Function Neural Network

A radial basis function considers the distance of any point relative to the center. Such neural networks have two layers. In the inner layer, the features are combined with the radial basis function. Then the output of these features is taken into account when calculating the same output in the next time-step. The radial basis function neural network is applied extensively in power restoration systems. In recent decades, power systems have become bigger and more complex. This increases the risk of a blackout. This neural network is used in the power restoration systems in order to restore power in the shortest possible time (Jordan and Mitchel, 2015).

iii. Multilayer Perceptron

A multilayer perceptron has three or more layers. It is used to classify data that cannot be separated linearly. It is a type of artificial neural network that is fully connected. This is because every single node in a layer is connected to each node in the following layer. A multilayer perceptron uses a nonlinear activation function (mainly hyperbolic tangent or logistic function) (Jordan and Mitchel, 2015).

iv. Convolutional Neural Network (CNN)

A convolutional neural network uses a variation of the multilayer perceptions. A CNN contains one or more than one convolutional layers. These layers can either be completely interconnected or pooled. Before passing the result to the next layer, the convolutional layer uses a convolutional operation on the input. Due to this convolutional operation, the network can be much deeper but with much fewer parameters. Due to this ability, CNN show very effective results in image and video recognition, natural language processing, and recommender systems. CNN also show great results in semantic parsing and paraphrase detection. They are also applied in signal processing and image classification. CNNs are also being used in image analysis and recognition in agriculture where weather features are extracted from satellites like LSAT to predict the growth and yield of a piece of land (Jordan and Mitchel, 2015).

v. Recurrent Neural Network (RNN)

A Recurrent Neural Network is a type of ANN in which the output of a particular layer is saved and fed back to the input. This helps predict the outcome of the layer. The first layer is formed in the same way as it is in the feed forward network. That is, with the product of the sum of the weights and features. However, in subsequent layers, the recurrent neural network process begins. From each time-step to the next, each node will remember some information that it had in the previous time-step. In other words, each node acts as a memory cell while computing and carrying out operations. The neural network begins with the front propagation as usual but remembers the information it may need to use later. If the prediction is wrong, the system self-learns and works towards making the right prediction during the back propagation. This type of neural network is very effective in text-to-speech conversion technology.

vi. Modular Neural Network (MNN)

A modular neural network has a number of different networks that function independently and perform sub-tasks. The different networks do not really interact with or signal each other during the computation process. They work independently towards achieving the output. As a result, a large and complex computational process can be done significantly faster by breaking it down into independent components. The computation speed increases because the networks are not interacting with or even connected to each other.

2.7 Review of Relevant Literatures

Several works have been carried out in this research area. Bunch et al. (2011) presented a review of computer vision technique for analysis of urban traffic. The study used computer vision technology to reconfigure video traffic cameras for vehicle tracking and analysis of traffic patterns in urban environment. These cameras were used as sensor for vehicle detection in developing intelligent accident prevention and control system.

Cui et al. (2011) presented a study on abnormal event detection in traffic video surveillance based on local features. The study developed a video-based system which capture traffic data based on local feature vectors and analyze to detect abnormal patterns and make decision. The study was limited to only traffic surveillance and congestion control and not ideally a solution for accident occurrence in highways.

Mehboob et al. (2016) presented a study on traffic event detection from road surveillance video based on fuzzy logic. The study used fuzzy rules to make decisions of abnormal vehicle behavior in traffic patterns. The limitation of the research is the need for improved accuracy from 87%.

Chen et al. (2016) presented a study on vision-based traffic accident detection method using extreme learning machine. The study collected data and train it with extreme learning algorithm for classification of vision data of vehicle as an accident detection system. The limitation with this research is the training dataset lack certain vehicles like the tricycles or instance.

Maaloul et al. (2017) presented a study on adaptive video-based algorithm for accident detection on high ways. In the study an adaptive algorithm was developed which enables vehicle detection nonlinearity from other cruise vehicle and apply control measures to prevent collision. This research despite the success has to be improved using control area network or artificial intelligence technique for reliability.

Boutheina (2018) presented a study on video-based algorithm for accident detection. The study used vehicle data structure to develop an accident detection algorithm. The algorithm detection vehicle behavior and intelligently apply control measures to avoid collision. This research despite the success can be improved using control area or artificial neural network technique.

Nancy et al. (2020) presented a research on highway accident detection and notification using machine learning technique. In the research CCTV camera was used as image acquisition tool. A dataset of 800mimages was used to train clustering algorithm and achieved accuracy of 93%.

III. MATERIALS AND METHOD

3.1 Materials

The materials used for this research were: Data of tricycles, Laptop, Test vehicle (Camry), Power system, Image sensor, Proximity sensor, Controller Area Network (CAN), etc.

3.2 Methodology

The research methodology used is the simulation method. This method employed are data collection; data extraction; development of the Inter-vehicle classification algorithm; development of the accident prevention and control system; and then model implementation.

3.3 Data collection

Data of tricycles were collected from the Delta State Ministry of Transport, Asaba. The sample size of data collected is 1,300 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 fig. 5.

Fig. 5: Samples of Data Collection

3.4 Data Extraction

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

3.5 Development of the Inter-Vehicle Collision Detection Model

To develop the inter-vehicle collision detection model, Feed Forward Neural Network (FFNN) was adopted and then used to develop the classification model. The model of the FFNN is presented using fig. 6.

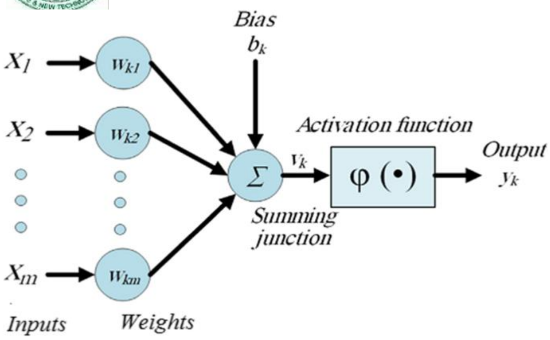

Fig. 6: Architectural Model of the FFNN

The fig. 6 presents a simple model of FFNN where x is the input neurons, w is the weights, b is the bias function, Vk is the summation junction, φ is the activation function and Yk is the output function. This FFNN was loaded with the data collected to configure the new FFNN as shown in fig. 7.

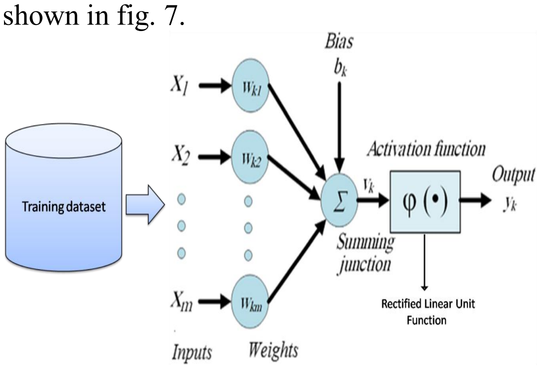

Fig. 7: The System Configuration of the FFNN with Training Data

The FFNN model was loaded with the training dataset to configure the FFNN for training using back propagation algorithm as shown in fig. 8.

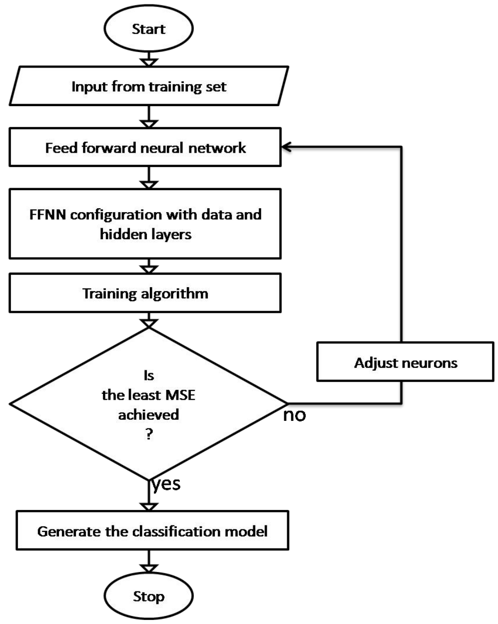

Fig. 8: Flowchart of the Classification Model with FFNN

The fig. 8 presents 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 fig. 9.

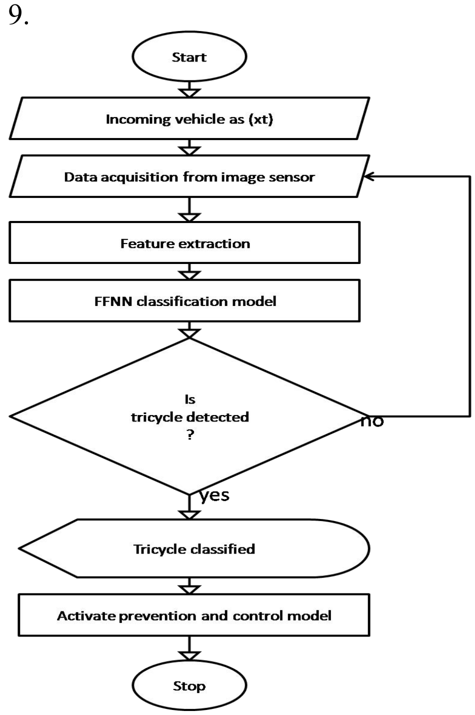

Fig. 9: Flowchart of Inter-Vehicle Collision Detection Model

3.6 Development 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 fig. 9 to develop a flowchart which showed the workflow for the prevention of accident in fig. 10.

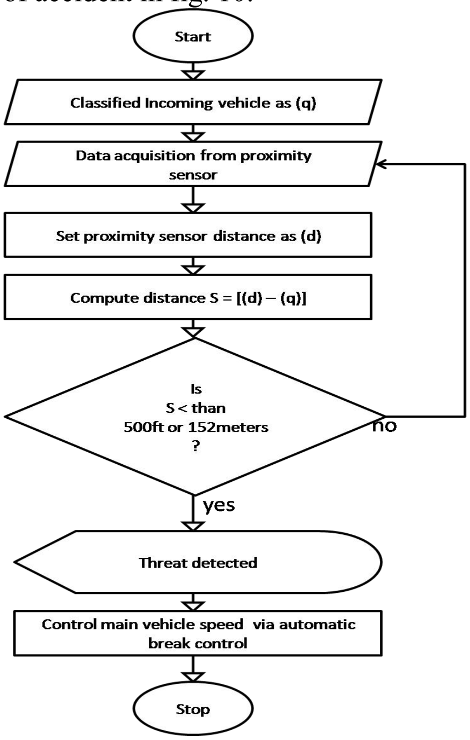

Fig. 10: The Accident Prevention and Control Flowchart

The fig. 10 presents 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 fig. 11.

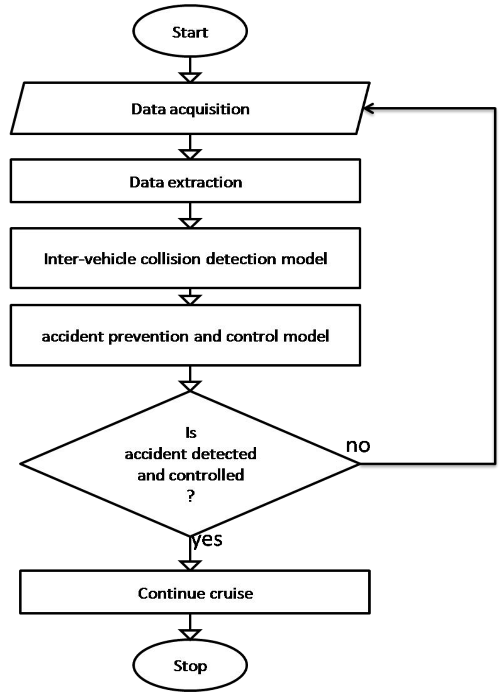

Fig. 11: The Complete System Flowchart

The fig. 11 presents the work flow of the complete accident prevention and control system developed with machine learning. From the flowchart in fig. 11, 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 fig. 9 and tricycle was detected from the vehicle, the distance was determined using the accident prevention and control model in fig. 10 to compute the distance from the main vehicle and if it do not satisfy the 500ft or 152meter 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.

3.7 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.

IV. RESULTS AND DISCUSSIONS

This section presents the results of the inter-vehicle collision detection model developed and validated the results, the results of simulated accident prevention and control system and the result of system integration to show the real live impact on accident control rate.

4.1 Result of the Inter-Vehicle Collision Detection Model

The performance of the inter vehicle collision detection system was evaluated using MSE, ROC curve and confusion matrix. The MSE was used 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 fig. 12 presents the result of the MSE performance.

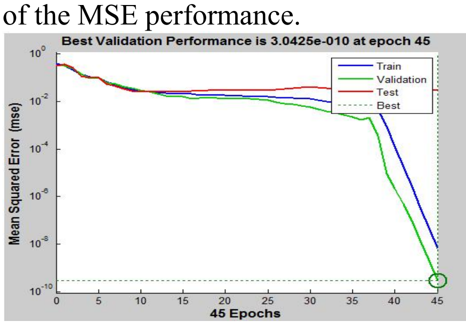

Fig. 12: MSE Result

The fig. 12 presents 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 fig. 13.

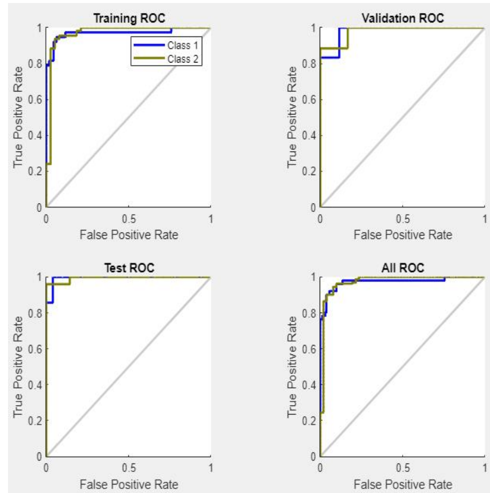

Fig. 13: ROC Analysis

The fig. 13 presents 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 fig. 14.

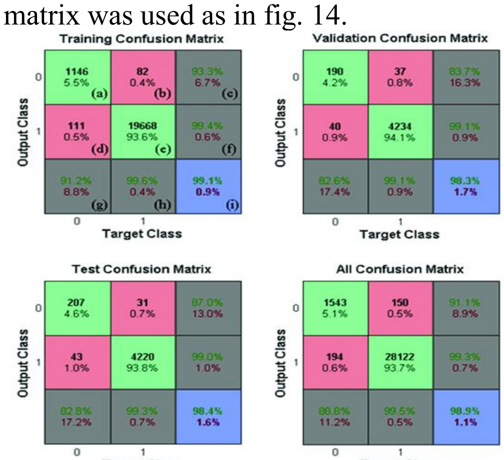

Fig. 14: Confusion Matrix

The fig. 14 presents 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 and control the potential accident on the road.

4.2 System Validation

Having evaluated the performance of the accident detection model developed and analyzed, the system was validated using the tenfold cross validation techniques and the results were presented in table 1.

Table 1: System Validation Result

S/N	ROC	MSE	Accuracy
1	0.9831	3.0425e-10	98.9%
2	0.9852	3.0555e-10	98.6%
3	0.9891	3.0414e-10	97.5%
4	0.9820	3.0543e-10	97.9%
5	0.9871	3.0756e-10	96.3%
6	0.9463	3.0744e-10	97.6%
7	0.9830	3.0701e-10	98.9%
8	0.9871	3.0943e-10	97.5%
9	0.9811	3.0401e-10	98.8%
10	0.9831	3.0473e-10	98.9%
Average	0.9807	3.0512e-10	98.1%

The system validation was presented in table 1 using the ROC, R and MSE. The average result achieved are 0.9807, 3.0512e-10 and 98.1%. The implication of the result showed that the accident detection model was able to correctly detect tricycle threat on the highway and then controlled.

4.3 Results of the Accident Prevention and Control System

Having tested, analyzed and validated the result of the accident prevention and control model developed, it was used to develop an accident control system and evaluated as shown in fig. 15.

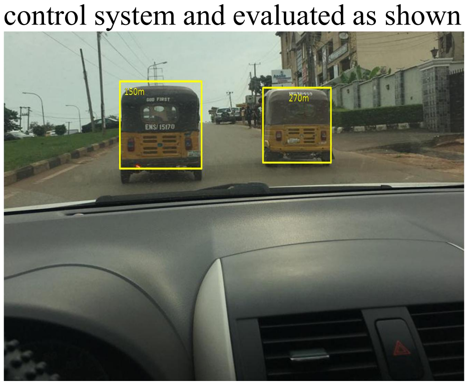

Fig. 15: Results of System Integration with Two Vehicles

The fig. 15 presents 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 classified 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 than 152m 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 152m in the front of the main vehicle, during translation and the speed was controlled. The next result presents another system evaluation as in fig. 16.

Fig. 16: Result of the System Testing with one Threat Vehicle

The fig. 16 presents where the accident detection and control system was able to detect a tricycle which was 92 meters in front of the main vehicle and then control to prevent accident. The next result presents the performance in another driving scenario and it was observed that potential accidents were detected and then controlled as shown in fig. 17.

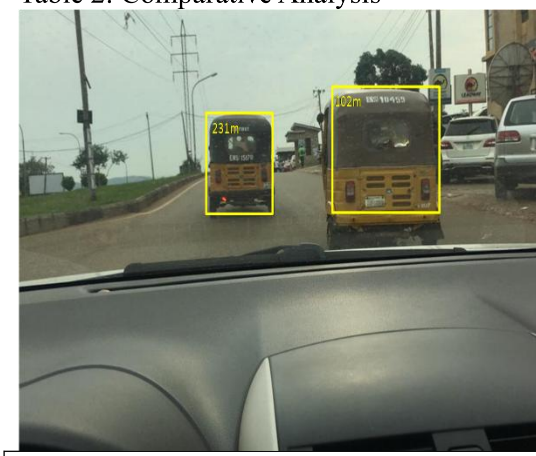

Fig. 17: The Result of the System Integration

4.4 Comparative analysis

In the comparative analysis, some of the sophisticated accident detection and control models developed over the years were analyzed as shown in table 2.

Table 2: Comparative Analysis

Authors	Technique	Accuracy (%)
Mehboobetal et al. (2016)	Fuzzy logic	87.0
Nancy et al. (2020)	Clustering technique	93.0
New system	FFNN	98.1
Nejdet and Abdulhamit (2014)	Agglomerative Hierachical clustering	90.2
Nejdet and Abdulhamit (2014)	K-Mean	79.0
Sreyan et al. (2019)	Convolutional neural network	95.0

The table 2 presents the comparative accuracy performance of the various accident detection and control model developed over the years. The percentage improvement from the best existing model is 5.8%. The results were analyzed using the bar chart in fig. 18.

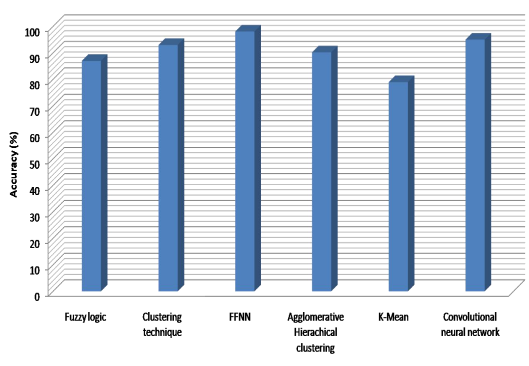

Fig. 18: Comparative Accuracy Performance

The fig. 18 presents a comparative analysis of selected accident detection and control models developed over the years and the new system developed with the FFNN. The result showed that the FFNN achieved better accuracy when compared with the others. The reason was due to the Hog feature extraction approach which was used to extract the required data or training with the FFNN. Because enough and quality data was trained, the performance of the classification model was better. The next result presented the ROC performance in a comparative form as in the table 3 while the graphical analysis was presented in fig. 19.

Table 3: Comparative ROC Performance

Author	Techniques	ROC
Bokaba et al. (2022)	Naïve Bayes	0.82
Bokaba et al. (2022)	Linear regression	0.41
Bokaba et al. (2022)	Support vector machine	0.16
Bokaba et al. (2022)	Adaboast	0.97
New system	FFNN	0.98

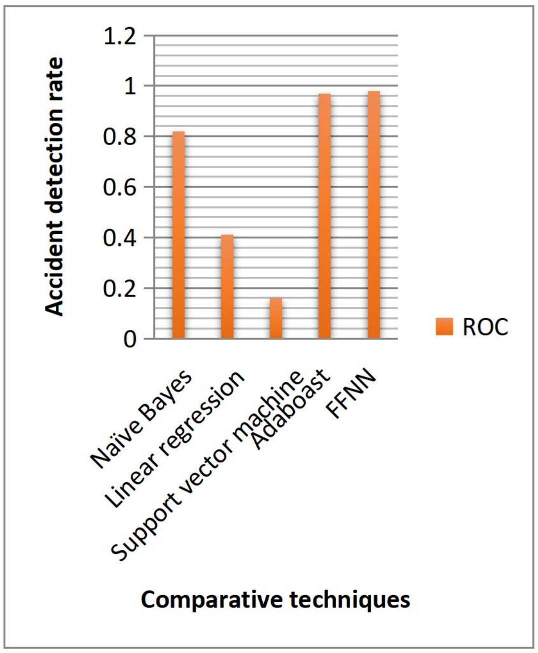

Fig. 19: Comparative Analysis of Accident Detection Techniques

The fig. 19 presents a comparative performance of accident detection models. The result showed that the FFNN achieved better detection performance when compared with existing system.

V. SUMMARY AND CONCLUSION

5.1 Summary

The need for an accident detection and control system which considered the evolving transport system in Nigeria which is the tricycle has remained a vital to help address the issues of vehicle collision. This was achieved in this research collecting data from the ministry of transport and then developing the accident detection and control model using FFNN. Rule based was used to develop the control model. All models were implemented with Simulink platform as an accident detection and control system. The result showed that when the main vehicle integrated was able to detect potential accident from tricycle and then control its behavior to solve the problem.

5.2 Conclusion

Many researchers 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%.

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