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Emotion Detection Using Facial Expressions

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Abstract - Facial emotion recognition is the process of detecting human emotions from facial expressions. The human brain recognizes emotions automatically, and software has now been developed that can recognize emotions as well. This technology is becoming more accurate all the time, and will eventually be able to read emotions as well as our brains do.

AI can detect emotions by learning what each facial expression means and applying that knowledge to the new information presented to it. Emotional artificial intelligence, or emotion AI, is a technology that is capable of reading, imitating, interpreting, and responding to human facial expressions and emotions.
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***Key Words*: ** SVM, Deep Learning, Random Forest

1.INTRODUCTION

Human emotion detection is implemented in many areas requiring additional security or information about the person. It can be seen as a second step to face detection where we may be required to set up a second layer of security, where along with the face, the emotion is also detected. This can be useful to verify that the person standing in front of the camera is not just a 2dimensional representation

Another important domain where we see the importance of emotion detection is for business promotions. Most of the businesses thrive on customer responses to all their products and offers. If an artificial intelligent system can capture and identify real time emotions based on user image or video, they can make a decision on whether the customer liked or disliked the product or offer .

We have seen that security is the main reason for identifying any person. It can be based on fingerprint matching, voice recognition, passwords, retina detection etc. Identifying the intent of the person can also be important to avert threats. This can be helpful in vulnerable areas like airports, concerts and major public gatherings which have seen many breaches in recent years.

Human emotions can be classified as: fear, contempt, disgust, anger, surprise, sad, happy, and neutral.

These emotions are very subtle. Facial muscle contortions are very minimal and detecting these differences can be very challenging as even a small difference results in different expressions [4]. Also, expressions of different or even the same people might vary for the same emotion, as emotions are hugely context dependent.

While we can focus on only those areas of the face which display a maximum of emotions like around the mouth and eyes [3], how we extract these gestures and categorize them is still an important question. Neural networks and machine learning have been used for these tasks and have obtained good results. Machine learning algorithms have proven to be very useful in pattern recognition and classification. The most important aspects for any machine learning algorithm are the features. In this paper we will see how the features are extracted and modified for algorithms like Support Vector Machines [1].

We will compare algorithms and the feature extraction techniques from different papers. The human emotion dataset can be a very good example to study the robustness and nature of classification algorithms and how they perform for different types of dataset. Usually before extraction of features for emotion detection, face detection algorithms are applied on the image or the captured frame. We can generalize the emotion detection steps as follows:

1) Dataset preprocessing
2) Face detection
3) Feature extraction
4) Classification based on the features

2. Body of Paper

Landmarks on the face are very crucial and can be used for face detection and recognition. The same landmarks can also be used in the case of expressions. The Dlib library has a 68 facial landmark detector which gives the position of landmarks.

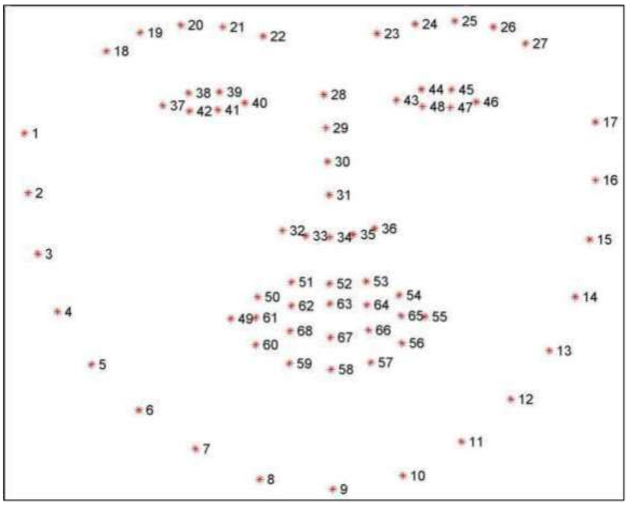

Figure 2: Landmarks on face [18]

Figure 2 shows all the 68 landmarks on face. Using dlib library we can extract the coordinates(x,y) of each of the facial points. These 68 points can be divided into specific areas

Good features are those which help in identifying the object properly. Usually the images are identified on the basis of corners and edges. For finding corners and edges in images, we have many feature detector algorithms in the OpenCV library such as Harris corner detector.

These feature detectors take into account many more factors such as contours, hull and convex. The Key-points are corner points or edges detected by the feature detector algorithm. The feature descriptor describes the area surrounding the key-point. The description can be anything including raw pixel intensities or co-ordinates of the surrounding area. The key-point and descriptor together form a local feature. One example of a feature descriptor is a histogram of oriented gradients. ORB (based on BRIEF), SURF, SIFT etc. are some of the feature descriptor algorithms .

Once the features are in place, the displacement ratios of these 19 feature points are calculated using pixel coordinates. Displacement ratios are nothing but the difference in pixel position in the image from initial expression to final expression.

Instead of using these distances directly, displacement ratios are used as these pixel distances may vary depending on the distance between the camera and the person. The dataset used for this experiment was the iBug-300W dataset which has more than 7000 images along with CK + dataset having 593 sequences of facial expressions of 123 different subjects.

Table 2: Distances calculated to determine displacement ratios between different parts of face [1]

Distance	Description of the distances
D1 and D2	Distance between the upper and lower eyelid of the right and left eyes
D3	Distance between the inner points of the left and right eyebrow
D4 and D5	Distance between the nose point and the inner point of the left and right eyebrow
D6 and D8	Distance between the nose point and the right and left mouth corner
D7 and D9	Distance between the nose point and the midpoint of the upper and lower lip

Geometrical facial features extraction

A set of 19 features are selected empirically by observing the landmark positions on the face and which are more related to human expressions. These 19 features are taken as a subset from an existing marker-less system for landmark identification and localization, which has actual 66 2D features [. These 19 features or landmarks on the face are given in Table 3 and Figure 9. Landmark positions in the image space are used to define two set of features: eccentricity features and linear features .

Eccentricity features

Eccentricity features are based on the concept of ellipses. The eccentricity of ellipses is the amount of deviation of the ellipse from being a circle. Eccentricity is between 0 and 1 for ellipses and 0 if the ellipse is a circle. For example, while smiling, the eccentricity will be greater than 0; but while expressing surprise it will be closer to 0 .

$$e = \sqrt{a^2} - b^2 / a \quad \text{where, } a = B_{Mx} - A_{Mx} / 2 \quad b = AMy - Um1y$$

Linear features

Movements that occur during expressing emotions between facial landmarks can be quantitatively evaluated using distances. These are the normalized linear distances.

The following distances are calculated to determine the linear feature vectors [9]:

L_1 – Movements between eyes and eyebrows

L_2 – Movements between mouth and nose

L_3 – Movements between upper and lower mouth points

Principle Components Analysis (PCA)

PCA is one of the most used linear dimensionality reduction technique. When using PCA, we take as input our original data and try to find a combination of the input features which can best summarize the original data distribution so that to reduce its original dimensions. PCA is able to do this by maximizing variances and minimizing the reconstruction error by looking at pair wised distances. In PCA, our original data is projected into a set of orthogonal axes and each of the axes gets ranked in order of importance.

PCA is an unsupervised learning algorithm, therefore it doesn't care about the data labels but only about variation

Machine Learning Models Used

Random Forest Classifier

Random Forest is a tree & bagging approach-based ensemble classifier. It will automatically reduce the number of features by its probabilistic entropy calculation approach.

Support Vector machines

Support vector machines with linear kernel and RBF kernel are used in this project. SVM uses the same input and implementation package as Naive Bayer

Deep Learning: Deep learning is a subset of **machine learning** in artificial intelligence that has networks capable of **learning** unsupervised from data that is unstructured or unlabeled. Also known as **deep** neural **learning** or **deep neural network**.

Results

We applied support vector machines, Random Forest, deep learning to our dataset and predicted the results. In our experiment SVM with linear kernel performed better than other kernels. Rbf gave us the worst performance, whereas poly was as good as linear kernel. We tried to keep the test set % same for both split and cross-validated data so as to have uniformity in results. The mean cross-validation score was also approximately equal to the accuracy score achieved by the split

SVM kernel	Accuracy (%)	Cross-Validation Accuracy Score (cv=4)
linear	78.05	0.78(+/- 0.07)
rbf	21.95	0.25(+/- 0.01)
poly	75.61	0.76(+/- 0.06)

Many of the samples were misclassified into other classes such as contempt, disgust, fear and sadness. Fear was detected accurately for all the samples. The samples for disgust and sadness were misclassified as anger in some cases. This can be due to the similarity of features between these emotions.

3. CONCLUSIONS

The Algorithm gives highly accurate results and works fine in live mode too.

This can be really helpful for companies who want to understand their customer's reaction regarding their product or service.

This can also be used in areas like security where facial expression can depict a person's emotion and further help in understanding human sentiment

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