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Face Detection in Color Images using Color Features of Skin

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Abstract**—**Because of increasing demands for security in today's society and also due to paying much more attention to machine vision, biometric researches, pattern recognition and data retrieval in color images, face detection has got more application. In this article we present a scientific approach for modeling human skin color, and also offer an algorithm that tries to detect faces within color images by combination of skin features and determined threshold in the model. Proposed model is based on statistical data in different color spaces. Offered algorithm, using some specified color threshold, first, divides image pixels into two groups: skin pixel group and non-skin pixel group and then based on some geometric features of face decides which area belongs to face.

Two main results that we received from this research are as follow: first, proposed model can be applied easily on different databases and color spaces to establish proper threshold. Second, our algorithm can adapt itself with runtime condition and its results demonstrate desirable progress in comparison with similar cases.

Keywords**—**face detection, skin color modeling, color, colorful images, face recognition.

I. INTRODUCTION

SECURITY in our integrated and complex world is a vital issue. Problems such as large networks hacking, credit cards sabotages and financial abuse of banks, make the importance of this topic more obvious. Technology of identifying people, who are in an environment, has provided the possibility of using biometric methods. These methods can be based on physical characteristics, face status or human behavior.Among the biometric methods, physical methods, in many cases, because of their fixed characteristics act better than other methods. Face detection, for instance, is one of the cases that today have found its place in individual identification area.

Importance of facial image consideration in security systems lead researchers' efforts towards the processing of human face images. These efforts to making an automated system seem necessary.

A general description of an automated face detection machine is as follows: getting some fixed or moving images from a given landscape (three-dimensional image regardless of location, direction and light status) as input, then categorizing input images into two distinct sets: images that have face in them and images without face. And finally, facial area detection among first set of categorized images [1]. Because of less amount of computation among first category, system performance will be higher.

Progress in the field of hardware and software, computing power enhancement and hardware prices decreasing are some of major reasons for more attentions to the image processing systems (such as face detection and recognition). By analyzing of face processing system, we can find out that first steps in such systems are determining facial area position, face direction(right, upward - rotary) and face mode (frontal - profile). Some of biometric systems' applications are: commercial and legal usages (especially in identifying criminals and guilties), to improve safe driving, security systems, visual phones, face recognition, signature detection and also medical applications such as MRI and CT-SCAN. Face detection, usually is one of the first stages of these applications. It is important to note that different light conditions, face direction against the camera, occultation (such as covering face by scarf) and quality of camera can make face detection process more complicated. Also, some algorithms, that are using face images, imagine face detection phase as a default and solved phase [2, 3].

During past years, most researches have been conducting on gray images. But recently, thanks to high quality digital cameras, researchers can take precise color images and do suitable study on them by fewer amounts of costs. Early color images had low quality, and that is why work on them was started later than work on gray images.

Evaluating previous works on facial images, we reached the conclusion that face detection in color and gray images are essentially similar. Many samples in Ming's work can be found [1]. These algorithms can be used to model human skin color, face features and color characteristics, and finally to detect faces.

Using color information, without doing additional calculations, skin areas can be found very rapidly. Identifying skin area causes focus on specific area and as a result, calculations will reduce and performance will be better. In this method, the skin areas will be found by locating those pixels that have skin color characteristics. Combinational methods using color and edge information of images, are also presented [4]

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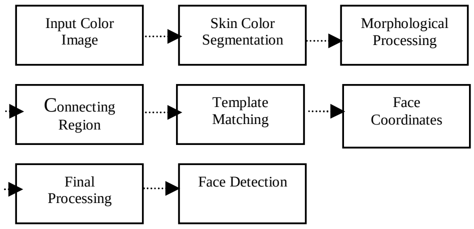

Fig.1 sample of face detection system

To face detection among color images, using color definition, a model or different models for human skin color should be offered. Logically to offer a model, it is necessary to present space or different color subspaces. By using different subspaces, different models for human skin are presented. Using this model and also other face features, the final decision on the face or non-face area will be made.

Considering the nature of research, this paper first presents the general definition of color, color spaces, skin color modeling and skin color classifications. Then one of the most important subjects i.e. human skin color modeling and existing methods for face detection, are identified separately. Face detection algorithms that work based on skin color have their own specific features, these features are highlighted briefly. And finally the proposed model, for identifying faces in color images is presented and the end results of the model, is given.

II. Color

Color is one of the most important information that is related to human vision. Reflected light that shine to an object will be received by the human vision system cells then processed by the nervous system, and ultimately leads to the perception of color by human. Therefore, color is replacement for perceptions that humans can get by reflected lights from an object surface. In addition to object color, in color image processing topics, also shape, structure and low-level color characteristics of an object, are considered as important information.

Considering that 45% of the normal human face consists of skin, skin color is appropriate choice, as a benchmark, to detect faces within an image. (Empirical experiments verify this claim). To detect faces in color images, the color models should be established and valid color ranges using predefined information should be utilized.

Although at the first glance, it seems that there are huge diversity and difference in people’s skin colors, research results show that the skin color ranges are considerably small and even in many cases, the differences are due to differences in image light intensity [5]. By accepting these results, we can set up face detection systems, based on the human color characteristics, with less calculation and more accuracy.

A.Color modeling

To conduct a research on the face processing and detection, and also implementation of such systems based on color characteristics of human face, it is necessary to study and analyze the color, color model and color images. Researches that have been done so far are include the existing definitions of color, available color models (YUV, RGB, HSI, HSV, Normal RGB, and YCrCb) and comparisons of such models [6].

Although, in general, Color face detection systems are the same, but in detail they have some differences. Now we discuss them as far as possible. In fact, all of the available color spaces can be converted into each other using one or more linear or non-linear transform. The RGB and red, green, blue are known as main color-space and colors respectively [7]. Other colors and color spaces can be achieved directly from the main space. The goal of selecting a particular color model is facilitating color description in a standard. Color modeling, actually, is determining a multidimensional coordinate system and the subspace inside it, in which each color is expressed only by a point. RGB color model is a model which is suitable to describe color consisting of the three rays: R, G and B. In this subspace, each color appears as a component of red, green and blue. The nRGB model is created based on the relative percentage of components red, green and blue in RGB model. In this model, sum (r, g, b) = 1 that by eliminating the component B in calculations, the data size is reduced. In YCrCb Model, color and lighting components are distinct from each other. In this model Y is considered as lighting component and Cr and Cb are color components. Because the color difference of people is mostly due to light and lighting, skin color distributions of individuals are placed in a limited area of color space. HSV, YIQ and CIE models, each one has its own different characteristics, which can be useful in its usage area. Color space transformations often reduce interference between skin and non-skin pixels. This interference reduction can happen by eliminating the components of light [5].

Since other color spaces can be obtained by linear and nonlinear transformation of RGB, nRGB and CIE-XYZ, these color spaces are categorized as main color spaces. Regarding that it is not possible to express conceptual features such as color Hue (H), Saturation (S) and Intensity (I), directly by red, green and blue components, several non-linear conversion for RGB to describe such features have been created. HSV, HSI and some related subspaces are known as conceptual color space. YCrCb, YIQ, YES, and YUV Color spaces, show color by statistical independent components and they reduce dimensions of the data in comparison with RGB. In these subspaces, usually light and color components are independent and therefore they are used widely in face detection algorithms [8].

There are two main approaches in face detection based on skin color:

• First approach is Pixel-Based Model, which is based on processing the pixels for all parts of the human skin color. In this approach each pixel is processed independently, and its final status, i.e. it is skin color or not, will be determined. Then, based on facial structure or other options, it will be decided that set of points that were marked as skin, it belong to face or not.

• The second approach, based on the status of a region of the image. In this approach at first, the necessary attempt is done to segregate the region that may produce a face within the given image. And then using the previous information and knowledge it will be decided that specifies if the region belongs to face or not.

B. Human skin color modeling

The main purpose of the skin color modeling is establishing the rules, which can distinguish skin pixels from non-skin pixels. In general, to create a model of human face, first, using pixels of color samples (which usually are selected manually), human skin color model is made and then using this model, skin pixels and non-skin pixels are distinguished.

The simplest model to determine a region on color subspace is classified using the selected threshold. (i.e. in YCrCb Subspace, the amounts of the components are: Cr1 < Cr < Cr2 and Cb1 < Cb < Cb2). Then using different processes on distinguished skin and non-skin pixels and also via evaluating effective parameters (such as symmetry, compare with predefined patterns and ets), the final decision about face or non-face pixels will be made.

Low level False Detection Rate (FDR) and False Rejection Rate (FRR), discovering different types of color and also resistance to different light changes are the most important requirements of a human skin color model.

All models of human skin color try to optimize one or several of the mentioned options. General steps for detecting face pixels in an image include displaying image pixels in an appropriate color space, modeling face and non-face pixels using the appropriate distribution and to classifying modeled distribution [9].

C . Classification of human skin color

From the viewpoints of classification, skin color detection is placed in a two-level classification group. One class is related to skin color pixels and the other class is non-skin color pixels. In researches, different models for this work has been presented, that most notable ones are explicit and direct models, non-parametric models and parametric models [6]:

• establishing clear threshold in color space (explicit and direct model): As noted, skin color of individuals will fall in a small area of color space. This threshold can be done very simply on a component or on a combination of several components. Simplicity of this method is its advantage and problems related to the human race, light and crowded backgrounds are its drawback and weak point [10, 11].

$$90 < Y < 180, \; 90 < Cr < 130, 80 < Cb < 150 \qquad (1)$$

• Histogram model with incomplete BIOS classification (non-parametric model): The main idea of this model is estimating skin color distribution, via educational data, without using clear skin color model. This model uses two and three dimensional diagrams to show distribution of skin color in a color space. In this case, color space is divided into the same amount of chart cells number (Lookup Table Cell). In each of these cells, the number of aggregated data will be recorded by sampling. Probability distribution of each of these points will specify the probability of being skin point of subspace. In more complete case, an appropriate threshold for probability can be considered. This threshold can be comparative option, such as probability of being skin pixel among skin pixels, divided by the probability of to not being skin pixel among non-skin pixels [6, 7]. In this case, a pixel will belong to skin pixel group when the obtained value is more than considered threshold.

$$\frac{P(Skin/c)}{P(nonSkin/c)} = \frac{P(c/Skin)}{P(c/nonSkin)} => \qquad (2)$$

In which, c is related to sample vector, Skin is skin vector and nonSkin stands for non-skin color vector. This method is known as normal search method, in which specific probability amount is assigned to each point in color space, which determines the probability of being skin for that point.

• Gaussian model (parametric model): regarding that non-parametric models need huge amount of data for training, so performance of such models is directly depends on the number and size of the educational data. Actually, in these models educational data are simulated using a special relationship. These models have two major groups, simple Gaussian model and combinational Gaussian model. In such models, the initial training data act, as parameters, to obtain other data.

III. PROPERTIES OF FACE DETECTION ALGORITHM BASED ON SKIN COLOR

In many proposed algorithms for face detection, there are certain properties that regardless of its system, affect directly on the final system performance. These properties, which can be considered for a system, are as follows:

• Color images entry and selecting color space: entered color images are mapped into selected color space. A system, because of state of light, can select YCrCb color space for entered image.

• Skin area separation: after selecting color space for entered images, required works, using necessary parameters, will be done for separation of skin area.

Fig. 2 skin pixel separation

• Geometric processing on face: to remove small areas that have been obtained in previous stage, geometric operations, using the available filters, will be done on this area. These processes (Dilation, Erosion), remove many of unacceptable areas from the entered image.

• Analysis of effective area in faces formation: results of previous stages are analyzed by relation between the face features, such as distance, direction and location.

• Template Matching: In many face detection systems, template matching is done between predefined templates and input images. The results of the matching, and also previous stages result, can facilitate decision making about selecting the candidate areas as a face.

• Selecting Candidate face areas: using results of previous stages, candidate areas for the face, will be selected. Because accepting non-face areas as a face or rejecting face areas, can strongly lessen system performance, this stage is the most important step in a face detection system.

• Final processing: by applying all of the previous steps and using other parameters, on the face candidate areas, the final decision on the face detection will be made. The results of this step are considered as final result.

In addition to general characteristics, Face detection algorithms, always try to find a way to increase performance using different techniques. Some of these techniques are as follows:

• neutralize light and Illumination: different algorithms using different techniques try to remove problems of light and Illumination.

• Linear and non-linear color space transforms: Many face detection algorithms that work on color images, try to separate the color components from the light and illumination components. This separation is done by linear and non-linear transforms to different color spaces (YCrCb, HSV), and can solve the problems of light and Illumination.

• propose a classifier model for skin color as a geometric shape: a simple classifier should propose a decision diagram area on the desired subspace (e.g. Gaussian distribution).

• Create a map for eyes, mouth and head features on the face: a face detection algorithm using structural operators on gray images (Erosion, Dilation), and also by information gathering and analysis of light and color, can create facial features map.

• Making a strong database of color images: Usually face detection algorithms have strong database for training and evaluating data include family pictures, published images on the Internet and news images.

For instance, a method that offered in [12], includes several stages of color classification. In this method, first the skin areas are detected and candidate as facial areas (although these candidate areas, in fact, can include non-face areas). Then some other steps such as feature extraction and eyes locating are applied for reaching the best true result. And after finding all of these three features on the desired area, final decision is made, using analysis of their distance.

IV . AVAILABLE METHODS FOR FACE DETECTION

Although different methods are proposed for face detection, but effective methods for face detection can be divided into four groups. During most researches following approaches has been applied [1]:

• Knowledge-based models: These methods, via some rules that can be used for forming face, try to detect faces within images. Usually these rules determine face features relationships, and are applied for facial features extraction. In these models, the aim is to use simple rules (such as two symmetric eyes, a nose, a mouth and distances between other features) to describe characteristics of a face. First face features extracted from entered image and then determine the face candidate's areas based on desired rules. Expanding this approach to detect faces in various states is difficult because considering all facial cases and states is very difficult.

• Invariant face feature Methods: these algorithms have been formed to find all structural features of faces that are fixed even in cases that face, landscapes and light conditions are changed. The aim of this method, like knowledge-based method, is to focus on finding facial features. This method is based on this fact that the human can detect faces and objects in various modes and environmental conditions (such as light, color, direction) with no effort. This situation proves that there are some features that are fixed for these states. Color-based methods are also in this group.

• Template matching methods: In this method, a face is defined, totally or partially, by several predefined standard patterns. After comparing the input image with the stored patterns, the amount of dependence and its relationship is calculated for face detection. These models are used for both faces detection and face features detection. Usable templates exist in two types: predefined patterns and deformable patterns. Usually predefined templates formed by a number of smaller templates, such as eyes, nose, mouth and presentable environment. Firstly, each of small patterns is compared with original image and then candidate areas are detected using correlation between these patterns. Then template matching is done between other small candidates within area. In other words, in first step, interested areas are determined and then in the second step for finding face within the areas some details are established. Deformable patterns are described by agent-oriented patterns. These patterns can change before adaptation, using analysis of existing image and affective factors on face.

• Appearance-based methods: Unlike template matching methods, these methods are developed by a set of training images that have variety in their appearance. Appearance-based methods are usually used for face detection. Generally, such methods are based on statistical analysis and machine learning techniques to discover facial and non-facial features.

Four proposed methods for face detection are listed briefly in table (I).

V.PRESENTED MODEL AND ALGORITHM

Various models and algorithms are provided for face detection based on color features. As mentioned in previous subjects, most of them follow a similar framework, but the important difference among them is in their implementation and also in the way they follow the framework. Color modeling, selecting appropriate color space, considering specific defaults (such as environmental and light conditions, ...), converting initial color space to selected color space, human skin color modeling, classifying pixels into two groups i.e. skin and non-skin groups, analysis parameters that influence on final decision, all have multiple factors complexity.

TABLE I
GENERAL METHODS FOR FACE DETECTION

Approach	Representative Works
Knowledge-Based	Multi-resolution rule-based method
Feature invariant -Facial Features -Texture	-Grouping of edges -Space Gray-Level Dependence matrix(SGLD) of face pattern
-Skin Color -Multiple Feature	-Mixture of Gaussian -Integration of skin color, size and shape
Template matching -Predefined face templates -Deformable templates	-Shape template -Active Shape Model
Appearance-based Model -Eigenface	-Eigenvector decomposition and Clustering
-Distribution-based	-Gaussian distribution and multilayer perceptron
-Neural Network	-Ensemble of neural networks and arbitration schemes
-Support Vector Machine(SVM) -Naive Bayes Classifier	-SVM with polynomial kernel -Join statistics of local appearance and position
-Hidden Markov Model	-Higher order statistics with HMM
-Information-Theoretical Approach	-kulback relative information

Required pre-processing to start work on a color image, removing additional areas and selecting suitable color space greatly reduce the computational loads. Although all of these three stages can have negative effects on the final result, they can reduce the amount calculation and this advantage is nothing to avoid. Some of works that have been done on face detection among color images are [12, 13, 14].

A . Formation of presented model

For presenting a model that can evaluate color features in color images, and also can detect available faces, first and the most important step is finding the threshold for the color components. Since at the beginning, there is no possibility to select any color space, so the presented model is as follows:

• A large number of family and official, or workplace environment images, that largely are different and varied, are selected as training database.

• Small pieces of skin areas (4 * 4 pixels) within available images are selected manually. The 8 selected areas, including 2 pieces on the nose area and 3 pieces on each cheek.

Fig. 3 selected areas on 4*4-size pieces

• Regarding that primary color data pieces that selected on skin, are in RGB subarea, therefore necessary transformation on all the pieces to nRGB, YCrCb and HSV subareas have been done. Each of the selected pieces normalized by mean function, and then has been used as a real example for acceptable threshold of skin color.

$$X = \frac{1}{16}\sum_{i=1}^{16} X_i \qquad (3)$$

Xi is vector of ith pixel in desired area:

• Using each mentioned subarea histogram, the primary range of the human skin color on the components of each subspace is specified.

• In each color space, the obtained components and thresholds will be used to evaluate different parameters in our algorithm.

• In each subspace, Pixel color classification, using obtained information in the model, has been done.

Fig.4 some examples of different faces

Regarding that before implementing the desired model, as an effective algorithm, the possibility of selecting a specific color subspace, does not exist, therefore some of these spaces, to cover all of subspaces has been selected and the algorithm has been founded in a way that covers all the desired subspaces.

B.Presented Algorithm

Presented Algorithm uses the results of designed model for determining the component thresholds of desired color. These results and different techniques in various stages, are trying to improve the results of running algorithm as a final output.

At the beginning of work, a sample colorful image I, is received as input. This image is sent to Kienzle algorithm [15], and primary candidate areas (Ix) are identified. It is important to note that Kienzle algorithm [15] uses SVM method for finding candidate faces among black and white (gray) images (Its detail has not been mentioned here).

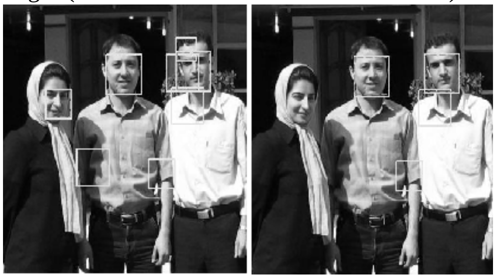

Fig.5 Output of algorithm [15] on gray images

With different thresholds, algorithm [15] will have different result. In fact, this algorithm is adjustable on thresholds from -10 to +10. That lower threshold causes more severity in selecting candidates region as a face. That is why FRR and FDR will change when the threshold changes (Figure 5).

Hereafter, instead of initial images (I), main processing will be done only on the identified candidate regions (Ix):

• Step One: candidate region Ix, is converted to desired color space using linear or non-linear transform. This conversion can be done to each subarea which has been afore mentioned.

• Step two: using determined thresholds in the proposed model for human skin color, the percentage of pixels Ix, which will be in skin group, is calculated. If

$$pt1 \leq Px \leq pt2 \qquad (4)$$

The algorithm would continue (pt1, pt2 are obtained low and high thresholds for the area for being skin), otherwise the area would be labeled as non-skin and the algorithm would terminates.

• Step Three: after normalization of points which specified as key points(using formula 3), these points are sent to a function, that its results based on having skin condition or not will be 1 or 0 respectively (Fig.6).

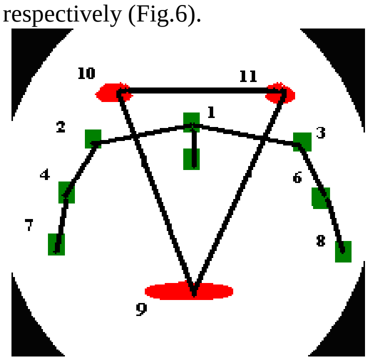

Fig. 6 main points of face (green: face and red: non face)

In fact, for each of green points, if they are in threshold range and for each of the red points if they are not in threshold range, the result of function will be 1

• Step Four: After considering all these pixels of image Ix, using desires function, sum of obtained scores is calculated for each point.

$$S = \sum_{i=1}^{11} F(i, I_x) \qquad (5)$$

In which F is determinant function and i is number of the desired pixel in Figure 6.

• Final step: If for the obtained result:

$$S > t\,(t = threshold\ for\ face) \qquad (6)$$

Ix will be considered as a face, and otherwise I is not part of a face.In different color spaces different results are obtained which in the evaluation section will be discussed

VI. OUR WORK EVALUATION

Regarding that the presented algorithm has the ability to match with real different environments, so it has been evaluated on different color subspaces and various ranges with different thresholds (both for the Kienzle algorithm [15] and our work). For this purpose, a personal database containing various family and workplace images has been created. Table (2) shows the results of evaluation on this database. These results show that whatever the considered threshold for the first part algorithm (Tr1), is smaller, FDR will be lower and FRR will be higher, and whatever the threshold of skin color parameters (Tr2) is selected higher, FDR will be lower and FRR will be higher. By evaluating different thresholds for a personal database, it is possible to show optimal thresholds as follows:

$$(pt1 = 45,\ pt2 = 97)$$
$$(Tr1 = 1, Tr2 = 7)\ or\ (Tr1 = 2, Tr2 = 4) \qquad (7)$$

TABLEII
FINAL RESULT OF PRESENTED ALGORITHM ON PERSONAL DATABASE

Tr1	Tr2	FDR (%)	TDR (%)	FRR (%)
1	4	4.2	87.2	12.8
	5	5.4	84.4	15.6
	6	5	82.2	17.8
	7	2.2	78.7	22.3
2	4	10.2	87.9	12.1
	5	9.8	85.3	14.7
	6	7.9	82.2	17.8
	7	6.9	78.6	21.4
3	4	24.5	88.4	11.6
	5	20.4	85.9	14.1
	6	16.7	81.6	18.4
	7	15.4	79.8	20.2
4	4	30.7	90.6	9.4
	5	29	87.7	12.3
	6	21.4	85.2	14.8
	7	20	80.6	19.4

Some samples of obtained results on color images are as follow:

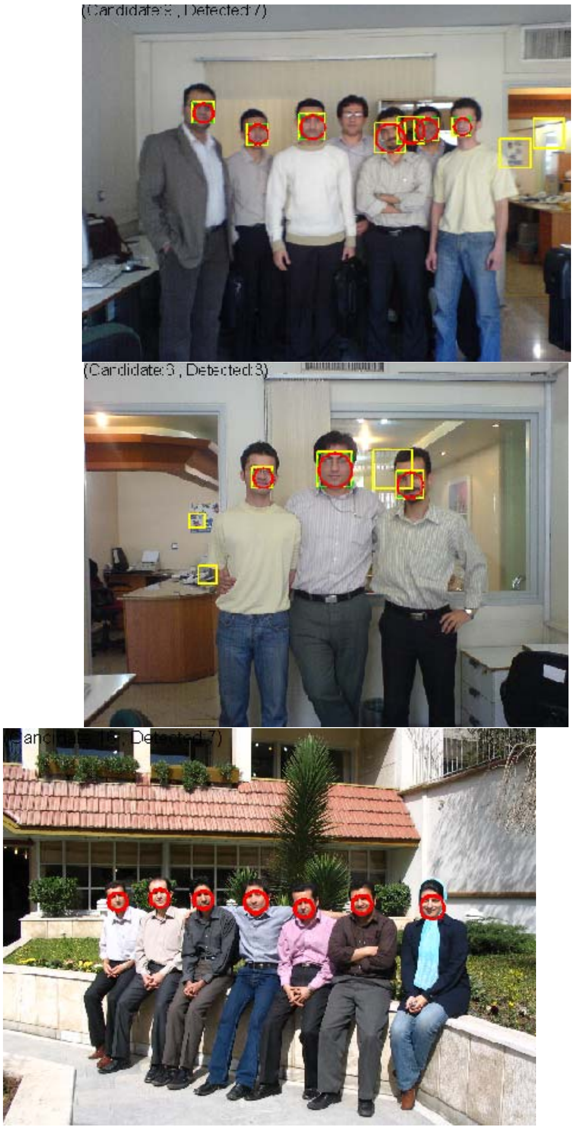

Fig.7 Some samples of obtained results (yellow rectangles: candidate faces by [15] and red circles: detected faces by our algorithm)

VII. CONCLUSION

In this article, in addition to general description of color, color spaces and color models of people, face detection methods among color and non-color images have been discussed. The main features of color-based algorithms have been totally explained. The most important part of this work includes providing practical model for human skin color (using statistical data). Using the model, it is possible to obtain thresholds to each color components of color spaces. Using combination of specified thresholds in presented skin color model and characteristics of the human face, an algorithm has been established that can improve the results of previous algorithms.

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REFERENCES

[1] Ming-Hsuan Yang, "Detecting Faces in Images: A Survey", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 24, No. 1, January 2002
[2] Yanwei Pang, Lei Zhang, Mingjing Li, Zhengkai Liu, and Weiying Ma, "A Novel Gabor-LDA Based Face Recognition Method", Microsoft Research Asia , 2003
[3] W. ZHAO, R. CHELLAPPA, P. J. PHILLIPS, A. ROSENFELD , "Face Recognition: A Literature Survey" , ACM Computing Surveys, Vol. 35, No. 4, pp. 399–458 , December 2003
[4] Sanjay Kr. Singh, D. S. Chauhan, Mayank Vatsa, Richa Singh, "A Robust Skin Color Based Face Detection Algorithm", Tamkang Journal of Science and Engineering, Vol. 6, No. 4, pp. 227-234, 2003
[5] J. Yang, W. Lu, A. Waibel, "Skin-color modeling and adaptation", ACCV98, 1998.
[6] Vladimir Vezhnevets _ Vassili Sazonov Alla Andreeva, "A Survey on Pixel-Based Skin Color Detection Techniques", Graphics and Media Laboratory, Faculty of Computational Mathematics and Cybernetics, Moscow State University,Moscow, Russia. 2003
[7] P. Kakumanu, S. Makrogiannis, N. Bourbakis , "A survey of skin-color modeling and detection methods", Pattern Recognition 40,pp 1106 – 1122 , 2007
[8] D. Brown, I. Craw, J. Lewthwaite, "A SOM based approach to skin detection with application in real time systems", BMVC01, 2001
[9] Son Lam Phung, Abdesselam Bouzerdoum, and Douglas Chai, "Skin Segmentation using Color and Edge Information" , IEEE , ISSPA 2003
[10] K.W.Wong, K.M. Lam,W.C. Siu, "A robust scheme for live detection of human faces in color images", Signal Process. Image Commun. Pp 103–114, 2003
[11] K. Sobottka, I. Pitas, "Extraction of facial regions and features using color and shape information", ICPR96, 1996.
[12] Saman Cooray and Noel O'Connor, "A Hybrid Technique for Face Detection in Color Images", Centre for Digital Video Processing, Dublin City University, Ireland, IEEE 2005
[13] Peter Peer, Franc Solina, "An Automatic Human Face Detection Method",Computer Vision Laboratory, Faculty of Computer and Information Science , 1998
[14] Nishant Shobhit, Naman Tyagi , "Face Detection in Color Images", International Institute of Information Technology ,Gachibowli, Hyderabad, India , September 2006
[15] Wolf Kienzle, G¨okhan Bakır, Matthias Franz and Bernhard Sch¨olkopf, "Face Detection—Efficient and Rank Deficient", Max-Planck-Institute for Biological Cybernetics, Germany , 2003