Vision Based Behavioural Approach to Drowsy Detection Using Viola Jones Algorithm and Artificial Neural Network

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Abstract: This paper presents a vision based behavioral approach to drowsy detection using Viola Jones algorithm and artificial neural network. The methods used are data acquisition and collection, computer vision training and classification result. The system design was done using structural method and pseudopodia. It was implemented with Simulink/Matlab and then tested. The result when achieved a mean square error (MSE) of 0.0023413Mu and Regression value of 0.97 which is very good after tenfold cross validation. The system was deployed for the detection of drowsiness and the result showed that it was very reliable as an accident prevention and monitoring system.

Keywords: *Viola Jones, Vision, Drowsy Driver, Accident, Classification, Regression*

I. INTRODUCTION

According to Strong Tie Insurance (STI), everyday over 10 people die of vehicle related accidentsin California,United States alone (STI, 2020). In Nigeria the Federal Road Safety Conference (FRSC) reported that over 12077 car related accident occur every year, with a record of 75400 fatalities on average (FRSC, 2015). According to Kekong et al. (2021) the leading causes of this accidents is drowsiness as it is defined as a state of nonlinear concentration by the driver as a result of fatigue, stress, hunger, drugs, alcohol, lack of sleep etc.

Over the year this problem have triggered many ideologies to address it which can be classified into three methods which are vehicle based approach, physiological approach and behavioral approach (Gwak et al. 2018; Hulnhagen et al., 2015; Li et al., 2015). The three classifications aforementioned all have their pros and cons;however the use of behavioral approach provides better result when compared to the res according to Kekong et al. (2021).

Behavioral approach involves the monitoring of the drivers behaviors via data collection using sensors and then process to detect the drivers behavior and alert for drowsiness when detected (Li et al., 2015).However, this technology despite the success still suffers issues of reliability, high cost, and false alarm among other challenges and as a result leaves great room for improvement. This research therefore proposes to solve this problem using Artificial Intelligence (AI) technique.

AI is simply a machine which can perform human related task perfectly and are of various classifications as in (Sharma, 2018; Bartosch et al., 2014), but the machine learning class provides better performance, compared to rest due to their ability to learn before making decisions and are of many algorithm, ranging from K-nearest neighbor, Support vector Machine, Clustering, Naïve Bayes, Artificial Neural Network among others (Nadia, 2020).

Over time many works have employed A.I algorithms to tackle this problem of drowsy driver. Some of the works includes (Ashish and Rasha, 2018; Tanaer et al., 2018) which used machine learning and visual based approach to address the problem of drowsy driver, but the solution proposed have issues of delay training time. Vesselenyi et al. (2017) proposed a neural network based system to solve the problem of drowsy driver, but the solution despite the success the solution never considered key drowsy attributes like head down and continues eye blinking which is vital to any reliable drowsy detection system. In Savas and Becerikli (2018), support vector machine was used to address the probe of drowsiness, but despite the success, there is still room for improvement. Kekong et al. (2021) used deep neural network algorithm to address the problem of drowsiness but despite the success suffers delay training time.However from the study it was observed that the use of neural network provides better result in terms of accuracy and speed of training. This algorithm will be used to develop a real time drowsy driver detection system for accident prevention and control.

II. METHODS

The methods used for the development of the new system are data collection, computer vision, training and classification result.

Data collection: The data collection process involved that collection of drowsy driver videos from self 10self volunteered drivers. This data were collected with video camera for 5secs each which displayed various drowsy attributes and stored in three different classes which are perfect driving behavior, critical drowsy behavior and minor drowsy behavior. The source of this data collect is Kekong et al. (2021) as the dataset contained all required features of drowsiness such as head down, eye closes, continues eye blinking, yawing, etc and are perfectly modeled to solve the problem of false alarm. The sample size of the data collected is 4900 video frames with 2000 stored as perfect driving attributes, 2600 stored as critical driving attributes and finally 300 stored as minor driving attributes.

Computer vision: this method is vital to detect and collect drowsy features intelligently. This was done using Viola and Jones algorithm which Asogwa and Ituma (2018) to develop an intelligent video based system which searches for drowsy symptoms from the drivers behavior and then classify and collect the features based on Adaboast learner and Haar classifier and to develop an intelligent video based system which searches for drowsy symptoms from the drivers behavior and collect the output as the training data.

Training: The paper which inspired this journal was Kekong et al. (2019), however despite the quality data developed, the training algorithm used is deep learning which is only reliable when very huge volume of data is used for training. Reliability is the key for every system as this measurement parameters supersedes other scales of preference as it is the main factors for acceptability of any system in the public domain.

To this end, this paper employed a simpler training model which is compatible with the dataset collected called feed forward neural network. This is a simple configuration of neurons into interconnected layers to solve pattern recognition problems. This was used to train the data collected and achieved a reference drowsy model used for the classification of drowsy behavior.

The training algorithm divided the training data into three sets of testing, training and classification sets before training and the output provided the necessary algorithm deployed for drowsy driving detection and accident control system.

Classification result: this process is the output layer of the neural network to produce the result of the training process which can be drowsy detect, driving in perfect condition or sensing drowsy behavior. Other result includes the performance evaluation of the training process such as the Mean square Error (MSE), and regression which are all discussed in the result section.

III. MODELLING

The system modeling was done sing structural method which employed logical diagrams to present the relationships between the variables which interacted to develop the new system. The section modeled the new training algorithm produced to learn the data and generate the reference drowsy model using the artificial neural network model in figure 1 and the configured training algorithm in figure 2;

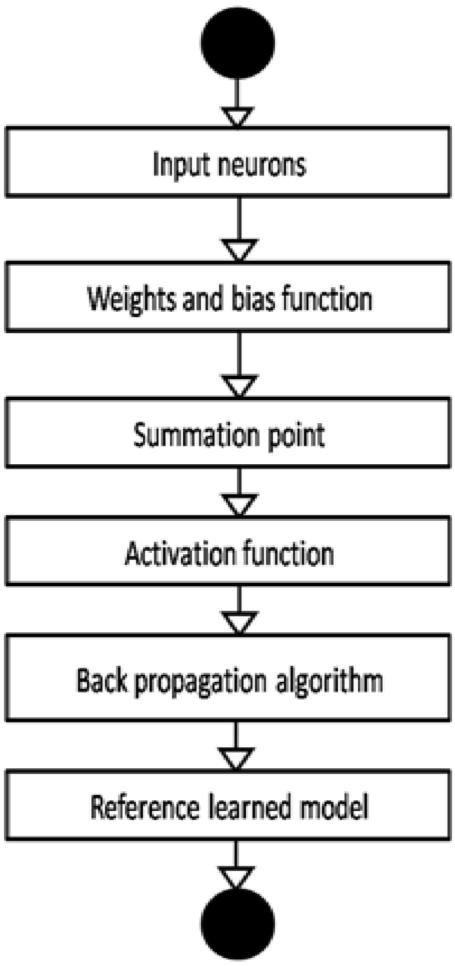

Figure 1: ANN structure

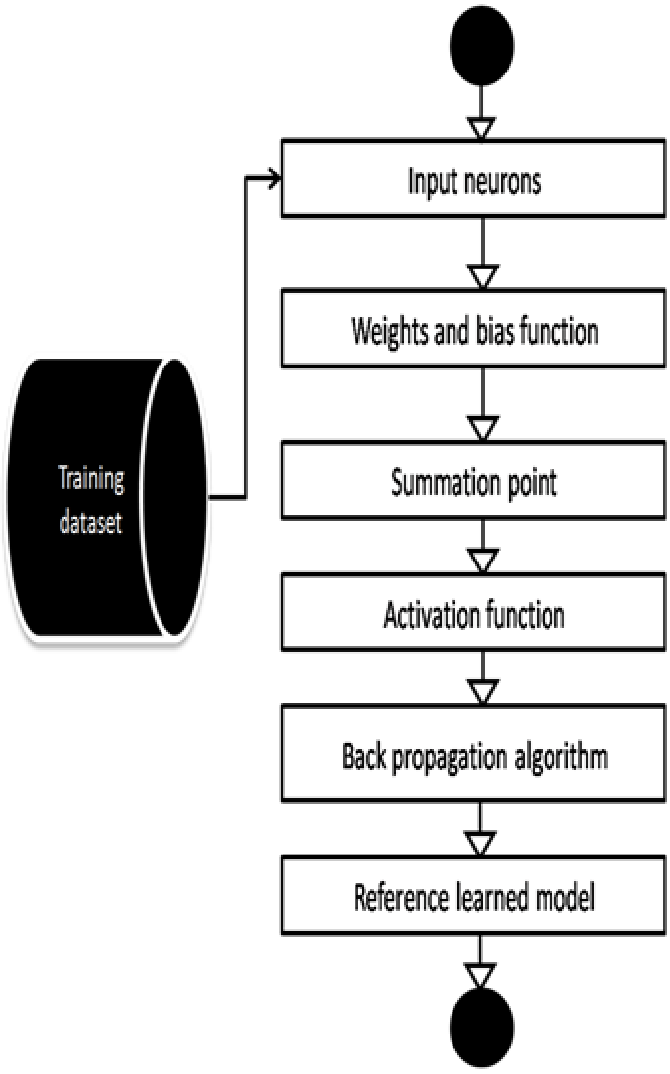

Figure 2: trained ANN model

The model in figure 1 presented the neural networks structure which ahs weights and bias function to sum up data input and then activate into statistical vectors using tansig activation function in Bartosch et al. (2014) and then train the data with back propagation algorithm in figure 3 to generate the reference drowsy model. The figure 2 showed how the dataset was channeled to the input layers of the neural network configured in the pseudopodia below and then trained. The parameters used for the configuration of the network are presented in table 1;

Table 1: ANN configuration parameters

Parameters	**Values**
The Training epochs	19
Size of the hidden layers	2
Iterations per epoch	10
Training segment	30
No. delayed reference inputs	2
Maximum feature outputs	2
Maximum feature inputs	9
Numbers of non hidden layers	10
Maximum interval time per sec	2
No. delayed outputs	1
No. delayed feature outputs	3
Learning rate value	0.001
Minimum reference	-0.7
Maximum reference	0.7

A. Pseudo Code of Training Algorithm (Back Propagation)

1. *Start*
2. *Activated drowsy feature vectors*
3. *Select feature variables*
4. *Initialize threshold for weights and bias functions*
5. *Vary the weights and bias iteratively*
6. *Check epoch performance at 10 step*
7. *Is training ok=true*
8. *Stop*
9. *Generate reference drowsy model*
10. *Else*
11. *Train until epoch is satisfied for true*
12. *End*

B. The System Flow Chart

The system flow chart presented the logical data flow of the drowsy driver developed showing how the data collected was achieved using computer vision algorithm to collect desired drowsy attributes which are loaded into the training algorithm developed for classification of drowsy behaviors and then the process continues. The flow chat is presented in figure 3;

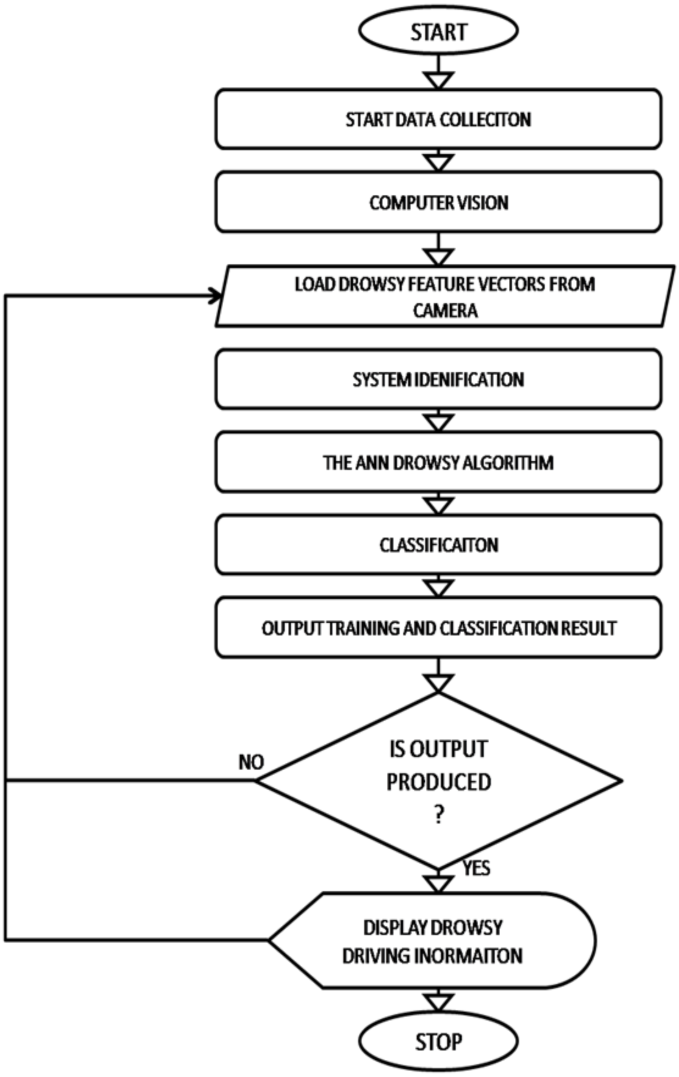

Figure 3: System flow chart

The figure 3 the system flow of operation was presented showing how the data acquisition system which is camera configured with Viola and Jones algorithm to collected drowsy features from the driver and then trained with the ANN algorithm developed to classify drowsy output and prevent accident.

IV. SYSTEM IMPLEMENTATION

The system was implemented with neural network toolbox, statistics and machine learning toolbox, data acquisition toolbox and Simulink. The data was loaded into the neural network toolbox and train to generate the drowsy reference script, deployed on Matlab as a drowsy driver detection system. The result of the system implementation was presented in the next section.

V. RESULTS AND DISCUSSION

The result presented the performance of the neural network training tool used to evaluate the performance of the algorithm. The evaluation was done using Mean Square Error (MSE) and regression analyzer and the result is in figure 4;

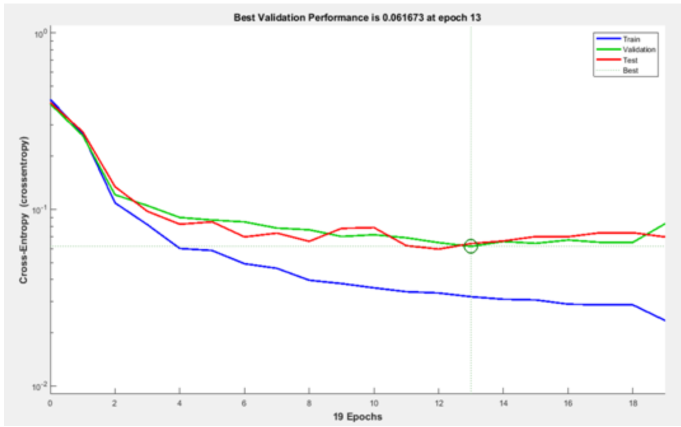

Figure 4: Result of the improved training algorithm

The aim of evaluating a system using MSE is to check the error rate in the system when deployed for use and also to achieve an approximate MSE value of zero.

The result achieved in the training process produced an MSE value of 0.061670Muachieved after 18.5 iterative epoch values and the epoch at which the best training result was achieved is 13. The implication is that at this epoch the neural network correctly learned the data and was able to detect drowsiness correctly.

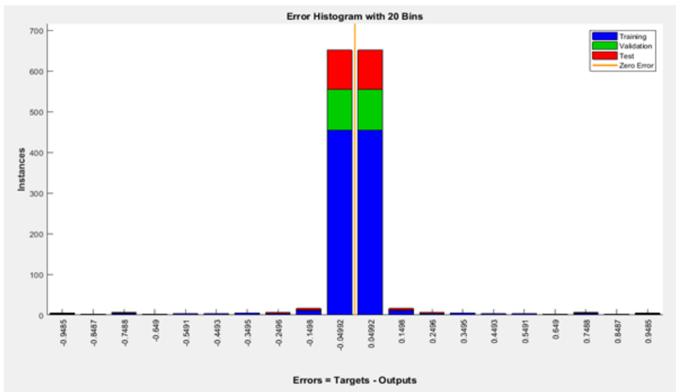

Figure 5: The error histogram result

The result in figure 5 presented the error histogram between the targeted values and then the predicted values after the algorithm was trained with the drowsy data. The result showed that the error range varies from -0.9485 to 0.9485 with an average weight of 1.897within divided into twenty bins of histogram and the values of the weight used to update the learning rate during the training process. In order words this result presented the value of the neural network weights used to update the update during the training process to achieve minimal error. The next result presented the regression performance of the train drowsy driver model.

Regression is a score used to measure the degree of correct classification output of the drowsy driver system using true positive rate and false positive rate. The true positive measure the correct classification of drowsiness by the diver while the false positive rate measures the correct classification of driver not displaying drowsy behaviors. The result is presented in figure 6;

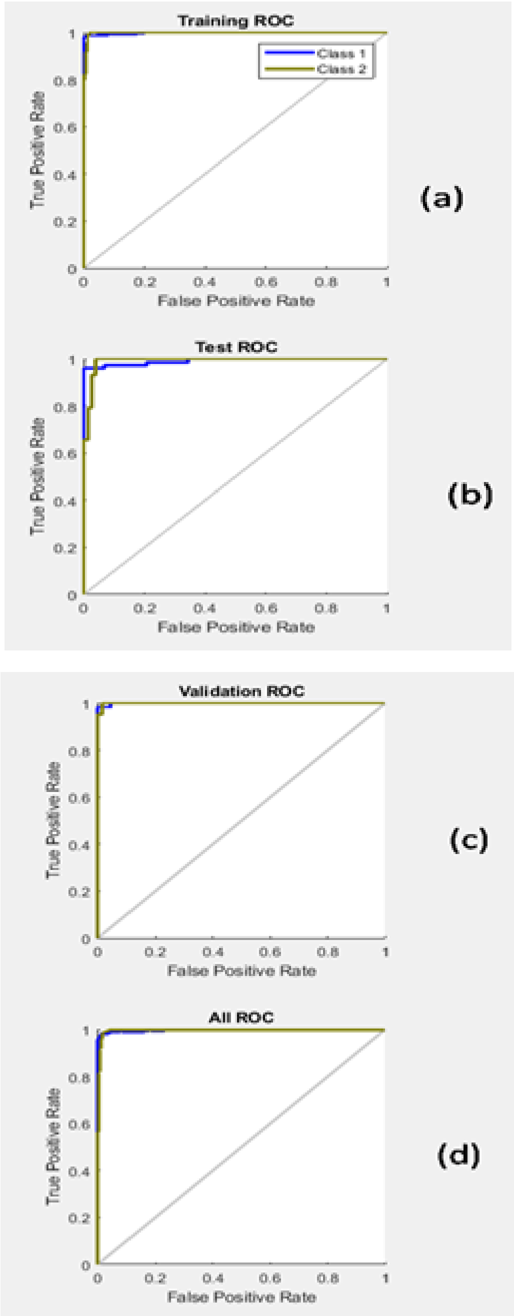

Figure 6: Regression result

From the figure 6, it was observed that the training tool evaluated the performance of the multi sets which are the training (a), test (b), validation (c) and then the overall average (d). from the graph presented it was observed that the average regression of the training process is 0.957 which is very good as it is close to the ideal regression score of 1 that indicates precision performance. Ten fold cross validation performance was further used to evaluate the result of the regression and MSE performance and the data recorded was presented in the table 2.

Table 2: Tenfold validation result

S/N	Regression	MSE
1	0.958	0.061670
2	0.925	0.041109
3	0.975	0.073310
4	0.956	0.022970
5	0.952	0.051330
6	0.955	0.071110
7	0.921	0.055170
8	0.945	0.049904
9	0.937	0.045451
10	0.939	0.060669
Average	0.946	0.053269

The table 2 presented the regression and MSE validation performance of the drowsy driver algorithm developed. The result showed that the average Regression value is 0.946 which is very good and the MSE value is 0.053269 which is also very good as they are both approximately the ideal value for each measurement standards. The next result presented the deployment of the algorithm as drowsy driver detection software to monitor driver's behavior while driving as shown in figure 7;

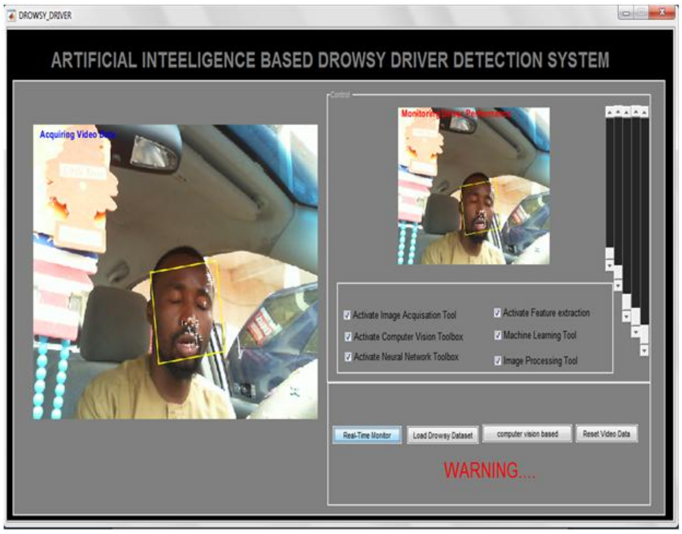

Figure 7: system performance during drowsy driver detection

From the system it was observed that the software was able to detect the behavior of the driver as sleeping and indicated warning sign which was used to notify user of the critical drowsy behavior which can cause accident. The next result also shows how he system was able to detect minor drowsy signs as in figure 8;

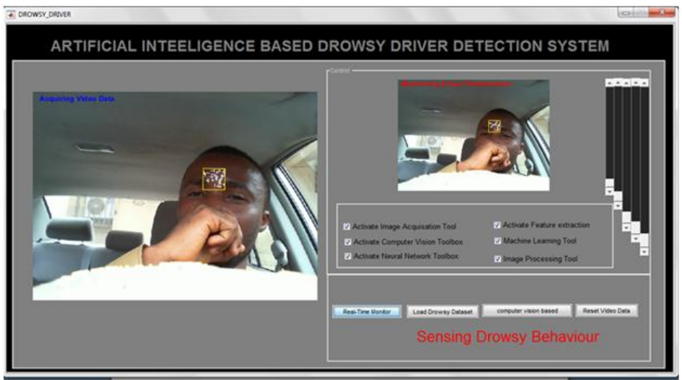

Figure 8: performance of the system when sensing minor drowsy behavior

The figure 8 presented the system performance during the detection of minor drowsy sign like yawing to notify the driver of the incident and hence takes precautionary measures on time before it gets to critical drowsy signs which has more tendencies for accident.

CONCLUSION

This research have successfully developed a drowsy driver detection system which is very reliable, cheap and considers all attributes of drowsiness to make accuracy classification using a neural network based algorithm. This system was deployed and tested in a vehicle with self volunteered driver and it was observed that is has the capacity and intelligence to correctly classify drowsy signs and notify the driver to prevent accident. The result when evaluated was reliable as it error rate is very minimal at a MSE value of 0.053269 which is very acceptable and then a regression value of 0.946 which is also very good score of regression for a classification model.

CONTRIBUTION TO KNOWLEDGE

The paper developed a reliable drowsy driver detection system using artificial intelligence technique.

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