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Facial Emotion Recognition by Deep CNN and HAAR Cascade

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Abstract: ***Emotion Recognition is of significance in the modern scenario. Among the many ways to perform it, one of them is through facial expression detection since it is a spontaneous arousal of mental state rather than a conscious effort. Sometimes emotions rule us in the form of the choices, actions and perceptions which are in turn, a result of the emotions we are overpowered by. Happiness, sadness, fear, disgust, anger, neutral and surprise are the seven basic emotions expressed by a human most frequently. In this period of automation and human computer interaction, it is a very difficult and tedious job to make the machines detect the emotions. Facial expressions are the medium through which emotions are shown. For one to detect the facial expression of a person, colour, orientation, lighting and posture play significant importance. Hence, the movements associated with eye, nose, lips etc. plays major role in differentiating the facial features. These facial features are then classified and compared through the trained data. In this paper, we have constructed a Convolution Neural Network (CNN) model and then recognised different emotions for a particular dataset. We have found the accuracy of the model and our main aim is to minimise the loss. We have made use of Adam's optimizer and used loss function as sparse categorical crossentropy and activation function as softmax. The results which we have got are quite accurate and can be used for further research in this field.***

Keywords – Face Detection-HAAR Classifier-Deep Convolutional Network-Cross Validation- Classification- Adam Optimizer-Emotion Recognition.

I. INTRODUCTION

Expression and communication both go hand in hand. In this 21st century, where technology has a very important role to play, emotion detection and recognition has a lot of scope for study and research. The most important cues for non verbal communication are facial expressions. This feature is only possible due to the ability of humans to recognize the emotions accurately and efficiently. Facial expressions play a vital role in helping communicate a person's feelings through emotions.

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For humans, their emotions are identified to have been divided in seven different emotions- happiness, fear, anger, neutral, sadness, surprise and disgust. These are the basic building blocks and a combination of these can form another emotion. For an efficient human interaction with the computer, an automatic facial recognition can have numerous applications. Monitoring humans, studying anti social motives of humans, and also generating various interaction styles can be the applications of facial emotion recognition. On the response obtained, the approach of the services provided can be altered. In a generalized form, the input for the images is a webcam, through which the image is fed to the face detection system. Once the facial area has been identified, features which represent the various characteristics of the basic emotions are extracted. These features are processed and pruned and then are classified into various types of emotions. Nowadays, with the increasing technology, there have been many classifier algorithms available to be used for improved detection.

II. LITERATURE SURVEY

There are numerous techniques and variations in these techniques in order to get the best and appropriate algorithm for facial emotion recognition
The following table discusses the methodology and various techniques existing along with their advantages and disadvantages (Table 1):

III. PROPOSED ALGORITHM

The facial emotion recognition is done through the usage of two algorithms. The dataset used is Cohn-Kanade (CK/CK+) dataset. The facial recognition is done by using the HAAR cascade classifier. The emotion recognition of these facial images is done through Deep Convolutional Networks. The Convolutional Neural Networks is modelled using Tensorflow and on Keras model. The activation function used is Rectified Linear Unit (in input layers and the hidden layers) and Softmax activation function (in the output layer).

The loss function applied to the Convolutional Neural Network is Sparse Categorical Cross entropy. To compile the Neural Network, ADAM optimizer is used (Figure 1)

Table 1

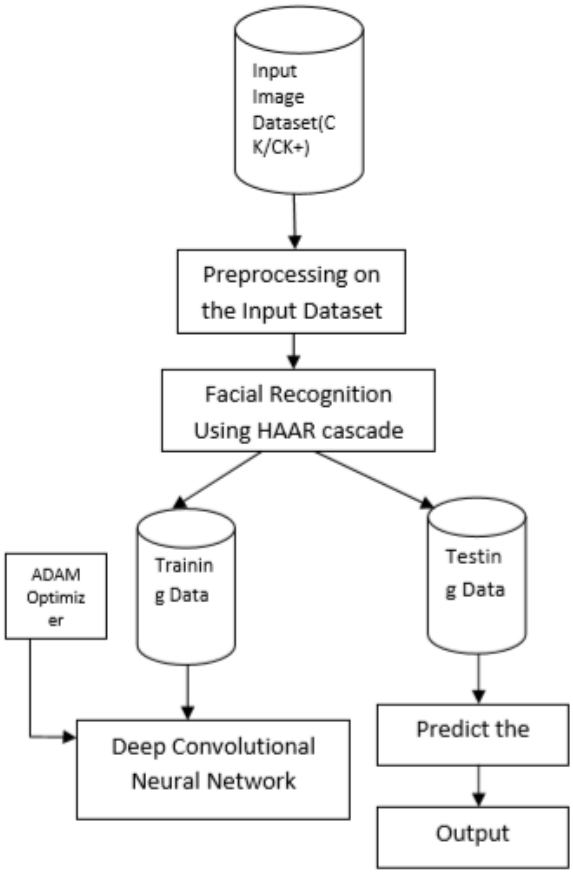
Sr. No	Authors/Title	Methodology	Advantages	Issues	Metrics Used
1.	A Comprehensive Survey on Techniques for Facial Emotion Recognition (2017) *Deshmukh, Renuka* *E Scholar, M* *Jagtap, Vandana*	1. Feed-Forward Neural Network 2. Multiple Deep Convolutional Neural Networks (CNN)	Increased accuracy of the framework by minimizing the log likelihood loss and the hinge loss	Problems faced in homogenous faces	Support Vector Machine (SVM)
2.	A Brief Review of Facial Emotion Recognition Based on Visual Information (2018) *Department of Computer Engineering, Keimyung University, Daegu 42601, Korea. niceko@kmu.ac.kr.*	1. Deep-learning-based FER approaches 2. CNN-based FER approaches 3. Nearest-mean classifier, Kernel subclass discriminant analysis	More focus on studies that are using visual expressions for interpersonal communication. Also "end-to-end" learning presented with FER approach	Illumination in the background and the pose in the 2-dimensional images caused discrepancy.	1. automatic facial emotion recognition (FER) 2. electromyography (EMG)
3.	Facial emotion recognition using min-max similarity classifier (2018) *Olga Krestinskaya, Alex Pappachen James*	1. Min-Max Classification 2. K-Nearest Neighbour for classification	Outliers are suppressed using min max classifiers. Problem of inter-class pixel mismatch during classification is removed	Additional memory space is consumed by the metric class (for templates) created, and its storage.	2-Dimensional Linear Discriminant Analysis(2D-LDA)
4.	A multi level classification approach for facial recognition (2012) Dev Drume, Anand Singh Jalal, GLA University, Mathura(devdrume.dev@gmail.com, anandsinghjalal@gmail.com)	Eigen faces employed principal component analysis (PCA)	For expression determination, support vector machine (SVM) is used for model creation, thereby causing it to create expression descriptors. These expression descriptors are used for expression detection.	Problems occurred when the variations are due to the effects of global components. Perspective and lighting, degrade the performance. On the other hand, local variations are effectively handled.	Level 1 classification scheme: Principal Component Analysis(PCA) Level 2 Classification Scheme: Support Vector Machine
5.	Emotion Recognition from 3D Videos using Optical Flow Method (2017) *GowriPatil, Suja P.*	Video Sequences of BU-4DFE database are used, from which six basic emotions are recognized. The optical flow method and the geometric feature based approach is combined.	The proposed methodology resulted in accuracy comparable with existing literature. Applications have been tested explicitly in environments which have Human computer interaction and also in security cameras.	Accuracy is inconsistent over large three dimensional computations	Classification Scheme: Random Forest and Hidden Markov Model Face expression evaluation through Reimannian Shape Analysis
6.	Emotion Recognition System using short term monitoring of Physiological Signals. (2004) *K. H. Kim, S.W. Bang, S.R. Kim*	Vector Machine used as a pattern classifier. Based on physiological signal databases, which were obtained from various sources, a user independent system was constructed.	1. The monitoring time of the signal is reduced 2. all signals that caused the user less inconvenience was used 3. The system was applicable to multiple users	Chaotic analysis and non linear analysis was not applicable, since the system did not support the long term monitoring of the signals.	Support Vector Machine: Hyperplane Separation satisfying $y_i(wVx_i+b)\rightarrow 1$ For each values of i=1,2,3,4…N
7.	Multilinear Image Analysis for Facial Recognition. (2004) *M.A.O. Vasilescu, D. Terzopoulos*	Similar to Principal Component Analysis, a multi-linear analysis method is proposed	The advantages include facial expression with high accuracy. This system recognizes 85.6 % of accuracy.	Sometimes image recognition does not take properly producing problem.	Using conventional matrix singular value decomposition.

8.	A Fuzzy Approach for Facial Emotion Recognition (2013) *FatemehShahrabiFarahani ; Mansour Sheikhan ; Ali Farrokhi*	Uses mouth and eye features for recognition. Mamdani Implications are used for facial features, encoding for their mapping to the emotion space.	Achieves 78.8% accuracy for the detection of the emotion. In this method, the fear, sad, angry and happy are more evidently detected.	The main issue is that the proposed methodology is worst for neutral, sad and disgust emotions.	The proposed method is evaluated using Ebner's database.
9.	Emotion Detection Algorithm Using Frontal Face Image. (2005) *M. Turk, A. Pentland*	Histogram analysis method, virtual face model and the fuzzy colour filter methods are used in this methodologyfor the image processing state.	Since the fuzzy colour filter is applied, the experimental results are better recognized.	Can not guarantee that the acquired facial image express accurate corresponding emotion.	Fuzzy method. Using histogram analysis. Histogram Input: [w_1, w_2, w_3, w_4….w_c] The largest segment is chosen
10.	Aggregating Local Image Descriptors into Compact Codes (2012) *HerveJ'egou, FlorentPerronnin, MatthijsDouze, Jorge S'anchez, Patrick P'erez, Cordelia Schmid*	Image indexing scheme for very large databases. Bag-of-words, Fisher Kernel and VLAD representations	Local feature aggregation is done by the use of Fisher Kernel framework. Once the dimensions are reduced to 128, which is of the same size as that of a single SIFT vector, the Fisher Kernel representation yields high accuracy and performance.		Mean Average Precision(mAP) recall@R
11.	Facial Expression Recognition Using 3D Facial Feature Distances (2008) *HamitSoyel and Hasan Demirel*	Distance measures extracted from 3D face vectors Neural network Classifier	Usage of 3- Dimensional distance vectors. This method is superior to other similar systems using 2-Dimensional facial feature analysis.	Since all of the methods use 2 Dimensional facial feature analysis, it is difficult to measure the efficiency of this 3- Dimensional approach to facial features	MPEG-4 Facial Definition Parameter Set (FDP)
12.	Speech Based Human Emotion Recognition Using MFCC (2017) *M. S. Likitha ; Sri Raksha R. Gupta ; K. Hasitha ; A. Upendra Raju*	Features are extracted using MFCC(Mel Frequency Cepstrocoefficients) . Standard Deviation Method used for decision making.	The method is 80% efficient in noisy environment, hence labelled as a noise robust system.	Feature extraction not accurate for noisy data compared to other models	MFCC set values obtained: $x=x_1+x_2+x_3+\ldots x_n$ Mean of these values are taken, serving as a reduction technique
13.	A Human Facial Expression Recognition Model based on Eigen Face Approach (2015) *Anurag Dea, AshimSahaa, Dr. M.C Palb*	Face Detection is done using Hue-Saturation-Value(HSV) PCA used for dimensionality reduction in the dataset.	The HSV(Hue-saturation-value) model detects the faces in the image in a similar manner as the humans do while they perceive the colour	The difference between the sorrow and fear human emotions are not distinguished, and can be referenced as a future work through a proper training model.	Euclidean Distance Measure
14.	A Real Time Facial Expression Classification System Using Local Binary Patterns (2012) *S L Happy, Anjith George, AurobindaRoutray*	Haar Classifier based method for face detection LBP based feature extraction method Dimensionality is reduced using Principal Component Analysis	The proposed method of facial expression recognition based on LBP and LFDA performs better than PCA, LDA as well as LPP and has an accuracy of 90.7% with 11 reduced features.	The methodology is bounded on the images which re frontal and aligned. But, occlusions in the images or when their orientation changes, the performance is thwarted.	LBP feature calculation procedure

15.	Robust Representation and Recognition of Facial Emotions Using Extreme Sparse Learning (2015) *SeyedehsamanehShojaeilangari, Wei-Yun Yau, Senior Member, IEEE, KarthikNandakumar, Member, IEEE, Li Jun, and EamKhwang Teoh, Member, IEEE*	HMM(Hidden Markov March) process, geometric displacement and dynamic bayes classifier are used for the recognition of the emotions.	Can learn (1). Non Linear classification (2). Set of basis, also known as a dictionary.	The challenges include: (1) the image to be only frontal and aligned (2) the facial landmarks should be enclosed and localized.	The ELM objective function is: minimum(β* k*H (X) β – Z*k 2 2 + k*β*k 2 2)
16.	SFS feature selection technique for multistage emotion recognition (2015) *TatjanaLiogienė, Recognition Processes Department Vilnius University Institute of Mathematics and Informatics* *GintautasTamulevičius, Department of Electronic Systems Vilnius Gediminas Technical University*	SFS technique for multistage scheme. This greedy search algorithm has a very low computational load. The feature subset is extracted, in turn proving to be effective.	There was a 20% superiority in using thre SFS technique. On the contrary, minimal cross correlation and maximal individual efficiency gave less accuracy. Also, there was a higher accuracy in the feature collection process.	There is complication in the classification of the dataset. This task then analyzes less features. It renders the task meaningless and inaccurate.	Feature Subset initialization: F0:f0-{phi}, i=0 New subset Fm =argmax[E(Fi + fm)>E(fi)], M=1,2,3…M; Fi+1={Fi+fm}, i=1,2,3…P;
17.	Performance evaluation of different support vector machine kernels for face emotion recognition (2015) *Ibrahim A. Adeyanju Department of Computer Engineering Federal University Oye-Ekiti (FUOYE)* *Elijah O. Omidiora, Omobolaji F. Oyedokun Department of Computer Science and Engineering LadokeAkintola University of Technology (LAUTECH)*	Average accuracy of 99.33% was reached with the Quadratic Function Support Vector Machines. It used SVM multiclass classification scheme.	The seven emotions were analyzed using different kernels (four). The most accurate kernel was the Quadratic function kernel.	The classifier performed at 99% accuracy for the kernel at an image dimension of 200*200. If the image dimension would have been increased, the method would result in an increased computational time.	Face Emotion Recognition with Support Vector Machine Linear and the Quadratic (sigmoid) functions with their equations
18.	One shot emotion scores for facial emotion recognition (2014) *Albert C. Cruz, B. Bhanu, and N. S. Thakoor*	A one-shot emotion score was designed. It measured a person independent face recognition value. This quantified the face. Also, a posed frontal face was not required for correct execution. This boosted the rate of classification.	When the dataset used was CK+ dataset, there was an increase in accuracy for about 15%. Also, the results on different datasets were achieved positively.	Excluding the MMI dataset, the method of one shot emotion score is the best performer over all other mixed datasets.	There is a computation of the OSES. There is an initial classification carried out, which characterizes the linear support vector machines. To improve the cost function: MSF (w (x)) = x sTj (x) − sQ (x+w (x))*(3)+α x *(u(x)−E(u(x)))^2
19.	A Study on Emotion Recognition Method and Its Application using Face Image (2017) *Hyeon-Jung Lee College of Information and Communication Engineering Sungkyunkwan University Suwon, 440-746, South Korea sghj99@skku.edu* *Kwang-Seok Hong College of Information and Communication Engineering Sungkyunkwan University Suwon, 440-746, South Korea kshong@skku.ac.kr*	Emotion recognition through deep learning. It used positive and negative emotion recognition. Was executed under Tensorflow, an open source library, and CNN was applied for the recognition of the faces.	There was 50.7% accuracy in applying the deep learning over the seven emotions. When the classification through positive and negative images was done, an accuracy of 72.3% was achieved.	Low accuracy among the positive emotion set recognition	Positive, negative and neutral value calculation through Arousal Valence (AV). Ends from -4 to +4 were held, for which the seven emotions were partitioned.

20.	Exploring the Emotion Specific Features for Emotion Recognition System using PCA Approach (2017) *Naga Padmaja. Jagini Computer Science and Engineering JNTUH, Kukatpally, Hyderabad India.* *Dr. R. Rajeswar Rao Computer Science and Engineering JNTUK- UCEV, Vizianagaram India.*	Principal Component Analysis (PCA) is applied on the specific features , which are combined using both prosody and spectral features. The feature combination used are: (1) MFCC(mel frequency cepstral coefficients) (2) Fundamental Frequency(f0) (3) Pitch Chroma (4) Formants features. These are then used as a model for testing anf the GMM(Gausian mixture model)	There is a better response rate with the LFPC, when compare to the LPCC and the features of MFCC	There are uncertainties among the non overlapping features of the prosodic and the spectral features.	A n8m feature matrix is used, where: n=number of samples present m= number of attributes/ features. The output of the reduced feature is represented as n*k matrix, where k is the reduced dimensionality of the original m attributes.

Figure 1:



IV. EXPERIMENT RESULTS

The dataset consisted of eight emotions out of which five emotions were used to train and test the dataset. The samples of the images for the various emotions are:

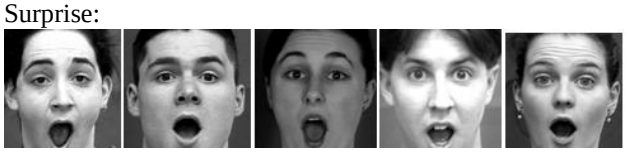
Anger:

Neutral:

Disgust:

Happy:

Surprise:



The accuracy of the emotion recognition was tested in the dataset at different proportions of training and testing data. The following table shows the accuracy and loss of the testing data:

Training	Testing	Max Accuracy	Min Loss
20	80	68.69	1.0780
30	70	77.22	0.7201
40	60	80.09	0.6752
50	50	81.62	0.6384
60	40	83.11	0.6174
70	30	88.07	0.5615
80	20	**90.28**	0.4361

In the training and testing of data at 80:20 proportion, the accuracy and loss curve during 36 epochs were:

The model characteristics of this data at 36th epoch were:

	precision	recall	f1-score	support
neutral	0.62	0.91	0.74	23
anger	1.00	0.44	0.62	9
disgust	1.00	0.64	0.78	11
happy	0.92	0.85	0.88	13
surprise	0.73	0.69	0.71	16
avg / total	0.80	0.75	0.75	72

V. COMPARATIVE STUDY

The emotion recognition has combined HAAR cascade with Convolutional Neural Network in order to predict the emotion of the face. The existing study had used CNN to detect the face in the image as well as classify the image. Also, face recognition has been implemented using HAAR cascade algorithm. Here, the HAAR cascade is used in the facial recognition part, while the convolutional model is built on the ADAMs optimizer. This usage of two algorithms to predict the output gives better accuracy of testing data even when there are less training samples for the network to be modelled.

Sr. No	Research Paper	Accuracy
1.	**Proposed Solution**	**90.28%**
2.	[9] Emotion Detection Algorithm Using Frontal Face Image Using FUZZY color filter	74.00%
3.	[18] One Shot Emotion Scores For Facial Emotion Recognition	90.90%
4.	[13] A Human Facial Expression Recognition Model based on Eigen Face Approach	85.38%

The proposed solution also gives better accuracy when lower proportions of training data are used.

VI. CONCLUSION

The project predicted the emotions with a maximum accuracy upto 90% in the given dataset when 80% of data was used to train while 20% of the data was used to test. On the other hand, on reducing the training samples upto 30%, the accuracy of validating the network on the remaining 70% of the data was 77%.

The project can be further extended to classify the emotions on the images which contain faces other than the frontal perspective. The emotion recognition can be integrated with the speech of the user in order to get accurate results. Also it can be used as an application to gather response of the person and study the human psychological behaviour.

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