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Computer Vision for Healthy Driving Detection Using Convolution Neural Network

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Driving involves a rigorous act where the driver controls the operation of a motor vehicle. There have been few deployments of healthy driving applications, while some of these applications are machine learning applications some are program-driven applications. Nigeria as a developing country has little or no trained datasets for healthy driving, therefore this research will be charged with collecting local data for driving events to be trained. The datasets were collected as images. These images were extracted for driving events braking, safe driving, and speeding. The images were locally collected for Nigeria driving settings and computer vision techniques were applied to the data. The machine learning algorithm used to evaluate the model is Convolution Neural Network, the editors used for image labelling and coding the system are Jupyter notebook and VS

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Code. Python programming language and its libraries were also used. The classification results for model loss, accuracy, validate loss and validate accuracy and the performance of the model is 0.99 or 99%, based on this the last epoch was recorded and the loss was 0.03 or 3%.This classification result proved that the data collected from Nigeria is trainable. The trained data can be used by researchers all over the world working on safe and healthy systems in Nigeria for driving. The result also presented a convolution neural network as an algorithm suitable for healthy driving detection using computer vision. The predicted values for the three driving events were all positive. The three driving events were all detected perfectly while running the parallel testing without being perverse.

Keywords: Machine learning; computer vision; convolution neural network; healthy driving.

1. INTRODUCTION

"Computer vision is a scientific field that extracts information from digital images" [1]. "The type of information gained from an image can vary from identification, space measurements for navigation, or augmented reality applications". [1] Defined computer vision again through its applications, He defined it as building algorithms that can understand the content of images and use it for other applications. Computer vision brings together a large set of disciplines. Neuroscience can help computer vision by first understanding human vision, as we will see later on. Computer vision can be seen as a part of computer science, and algorithm theory or machine learning is essential for developing computer vision algorithms.

The application of information technology in safe driving and artificial transportation systems requires a good understanding of human driver behavior [2]. "Automating safe driving isn't handiest essential to guarantee secure and good enough overall performance, but also to regulate the drivers' desires, enhance their acceptability, and ultimately meet drivers' alternatives in a secure environment" [3]. "The ability to drive is one of the most important activities of daily living. Modeling and recognizing human driving behavior have interested researchers from many different disciplines like psychology, physiology, and ergonomics for more than half a century" [4]. "Modeling and recognizing human driving behaviour have interested researchers from various disciplines, including psychology. Drivers must make correct perceptions and cognitions about their driving decisions, the driver's state, and their vehicle performance" [3]. Healthy driving can be likened to behaviour or attitude, a hungry driver can never make a good driving and an angry driver can never make a good driving. Even psychological effects can be likened to the behaviour or attitude of a person and can therefore affect his behaviour while driving. Therefore safe driving does not only involve monitoring vehicle safety, road safety, weather conditions and so on, but we have to actually look at persons driving these vehicles and how to monitor their behaviour and attitudes towards driving and then return feedback which is likely to assist them to adjust their driving styles. When this system is achieved, human driving skills and behaviours will be encouraged and the results can be used to deploy vehicle onboard systems which now improve the vehicle's functionalities and driver's safety.

"The roads have been a concern of authorities to avoid unwanted circumstances. These roads are vulnerable to scenarios such as traffic load, weather conditions, age, poor material used for construction, and miserable drainage system, exhibiting two major road failures such as cracks and potholes" [5]. In this paper, the objective is to build a model for the detection of healthy driving events by using a local dataset extracted from Nigeria.

2. LITERATURE REVIEW

In the review done by Anigbogu et al. [3] in their work intelligent feedback model for healthy driving style they were able to draw two conclusions after reviewing works done on healthy driving style and safe driving, firstly, no available trained dataset for healthy driving style and secondly no model for healthy driving style using machine learning has been built for Nigeria.

Jaswanth [7] Investigated "the performance of the CNN (Convolutional Neural Network) model in identifying driver mobile usage. The data collection (State Farm dataset from Kaggle) and also validation process of the approach were conducted on laboratory-dependent driving testbeds. The dataset used includes the safe driving and distracted driving images of the respective drivers. His work identified the distracted drivers and categorize them using the CNN model and also compared the performance of various architectures of CNN in mobile usage detection. Their modified architecture attained an accuracy of about 96.95 percent and they concluded from their research that the deep learning model provides better accuracy in the detection of driver distraction. Adding to that it has provided better accuracy of mobile usage detection with their experimental results".

Hou et al. [8] Designed "a driver's phone usage detection system. It is composed of the mobile terminal and PC part. They used mobileNet combined with the single shot multi-box detector to achieve object detection. They also compared their method with the Yolov3 and Faster-RCNN network. From their result, the accuracy of the three methods is high, but the running times of the three methods are different. Their method achieved 46 milliseconds, while Yolov3 network cost 4799.8 second, and the Faster-RCNN was demonstrated to be not applicable to raspberry pi used in their system due to its high computational cost. Moreover, the SSD mobilenet v3 and Yolov3 models were demonstrated to have the better accuracies used in their system than that of the Faster-RCNN".

Shirajum et al. [9] Presented "a cognitive behavioral-based driver mood repairment platform in intelligent transport system for road safety. They proposed a driving safety platform for distracted drivers. In their developed driving safety platform, they employed five artificial intelligence and statistical-based models to infer a vehicle driver's cognitive-behavioral mining to ensure safe driving during the drive. They deployed capsule network (CN), maximum likelihood (ML), convolutional neural network (CNN), Apriori algorithm, and Bayesian network (BN) for their driver activity recognition, environmental feature extraction, mood recognition, sequential pattern mining, and content recommendation for affective mood repairment of the driver, respectively".

Rajput et al. [10] Made "use of deep learning algorithms viz. SSD (singleshot multibox detector) and Faster- RCNN (Faster region dependent Convolutional Neural Network) to detect the usage of mobile phones. They highlighted the significance of detecting cell phone usage and the major challenges involved within the detection. The dataset of state Farm has been extracted from the Kaggle which is referred to as the Kaggle driver dataset. Deep learning models have been trained and evaluated on the gathered datasets. Specifically, SSD (Single Shot Multibox detector) and Faster RCNN have been used for a better range of detection. In addition, they created a dataset on mobile phone usage, which they termed IITH-dataset on mobile phone usage (IITH-DMU). They have obtained better accuracy in the detection of mobile phone usage. They captured various images in 15 different situations which show the high variation in background and foreground scenes and the clutter amount. On the kaggleDriver dataset, the AP at 0.5Iou is 98.97% with SSD and 98.84% with Faster-RCNN. On IITH-DMU dataset, these numbers are 92.6% for SSD and 95.92% for Faster-RCNN".

Xue et al. [11] Proposed "a driving style recognition method based on vehicle trajectory data extracted from the surveillance video. The trajectory data was collected by U.S. Federal Highway Administration (FHWA) in 2005. The driving style of each driver in training data were labelled based on their collision risk level using K-mean algorithm. Then, the driving style recognition model's inputs were extracted from vehicle trajectory features, including acceleration, relative speed, and relative distance".

Anigbogu et al. [12] In their work an intelligent mobile application for safe driving, they presented a safe driving application that assists drivers by detecting and predicting potholes while on the road to curb road accidents in Nigeria. The datasets used in this research were potholes images extracted from kaggle which were classified into two; potholes and normal roads. The object detection algorithm that was used to evaluate the model is YOLOv5. The results proved that our model was not perverse. We deployed the model to the mobile application, the mobile application when launched activates the camera by default enabling the system to detect and predict between normal roads and potholes. The predicted values were all positive. The two classifiers were all detected perfectly in real-time while testing without being perverse. The system presents its predicted value in percentage, therefore showing the level of adherence to each of the classes detected.

3. MATERIALS AND METHODS

3.1 Data Collection

The dataset used in this work are structured and unstructured dataset, the structured data is the primary data collected real time while the unstructured dataset were extracted from online platforms using Google search engine restricted to Nigeria driving event settings and this was used for the analysis. The feature of these datasets i.e., class value has three possible values which are the driving events that were adopted for this work: braking, speeding and safe driving, these driving events are the class labels. The dataset containing a total of 5274 instances was used in this work. 70% of the dataset was used for training and 30% for testing.

3.2 Model Selection

We adopted the Convolution Neural Network model for this work.

3.3 Choice of Programming Environment

The program was developed using machine learning techniques; and the editors used for coding the system are Jupyter notebook and VS Code. Python programming language and its libraries were also used.

Jupyter notebooks basically provides an interactive computational environment for developing Python based Data Science applications. They are formerly known as ipython notebooks. The following are some of the features of Jupyter notebooks that has made it one of the best components of Python ML:

- Jupyter notebooks can illustrate the analysis process step by step by arranging the features like code, images, text, output etc. in a step-by-step manner.
- It helps a data scientist to document the thought process while developing the analysis process.
- One can also capture the result as the part of the notebook.
- With the help of Jupyter notebooks, we can share our work with a peer also.

Visual Studio Code focused mainly on the code editor. Its cross-platform supports syntaxes for a large number of programming languages. The environment is not fancy and focuses exclusively on providing flexibility and simplicity to promote compatibility across the platforms offered, beyond support for Git repositories or the ability to open multiple files iterations in one window.

Convolutional Neural Network architecture has three kinds of layers: convolutional layer, pooling layer, and fully-connected layer [6].

- A convolutional layer is responsible for recognizing features in pixels.
- A pooling layer is responsible for making these features more abstract.
- A fully-connected layer is responsible for using the acquired features for prediction.

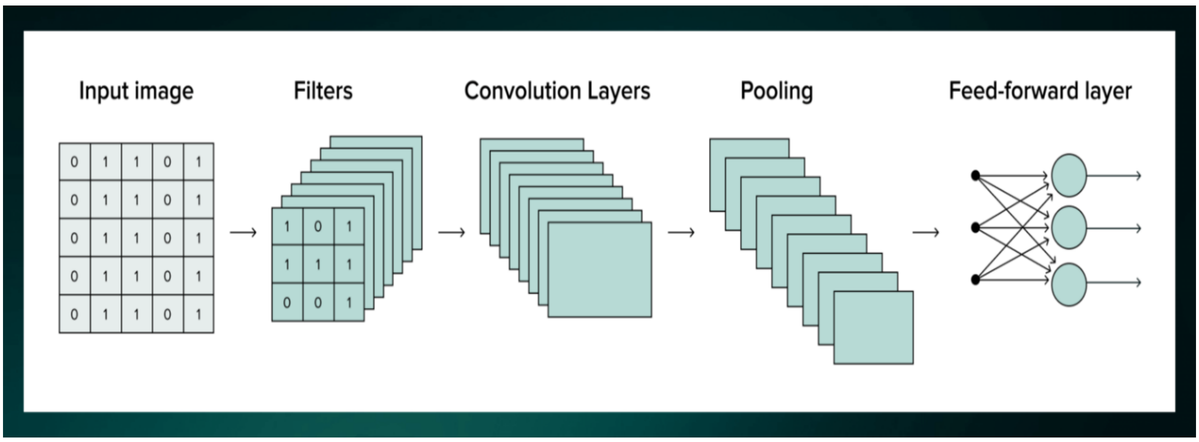


Fig. 1. Convolutional neural network architecture [6]

4. RESULTS AND DISCUSSION

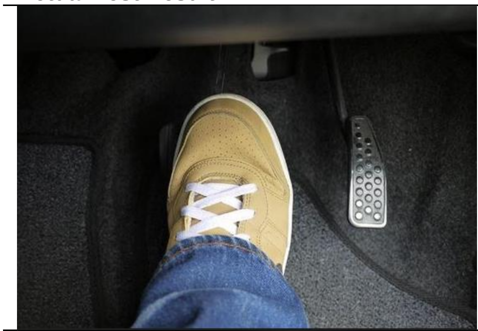
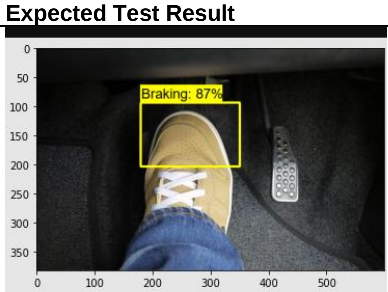
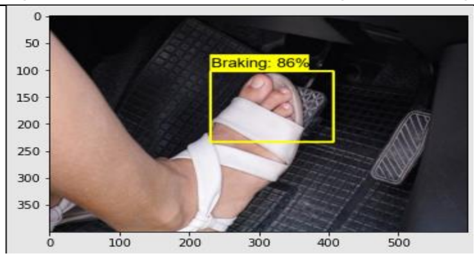
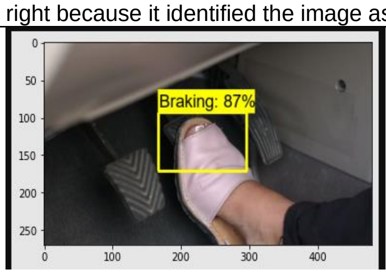
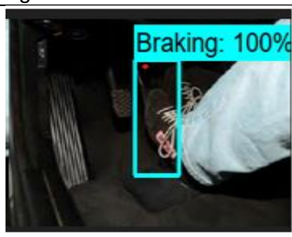
This section focused on the discussion and results obtained in this paper. The system was implemented with three class labels (braking, safe driving and speeding). Convolution Neural Network was used to train the data and the model was built from it. This dataset was pre-processed and feature extracted before applying a classification algorithm to it. The classification used captured all the required training samples of data and used the test data to make detection and prediction as well as evaluate the model performance.

4.1 Model Evaluation for CNN

Actual Test Result versus Expected Test Result.

Table.1 presents the actual test result and expected test result for CNN.

Table 1. Comparative overview of actual test result and expected test result for CNN

Actual Test Result	Expected Test Result
	 The prediction was perfect with 87% score, the detection was right because it identified the image as braking.
	 The prediction was perfect with 86% score, the detection was right because it identified the image as braking.
	 The prediction was perfect with 87% score, the detection was right because it identified the image as braking.
	 The prediction was perfect with 100% score, the detection was right because it identified the images as braking.

The Table 1 presented the sample data that was used for testing and the parallel testing results, the results were all classified well as none of them were perverse.

Table 2. Model performance evaluation for CNN iteration of Epoch 5/5

Epoch 1/5	[==============================]	604s 15s/step	**loss** 0.7851	**Accuracy** 0.7934	**val_loss** 8.6986	**val_accuracy** 0.2687
Epoch 2/5	[==============================]	10s5 15s/step	**loss** 0.1247	**Accuracy** 0.9604	**val_loss** 1.1068	**val_accuracy** 0.6806
Epoch 3/5	[==============================]	510s 15s/step	**loss** 0.0483	**Accuracy** 0.9850	**val_loss** 0.4407	**val_accuracy** 0.9192
Epoch 4/5	[==============================]	493s 14s/step	**loss** 0.0455	**Accuracy** 0.9862	**val_loss** 0.1256	**val_accuracy** 0.9776
Epoch 5/5	[==============================]	463s 13s/step	**loss** 0.0303	**Accuracy** 0.9912	**val_loss** 0.1648	**val_accuracy** 0.9387

Table.2 illustrate the level of CNN model train with batch size of 70 and iteration epoch of 5 respectively for model loss, accuracy, validate loss and validate accuracy and the performance of the model is 0.99 or 99%, based on this the last epoch is recorded and loss is 0.03 or 3%. Hence below graph depict the differences between the model accuracy and model loss.

3.2 System Testing

For machine learning systems, the testing is done on the process of running the model evaluation and model testing in parallel.

Model evaluation covers metrics and plots which summarize performance on a validation or test dataset.

Model testing involves explicit checks for behaviors that we expect our model to follow.

Both of these perspectives are instrumental in building high-quality models. In practice, most people are doing a combination of the two where evaluation metrics are calculated automatically and some level of model "testing" is done manually through error analysis (i.e., classifying failure modes). Developing model tests for machine learning systems can offer a systematic approach towards error analysis.

5. CONCLUSION

This research has shown that using image data for machine learning by applying computer vision technique is one of the best means of training a model. Convolution Neural Network has once again presented itself as one the best machine learning algorithm for image data, especially the unique dataset from this part of the world (Nigeria). The data were collected, preprocessed and prepared in suitable format to be used by the machine learning algorithm. The results after the classification and parallel testing is encouraging as the system presented good detections and predictions. These results can be adopted by researchers seeking to work in this part of the world. The results can be used to deploy applications like safe driving, vehicle security and many other model as related to intelligent transport systems. Feedbacks from the applications will go a long way in improving healthy driving behaviour of driver while driving.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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