International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Facial Expression Recognition from Color Images using Log Gabor Filter

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Accepted 07 April 2015, Available online 12 April 2015, **Vol.5, No.2 (April 2015)**

Abstract

Facial Expressions play an important role in recognizing the human emotions without any verbal communication. Face emotion recognition is one of the main applications of computer vision. The research of emotion recognition includes facial expressions, voice recognition, gesture recognition, text etc. For efficient human-computer interaction, recognizing human emotional state is an important component. The techniques for recognizing facial expression play an important role in monitoring people with mental problems, neuro-developmental disorders, etc. Facial expression recognition systems mainly consists of 3 main parts: face detection, feature extraction and classification. Once the face is detected, the facial feature regions such as eyes, eyebrows, mouth are extracted. Based on the extracted features, expressions are classified. The proposed method is based on information contained in color facial images. The face area is detected from the input image and it is normalized. The purpose of color normalization is to reduce the lighting effect. Features are extracted from the normalized image using log gabor filters. A bank of 24 Log-Gabor filters is used to extract the facial features. Six scales and four orientations are implemented to extract features from face images. These features are then used to detect the facial expressions. The system also detects the facial expressions from blurred images.

Keywords: *Facial Expression, Normalization, Feature extraction, Gabor filter.*

Introduction

Emotions are an important aspect of human life and basic research on emotions of the past few decades has produced several discoveries that have led to important real world applications. The research of facial expression recognition supports potential applications in a wide range of areas including Human computer interaction, Disease diagnosis, Crime prevention, Lie detection, Surveillance system. There exist two main methodologies to analyze expressions vision based methods and audio based methods. Vision based methods for expression analysis operate on images or images sequences. Generally, Vision based facial expression recognition system consists of three steps: face detection, feature extraction and classification. The first step in facial expression analysis is to detect the face in the given image or image sequence. Locating the face within an image is called face detection whereas locating the face and tracking it across the different frames of a video sequence is called face tracking. Extraction of selected features is the second and the most important step to successfully analyze and recognize facial expressions automatically. The extracted features should minimize within-class variations of expressions, but maximize between class variations. Third and the last step of automatic expression analysis system is classification. Classification deals with labelling new sample/data on the basis of a training data.

Problem definition

Detecting Facial expressions from face image is now become an important component for human computer interaction. Facial expressions can either be interpreted in terms of shown affective states (emotions) or in terms of activated facial muscles underlying the displayed facial expression. Here the problem is to find the expressions from face images that are blurred.

Literature Survey

With the recent advancements in the field of robotics and automated software, the requirement for a robust expression recognition system is very clear. As humans respond to others through emotional states, computers or automated systems must also be able to this. Through the advancements in human computer interaction study, researchers are trying to bridge the gap between human and computer sensors. Facial

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expression analysis will be very useful in video games consoles such as Kinect sensor, sleep detection sensors in automobiles etc. (Dewan Ibtesham *et al*, 2004)

The commonly used facial expression coding system is based on six basic emotions / expressions proposed by Ekman. Each of those expressions possess a distinctive content together. The six basic emotions are happiness, sadness, fear, disgust, surprise and anger. These expressions are also referred as universal expressions. Ekman's six basic emotions are used extensively to test various systems for recognizing facial expressions. (P. Ekman *et al*, 1971)

Facial Action Coding System (FACS) detects and measures a large number of facial expressions by observing a small set of facial actions. The system decomposes the face into 46 Action Units (AUs), each of which is related to the contraction of either a specific facial muscle or a set of facial muscles. AUs are considered to be the smallest visually identifiable facial movements. They are atomic, no AU can be split into two or more smaller components. Any facial expression can be uniquely identified by a combination of AUs. Multiple AUs can also occur simultaneously. (Michel F. Valstar, Maja Pantic *et al*, 2012)

Every facial expression recognition system must perform a few steps before classifying the expression into a particular class. The first step in facial expression analysis is to detect the face in the given image. Locating the face within an image is termed as face detection. After detecting face in input image, feature selection is an important step to successfully analyse and recognize facial expressions automatically. Methods for extracting facial features are categorized either as appearance based methods or geometric feature based methods. Geometric features present the shape and locations of facial components (including mouth, eyes, brows, nose), while the appearance features present the appearance (skin texture) changes of the face. Last step of automatic expression analysis system is classification.

Pedro Martins, Joana Sampaio and Jorge Batista (Pedro Martins, Joana Sampaio, Jorge Batista *et al*, 2004) presents an appearance-based face recognition which involves image preprocessing and the use of statistical redundancy reduction. To process a complete image face, both shape and texture are modeled. Active Appearance Model is a statistical based segmentation method, where the variability of shape and texture is captured from the data set. The facial expression recognition procedure is performed by describing a set of faces using the AAM model. Each vector of appearance is projected into Fisherspace, by applying a Linear Discriminant Analysis (LDA). LDA is a supervised learning technique performs by optimizing the separability of the data set observations according to the expression class they belong to. This is done by maximizing the between-class variance and minimizing the within-class variance. LDA transformation also involves an eigenvector decomposition. The classification for an unknown face image consists of two steps. The first is projecting its appearance vector and the second is to estimate to which group this projected point belongs to. Here this is done by using an adaptation of the nearest-neighborhood algorithm, which takes into consideration the distance of the point to the centre of each group and its dispersion. The distance to each group is measured using Malahanobis distance.

Aliaa A. A. Youssif and Wesam A. A. Asker (Aliaa A. A. Youssif, Wesam A. A. Asker *et al*, 2011) presents a computer vision system for automatic facial expression recognition. First, face detection process is carried out. Then the feature extraction process is applied on the face image to produce a feature vector that consists of two types of features: geometric features and appearance features which represents a pattern for facial expression classes. Finally, this feature vector used as an input into the radial basis function of the artificial neural network to recognize the facial expressions. For geometric feature extraction, the segmentation process is performed to divide the face image into three regions of interest: mouth, nose and two eyes and two eyebrows. Then the facial characteristic points (FCPs) are located in each face component using mouth, nose, eyes and eyebrows FCPs extraction techniques. Finally, the distance between FCPs are calculated using Euclidean distance. In appearance based feature extraction, the normalized image is reduced 250*200 pixels by removing 50 pixels from left, right and top to focus on the face. This paper does not deal with image sequence. Also, dealing with image sequence may require approaches with very low execution time.

Yongsheng Gao, Maylor K. H. Leung, Siu Cheung Hui, and Mario W. Tananda (Yongsheng Gao, Maylor K. H. Leung, Siu Cheung Hui, and Mario W. Tananda *et al*, 2003) presents a methodology for facial expression recognition from a single static image using line-based caricatures. The recognition process is completely automatic. This method uses structural and geometrical features of a user sketched expression model to match the line edge map (LEM) descriptor of an input face image. To generate the LEM, the dynamic two strip algorithm (Dyn2S) is used to detect dominant points on the facial edge curves. In Dyn2S algorithm, a strip is fitted to the left and right of each point on the curve, and the points inside each strip are approximated as a straight line. The orientation and width of the strip are adjusted automatically. Longer and narrower strips are favoureds. The LEM representation enhances the geometrical structure properties in the edge map. By grouping low level pixels into higher level line features, the oriented structural features are extracted to characterize the facial expressions.

Overview of the system

The proposed method is based on information contained in color facial images. The face area is detected from the input image and it is normalized.

Features are extracted from the normalized image using log gabor filters. A bank of 24 Log-Gabor filters is used to extract the facial features. Six scales and four orientations are implemented to extract features from face images. These features are then used to detect the facial expressions.

Steps

1. Read the input face image dataset
2. Detect the face region from the input image
3. Resize the detected face images into same size
4. Perform normalization on the detected face image
5. Extract the facial features using gabor filters
6. Enter a test image with blur to detect the facial expression
7. Detect face region of the test image
8. Perform normalization on the test image
9. Classify the expression into sad, angry, disgust, crying, happy or surprise using SVM classifier
10. Return the result to the user

Face Detection

Face detection is used to determine the locations and sizes of human faces in digital images. Face detection can be regarded as a general case of face localization. In face localization, the locations and sizes of a known number of faces are found out. In face detection, face is processed and matched bitwise with the underlying face image in the database. Face-detection algorithms focus on the detection of frontal human faces.

The aim of this module is to detect face. The face area of the input image is detected and the pixels selected from rectangular areas imposed over the picture. After face detection stage, the face images are scaled to the same size.

Normalization

Normalization changes the range of pixel intensity values. Normalization is also called contrast stretching or histogram stretching. The purpose of color normalization is to reduce the lighting effect. Face recognition accuracy depends heavily on how well the input images have been compensated for pose, illumination and facial expression. Illumination changes caused by light sources at arbitrary positions and intensities contribute to a significant amount of variability. Here color values of face images are normalized with respect to RGB values of the image.

Feature Extraction

Gabor filter is a linear filter used for edge detection. Gabor filters are used for obtaining localised frequency information. Gabor filters have two main limitations:-

1. The maximum bandwidth of a Gabor filter is limited to approximately one octave.
2. Gabor filters are not optimal for broad spectral information with maximal spatial localization.

An alternative to the Gabor function is the Log-Gabor function. Log-Gabor filters (Seyed Mehdi Lajevardi, Hong Ren Wu *et al*, 2012) can be constructed with arbitrary bandwidth and the bandwidth can be optimised to produce a filter with minimal spatial extent. A bank of 24 Log-Gabor filters is used to extract the facial features. Six scales and four orientations are implemented to extract features from face images. The image filtering is performed in the frequency domain because it is faster compared with the spacial domain convolution. The optimum features are selected based on mutual information. If a feature vector is strongly different from other features, their mutual information will be large. The polar form of 2-D Log-Gabor filters in frequency domain is given by,

$$H(f,\theta) = \exp\left\{\frac{-\left[ln\left(\frac{f}{f_0}\right)\right]^2}{2\left[ln\left(\frac{\sigma_f}{f_0}\right)\right]}\right\}\exp\left\{\frac{-(\theta-\theta_0)^2}{2\sigma_\theta^2}\right\}$$

(Seyed Mehdi Lajevardi, Hong Ren Wu *et al*, 2012)

where H(f, θ) is the frequency response function of the 2-D Log-Gabor filters, f and θ denote the frequency and the phase/angle of the filter, respectively, f_0 is the filter's center frequency and θ_0 the filter's direction. The constant σ_f defines the radial bandwidth and the constant σ_θ defines the angular bandwidth.

Classification

Support Vector machines belong to a family of generalized linear classifiers which uses linear functions in a high dimensional feature space. They are trained with a learning algorithm derived from statistical learning theory. SVM is a useful technique for data classification which involves both training and testing data sets. The primary goal of SVM is to produce a model which predicts the output value of data instances contained in the testing set. After the features are extracted, the expressions are classified based on them. Here SVM is used for classifying the expressions into six categories-happy, sad, disgust, angry, crying and surprise.

Conclusions

A facial expression recognition system for recognizing color images with blur and illumination is proposed here. The database contains face images of 5 different persons with 6 different facial expressions. Here the database contains face images with and without blur. Blurring is done manually before training. The features are extracted using a bank of 24 Log-Gabor filters, and the main features were selected based on mutual information. Then given input image is classified into six different expressions using SVM classifier.

Future Work

The proposed method detects the facial expressions from color images with blur. When the face image is

slightly occluded or there is some variations in the head position it is difficult to detect the expressions. To overcome the head pose variations, some image registration methods can be introduced. New methods have to be implemented to detect expressions from occluded image.

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