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FACE DETECTION ALGORTIHM WITH FACIAL FEATURE EXTRACTION FOR FACE RECOGNITION SYSTEM

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ABSTRACT

A face recognition system is one of the biometric information processes, its applicability is easier and working range is wider than other systems like; fingerprint, iris scanning, signature, etc. The detection methods are designed to extract features of face region out of a digital image. The output face image of the detection algorithm should be similar to the recognition input image. Face detection is performed on live acquired images without any application field in mind. The developed system uses white balance correction, skin like region segmentation, facial feature extraction and face image extraction on a face candidate. System is also capable of detecting multiple faces in live acquired images.

Keywords: face, detection, facial feature, extraction

1. INTRODUCTION

Face recognition systems are part of facial image processing applications and it is one of the challenging topics in IT research. Biometric information of humans are used instead of fingerprint, iris, signature etc., because these types of biometrics are not much suitable for non-collaborative people. Face recognition systems are usually used and preferred for security cameras in metropolitan life. These systems can be used for crime prevention, video surveillance, person verification, and similar security activities.

Face detection is the first step of face recognition system. Output of the detection is location of a face region with facial features (i.e. eyes, mouth, eyebrow, nose etc.) [1]. Detection methods in the literature are classified into two groups as Knowledge-Based Methods and Image-Based Methods.

Knowledge-Based methods use information about Facial Features, Skin Color or Template Matching. Facial Features are used to find eyes, mouth, nose or other facial features to detect the human faces [2 - 7]. Skin color is one of the most significant features of human face. Skin color can be modeled with parameterized or non-parameterized methods. Skin color region can be identified in terms of threshold region, elliptical modeling, statistical modeling (i.e. Gaussian Modeling), or Neural Network. Skin color is modeled in each color spaces like RGB, YCbCr, HSV, YUV, and in statistical models [8 - 14]. Face has a unique pattern to differentiate from other objects and hence a template can be generated to scan and detect faces [15 - 16].

Image-Based methods use training/learning methods to make comparison between face and non-face images. For these methods, large number of images of face and non-face should be trained to increase the accuracy of the system. AdaBoost [17], EigenFace [18 - 20], Neural Networks [21 - 26] and Support Vector Machines [27 - 30] are kind of methods that are used commonly in face detection algorithms.

2. FACE DETECTION ALGORITHM

Face detection performs locating and extracting face image operations for face recognition system. Face detection algorithm of the proposed system is given in Figure 1.

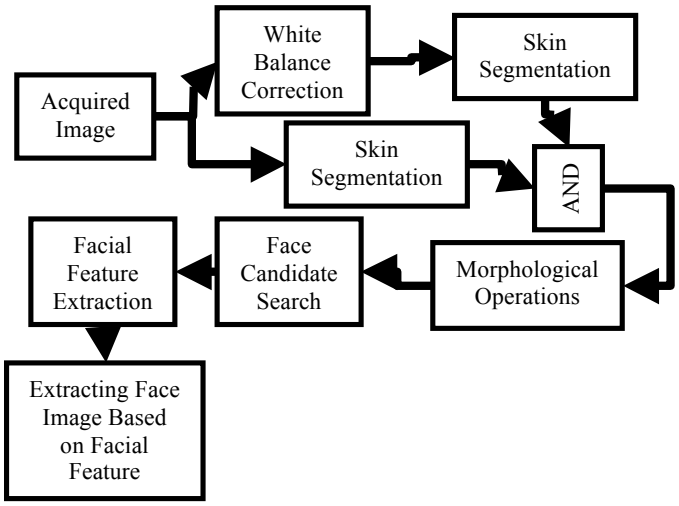

Figure 1. Algorithm of Face Detection Part

Our experiments reveal that skin segmentation, as a first step for face detection, reduces computational time for searching whole image. While segmentation is applied, only segmented region is searched whether the segment includes any face or not. After the acquired image is segmented, it continued with the face candidate search and facial feature extraction to validate the candidate. To perform the facial feature extraction four different filtering approaches are performed for useful enhancements on facial features. Finally, the validated face is extracted based on the facial features to send to the face recognition algorithm.

2.1. White Balance Correction

White balance of images differs due to change in lighting conditions of the environment while acquiring image. This situation creates non-skin objects that belong to skin objects. Therefore, white balance of the acquired image should be corrected before segmenting it.

The implemented white balance algorithm is given below [34]:

- Calculate average value of red channel (R_{av}), green channel (G_{av}), and blue channel (B_{av})
- Calculate average gray, $Gray_{av}=(R_{av}+G_{av}+B_{av})/3$
- Then, $K_R=Gray_{av}/R_{av}$, $K_G=Gray_{av}/G_{av}$, and $K_B=Gray_{av}/B_{av}$
- Generate new image (NewI) from original image (OrjI) with RGB channel by $New(R)=K_R*Orj(R)$, $New(G)=K_G*Orj(G)$, and $New(B)=K_B*Orj(B)$

2.2. Segmentation

Skin segmentation is applied as a first step of detection part. RGB color space is used to describe skin like color [13], and also other color spaces are examined for skin like colors, i.e. HSV&YCbCr [31], HSV [32], and RGB&YCbCr&HSV [33]. However, best results give RGB color space skin segmentation. The results of skin segmentation on different color spaces are given in the Figure 2. Skin color like pixel conditions are given below in RGB color space [13]:

(r>95) & (g>40) & (b>20) & (max(r,g,b)-min(r,g,b)>15) & (|r-g|>15) & (r>g) & (r>b)

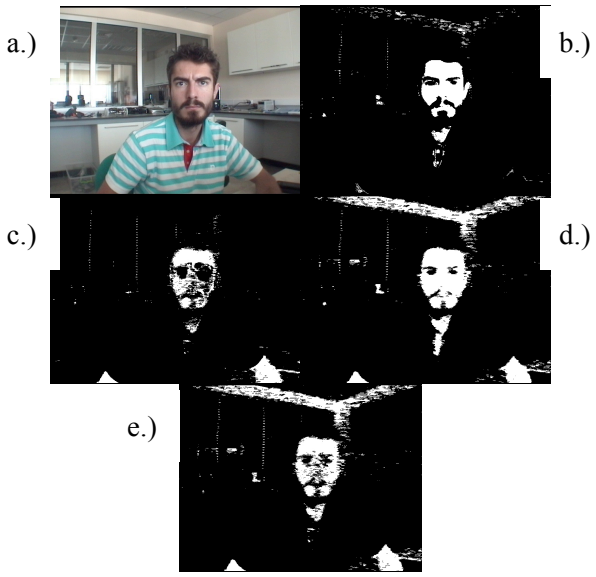

Figure 2. Example Segmentation on the Image (a.)Original Image (OI), b.) RGB Segmentation on OI, c.) HS Segmentation on OI, d.) CbCr Segmentation on OI, e.) HCbCr Combination Segmentation on OI)

"r", "g", and "b" parameters are red, green and blue channel values of pixel. If these seven conditions are satisfied, then pixel is said to be skin color and binary image is created from satisfied pixels.

2.3. Face Candidate Search

If the image is not balanced, then some part of the wall will be taken as skin color as in Figure 3 due to poor ligthing.

Under some lighting conditions, acquired image color can be wrong. Therefore, this process will generate unwanted skin color like regions.To get rid of this problem, segmentation is performed on both original image and white balance corrected image. To create final skin image, logical "and operation" is

applied on both segmented original image and corrected image. This operation will eliminate change of color value due to change of lighting condition.

Figure 3. Example of taken/white balance corrected image and skin color segmentation (a.) Original Image (OI), b.)Segmentation on OI, c.)White Balance Correction on OI (WBI), d.) Segmentation on WBI)

After "and operation" is applied on segmented images, noisy like small regions are eliminated and morphological closing operation is applied to merge gaps. Then, a region is said to be a face candidate if the ratio of bounding box, width over height, lies between 0.3 and 1.5 and covering some gaps inside the region.

Based on these conditions, face candidates are extracted from the input image with modified bounding box. The height of bounding box modified as 1.28 times bigger than width of bounding box because width of face candidate does not change if candidate includes chest/neck or not. After this modification, new bounding box covers only face. These face candidates will be sent to facial feature extraction part to validate the candidates.

2.4. Filtering for Facial Feature Extraction

Facial feature extraction bridges between detection and recognition parts. First trial on extraction is made with profile extraction of face candidate. Vertical profile of candidate is performed by taking mean of each row of image matrix. Then, local minimum shows possible positions of eyebrow, eye, nose tip, mouth, and chin. After eye position is determined in vertical profile, then horizontal profile is extracted to determine eyes positions. Vertical and horizontal profiles of two test face images are given in Figure 4 and 5. Determination of exact position of eye position and mouth position is difficult to determine in vertical profile. Also, it is difficult to determine position of eyes in horizontal profile even the veritcal position of eyes are determined in vertical profile.

Due to difficulty in determination of position in vertical and horizontal profiles in face candidate, face profile extraction is discarded and converting Black-White image to find facial feature is performed. On the other hand, binary thresholding is sensitive to lighting. If shadow appears on some part of the face, some facial feature components can be eliminated. Some experiments are performed and results are given in Figure 6.

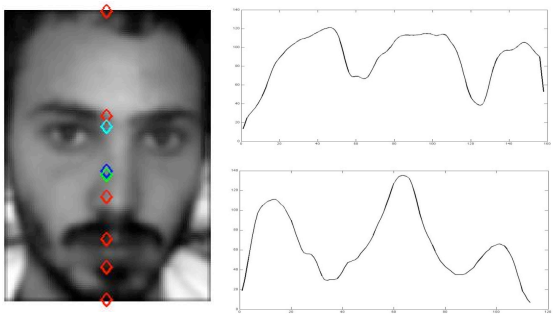

Figure 4. Test Image 1 (Left) & Vertical (Right-Top) - Horizontal (Right-Bottom) Profiles

Edge detection methods are nearly insensitive to light change. Sobel edge detector is used to extract features. Figure 6 shows results of edge detection on test image 3. Edge detection is not sensitive to light condition as Black-White conversion. On both images, eyes and mouth can be selected with human eyes but mouth can be difficult to extract on the images and eye parts also vary on shapes. Also, edge detection has high responses.

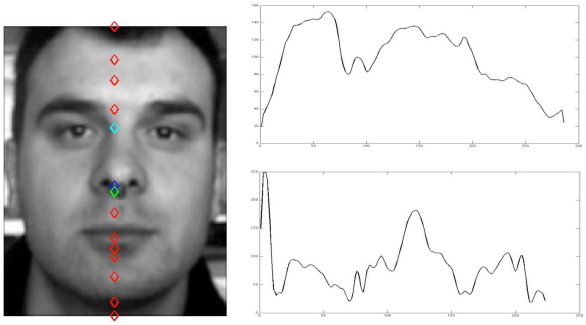

Figure 5. Test Image 2 (Left) & Vertical (Right-Top) - Vertical (Right-Bottom) Profiles

In order to use edge detection, Laplacian of Gaussian (LoG) filter can be used. LoG filter has low responses than edge detection. It makes usefull

enhancements on facial features extraction. Figure 6 shows results of LoG filter on test image 3.

LoG filter has better performace than the previous three trials. Mouth is more significant than others and eyes can be selected more accurately.

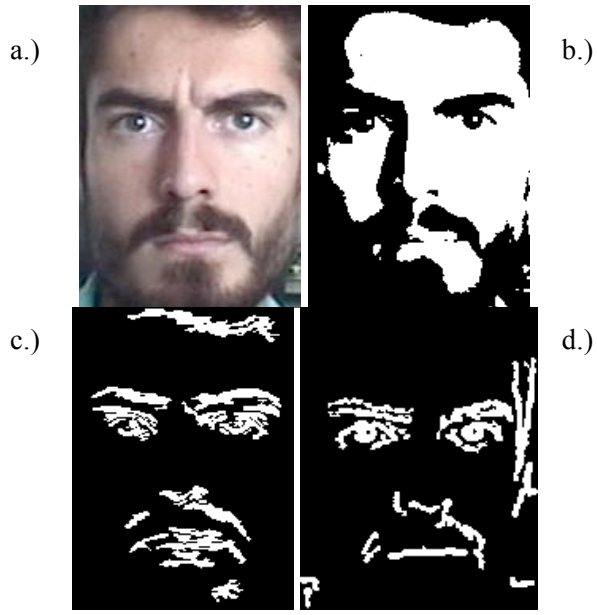

Figure 6. Filter Application on Test Image (TI) 3(a.) TI 3, b.) BW Conversion on TI 3, c.) Edge detection on TI 3, d.) LoG on TI 3)

2.5. Facial Feature Extraction and Face Image

Facial feature is one of the most significant features of face. Facial features are eyebrows, eyes, mouth, nose, nose tip, cheek, etc. If some of these features are found in the candidate image, then the candidate image will be considered as face. Two eyes and mouth generate isosceles triangle, and distances between eye to eye and mid point of eyes distance to mouth are equal [6]. Some filtering operations are applied to extract feature candidates and steps are listed below:

- Laplacian of Gaussian Filter on Red channel of candidate
- Contrast correction to improve visibility of filter result
- Average filtering to eliminate small noises
- Converting to binary image
- Removing small noises from binary images

After obtaining filtered image, labeling operation is applied to determine which labels are possible to be facial features. Then, filtered image is divided into three regions which is illustrated in Figure 7.

In Figure 7, R denotes right region, L denotes left region, and D denotes down region of face. Criteria checking are applied on each label to determine left and right eyes [35].

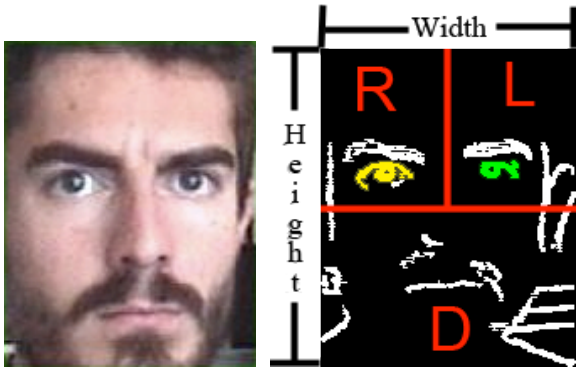

Figure 7. Result of filtering operations on face candidate and regions of filtered Image

Rigth eye and left eye are determined by criteria which are illustrated by yellow and green color respectively. Left and right eye are mostly found correctly but sometimes bottom eyelid is found falsely. If left and right eyes are detected, then mouth finding application can be applied.

Each label inside down region chooses as mouth candidate and candidate property vector is calculated. Euclidian distance of right eye to mouth candidate (right-distance) and Euclidian distance of left eye to mouth candidate (left-distance) are calculated. Also, Euclidian distance between two eyes (eye-distance) and Euclidian distance between mid point of eyes to mouth candidate (center-distance) are calculated. Then, with respect to the property vector, the mouth label is found which satisfies isoceles triangle with the eyes. Required facial features are found which are right eye, left eye and mouth. Face image can be extracted which covers two eyes and mouth. Face covering is created with a rectangle in which covers eyes and mouth. Facial feature extracted image from face candidate and face image are given in Figure 8.

This proposed algorithm is implemented using MATLAB and tested for more than hundred images. This algorithm detects not only one face but also more than one face. Small amount of oriented face are acceptable. Results are satisfactory for all purpose.

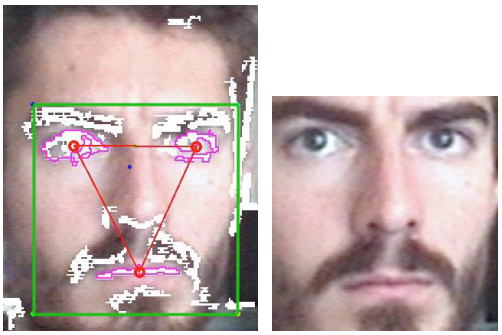

Figure 8. Facial Feature Extractions (Left) and Face Image (Right) for the author

6. CONCLUSION

Face recognition systems are part of facial image processing applications and their significance as a research area are increasing recently. Implementations of system are crime prevention, video surveillance, person verification, and similar security activities. The face recognition system implementation will be part of humanoid robot project at Atılım University.

Knowledge-Based face detection methods are used to find, locate and extract faces in acquired images. Implemented methods are skin color and facial features.

RGB color space is used to specify skin color values, and segmentation decreases searching time of face images. Facial components on face candidates are appeared with implementation of LoG filter. LoG filter shows good performance on extracting facial compoments under different illumination conditions. Proposed algorithm is capable of detecting multiple faces, and performance of system is acceptable.

Proposed system can be affected by pose, presence or absence of structural components, facial expression, imaging condition, and strong illumination.

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