

Deep Learning on Facial Expression Detection : Artificial Neural Network Model Implementation

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Abstract

The moods, emotions, and even medical issues of a person can frequently be seen directly reflected in their facial expressions. The fields of social science and human-computer interaction have recently begun to pay more attention to facial emotion detection as a result of this. The primary focus of this study is on the automatic recognition of human facial expressions using an artificial neural network (ANN) model and a technique based on straightforward convolution. The dataset utilized is a self-mined dataset that was obtained by utilizing the web scraping approach on Google Image with the help of the Selenium package for Python. A dataset containing six categories of fundamental human expressions that are likely to be met on a daily basis, namely anger, confusion, contempt, crying, sadness, disgust, and happiness, with a total of 6,016 photos being used. The goal of this research is to determine how accurate the model of artificial neural networks can be in predicting.

Keywords — Human Expression, Artificial Neural Network, Expression Recognition, Convolution

1. INTRODUCTION

The human face conveys a great deal of information that cannot be spoken verbally about how we are feeling. Consider spontaneous and introspective reactions to emotional situations as being the source of facial expressions^[1]. Human-computer interaction^{[2]-[4]}, robotics^{[5]-[7]}, and healthcare^{[8]-[10]} are just a few of the many fields that could benefit from a better understanding of how people express how they are feeling through their facial expressions.^{[2]-[4]} Human-computer interaction^{[2]-[4]} Robotics^{[5]-[7]} and healthcare^{[8]-[10]}. However, in order to sustain relationships that are meaningful, it is very necessary to be aware of and react appropriately to one's emotions in everyday life. This is because emotions have a significant impact on how individuals behave^{[11], [12]}. Effective communication is essential to human-machine interaction, which is why the categorization of feelings is so vitally crucial. Classifying expressions can be helpful for enhancing fields as different as the diagnosis of autism^{[13]-[15]} and depression^{[16]-[18]}, consumer and retail satisfaction surveys^{[19],[20]}, and classroom education^{[21]-[23], [13]-[15]} and ^{[16]-[18]} are only couple examples. The field of emotion recognition is gaining popularity among academics and is seeing an uptick in the amount of studies that are being conducted and published on the subject. In certain configurations, all of the systems that were just described make use of previously learned facial expressions in

order to rapidly generate animated visuals^{[24]–[26]}. The majority of earlier research on facial expressions depended on a system called the Face Action Coding System^{[27]–[29]}. This system groups expressions into basic Action Units^[29] according to the amount of activity that is produced by the facial muscles. Recognizing facial expressions that are related with facial expressions has been the major focus of the majority of recent research^{[30]–[33]}, which has been conducted using classic machine learning (ML) or deep learning (DL) models. Traditional machine learning and deep learning models have been shown to be capable of estimating face expressions, particularly when they are trained on large data sets that are extensively annotated and evaluated inside reasonably controlled retrieval settings.

2. RESEARCH METHOD

Research Methods (can include analysis, architecture, methods used to solve problems, implementation), in this discussion the author can describe how the research will be carried out.

2.1. Datasets

The dataset that was used is obtained from Google Image^[34]. It has a total of 6016 photos and is organized into seven distinct classes, each of which depicts one of seven fundamental human emotions or expressions: anger, confusion, contempt, crying, sadness, disgust, or happiness.



Figure 1. Sample data from each classes: (a) anger; (b) confusion; (c) contempt; (d) crying; (e) sadness; (f) disgust; (g) happiness

Web scraping, utilizing the Selenium Python package, was utilized in order to acquire these photos^{[35], [36]}. Selenium makes it possible to automate processes like searching for images and saving them in folders using web drivers^{[37]-[39]} and image capture methods. This is made possible by the use of image capture techniques.

2.2. *Artificial Neural Network*

While learning in the human brain requires changes in neurons and the synaptic connections between them^[40], artificial neural networks (ANN) use technical solutions to mimic the structure and function of the nervous system of the human brain. This allows ANNs to perform tasks that were previously impossible. An artificial neural network (ANN) is a specific kind of mathematical model that replicates the functioning of genuine neural networks by employing a neural network architecture that is analogous to that of real neural networks. In 1943, McCulloch and Pitts were the first to suggest the concept of ANN^{[41], [42]}. Because its fundamental concept endows both data sets with a powerful nonlinear mapping capability, ANN is ideally suited for the task of resolving mapping difficulties that exist between them^{[43], [44]}. On the basis of the method by which signals are sent, ANN can be classified as either Feedforward ANN or Backpropagation ANN.

Although feedback neural networks like Elman neural networks play an important role in the field of artificial intelligence, they have only been used in a few situations dealing with solid waste problems (representing only 3% of the studies examined). This is due to the fact that these types of networks have not been widely adopted in the field of artificial intelligence. It has been demonstrated that feedforward neural network models, such as multilayer perceptron artificial neural network (MLPANN), had fewer prediction errors (10%) than feedback neural network models, such as Elman neural networks, when applied to the problem of biosorption capacity. In the relevant study, feedforward neural networks are employed frequently (97% of the studies evaluated utilized them). This is because feedforward neural networks are easier to implement. The following materials will, therefore, mostly introduce its properties, unless something else is specifically stated.

The investigation was carried out by the researchers using laptops that contained an AMD Ryzen 9 5900HS CPU combination, 16 gigabytes of random access memory (RAM), and NVIDIA GeForce RTX 3050 graphics processing with CUDA capability. In addition, the configuration that was utilized for the model in general, which included image dimensions of 618 by 618, batch dimensions of 16, a total of 100 epochs.

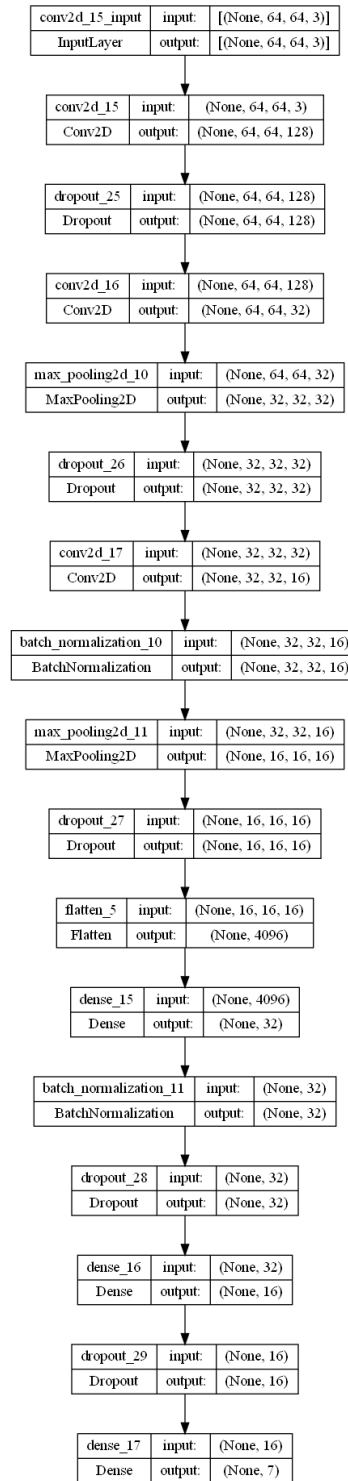


Figure 2. Layer configuration of the proposed model

This research makes use of a model that comprises a Dense neuron layer and a 2-D convolution layer. Both of these layers operate invisibly to generate rules for the classification procedure. In addition, MaxPooling2D, a form of layer pooling, is employed to ensure that only the necessary information are processed by the neurons. Pooling data serves to speed up processing and cut down on the cost of resources needed to carry out training.

Layer (type)	Output Shape	Param #
conv2d_15 (Conv2D)	(None, 64, 64, 128)	3584
dropout_25 (Dropout)	(None, 64, 64, 128)	0
conv2d_16 (Conv2D)	(None, 64, 64, 32)	36896
max_pooling2d_10 (MaxPooling2D)	(None, 32, 32, 32)	0
dropout_26 (Dropout)	(None, 32, 32, 32)	0
conv2d_17 (Conv2D)	(None, 32, 32, 16)	4624
batch_normalization_10 (Batch Normalization)	(None, 32, 32, 16)	64
max_pooling2d_11 (MaxPooling2D)	(None, 16, 16, 16)	0
dropout_27 (Dropout)	(None, 16, 16, 16)	0
flatten_5 (Flatten)	(None, 4096)	0
dense_15 (Dense)	(None, 32)	131104
batch_normalization_11 (Batch Normalization)	(None, 32)	128
dropout_28 (Dropout)	(None, 32)	0
dense_16 (Dense)	(None, 16)	528
dropout_29 (Dropout)	(None, 16)	0
dense_17 (Dense)	(None, 7)	119
=====		
Total params: 177,047		
Trainable params: 176,951		
Non-trainable params: 96		

Figure 3. The parameter size on each layer of the proposed model

In Figure 2 we can see the basic structure of the model that was employed in this research. Figure 2 shows the model's structural layers, and it also makes use of a Batch Normalization layer to standardize data from the previous layer, which helps reduce bias during training. To further reduce the amount of memory space needed for training, the Dropout layer is applied to each dataset before it is used. The input size determines which parameters are used for each layer. Figure 3 shows the total amount of parameters for the model to be 177.047, with a breakdown of the parameters for each layer.

2.3. Optimizer

The primary goal of developing machine learning models is to generate an ideal model capable of handling challenging situations, whether they have been previously handled or are brand-new and unresolved. This is possible through the use of optimization methods. At least two methods exist for attaining the optimal model, namely the empirical risk minimization approach^{[45], [46]} and the gradient descent method^{[47], [48]}. In this study, researchers optimized the training model using a gradient descent approach. The gradient descent approach serves as a barometer in the machine learning model training process, with the goal of increasing accuracy by updating the employed parameters each time^[49]. Gradient descent consists of two primary

components: learning rate^{[50], [51]} and cost function^{[52]–[55]}. Gradient Descent Step (Learning Rate) is a step used to reach a minimal point (local minimum and global minimum). In general, the learning rate is fairly low, however the value must be modified in order to reach the desired objective. If the value of the learning rate is too high, the model will have difficulties attaining the minimal value because the target point may be missed; conversely, if it is too low, the model may have trouble locating the lowest point because it only undergoes minor changes and the memory required for training will be reduced.

To further quantify the gap between y and the model's prediction, we employ a cost function (also called a loss function) to quantify the magnitude of this discrepancy. The goal of this measurement is to give the model some information so that it can refine its settings to reduce the error value as much as possible.

There are currently multiple popular optimizers. Rectified Adam optimizer (RAdam) is used in this investigation due to its superior efficiency over the Adam optimizer.

$$r = \sqrt{\frac{(\rho_t - 2)(\rho_t - 4)\rho_\infty}{(\rho_\infty - 2)(\rho_\infty - 4)\rho_t}} \quad (1)$$

A confusion matrix [56] is used for the evaluation in this research. Confusion matrices are used to evaluate the success of a trained classification model. True positives (TP), false positives (FP), true negatives (TN), and false negatives (FN) are the four main factors in the confusion matrix (FN).

A number of metrics, including accuracy, recall, precision, and F1-Score^{[57]–[59]}, are displayed in the confusion matrix to show how well a model is developed.

$$Accuracy = \frac{TP + TN}{Total\ Prediksi} \quad (2)$$

How well a model does in predicting a label from a given set of data is represented by the accuracy value.

$$Loss = \frac{TP}{TP + FN} \quad (3)$$

The accuracy of a model can be evaluated via recall by counting how many correct and correct classifications are incorrect.

$$Precision = \frac{TP}{TP + FP} \quad (4)$$

Comparing the actual number of correct classifications to the predicted number of correct classifications is how precision measures the model.

$$F1 - Score = 2 \left(\frac{Loss * Accuracy}{Loss + Accuracy} \right) \quad (5)$$

The F1-score, which is a harmonic mean, can be used to compare recall and precision after the values have been obtained.

3. RESEARCH RESULTS AND DISCUSSION

The research employs a very basic model of a neural network. For our purposes, we employ 64x64 pixel images that are processed in 32 batches. The CUDA model was implemented with 500 iteration epochs to optimize graphical processing. Before beginning the training process, however, the face recognition model is implemented to extract faces from each image. Facial extraction is performed by inferring each shot using a pretrained MTCNN model to concentrate training on the face area. In addition, the extraction procedure plays a role in data cleansing, so that data without facial elements are not processed. This procedure has been shown to lower the loss generated by the model during training.

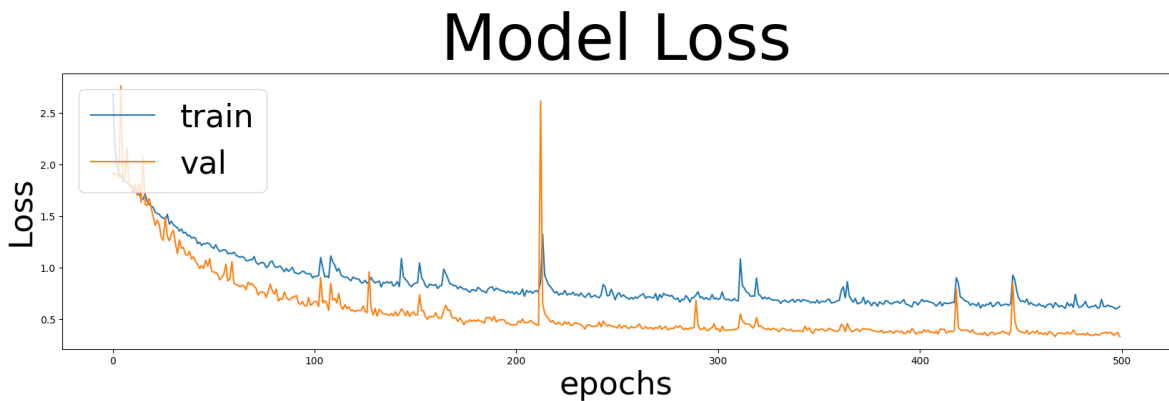


Figure 4. Model loss on training history

Figure 4 depicts the loss incurred during the training procedure. If we pay closer attention, we can greatly reduce the resulting loss, although it is still capable of causing bias. However, if the epoch is performed for more than 200 iterations, the bias loss created during training can be appropriately managed.

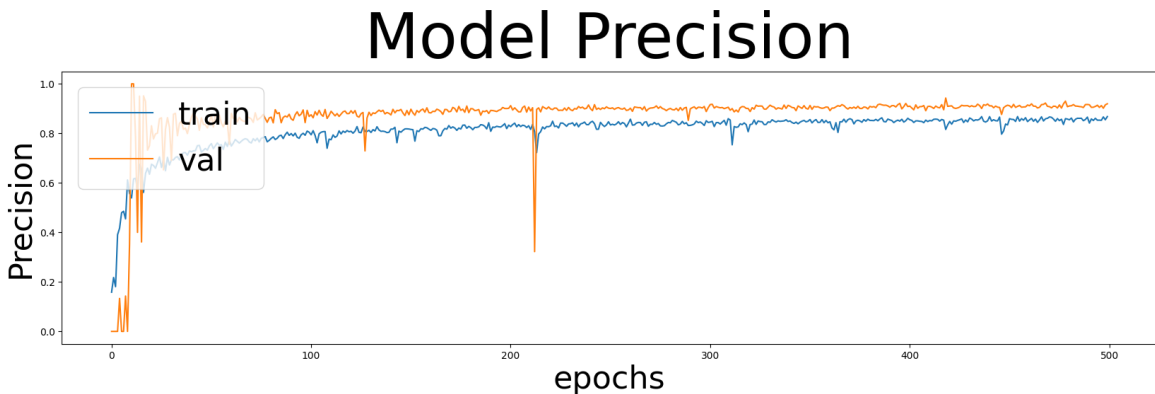


Figure 5. Model's precision on training history

In addition to minimal loss, the model has been shown to produce sufficient precision. If depicted in Figure 5, the model is deemed capable of maintaining precision greater than 0.70 or 70%. In addition to maintaining precision, the model can also handle precision bias, resulting in a smooth precision curve during training.

Model Recall

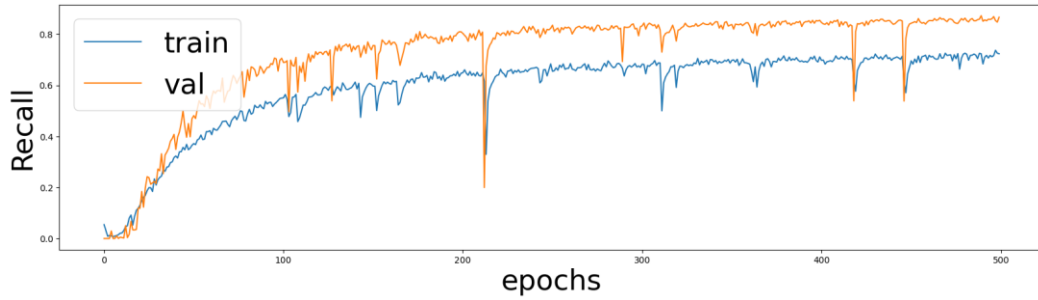


Figure 6. Model’s recall on training history

However, resulted in a sharp figure 6 reveals that the resulting recall is subpar. This is because the suggested model prioritizes precision and accuracy, necessitating a trade-off between precision and recall. In other words, the generated re-calls are still below 0.8 and are still very biased.

Model Accuracy

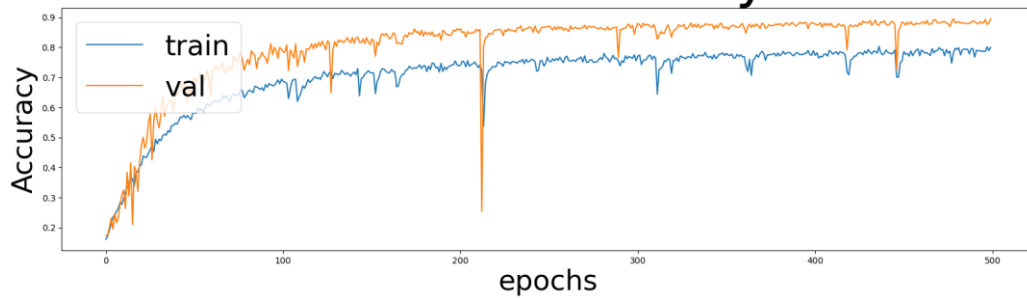


Figure 7. Model’s accuracy on training history

On the other hand, due to the suggested model's emphasis on accuracy and precision, the model's accuracy is excellent. In figure 7, it can be shown that the model accuracy can achieve a value of 0.90 and sustain a value above 0.80.

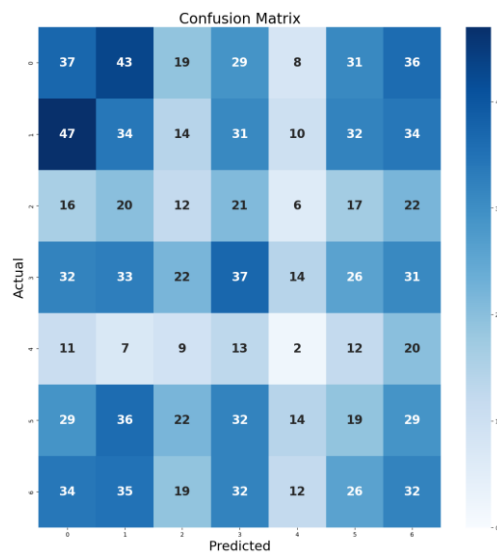


Figure 8. Model’s confusion matrix

Moreover, the testing procedure is applied to the provided model. The model is evaluated using test data that is distinct from the training data. Considering the confusion matrix, the model continues to encounter confusion in a number of classes, but is able to handle confusion in a number of other classes. This model may face confusion if the dataset used for testing is too complex to infer or if the model is overfit.

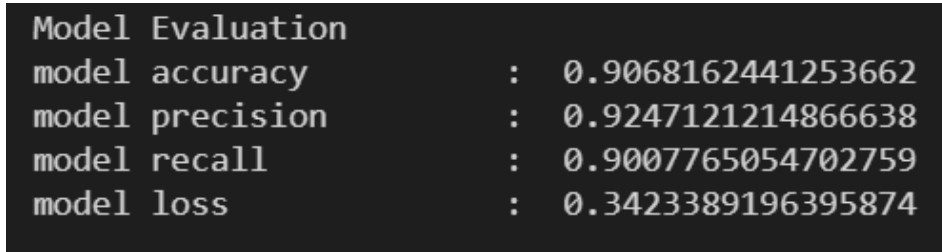


Figure 9. Model evaluation result

In contrast, as shown in Figure 9, the findings of the model evaluation are quite promising. This evaluation's outcomes are determined by data testing. Based on the model evaluation findings, it can be inferred that the suggested model does not exhibit overfitting, as the evaluation outcomes are pretty good. If the model is overfit, the accuracy, precision, and recall values will be quite low in the evaluation results. However, the evaluation results presented in Figure 9 are quite excellent, with values of 0.91, 0.92, and 0.90 for accuracy, precision, and recall, respectively. In addition, the loss caused during the evaluation phase is fairly modest, amounting to 0.34.



Figure 10. Model's prediction on random image

In addition, the model utilized in this work was evaluated using randomly selected public photos chosen by the researcher. This random test was conducted to determine whether the model can accurately predict face expressions. Based on the findings of the probability prediction, the model can properly predict the class of facial expressions with a probability of 31.18 percent. This value is obtained as a result of the model's use of the multi-class approach, which ensures that each other class still receives a probability value, but one that is less than the final class value.

4. CONCLUSION

This study aims to demonstrate the applicability of the neuron network model for classifying human face expressions. In this study, researchers employed a number of procedures, including data mining with selenium on Google Image. The received data is then extracted to take photographs of the face using a pre-trained MTCNN model, so that the data owned concentrates solely on the facial area. In addition, training, testing, and evaluation are carried out on the proposed model. As the hidden layer, the suggested model is a simple neural network model with a dense neuron layer and a 2-D convolution layer. The training results indicate that the final model is highly qualified for classifying human facial expressions. The results of the training indicate that the model can sustain accuracy and precision values above 0.8 and loss values below 0.4. In addition, the results of testing and analyzing the model are extremely encouraging, with precision, accuracy, and recall values above 0.90 and loss reaching 0.30. In addition, the model is considered suitable for real-time classification because the projected results of face expression classification using random image data are quite accurate. Therefore, further research will make it possible to apply the concept as a simple prototype so that it may be used in a variety of disciplines, including education, customer service, and the health sector.

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