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Human Skin Detection by Designing a Fuzzy System in Color Space

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ABSTRACT

one of the issues which are dealt with as an important issue in identification of a human in images is skin detection. Human skin detection with suitable speed and high accuracy is very necessary and very valuable in promoting quality of detection and can give suitable features for more correct detection. In this paper, a new fuzzy method is studied to identify human skin based on YCBCR colorful model. Skin color in YCBCR space forms a continuous set. Considering histogram of continuous set in color space, suitable membership functions are considered for fuzzy system. Based on inputs of fuzzy system, decision is made about each pixel. Tests have been performed on fei database and the obtained results show accuracy of 97% on test images.

KEYWORDS: skin color detection, fuzzy system, YCBCR color space

1. INTRODUCTION

Humans see each other and remember each other based on memorization of a series of features. Human mind detects and identifies different humans based on extraction of a series of features and its adaption to the surrounding environments. Face detection in images has broad applications in supervision and tracking of face and human-system interaction. Human skin detection has broad cultural and military applications. Of its applications are attention of researchers in the country to an unethical images detection system and use of this image processing branch in security and military systems in modern world [1-5].

Face detection in images has broad applications in video supervision, human-system interaction and tracking. Many studies have been conducted in this case. One of the most important applications of digital image processing is face detection. Face detection has gained high popularity and importance in computer visual society. With concurrent attendance of new information technology and mass media, more effective and familiar methods are developed for human-system interactions (HSI). Human –computer interfaces which are based on facial expressions and body motions of human have been used as methods which have replaced traditional interfaces such as keyboard, mouse and displays. The expanding researches on face processing are based on the fact that information about identity, position and intention of a user about images can be extracted and consequently, the correspondent computer also can show reaction.

Efforts are made to process face include face detection, face tracking, facial expressions detection, face verification and detection. To make automatic systems which analyze the information included in face images, effective and powerful face detection algorithms are required. With a separate image, goal of face detection is to determine all areas of face which include face apart from three-dimensional condition of image, its direction and luminance condition.

In recent years, many activities have been performed to detect face4. Many supervisory and commercial applications have been developed in the field of these activities. Many techniques have been suggested for face detection in separate images. These methods have been classified into two more general groups based on feature and image each having its social advantages and disadvantages. Among these methods, chrominance methods and Support Vector Machine (SVM) Based methods are more common and they are more efficient than other methods. Chrominance techniques are very safe but they may result in numerous false detections. As a result, they should be combined with other methods [9-10]. Support Vector Machine Based methods which are based on learning and classification algorithms usually include numerous parameters which should be adjusted and these operations are time consuming. Face detection action is a partial and negligible action for human brain while it has left hard challenges and problems for the computer to detect face. Some performed works in this case have been limited to face detection in gray-level images [5] where face has been detected in images from the opposite direction with emphasis on features of face such as eyes and corners of lip. Other works such as [5] have been limited to face detection in the image while face detection is necessary in the images which have several human faces. On the contrary, goal of this paper is to detect face in broad scope of directions to be viewed or from different perspectives with emphasis on general features of face. The feature used for face detection is skin color of the human. The first step for achieving this goal is detection of skin area in image. One of the methods which have been used in skin color detection is based on a model for skin color [4]. When ycbcr is formed, it is necessary to note that skin color in color space gives a cluster and for this reason, a direct approach to neural or fuzzy networks seems suitable for skin color detection. Many studies have been conducted in this field. In some studies conducted so far, face detection is limited to gray-level images in which one can detect face by relying on location of eyes and corner of lips [5]. In this paper, the goal is to detect face in all directions to be viewed with emphasis on general feature of face. The feature used for face detection is skin color of the human. One of the methods which have been used in skin color detection is based on a

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model which was presented in paper [6] where skin color in YCBCR color space gives a cluster. In this paper as a new research, fuzzy logic has been used for detecting areas of human skin and non-skin areas. In this paper, first, color spaces have been introduced. In section 2, feature of human skin color has been studied in YCBCR color space and in section 3, pixels classification method has been studied into classes of human skin and non-skin area using fuzzy logic. Section 4 gives results and section 5 relates to conclusion.

2. Extraction of Feature in Color Space

Output of most colorful cameras is colorful images in RGB color space. Each one of the pixels in each location has comprised of three colorful components of red, green and blue. In this format, luminance information as Y and chrominance information as two parts of CR and CB are stored. To convert color space of RGB to YCBCR ,one can use relation 1.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} \quad (1)$$

Input image of YCBCR can be in each one of the image classes and data class of output image will be similar to input image.

2.1. features of human skin in color space

In many video applications, colors are classified into luminance and chrominance components. Psychological experiments show that perception of colors has three features of light intensity, saturation and color. In YCBCR color space, human skin color forms special class of colors which can be separated from many surrounding colors. Although there are different skin colors, one can detect color of skin with two components of CB and CR in many cases and minimize effect of light intensity which is in Y component.

Although skin color can vary considering race, skin color is in a limited two-dimensional space in most cases.

Luminance rate of y is ignored in detection of skin color. As shown in figure 1, skin color distribution forms a cluster in CB and CR space which can be considered as input for a fuzzy system.

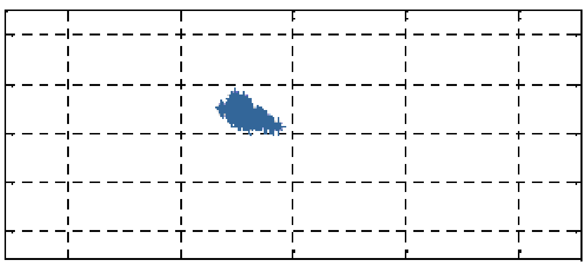

***Fig. 1**. distribution of skin samples in Cb-Cr color space [7]*

3. Fuzzy systems and proposed method

Fuzzy logic believes that there is ambiguity in nature of science. Crisp sets are ordinary sets which are introduced at the beginning of sets classic theory. Adding crisp trait creates point of difference with which one can easily create one of the heuristic and critical concepts in fuzzy logic as membership function. In crisp sets, membership function has only two values in its board and these two yes and no (one and zero) are two possible values in classic Boolean logic, therefore:

$$\mu_A(x) = \begin{cases} 1 & \text{if } x \in A, \\ 0 & \text{if } x \notin A. \end{cases} \quad (2)$$

Where is membership function of element x in crisp set of A. fuzzy system is described by a set of expert knowledge –based linguistic rules which include 4 parts of fuzzifier, knowledgebase , inference engine, and defuzzifier. In a fuzzy system, knowledgebase includes basic data and basic statements. Basic data include a set of membership functions and input-output variables which produce required information for performance of fuzzifier, inference engine, and defuzzifier. Fuzzifier converts input signals to fuzzy signals which are lingual variables using fuzzy sets theory. Fuzzy inference engine converts input to output using fuzzy rules and finally defuzzifier converts fuzzy outputs into clear and final control signals.

3.1. Proposed Method

Database images should have desirable exposure and contrast. Exposure and contrast should be set in preprocessing operations.

In figures 2&3, membership functions of fuzzy system input which is based on the obtained histograms.

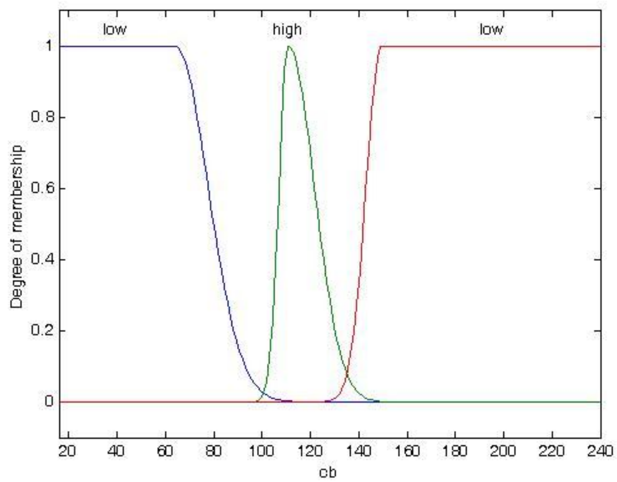

Fig. 2*. fuzzy system first input CM membership functions*

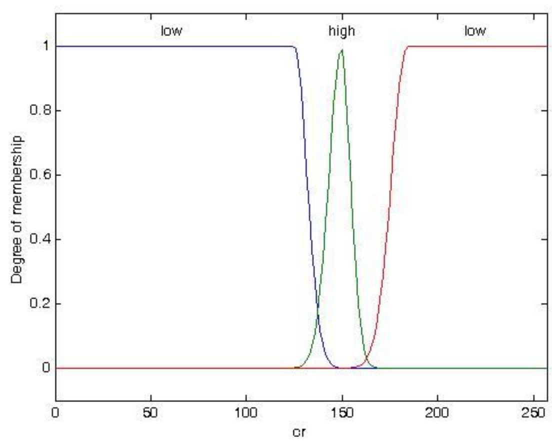

Fig. 3.*fuzzy system second input CR membership functions*

Membership functions of figures 2&3 have direct relationship with figure 1. Based on the tests which we performed on different databases, the following results were obtained. In CR input, most human skin color pixels had value of 151 and are similar to a Gaussian function in other values. For CB input, human skin color pixels almost had value of 111 and are similar to a Gaussian function in other values. Based on the above function, fuzzy membership functions of figures 2 and 3 are applied. Membership function used for output of fuzzy system is shown in figure 4. This function has been created such that one can easily divide pixels into two groups of pixels belonging to human skin and false pixels.

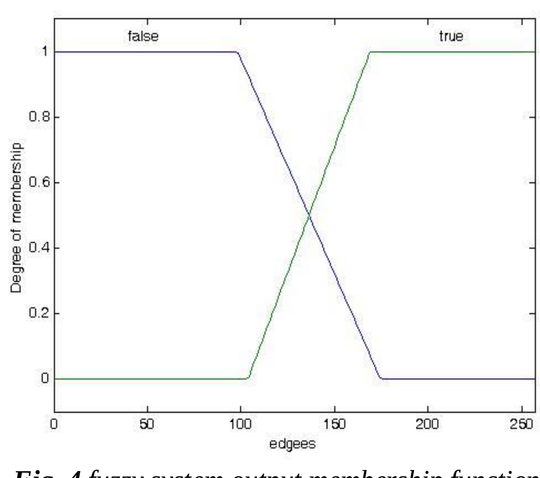

Fig. 4.*fuzzy system output membership functions*

In table 1, relationship between different inputs of fuzzy system is shown and we obtained these rules with trial and error based on different tests.

Table 1. *- the applied fuzzy system rules*

First input / Second input	**Low**	**High**	**Low**
Low	false	False	False
High	false	True	False
Low	false	False	False

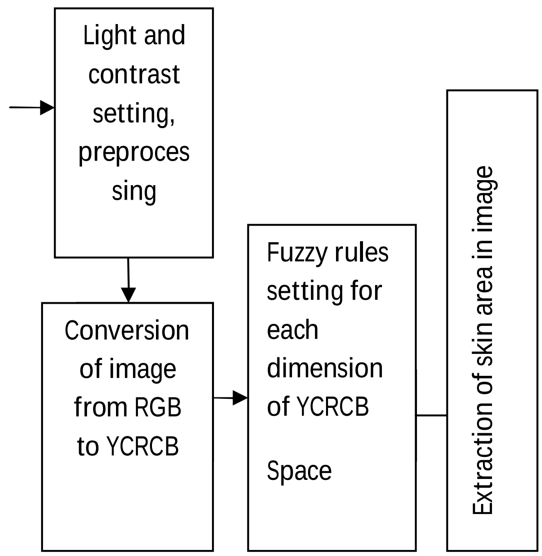

Fig. 5.general proposed algorithm for extraction of skin area

In table 1, relationship between different inputs of fuzzy system is shown and we obtained these rules with trial and error based on different tests.

4.Obtained Results

We applied the proposed algorithm to some images of human skinfrom fei database [8]. In this research, frequency of face skin pixels in two inputs of cb and cr was studied using information about histogram of 50 images of fei database. Fei database is a database of the images which has been prepared in Brazil and there are more than 2800 faces of different persons in different expressions.

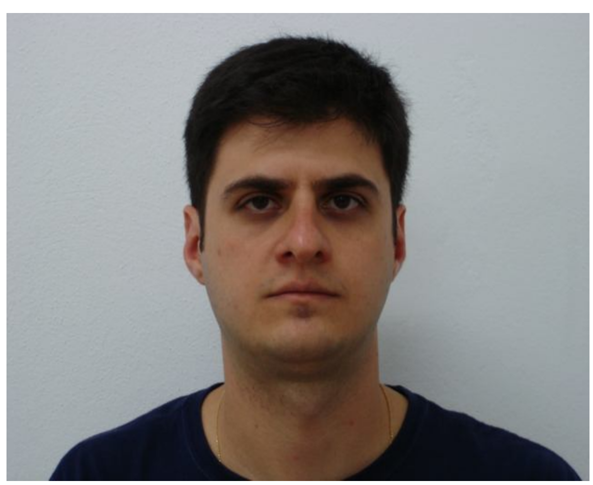

Fig. 6.color image of fei database

Figures 6, 8&10 show results of the proposed algorithm on figures 5, 7&9. To compare the proposed method with other studies conducted so far, we compared the obtained results with results of the proposed method in [7]. In [7], a neural system has been used for this purpose. Comparison of the results obtained from two methods show that the proposed method is more efficient.

Fig. 7.extracted image of skin color with the proposed algorithm

Fig. 8.color image of fei database

Fig. 9.extracted image of skin color with the proposed algorithm

Fig. 10.color image of fei database

Fig. 11.extracted image of skin color with the proposed algorithm

Below is an example of other methods in which preference of the proposed method over other methods [9-10] is evident:

Fig. 12.extracted image of skin color with the other methods

5. Conclusion

To detect human skin based on YCBCR color model, a new fuzzy method was proposed in this paper. Fei database was used to perform tests and accuracy of 97% was obtained. Considering that all color spaces-dependent systems only extract chrominance features, there is probability of error for environmental colors which are close to color of human skin. To continue work, it is necessary to reduce error.

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