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Performance Evaluation of RGB Skin Color Segmentation Based Face Detection Technique

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Abstract

Face detection is complex problem of image processing due to the problems of illumination, occlusion, and imaging condition. This paper presents algorithm for face detection based on segmentation process. Segmentation is applied to detect skin region in RGB color space. The illumination problem eliminated by white balance correction of input image and the segmentation performance improved. Computation time is reduced by segmentation process. Logical 'and operation' is performed on input image and white balance corrected image. Then dilation and erosion morphological operations are performed. Bounding box ratio is used to extract the face region. The bounding box ratio, width over height, is decided experimentally. Face feature extraction is performed by using Laplacian of Gaussian Filter (LoG). Isosceles triangle property is used to find face features. On the basis of face features, face image is detected.

Keywords: *Detection, segmentation, Laplacian of Gaussian, isosceles triangle, and illumination.*

1. INTRODUCTION

Significance of face detection increases recently in the field of research. Biometric features are used for recognition and can apply without cooperation of individual. Other applications of face detection systems are person verification, video surveillance and crime prevention. Face recognition syatem has two parts – face detection and recognition. Face position is find out by detection algorithm and classification of given image is done by recognition algorithm. Face recognition algorithm is more complicated in comparison of single recognition algorithm. First step of face recognition system is to acquire image, second step is to detect face, third step is recognition and last step is identity of individual.

There are a number of techniques available for face detection. These techniques can be divided in two main groups- knowledge-based and appearance-based techniques. Knowledge-based techniques are used to find face features on the basis of human knowledge like face geometry and relation between features. The distance between two eyes, distance from eyes to mouth and their ratios can be used. Appearance-based techniques find faces basis on learning techniques.

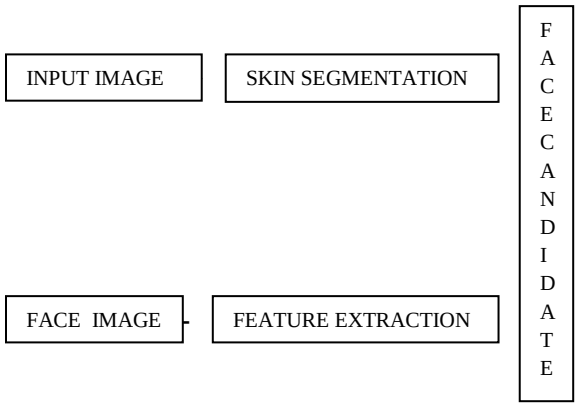

Fig.1 Basic face recognition process

Face and non-face parts are decided by scanning of face using a certain window. Identity of person is done by recognition of detected face. A face library of standard images is available for the verification of face recognition techniques [30]. Before recognition process, detected face images are required to convert into standard images. For the classification purpose 2D and 3D methods are available. 2D images are used in 2D methods and 3D images are used in 3D methods [40].

Different imaging conditions, orientation of image, face expression, pose, and occlusion are the major problems associated with face recognition methods. Only some problems can be removed with a single available technique and can work well for particular problem. The development of such a system which can handle all the problems is difficult.

2. RELATED WORK

Face detection and recognition are the two parts of any face recognition system. There are a number of face detection methods available. YCbCr color space is used to extract the facial features by Zhi-fang et al. [1]. Principal Component Analysis (PCA) is used to find eyes and according to structure mouth is identified. In [2], color snakes are used to approximate eyebrows, eyes and mouth. Ruan and Yin [3] apply YCbCr color space for feature extraction and Linear Support Vector Machine (SVM) is used for face detection. Difference of Cb and Cr is applied for detection process. If CB is greater than Cr, then region is eye other region is mouth. Some techniques used statistical model for detection of skin region. Cb and Cr values of YCbCr color space are used to construct the statistical model. Then, rectangular ratio is used to decide face region and mouth and eye map [4] is applied for confirmation of face. Face region can extract by using RGB color space and verified by facial features. Isosceles triangle is used to find eyes and mouth. The distance between mouth and midpoint of eyes is same as the distance between eyes. In [5], final verification is done by FeedForward Neural Network (FFNN). Bebar et al. [6] use YCbCr color space for segmentation and segmented and edged image are used for facial feature detection. Mouth and eyes position is decided by the vertical and horizontal profiles of image. Skin segmentation is used to reduce computation time by eliminating non-face components.

Cb and Cr channel of YCbCr color space are used with Gaussian distribution by Kherchaoui and Houacine [7]. Face region is selected by bounding box and face is decided by template matching. In [8], edge detection with YCbCr color space is used to eliminate background and then skin segmentation is applied on YCbCr color space. Face region is decided as segmented regions and entropy calculation and thresholding is used for final verification. White balance correction is used by Qiang-rong and Hua-lan [9] before face detection. White balance correction is used to reduce the problem of false colors reflection and elliptical model is used for segmentation. Finally bounding box ratio is used for face verification. In [10], some threshold value is used for segmentation in Normalized g, Normalized r, Cr and Cb. bounding box ratio is applied for selection of face region and AdaBoosting method is used for final verification. Self Organizing Map (SOM) Neural Network (NN) is used for segmentation and decided as face if they fit into elliptic region.

Human face pattern is another important parameter for detection purpose. 40x40 pixel window can be used for scanning. More time is required to scan complete image for detection of face. Due to consideration of segmented regions only, less computational time is required by template matching. Chen et al. [14], reduces computational time by using half-face template. In [15], abstract templates are used which consists of size, shape, color, and position parameters. YCbCr color space is used to extract skin region and abstract templates applied to detect eyes and their orientation. Final face verification is done by Texture template.

Wavelet features are used to decide face and non-face image in AdaBoost method [16]. In AdaBoost method, strong classifier is constructed with the combination of weak classifiers. AdaBoost technique is used to find face candidate and cascade classifier perform verification.

In eigenface method, feature vector is generated by principle component Analysis (PCA). Template matching is used to detect face by Wang and Yang [17] and feature vector is extracted with 2D PCA. 2D PCA decreases computational time by using image matrix directly. Classification purpose is done by using Minimal Distance Classifier. In [18], PCA and NN (neural network) are used for the detection of face. Face candidate is extracted by using PCA and classification is done by NN. Geometrical distribution of edges is used for verification of face. In [19], window scanning method uses Adaboost and PCA for face detection. PCA generate feature vector which is applied to Adaboost.

Neural network (NN) can also be used for classification of face and non-face images. Anijiantis et al. [20] use NN and two-layer perceptron to classify face and non-face images. Detection of face is done by window scanning method. Anagnostopoulos et al. [21] apply Fuzzy Logic in RGB color space for skin segmentation and Probabilistic NN is used for face verification. In [22], computational time decreases by using YUV color space to extract skin regions. Face candidate is detected by using BackPropagation (BP) NN and final verification is done by Bayesian Decision. In [23], segmentation is done on YCbCr color space and wavelet invariant moment is used to generate feature vector. Finally, classification is done by Self Organizing Competitive NN. Skin like region segmentation can be performed by HSV color space and 2D Discrete Cosine Transform

(DCT) used for generation of feature vector. Skin like region is extracted by BPNN classifier [24].

Support Vector Machines (SVM) can be used to classify face and non-face images. Some SVM techniques are published in [26 - 29]. In [26], generalized symmetry of eyes is used to detect face and SVM is used for the final decision. Jee et al. [28] use YCbCr color space for segmentation and edge detection is used to find eyes. SVM is used to decide the eyes and face is decided according to the eyes position. Finally SVM is used for verification of face.

3. PROPOSED METHOD

Face detection application is used to locate the position of the faces in a given image. In proposed method, skin segmentation is the first step to reduce the computational time. Skin like region is extracted by using RGB color space.

Skin color like pixel conditions are given below [12]:
- r > 95
- g > 40
- b > 20
- |r-g| > 15
- r > g
- r > b
- max(r, g, b)-min(r, g, b) > 15

r", "g", and "b" stands for red, green and blue channel values of pixel. Skin color pixel satisfies these conditions.

Due to different lighting conditions, non-face objects appear as skin objects. To overcome this problem, white balance is corrected of the input image.

Cold image is converted to hotter and hot image is converted to colder by using white balance algorithm. Skin image is extracted by performing logical 'and operation' on white balance corrected and original image segments.

Face candidate is detected by applying some morphological operations. Applied morphological operations are dilation operation and erosion operation. Two conditions are applied to detect face candidate. First condition is to apply Bounding box ratio. The ratio width over height should be determined experimentally. Lower limit should be such that neck included with facial part. To cover gap is the second condition. Face is differentiated from other regions of body by using this property.

Modified bounding box is used to extract face candidate. Modified bounding box covers only face and neck is eliminated. Facial features are extracted from these face candidates for final verification of face.

By the application of white balance correction, skin segmentation and morphological operation, the face candidate is detected. Face features are extracted for final verification of face. Examples of face features are cheek, nose, mouth, eyebrows, eyes, etc. isosceles triangle is generated by two eyes and mouth. Distance between midpoint of eyes to mouth and distance between eyes are equal [5].

(a) (b)

Fig.2. (a) Original Image, (b) White balance correction on original image.

Face features are extracted by applying some filtering operations. Laplacian of Gaussian Filter, Contrast correction and Converting to binary image operations are performed

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Fig.3 Result of filtering operations on face candidate

By using binary thresholding some facial feature may eliminate because it is sensitive to lighting. So, in proposed method facial features are extracted by Laplacian of Gaussian (LoG) Filter.

After filtering operation, image is divided into three regions- left region (L), right region (R), and down region (D).

Left eye is detected in left region (L) and right eye is detected in right region (R). Euclidian distance between eyes and mouth, and distance between two eyes and, distance between mid-point of eyes and mouth are calculated.

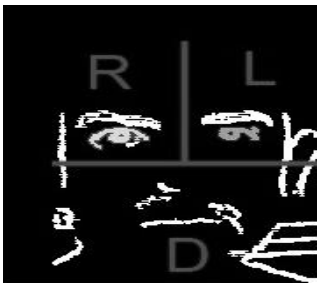

Fig.4 Regions of Filtered Image

Mouth can be detected by using these distances. On the basis of detected features face image extracted, which includes left eye, right and mouth.

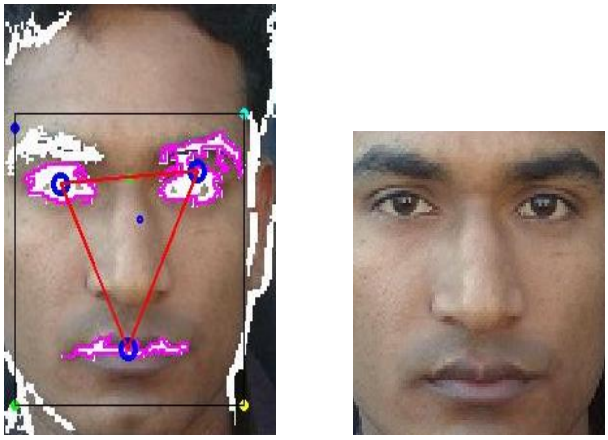

Fig.5 Facial Feature Extractions (Left) and Face Image (Right)

4. EXPERIMENTS & RESULTS

AR face database is used for experiment. It contains 4000 color images of 70 men and 56 women. Images with front view face and other different conditions are included. Experimental results shows that proposed detection algorithm is good for skin color segmentation. This algorithm achieved 82% accurate results and false detection rate is high.

5. CONCLUSION

This paper presents designing and implementing techniques of face detection. Image processing applications cover the face detection field. The input image may have the problem of illumination, pose, size, and white balance difference. Skin color and face feature techniques are used to perform face detection. Skin color techniques reduce the computational time and face feature technique increases the accuracy of detection of face. Also, color problem is eliminated by performing white balance correction. In our algorithm RGB color space is used for segmentation. Statistical model may give more accurate results for segmentation process. Color problem is reduced by performing 'and operation on input image and white balance corrected image. Face image is detected by performing facial feature extraction operation on segmented region.

The segmentation of skin color can be improved. Statistical modeling can apply to achieve improvement in segmentation. More faces can be detected if the segmentation of skin color is accurate. YCbCr color

space can also be used for statistical modeling, because Cb and Cr values are free from illumination condition. Some improvements may be applied to reduce the face feature extraction computation.

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