IOSR Journal of VLSI and Signal Processing (IOSR-JVSP)
Volume 3, Issue 6 (Nov. – Dec. 2013), PP 37-43
e-ISSN: 2319 – 4200, p-ISSN No. : 2319 – 4197
www.iosrjournals.org

Log-Gabor Filters and Lda Based Facial Expression Recognition

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Abstract: *This project introduces a tensor perceptual color framework (TPCF) for facial expression recognition (FER), which is based on information contained in color facial images. The TPCF enables multilinear image analysis in different color spaces, and demonstrates that color components provide additional information for robust FER. Using this framework, the components (in either RGB, YCbCr, CIELab space) of color images are unfolded to 2-D tensors based on multilinear algebra and tensor concepts, from which the features are extracted by Log-Gabor filters.*

The mutual information quotient method is employed for feature selection. These features are classified using a multiclass linear discriminant analysis classifier. The effectiveness of color information on FER using low-resolution and facial expression images with illumination variations is assessed for performance evaluation. Experimental results demonstrate that color information has significant potential to improve emotion recognition performance due to the complementary characteristics of image textures. Furthermore, the perceptual color space CIELab are better overall for FER than other color spaces, by providing more efficient and robust performance for FER using facial images with illumination variation.

I. Introduction

Basic goal of the human–computer-interaction (HCI) system is to improve the interactions between users and computers by making computers more users friendly and receptive to user's needs. Automatic facial expression recognition (FER) plays an important role in HCI systems and it has been studied extensively over the past twenty years. Border security systems, forensics, virtual reality, computer games, robotics, machine vision, user profiling for customer satisfaction, broadcasting, and web services are but a few different real world applications.

The use of facial expression for measuring people's emotions has dominated psychology since the late 1960s when Paul Ekman reawakened the study of emotion by linking expressions to a group of basic emotions (i.e., anger, disgust, fear, happiness, sadness, and surprise). The research study by Mehrabian has indicated that 7% of the communication information is transferred by linguistic language, 38% by paralanguage, and 55% by facial expressions in human face-to-face communication. This, therefore, shows that facial expressions provide a large amount of information in human communication.

It was first reported in that taking account of color information improves Recognition rate when compared with the same scheme using only the luminance information. It was shown in that color components helped to improve face retrieval performance. Liu and Liu proposed a new color space for face recognition Young, Man, and Plataniotis demonstrated that facial color cues significantly improved face recognition performance using low-resolution face images. It was reported in that the RGB color tensor has improved the FER performance; however, it did not consider the images with different illuminations.

This project analyzes and implements the Log-Gabor filters and LDA based facial expression recognition. The use of facial expression for measuring people's emotions (i.e., anger, disgust, fear, happiness, sadness and surprise). Which is based on information contained in color facial images, and the color components RGB, YCbCr, CIELab provide additional information for robust FER. The face area of an image is detected using the Viola–Jones method based on the Haar like features, by using Log-Gabor filters we can extract the features. The mutual information quotient method is employed for feature selection. These features are classified using a multiclass linear discriminant analysis classifier.

M. Corbalan explained about a color pattern recognition system must identify a target by its shape and color distribution. In real situations, however, the color information is affected by changes of the light source (e.g., from indoor illumination to outdoor daylight), often making recognition impossible.

M. Thomas explained to perform recognition of color images; we use the characteristics of a 3D color tensor to generate a color LDA subspace, which in turn can be used to recognize a new probe image

Paul Viola describes a face detection framework that is capable of processing images extremely rapidly while achieving high detection rates. There are two key contributions. The first is the introduction of a new image representation called the "Integral Image" which allows the features used by our detector to be computed very quickly. The second is a simple and efficient classier which is built using the AdaBoost learning algorithm to select a small number of critical visual features from a very large set of potential features.

Juergen Luettin explained about automatic facial expression analysis has become an active research area that 0nds potential applications in areas such as more engaging human–computer interfaces, talking heads, image retrieval and human emotion analysis. Facial expressions reflect not only emotions, but other mental activities, social interaction and physiological signals. He introduces the most prominent automatic facial expression analysis methods and systems presented in the literature.

II. Existing Methods Of Facial Expression Recognition:

In the previous techniques for facial expression classification mostly focus on gray-scale image features, while rarely considering color image features. Facial Expression plays an important role in human-to human interaction, allowing people to express themselves beyond the verbal world and understand each other from various modes. Some expressions incite human actions, and others fertilize the meaning of human communication.

Color space models are three types. They are

- RGB
- YC_bC_r
- CIELab

The RGB colour model is an additive colour model in which red, green, and blue light are added together in various ways to reproduce a broad array of colours. The main purpose of the RGB colour model is for the sensing, representation, and display of images in electronic systems, such as televisions and computers, though it has also been used in conventional photography. Before the electronic age, the RGB colour model already had a solid theory behind it, based in human perception of colours.

$YC_bC_r$is yet another hardware-oriented model. However, unlike the RGB space, here the luminance is separated from the chrominance data. The Y value represents the luminance (or brightness) component, while the C_r and C_b values, also known as the colour difference signals, represent the chrominance component of the image. These are some, but certainly not all, of the colour space models available in image processing. Therefore, it is important to choose the appropriate colour space for modelling human skin colour. The factors that need to be considered are application and effectiveness. The intended purpose of the face segmentation will usually determine which colour space to use; at the same time, it is essential that an effective and robust skin colour model can be derived from the given colour space. For instance, in this paper, we propose the use of the YC_bC_r colour space, and the reason is twofold. First, an effective use of the chrominance information for modeling human skin color can be achieved in this color space. Second, this format is typically used in video coding, and therefore the use of the same, instead of another, format for segmentation will avoid the extra computation required in conversion. Color space defined by the CIE, based on one channel for Luminance (lightness) (L) and two color channels (a and b). One problem with the XYZ color system is that colorimetric distances between the individual colors do not correspond to perceived color differences.

Gabor filters: It is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. This method is used in feature extraction process in image based FER system. A set of Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image.

Its impulse response is defined by a sinusoidal wave (a plane wave for 2D Gabor filters) multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. The filter has a real and an imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually.

Principal component analysis (PCA)

It is a mathematical procedure that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to (i.e., uncorrelated with) the preceding components. Principal components are guaranteed to be independent if the data set is jointly normally distributed. PCA is sensitive to the relative scaling of the original variables. PCA is closely related to factor analysis. Factor analysis typically incorporates more domain specific assumptions about the underlying structure and solves eigenvectors of a slightly different matrix. PCA is also related to canonical correlation analysis (CCA). CCA defines coordinate systems that optimally describe the cross-covariance between two datasets while PCA defines a new orthogonal coordinate system that optimally describes variance in a single dataset.

It concludes that by using grey-scale images we can get facial expression recognition. But we want robust recognition, that's why we have to use color images in proposed method.

FACIAL IMAGE PROCESSING AND ANALYSIS:

Face recognition systems are progressively becoming popular as means of extracting biometric information. Face recognition has a critical role in biometric systems and is attractive for numerous applications including visual surveillance and security. Because of the general public acceptance of face images on various documents, face recognition has a great potential to become the next generation biometric technology of choice. Face images are also the only biometric information available in some legacy databases and international terrorist watch-lists and can be acquired even without subjects' cooperation. This special issue is particularly interested in recent progress in face detection and recognition that explores emerging themes such as digital video, 3D, near infrared, occlusion and disguise, long-term aging, and/or the lack of sufficient training data.Face and feature detections are

- Face detection for best-shot selection
- Facial feature detection and extraction
- 3D head modeling and face tracking

These detection methods are

- Viola-Jones method
- Log-Gabor filters
- Mutual information coefficient and linear discriminate analysis.

Facial expression recognition:

facial expression is a visible manifestation of the affective state, cognitive activity, intention, personality, and psychopathology of a person it plays a communicative role in interpersonal relations. Facial expressions, and other gestures, convey non-verbal communication cues in face-to-face interactions. These cues may also complement speech by helping the listener to elicit the intended meaning of spoken words. As cited Mehrabian reported that facial expressions have a considerable effect on a listening interlocutor; the facial expression of a speaker accounts for about 55 percent of the effect, 38 percent of the latter is conveyed by voice intonation and 7 percent by the spoken words. As a consequence of the information that they carry, facial expressions can play an important role wherever humans interact with machines. Automatic recognition of facial expressions may act as a component of natural human machine interfaces (some variants of which are called perceptual interfaces or conversational interfaces). Such interfaces would enable the automated provision of services that require a good appreciation of the emotional state of the service user, as would be the case in transactions

III. Construction Of An Image-Based Fer System

The principal approaches (i.e., image-based and model based) to FER using static images are described. Image-based methods extract features from images without relying on extensive knowledge about the object of interest, which are typically fast and simple, whereas model based methods attempt to recover the volumetric geometry of the scene, which are typically slow and complex. The geometric features present the shape and locations of facial components (including mouth, eyes, eyebrows, and nose). The facial components or facial feature points are extracted to form a feature vector that represents the face geometry. The appearance features present the appearance (skin texture) changes of the face, such as wrinkles and furrows.

The appearance features can be extracted from either the whole face or specific regions in a face image. This paper focuses on the static color images and a holistic technique of the image-based method is used for feature extraction. The image based FER systems consist of several components or modules, including face detection and normalization, feature extraction, feature selection, and classification. Fig. 1 shows the system level diagram of the FER system. The following sections will describe each module in detail. Furthermore, different color spaces are briefly described including YC_bC_r, CIELab.

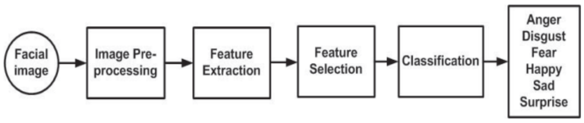


Fig4: system level diagram

FACE DETECTION

The aim of this module is to obtain face images, which have normalized intensity, are uniform in size and shape and depict only the face region. The face area of an image is detected using the Viola–Jones method based on the Haar-like features and the AdaBoost learning algorithm. The Viola and Jones method is an object detection algorithm providing competitive object detection rates in real-time. It was primarily designed for face detection. The features used by Viola and Jones are derived from pixels selected from rectangular areas imposed over the picture, and exhibit high sensitivity to the vertical and the horizontal lines.

Viola-Jones method:

It is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. Although it can be trained to detect a variety of object classes, it was motivated primarily by the problem of face detection. Our face detection procedure classifies images based on the value of simple features. There are many motivations for using features rather than the pixels directly. The most common reason is that features can act to encode ad-hoc domain knowledge that is difficult to learn using a finite quantity of training data. The simple features used are reminiscent of Haar basis functions. More specifically, we use three kinds of features.

NORMALIZATION:

After face detection stage, the face images are scaled to the same size (e.g., 64×64 pixels). The color values of face images are then normalized with respect to RGB values of the image. The purpose of color normalization is to reduce the lighting effect because the normalization process is actually a brightness elimination process. Given an input image of N1 × N2 pixels represented in the RGB color space x = {xn3 [n1, n2]| 1 ≤ n1 ≤ N1, 1 ≤ n2 ≤ N2, 1 ≤ n3 ≤ 3}, the normalized values, xn3 norm [n1, n2], are defined by

Where xn3 norm [n1, n2] for n3 = 1, 2, 3 corresponding to red, green, and blue (or R, G, and B) components of the image, x.

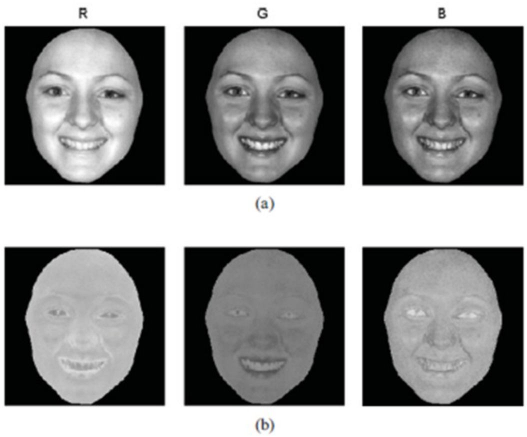


Fig9: Facial expression images: (a) the original color components and (b) the normalized color Components.

FEATURE EXTRACTION:

Various methods of feature extraction have been studied and compared in terms of their performance, including principal component analysis, independent component analysis, linear discriminate analysis (LDA), the Gabor filter bank, etc. Fasel and Luettin reported that the Gabor filter bank has better performance than the rest. The Gabor filters model the receptive field profiles of cortical simple cells quite well However, the Gabor filters have two major limitations, i.e., the maximum bandwidth of Gabor filters is limited to approximately one octave, and the Gabor filters are not optimal to achieve broad spectral information with the maximum spatial localization.

Log- Gabor filters: An alternative to the Gabor function is the log-Gabor function proposed by Field [1987]. Field suggests that natural images are better coded by filters that have Gaussian transfer functions when viewed on the logarithmic frequency scale. (Gabor functions have Gaussian transfer functions when viewed on the *linear* frequency scale). On the linear frequency scale the log-Gabor function has a transfer function of the form

Where w_o is the filter's centre frequency. To obtain constant shape ratio filters the term k/w_o must also be held constant for varying w_o. For example, a k/w_o value of .74 will result in a filter bandwidth of approximately one octave, .55 will result in two octaves, and .41 will produce three octaves. There are two important characteristics to note. Firstly, log-Gabor functions, by definition, always have no DC component, and secondly, the transfer function of the log Gabor function has an extended tail at the high frequency end.

FACIAL EXPRESSION IMAGES UNDER ILLUMINATION:

The International Commission on Illumination (CIE) tristimulus system proposed alternative color spaces in terms of its three coordinates relating usually a standard luminance to a reference color. The CIELab is one of the colorimetric color spaces, which separates a luminance

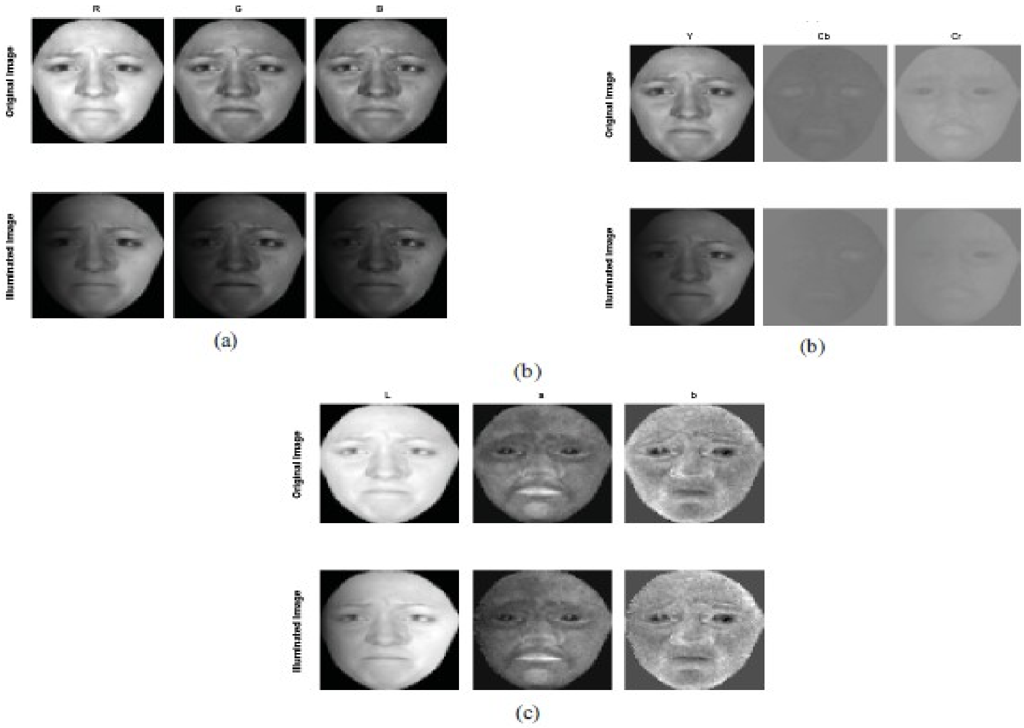


Fig. 11. Facial expression images in (a) RGB, (b) YCbCr, (c) CIELab, and color spaces. Top row: original image.

Bottom row: image under illumination variation Variable "L" from two perceptually uniform chromaticity variables ("a", "b"). The CIELab is widely used in several image processing applications include: perceptual image quality assessment, face detection, skin detection, and image segmentation, etc. Despite the many advantages of such color space, it has rarely been used in pattern recognition. In this project, the performance of the FER system in both CIELab color space is investigated. However, the threshold for filter is not constant due to variation of illumination. In addition, this filter is nonlinear filter and makes the computational complex of the system high. Therefore, it is computationally more costly to use this filter for FER system. An alternative is Retinex color image enhancement algorithm, whose theory models the effect of varying intensity of light on color perception of human vision.

It concludes that TPCF was proposed for FER system in perceptual color space. Based on TPCF, the RGB color images were first transformed to perceptual color spaces after which the horizontal unfolded tensor was adopted to generate the 2-D tensor for feature extraction. The 2-D tensor was normalized before the features were extracted using a bank of 24 Log-Gabor filters, and the optimum features were selected based on MIQ algorithm. The images under slight illumination variation were used to test robustness of the FER system performance.

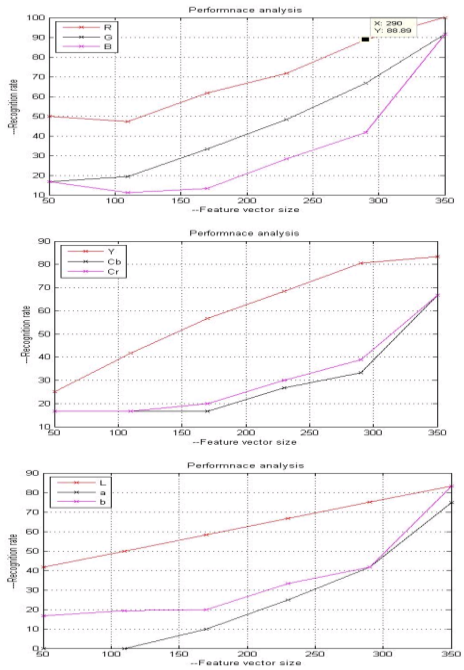
IV. Experimental Results

In this process first we take color facial image,after that by using Viola-Jones detect the face image. After face detection stage, the face images are scaled to the same size (e.g., 64×64 pixels).The color values of face images are then normalized with respect to RGB values of the image. The purpose of color normalization is to reduce the lighting effect because the normalization process is actually a brightness elimination process.

After pre processing stage extract the features on normalized the image, by using Log-Gabor filters. In This filter six scales and four orientations are implemented to extract features from face images. This leads to 24 filter transfer functions representing different scales and orientations.

Size of image is 128×128, and by comparing RGB, YCbCr, CIELab we get robust recognition rate on CIELab. The results are shown below

Red line is represented as R-component, black is represented as G-component and pink line is B-component



(a)

(b)

(c)

Fig12: Comparative evaluation of performance in different color spaces from 128×128
(a)RGB . (b) YCbCr, (c)CIELab

Red line is represented as L-component, black line is represented as a-component and pink line is b-component.

By comparing all the three components CIELab will get more recognition rate compare to rest of the color components. The values are shown in below table.

TABLE-I
COMPARISON OF AVERAGE RECOGNITION RATES FOR COLOR SPACES

size	RGB		YCbCr		CIElab	
	FV	RR	FV	RR	FV	RR
128×128	110 170 230 290	47.22 61.67 71.67 88.89	110 170 230 290	41.67 56.67 68.33 80.56	110 170 230 290	50 58.33 66.67 75
128×128	110 170 230 290	19.44 33.33 48.33 66.67	110 170 230 290	16.67 20 30 38.89	110 170 230 290	19.44 20 33.33 41.67
128×128	110 170 230 290	11.11 13.33 28.33 41.67	110 170 230 290	9.11 16.67 26.67 33.33	110 170 230 290	5.5 10 25 41.67

FV: feature vector **RR**: recognition rate

By comparing all the three color spaces CIELab gives much recognition rate, because
It considers the different illuminations and different angles.

V. Conclusions

It concludes that by using grey-scale images we can get facial expression recognition. But we want robust recognition, that's why we have to use color images in proposed method.

It concludes that by using color analysis we can get robust facial expression recognition. Illumination and viewpoint as a problem in multilinear algebra. Within this mathematical framework, the image ensemble is represented as a higher dimensional tensor.

It concludes that TPCF was proposed for FER system in perceptual color space. Based on TPCF, the RGB color images were first transformed to perceptual color spaces after which the horizontal unfolded tensor was adopted to generate the 2-D tensor for feature extraction. The 2-D tensor was normalized before the features were extracted using a bank of 24 Log-Gabor filters, and the optimum features were selected based on MIQ algorithm. The images under slight illumination variation were used to test robustness of the FER system performance.

Finally it concludes that by using color spaces we get robust results for facial expression recognition.

FUTURE SCOPE

This project can also be used in recognition of facial expressions in vedios by implementing it further

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