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Facial Emotion Recognition And Detection Using Convolutional Neural Network

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ABSTRACT

Human emotions have important role in communication especially to understand the emotions of those with speech problems. Various facial emotion recognition and detection systems have been developed but most of these systems have difficulty in performing a muti-class classification and yielded lower accuracy. Therefore, this research employed convolutional neural network for recognition and detection of four basic emotions: happy, sad, angry, neutral. The dataset for training the convolutional neural network model was obtained locally and it include about 133 images. Results show that the system developed performed well with an accuracy of 0.9533, precision of 0.97, F1-score of 0.94 and recall of 0.93. The approach used showed a significant improvement over traditional machine learning methods and be a useful tool for those with speech problems and visually to predict human emotion.

1.0 INTRODUCTION

People express their emotion on their faces to show their psychological activities and attitudes in the interaction with other people. Facial expression indicates how a person feels when communicating with another person [1]. It helps to determine how to keep a conversation going and the state of mind of an individual. Facial expression is important because it helps to convey non-verbal communication to other people thereby promoting interpersonal relationship among them [2]. However, from the United Nations report of 2018, about 1.1 million Nigerians are visually impaired and almost ten million people have hearing and speech disabilities in Nigeria [3]. It is difficult to understand the emotions of those with speech problems and the visually impaired find it difficult to understand people's emotions, hence the need for facial emotion recognition systems.

Various facial emotion recognitions systems have been developed using the following algorithms: support vector machine, relevance vector machine and k-nearest neighbor algorithm. The limitations of these algorithms are: difficulty encountered while performing multi-class classification which is attested to with regards to the training time, computational time and insufficient memory space [4]. Other approaches include: scale invariant and feature transform (SIFT) and histogram of oriented gradients (HOG) which perform reasonably well on datasets of images captured in a controlled condition but fail to perform well on more challenging datasets with more image variation and partial faces [5]. AdaBoost algorithm which is an ensemble approach has also been used by previous research for facial emotion recognition but the limitations of the approach are its high sensitivity to noisy data and outliers. Therefore, this research developed a facial emotion recognition system for four basic emotions: happy, sad, angry and neutral using Convolutional Neural Network (CNN). CNN is a deep learning algorithm that takes an input image, assigns importance (learnable weights and biases) to various aspects/objects in the image and can differentiate between images. The algorithm was chosen because it requires lesser pre-processing methods compared to other classification algorithms and can process images easier and faster. It also provides an efficient dense network which performs the prediction oridentification successfully [6]. Jaiswal et al (2020) [7] focused on CNN-based emotion recognition and it include: face detection, features extraction and emotion classification and a good accuracy was achieved.

2.0 RELATED WORKS

Li et al (2021) [8] developed a system that recognizes students' emotions from their faces. The system employed Haar Cascades for face detection and carried out normalization and emotion recognition using deep learning. Pathar et al (2019) [10] worked on real time emotion recognition to acquaint the machine with human like ability to recognize and analyze human emotions. The research categorized a facial image into one of the seven emotions considered in the study by building a multi class classifier and analyzed the performance of different network architectures in recognizing human emotion. Khan et al (2022) [10] developed an emotion recognition system to predict customer satisfaction using support

vector machines. Geometric features which form customer's emotional faces were obtained by capturing customers faces using a local camera placed near the products and predict customer satisfaction using the SVM model.

Sang et al (2017) [11] proposed effective deep Convolutional Neural Networks (CNNs) that can accurately interpret semantic information available in faces in an automated manner without hand-designing of features descriptors. Song (2021) [12] carried out research on the emotion recognition method based on speech. The work recognized the emotion of individuals by applying speech signals and a good accuracy was obtained. Schoneveld et al (2021) [13] carried out research on audio-visual emotion recognition using deep learning. The work fused deep feature representations of the audio and visual modalities on a model-level fusion strategy and employed a recurrent neural network to capture the temporal dynamics. Sariyanidi et al (2015) [14] worked on automatic analysis of facial affect regression, representation and recognition using deep learning while Liliana *et al,* (2017) [15] made research on human facial emotion recognition using stepwise linear hidden conditional random fields. Zheng et al (2014) [16] carried out research on EEG-based effective models without labeled target data using transfer learning techniques (TCA-based Subject Transfer) and research show that the approach achieved 85.01% accuracy.

3.0 METHODOLOGY

The deep learning approach used in this research is convolutional neural network model. Convolutional neural network takes the image's raw pixel data, trains the model, then extracts the features automatically for better classification. A facial emotion recognition and detection data set was obtained locally and pre-processed to remove outliers and noise. Preprocessed dataset was splitted into training and test dataset the model was trained using CNN. The performance of the model was evaluated using Accuracy, recall, precision and F1-score. Figure 1 shows the block diagram of the CNN-based facial emotion recognition Model.

3.1 Data collection

The dataset used in training the CNN model was collected locally and it consist over 133 images with four different emotions which are: happy, sad, angry and neutral as shown in Table 1. Preprocessing was carried out on the dataset by removing the noise through filtering the images and conversion of images to binary or Grayscale. Pixel brightness transformation was done to modify the pixel brightness and geometric transformation was done by rescaling or normalizing the dataset using sklearn.

Table 1: Description of 133 images of emotion from dataset

S/N	Emotions	No of emotion
0	Happy	30
1	Sad	33
2	Neutral	40
3	Angry	30

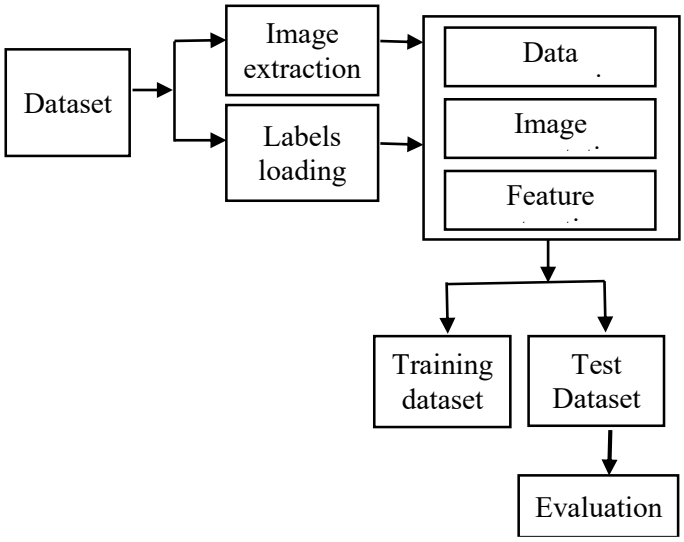


Figure 1: Block diagram of CNN-based facial emotion recognition Model

3.2 Face Registration

Face registration steps include: facial feature extraction and emotion classification. The following features were extracted: Lips, Eyes, Eyebrows and Nose tip. After facial features extraction, the emotions were classified into four states: happy, sad, neutral and angry.

3.3 Model Training

The convolutional neural network model was trained for

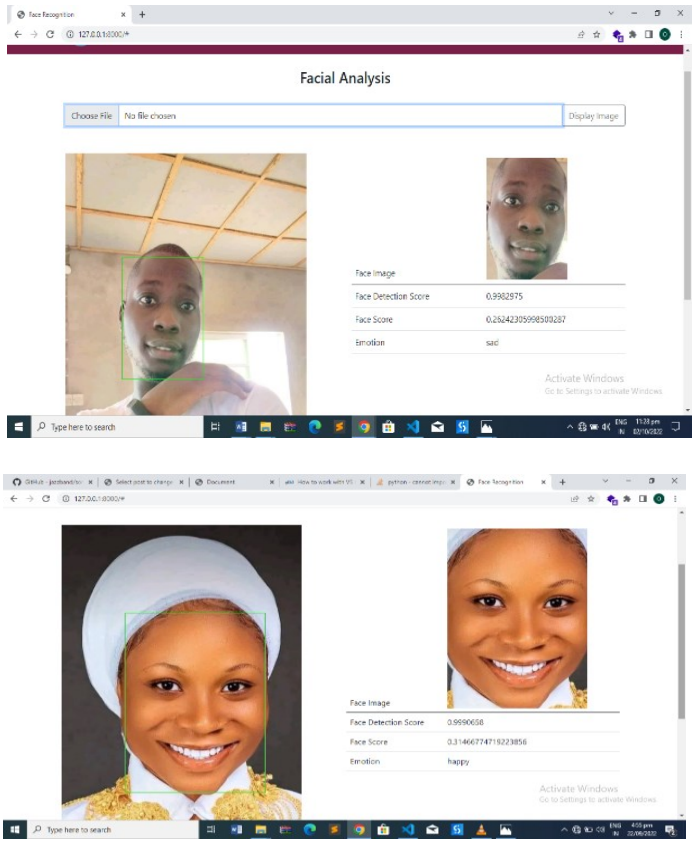
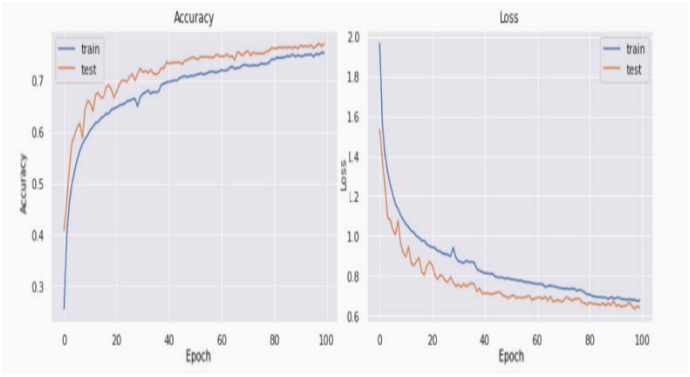


Figure 2: Happy Emotions



facial emotion recognition and detection using the dataset collected locally. The dataset consist of 133images and was splitted into training and test dataset. Eighty percent (80%) was used for model training and twenty percent (20%) for testing the model. Each images is passed in as 784 dimensional vector (28pixels × 28 pixels = 784). There were two convolutional layers and the first convolutional layer has 64 filters (output would be 64 dimensional), with 3 × 3 filters size while the second convolutional layer has 32 filters (output would be 32 dimensional), and filters size is 3 × 3. Both pooling layers are Maxpool layers with pool size of 2 by 2.

3.4 Implementation of the CNN-based Model

The developed model was deployed using DJANGO, a Python-based web application framework. Figure 2 shows the screenshot of the page displaying happy emotion, Figure 3 shows the model displaying neutral emotion, Figure 4 shows the model displaying sad emotion and Figure 5 shows the page displaying angry emotion.

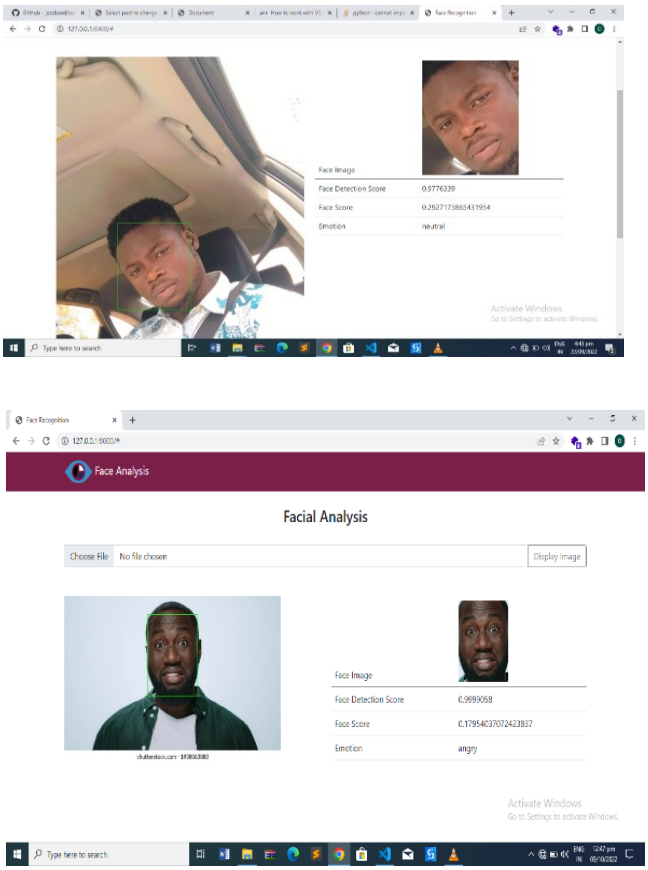


Figure 5: Angry Emotion

4.0 RESULT AND DISCUSSION

Using confusion matrix, the classification result for True Positive, False Negative, False Positive, and True Negative were recorded. 98 emotions were correctly classified as true positive (TP), 45 emotions were correctly classified as true negative (TN), 3 emotions were classified as False Positive (FP) and 7 emotions were as false negative (FN). The Negative class was represented as 0 while the Positive class was represented as 1. Overall results obtained for f1-Score, precision and recall are 0.94, 0.97 and 0.93 respectively as shown in Table 2. The overall accuracy of the developed facial emotion recognition and prediction model is 0.95.

Table 2: Result from Evaluation of the developed CNN Model.

Class Label	Precision	Recall	F1-score
0	0.97	0.93	0.94
1	0.97	0.93	0.94

Figure 6 show the graph of accuracy and loss of the developed facial emotion recognition and detection model. The results obtained from the developed facial emotion recognition and detection model was compared to previous research using VGGNet by Khaireddin and Chen (2021) [17], sequential minimal optimization by Drimalla *et al,* (2020) [18] and logistic regression (Akcay *et al.,* 2020) [19] with accuracies of 84.00%, 87.85% and 83.74% respectively as shown in Table 3. It was revealed that the developed CNN model outperformed the previous works by up to 0.1. The reason is the inherent ability of the convolutional neural network to capture local patterns.

Authors	**Algorithm**	**Accuracy**
Khaireddin and Chen 2021	VGGNet	73.28%
Drimalla et al, 2020	Sequential minimal optimization	87.85%
Akcay et al., 2020	logistic regression	83.74%
	Developed CNN-based Model	95.33%

5.0 CONCLUSION

This research used convolutional neural network model for facial emotion recognition and detection. The developed system achieved very good performance with accuracy of 0.95, precision of 0.97, recall of 0.93 and f1-score of 0.94. The system developed show how well convolutional neural network perform in predicting human emotions. When compared to previous works, the developed model outperformed previous machine learning models considered by up to 0.1% accuracy. It is recommended that future research increases the number of emotions and dataset for model training to improve model accuracy.

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