EMOTION DETECTION

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Problem Statement

Facial Emotion is always been an evident parameter of judging one's state of mind. There are different categories of emotions such as anger, happiness, surprise, sadness and fear. Every emotion has a specific facial orientation corresponding to it. It is relatively tedious task to differentiate between the different orientations. In our project we would be focusing on different facial action units of face such as lips, cheeks, eyes, and thus realize different algorithm combinations to detect the final facial expressions.

Literature Survey

The first known work on facial recognition is by Darwin in 1878 [1] after that a subtle amount of research has been done on this area. A facial Action coding System (FACS) for the categorization of facial expression is uses by the Ekman et al. [2] which is used extensively in the areas of analysis of facial expression. In FACS system the facial attributes are represented. In their study Wu et al. uses Gabor filters for feature extraction in frame by frame analysis of videos. It mainly used as edge detection algorithm and helps to reduce variability due to its different orientation and frequency. Lyons et al in their work used LDA as classifier. LDA allows fast and simple training from data. The input features are easily interpreted from this. Kim et al. uses Convolution neural network (CNN) in their study due to evolution of deep learning features. In our project we will use state-of-art techniques to obtain the results.
A novel mapped LBP feature [5] was proposed for illumination-invariant FER. Scale invariant feature transform (SIFT) features that are robust against image scaling and rotation are employed for multi view FER tasks.

Introduction

Every emotion is carried out by the contraction or expansion of some face muscles. Facial expressions can be used as an efficient way of emotion detection. Each facial muscles can be captured in the form of Facial Action Units(AU's). In this project we would be working on different facial action units like eyes, cheeks and lips, which are responsible for different expression. Emotion detection can also be useful for Intelligent Human-Computer Interaction (HCI). The set of action unit represent a particular expression. For example AU6 and AU12 together indicates happy Emotion. Some feature extraction algorithms would be applied on action units relative to the emotion and classification will be perform on that using different classifiers. The result of different feature extraction algorithm will be compared with different classifiers. This work plays a predominant role in fields such as psychology, indirect customer's feedback in different places like malls and also helpful in trading.

Methodology for FER

From experiments we can infer that the low level features are not performing well on FER2013[4]. So we use features from pertained convolutional neural networks AlexNet,VGG-16, Inception_v3, Densenet161 among which Densenet161 give the best result. These deep convolutional neural networks are trained on ImageNet dataset that do not have any facial expression class. So, we trained our own 9 layer network on that help us outperforming the approach of classification using features from these features.
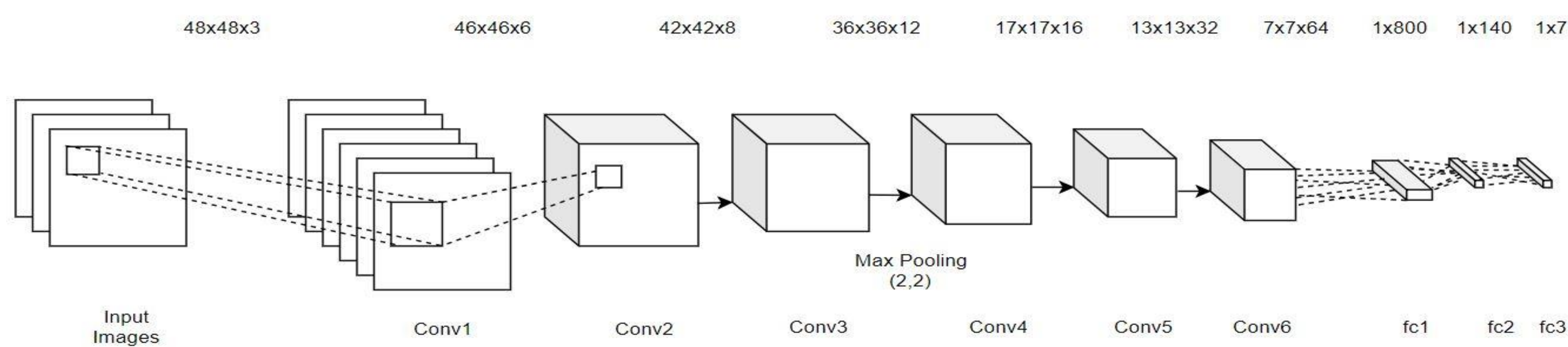
Fig 1: CNN architecture used for classification of FER dataset. Conv$_i$ define the i'th convolutional layer and fc$_j$ define the j'th fully connected layer. Dimensions mentioned in the image are output size of the each layer.

Architectural details

Architectural details	
Average Top-5 validation accuracy	49.87%
Average Top-5 accuracy	51.2%
Number of Layers	9Layers(6 convolutional Layer and 3 Fully Connected layers)
Activation Function	ReLu
Batch Size	32
Training	250 epoch
Loss Function	Cross Entropy

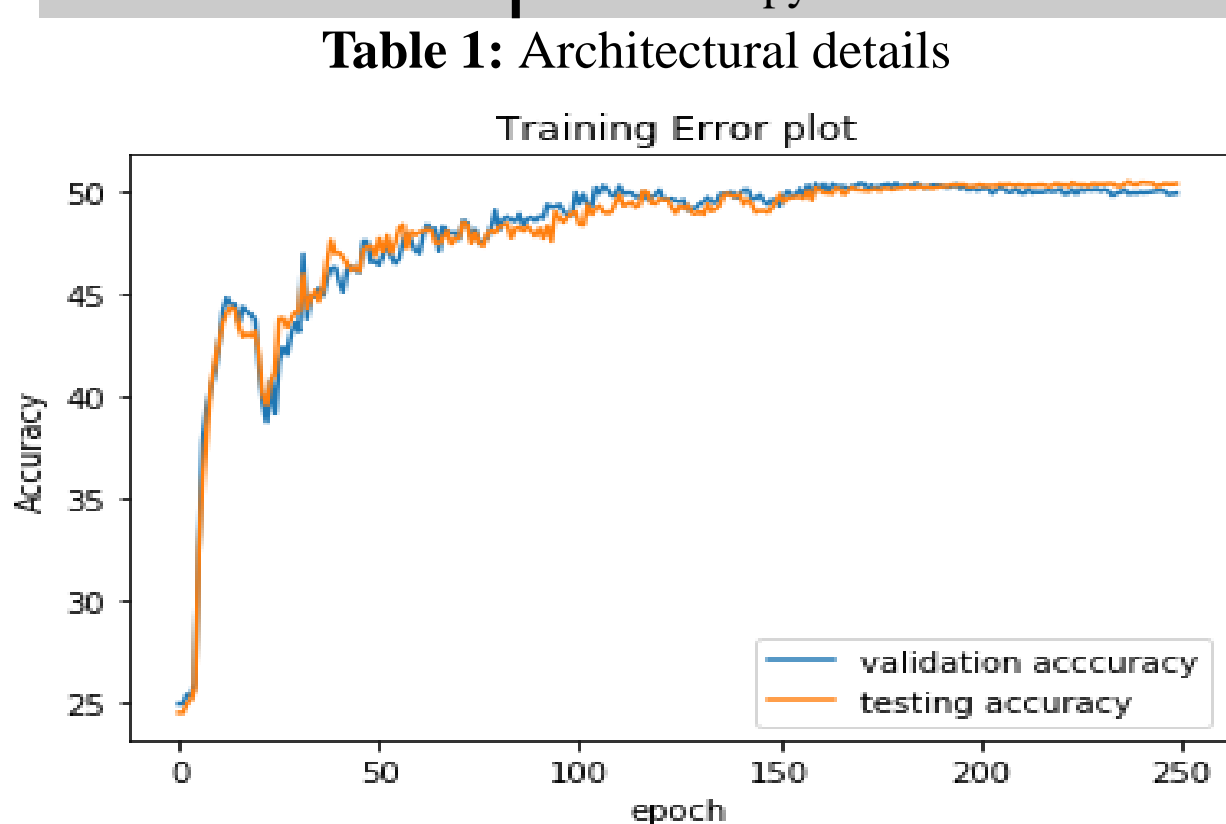**Table 1:** Architectural details

Fig 2: Error plot

Dataset Description

In our project we used two Dataset CK+ [3] and FER2013[4]. In CK+ there were eight emotions anger, contempt, disgust, fear, happiness, neutral, sadness, surprise. This dataset is imbalance with neutral having high frequency of images. There are total 1256 images in the dataset. All subjects in the images having still head posed. We used 1004 for training and 252 for testing purpose.
The FER dataset used was having more images and was challenging also. There dataset consist of 7 emotions anger, disgust, fear, happy, sad, surprise, neutral. Each image is 48*48 pixel grayscale image. The training dataset consists of 28709 examples and test consist of 7178 examples. Which are divided into two parts, i.e. Public Test and Private Test, Each consisting of 3589 images. The main challenge in this dataset is that the subjects in the images having head posed in different orientation.

Emotion	CK+		FER	
	Count	Images	Count	Images
Angry	79		3995	
Fear	65		4097	
Disgust	99		436	
Happy	109		7215	
Sad	67		4830	
Neutral	632		4965	
Surprise	119		3171	
Contempt	86			

Methodology for CK+

➢The following pipeline is used in CK+ Dataset to get an accuracy around 90 percent. The Facial Landmarks from the input image is generated. With the help of facial landmarks, parts of facial action units were extracted such as lips, left eye, right eye, cheeks. The hog feature of each extracted parts is calculated. 30 components of each hog features of extracted parts were taken with the help of PCA algorithm
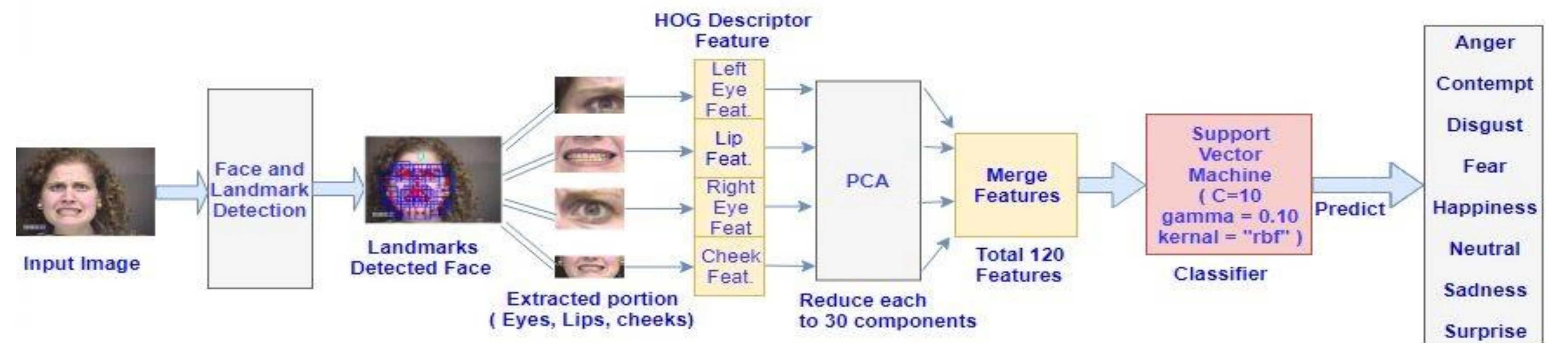
Figure 3 . A total of 120 features were trained on Support vector Machine with "rbf" kernel with parameter C=10 and gamma = 0.10. "rbf" kernel was used as data was not linearly separable.

Results

Dataset	Best Model accuracy	Confusion matrix	ROC
CK+	89.8%		
FER	51.2%		

Table 2: Results for two different datasets with accuracy, confusion matrix and ROC

Analysis

➢ In the CK+ dataset the angle of capturing and the posture of subjects have less variance.
➢ In FER dataset there is a lot of variance in subject postures and the image capturing angle also there is occlusion and varying illumination that hide most important features like lips movement etc. that makes the task more challenging.
➢ By visualizing both the datasets we can conclude that they are not linearly separable so we have to use non-linear classification techniques like Support vector machine with rbf kernel , Neural Networks etc.
➢ From several experiments it is clear that even features of pre-trained deep convolutional neural network are also not very helpful for classification of FER dataset.
➢ By taking motivation from above we trained our own CNN from scratch using FER training data that help us over performing all of our previous attempts.

Model	Accuracy(in %)
Without face detection + Hog features + PCA(0.99 Eigen energy) (Total features = 170) + SVM (C = 20 and gamma = 0.01,"rbf" kernel)	75.17%
With face detection + Extract Face +Hog features + PCA(0.99 Eigen energy) + SVM (C = 15 and gamma = 0.05,"rbf" kernel)	87.79%
With Facial landmarks Detection + Extract parts of Facial Action Units (Lips, Eyes, Cheeks) + Hog feature + PCA (30 component) (Total features = 120) + SVM (C = 10 and gamma = 0.1,"rbf" kernel)	89.80%

Table 3: Accuracy obtained on CK+ dataset

Model	Accuracy
HOG + LBP with multi class Logistic regression	28%
AlexNet with SVM(rbf kernel) + PCA(512 components)	38%
VGG16 with SVM(polynomial kernel) + PCA(1800 components)	40.0%
Densenet161 with SVM(rbf kernel) + PCA(1024 components)	49.8%
Proposed CNN	51.2%

Table 4: Accuracy obtained on FER dataset

Conclusions

➢ Experimentally we found that combination of HOG and LBP along with PCA is performing best among all other models and give an accuracy of 89.8%.
➢ For this project we use two datasets i.e. FER and CK+. Both datasets consist of images of different facial expressions.
➢ FER is more complex dataset then CK+ so we used pre-trained deep convolutional neural networks for feature extraction.
➢ Finally we trained our own 9 layer convolutional neural network using FER dataset that help us achieving an accuracy of 51.2%.
➢ The proposed methodology is limited to classify frontal image only. However, rotation of face or occlusions degrades the performance of the system. In the future, the research will be extended to 3-D face modeling using multiple cameras to improve the proposed facial expression recognition system.

References

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[4] https://www.kaggle.com/c/challenges-in-representation-learning-facialexpression-recognition-challenge (accessed on 13-02-2019 at 23:50).
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