Mood detection of psychological and mentally disturbed patients using Machine Learning techniques

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Summary
This paper describes a simple and novel approach for detection of mood of a psychological patient using face images. We developed a system using different machine learning techniques to automatically classify and detect the mood of the psychological or mentally disturbed patient under observation. We can divide the main problem into three sub parts. In the first step we divided the mood of a person into five distinct classes i.e. Sad, Angry, Happy, Normal and Surprised. For every class we use a set of input images to train the K nearest neighbor (KNN) classifier. In our system we used Speeded-up robust features (SURF) for detection of local features and descriptors from the input sets of images. These features are used for training KNN classifier. In the second step we extract SURF features from test image, i.e. when a test image is passed to the system for classification, the system uses the SURF technique for extraction of features and descriptors from the test image. In third step, the descriptors and features extracted from test image are passed to the trained KNN classifier, which classify the image into one of the classes. After performing 250 experiments for each class, we got an over all accuracy of 77.4% for the classifier. This is a novel approach to detect the mood of a person using face images.

Key words:
Mood, SURF, Machine Learning, Psychological patients

1. Introduction

A human detect the mood of a person using face expressions. This natural instinct is an important trait, which is very useful for human beings. In real world many decisions are taken by keeping in mind the mood of the person. Scientists have indicated that 55% messages [1] are delivered using facial expressions alone, while the rest can be delivered using language and voice intonation. In order to make human computer interactions more real, it is important that computer understands and take into effect the mood when deciding any action. This paper is about an intelligent system, which can detect the mood of psychological and mentally disturbed patients. As in certain countries including Pakistan, the doctor to patient ratio is very low which make it impossible to keep every patient under constant observation.

Many research projects are already under way for mood detection of humans using face expressions. Recognizing facial expressions with principle component analysis (PCA) and singular value decomposition (SVD) using an input image [2] for robots is a project in this category. In this work Mandeep & Rajeev used PCA with SVD to extract features and determine different emotions of a person. The recognition rate for this PCA based method show less degradation due to face images with glasses. C. Fan [3] in his paper analyzes six facial expressions using regression analysis. They use a pre processor for locating faces and eyes in images. A database of different face expressions is used for training support vector machine (SVM) classifier. C. Fan stated that this method can be used for real time applications, as it requires less computational power. A. Saxena [4] uses spatially localized geometric models for recognizing of four different expressions. They used edge projection analysis for feature extraction followed by classification using feed forward network classifier.

Facial expressions are very important in detecting mood of the person. Ekman and Friesen [5] developed the facial action coding system (FACS) to measure the facial expressions and behavior. The facial action coding system differentiates facial expressions into action units (AU) based on the fundamental muscular movement that creates quick fluctuations in the facial expression. An expression is additionally recognized by appropriately classifying the AU (action unit or group of action units) associated to a specific expression. Fasel and Luettin [6] also worked on the recognition of facial AU's, i.e. emotion-identified expressions. For localizing face images they have used the Canny edge detector. Bartlett [7] discovers and relates techniques for automatically identifying facial actions and expressions in series of images. These methods comprise of analysis of facial motion through approximation of optical flow, spatial analysis such as local feature analysis, and component analysis.

Rajneesh Singla and Sahil Bansal [8] have implemented PCA * with fisher face algorithm to identify and detect moods. The key part of their work is emotion based image database which comprise of images of faces, their resultant AU's * and their labels. This database is used by the system in order to identify facial expressions and moods. Priti B. Badar, Urmila Shrawankar [9] proposed a relatively easier method for mood/facial expression

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identification. They used SVM classifier to classify the facial expressions. Main problem was sub-divided in 3 key modules. In first module face is detected through skin color filter and face segmentation. They gave extra stress on feature extraction. The second step is facial feature extraction and is an important part for expression/mood identification. They have used "Edge Projection Analysis". In the final step the extracted features vector is passed from SVM classifier for mood/expression identification.
A person has many moods, but in this study we have divided and generalize the mood of a person into five broad categories or classes: i.e. Happy, Sad, Angry, Surprise, Normal.

In this study we can divide the main problem into 3 parts.

1. In the first step we divided the mood of a person into five distinct classes. For every class we use a set of input images from Cohn-Kanade database [10] to train the K nearest neighbor (KNN) classifier. In our system we used Speeded-up robust features (SURF) for detection of local features and descriptors from the input sets of images. These features are used for training KNN classifier.
2. In the second step we extract SURF features from test image, i.e. when a test image is passed to the system for classification, the system uses the SURF technique for extraction of features and descriptors from the test image.
3. In third step, the descriptors and features extracted from test image are passed to the trained KNN classifier, which classify the image into one of the classes.

This technique is a novel approach to mood detection using SURF features and KNN classifier. We have used Matlab [15] image processing toolbox for implementation of this technique. Matlab is easy to use and most of the functions are built-in which save time of developer.

2. Cohn Kanade Database & Pre processing

The Cohn-Kanade (CK) [10] database can be used to detect different facial expressions. This database is one of the most commonly used databases for algorithm development and assessment. It has been used for both Action units (AU) and emotion detection. The Cohn-Kanade images database is available in three versions with a number of poses and expressions.

We performed the following steps for pre-processing the images:

- In first step of data pre-processing, we selected 150 images for every class from Cohn-Kanade images database [10]. The total images selected are 750.
- Convert all images into gray scale using **rgb2gray()** function of Matlab [15].
- Extract the faces from the images using a pre-defined boundary of 200 into 200. We can use.
- Matlab function **imcrop()** for this purpose[15].
- Images of respective class are placed in separate folders.

Figure 1. Pre-processed images extracted from Cohn-Kahade [10]

3. Features extraction using surf techniques

Speeded-up robust feature technique is used to detect local features and descriptors [12]. Speeded up robust features (SURF) can be used for different tasks which includes identification, image registration and classification. SURF is somewhat inspired by scale invariant feature transform (SIFT) descriptors. We are using SURF instead of SIFT because it is several times faster and accurate [14]. Speeded up robust feature's algorithm have three parts to extract the features, namely:

1. Interest point detection
2. Neighborhood description
3. Matching

In interest point detection, SURF uses squared shaped filters for approximation of Gaussian blur. The integral image can be used to evaluate the sum of the original image within the rectangle. Speeded up robust features uses an integer approximation of the determinant of Hessian blob detector for the detection of interest points [12]. It is used for measuring local change around a point. Those points are chosen where the determinant is maximum. The determinant of Hessian is also used for selecting scale. The Hessian H is given by (see Eq. 1).

$$H(p,\sigma) = \begin{pmatrix} L_{xx}(p,\sigma) & L_{xy}(p,\sigma) \\ L_{xy}(p,\sigma) & L_{yy}(p,\sigma) \end{pmatrix} \quad (1)$$ [13]

After interest point's detection, descriptors are computed for each point. Descriptors can be calculated locally as well as globally. When descriptors are calculated for each point, matching can be performed, by using the descriptors.

4. Training Classifier (KNN)

K nearest neighbor [11] is a non-parametric method used for regression as well as classification. The input in every case comprises k neighboring training instances in the feature space. As we are using KNN for classification, so the output will be a class membership. The input instance or in our case the image will be classified by a majority vote of its neighbors. The image will be assigned to the class which will have more votes or which is more common among the nearest neighbors.

In our system, features are extracted from training set of images using SURF technique. These features are stored using KDTreeSearcher [15]. KDTreeSearcher is used for storing distance metric and training data in each leaf node [15]. KD-tree algorithm can be used for partitioning an X by K (X/K) dataset. This can be achieved by repeatedly splitting, X points in K dimensional space into a binary tree [15]. When finding the nearest neighbor for classification, KDTreeSearcher limits the space of training data to the training observations in the leaf node [15].

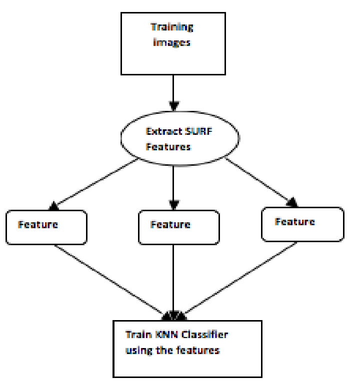

Figure 2. Training classifier using training images

5. Algorithm and Classification

Following are the steps of the algorithm:

- Identify training images for each class (happy, sad, normal, surprise, angry) from Cohn-Kanade database and place them in separate folders.
- Initialize and extract the images from the folder one by one through a "for" loop in Matlab.
- Convert each image into grey if not grey already.
- Extract SURF feature points using Matlab function **detectSURFFeatures ()** [15].

Figure 3. Features extracted from training images shown in green color

- Make a data set from features for every class
- Use **KDTreeSearcher()** function [15] to store the data sets. When KDTreeSearcher model Object is trained, we can use **Knnsearch**() [15] function to find the neighbor points by searching the stored tree.
- To test the trained model, we can use some random images from the same Cohn-Kanade [10] database.
- Convert these images into grey scale using **rgb2gray()** function of Matlab [15].
- Extract the face from this image using a pre-defined boundary of 200 into 200. We can use Matlab function **imcrop()** for this purpose.
- Extract features from these images using **detectSURFFeatures()** [15] function.

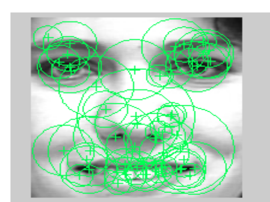

Figure 4. Features extracted from test image shown in green color

- Use **Knnsearch**() [15] function to find the nearest neighbor points by searching the stored tree.
- Match every feature of test image to 7 (K = 7) features in the data set (training collection of images).
- Count the number of matches for each class using histogram

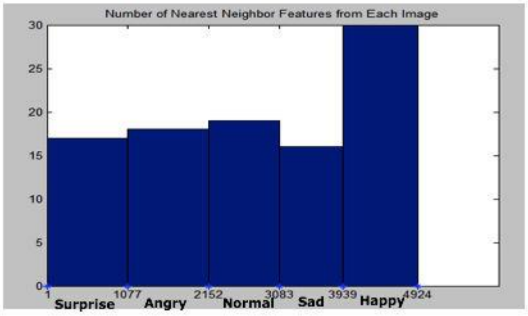

Figure 5. Histogram nearest neighbor features for every class

- Check the maximum count and classify the query image on the basis of maximum feature count.

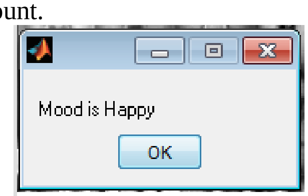

Figure 6. Classification message generated by the system

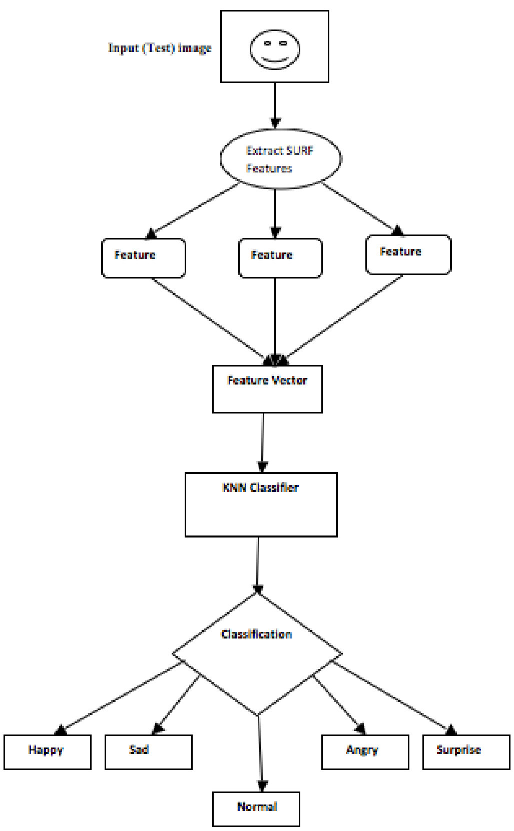

Figure 7. Complete flow of algorithm

6. Experiments and results

We selected 250 test images for each class from the Cohn-Kanade database. The total time taken by KNN classifier to classify an image (including the build time) was 6.377 seconds. After performing 250 experiments per class we have got the following results (see Table. 1). The overall or average accuracy of the system is 77.4%. The algorithm is more useful when K (the number of nearest neighbors) is less then 10.

Table 1: Class wise results

Mood (Class)	Result
Happy	78%
Sad	77%
Surprise	76.8%
Angry	78%
Normal	77.2%

7. Future enhancements and prospects

The system can be enhanced and developed further to improve the accuracy using hybrid or mix classifiers such as support vector machine and KNN. Also in future more classes (Moods) can be added to the system. Currently we are selecting the boundaries of the input image (classification image) manually; in future it can be automated as well.

8. Conclusions

In this paper we presented a system that can be used for mood detection of psychological patients as well as other humans. We used Simple and low cost computational method. The total time taken by KNN classifier to classify an image (including the build time) was 6.377 seconds. The over all accuracy of the system after performing 250 tests for each class was found to be 77.4%. This system can be used for other purposes such as:

- Childcare
- Security systems
- Examination centers
- Schools

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