Human Face detection in color image By using different color space

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المستخلص

في هذا البحث نقدم طريقة لاكتشاف وتحديد الوجه في الصور الملونة باستخدام مساحات لونية مختلفة (YCbCr and HSV) يقسم هذا العمل الى مرحلتين مستقلة الواحدة عن الاخرى. المرحلة الاولى هي مرحلة استخراج القوانين من خلال استخدام مجموعة من الصور تحتوي على مناطق جلدية والثانية مرحلة تحديد منطقة الوجه.

المرحلة الاولى تتضمن استخدام عدد من الصور الملونة. يتم تحويل هذه الصور الى التحويلات اللونية (YCbCr and HSV) . بعدها يتم تحديد المناطق الجلدية فقط في هذه الصور. ثم تحسب القيم اللونية لكل لون في هذه المناطق ورسم مخخط لكل لون و من خلاله نستطيع الحصول على الارقام التي تساعدنا في استخراج القوانين. هذه القوانين تستخدم في تصنيف نقاط الصورة الى نقاط تحمل لون الجلد واخرى غير جلدية.

المرحلة الثانية تتضمن ادخال صورة ملونة ثم تحلويلها الى صورتين كل واحدة تمثل تحويله لونية مختلفة (YCbCr and HSV). بعدها يتم استخدام

القوانين المستخرجة في المرحلة الاولى لتصنيف نقاط كل صورة الى نقاط تمثل لون الجلد واخرى لا تمثل لون الجلد ثم يتم حذف النقاط التي تمثل ضوضاء من كل صورة من خلال استخدام فلتر الوسط يتم بعدها تجميع النقاط الجلدية للحصول على مناطق ذات معنى قد تمثل (الوجه ، اليد، الخ..) في كل صورة. بعدها تجمع المناطق الجلدية المتكونة في الصورتين للحصول على صورة واحدة تفحص هذه المناطق من خلال تطبيق ثلاث اختبارات (Compactness, Solidity and Orientation) على كل منطقة لتحديد اذا كانت تمثل وجه أم لا .اخيرا يتم تاشير منطقة الوجه من خلال رسم مستطيل حولها .

Abstract:

This paper presents a novel model to detect the human face in color image by using different color spaces (YCbCr and HSV). This work is divided into two independent stages. First stage extracts rules through using a number of images that contain skin regions and the second stage detects face regions.

First stage includes using a number of color images. These images are converted into another color space (YCbCr and HSV). Then limiting only the skin regions in these images. After that compute the color values for each color space in these skin regions and draw a histogram for each

color, through it, to get out the numbers that will help us to extract the rules which would be used to classify image pixels into skin or non-skin color.

Second stage includes entering color image then convert it into two images each one represents different color space (YCbCr and HSV) , after that extracted rules in first stage are used to classify the pixels of each image into skin or non-skin color. Then delete the pixels that represent noise from each image by using the medium filter. After that these skin pixels combined to make meaningful regions (i.e. face, hand, etc.) in each image. Gathering the skin regions that are in the two images to get one image. Examining these regions throughout applying three tests (Compactness, Solidity and Orientation) on each region to decide whether it is a face or not. Finally the region face can be pointed out through drawing a box round it.

1. Introduction:

Detecting human faces automatically is becoming a very important task in many applications, such as security access control systems or content-based indexing video retrieval systems like the Distributed audio Visual Archives Network system [1].

When building a system, that uses skin color as a feature for face detection, the researcher usually faces three main problems. First, what colorspace to choose, second, how exactly the skin color distribution should be modeled, and finally, what will be the way of processing of color segmentation results for face detection [2].

The main challenge in face detection is to cope with a wide variety of variations in the human face such as face pose and scale, face orientation, facial expression, ethnicity and skin color. External factors such as occlusion, complex backgrounds, inconsistent illumination conditions and quality of the image may also contribute significantly to the overall problem [3].

2. Colorspaces used for skin modeling

Colorimetry, computer graphics and video signal transmission standards have given birth to many colorspaces with different properties. A wide variety of them have been applied to the problem of skin color modeling. Bellow the most popular colorspaces and their properties [4] [2].

2.1 YCbCr

YCbCr is an encoded nonlinear RGB signal, commonly used by European television studios and for image compression work. Color is represented by luma (which is luminance, computed from nonlinear RGB [5]), constructed as a weighted sum of the RGB values, and two color difference values Cr and Cb that are formed by subtracting luma from RGB red and blue components.

$$Y = 0.299R + 0.587G + 0.114B$$
$$Cr = R - Y$$
$$Cb = B - Y \qquad \text{...................} \qquad (1)$$

The transformation simplicity and explicit separation of luminance and chrominance components makes this colorspace attractive for skin color modeling [6][2][7]

2.2 HSI, HSV, HSL - Hue Saturation Intensity (Value, Lightness)

Hue-saturation based colorspaces were introduced when there was a need for the user to specify color properties numerically. They describe color with intuitive values, based on the artist's idea of tint, saturation and tone. Hue defines the dominant color (such as red, green, purple and yellow) of an area; saturation measures the colorfulness of an area in proportion to its brightness. The intensity, lightness or value is related to the color luminance. The intuitiveness of the colorspace components and explicit discrimination between luminance and chrominance properties made these colorspaces popular in the works on skin color segmentation. However, points out several undesirable features of these colorspaces, including hue discontinuities and the computation of brightness (lightness, value), which conflicts badly with the properties of color vision [2][8][9].

$$H = \arccos \frac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B))}}$$

$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B}$$

$$V = \frac{1}{3}(R+G+B) \qquad \text{.......} \quad (2)$$

3. Face Detection Operators:

A set of operators, Compactness, Solidity and Orientation, are applied over these regions to decide whether they represent a face or not. These operators make use of basic assumptions about the shape of the face. Components that can be excluded from the face candidates based on their shape are removed. These simple but effective decision criteria rely on the combinations of the area, A, the perimeter, P, and the size, Dx Dy (height and width) of the box of the connected region. Thus features have to be computed only once for the three operators.

Compactness of a connected region defined as the ratio of its area to the square of its perimeter.

$$Compactness = \frac{A}{P^2} \qquad \text{K K} \qquad (3)$$

This criterion is maximized for circular objects. Faces are nearly circular in shape and hence face region exhibit a high value for this operator. A threshold is fixed for this operator based on the observations on various face regions. If a particular region shows a compactness value greater than this threshold **(0.025)** it is retained for further analysis, else discarded.

Solidity of a connected region is defined as the ratio of its area to the area Dx Dy (height and width) of the box.

$$Solidity = \frac{A}{D_x D_y} \qquad \text{K K K} \quad (4)$$

Solidity gives a measure of area occupancy of a connected region within its (height and width) rectangle dimension. The solidity also assumes a high value for face components. If the solidity of a **component is** lesser than a specified threshold value **(0.5218)**, it is eliminated, otherwise retained for further analysis.

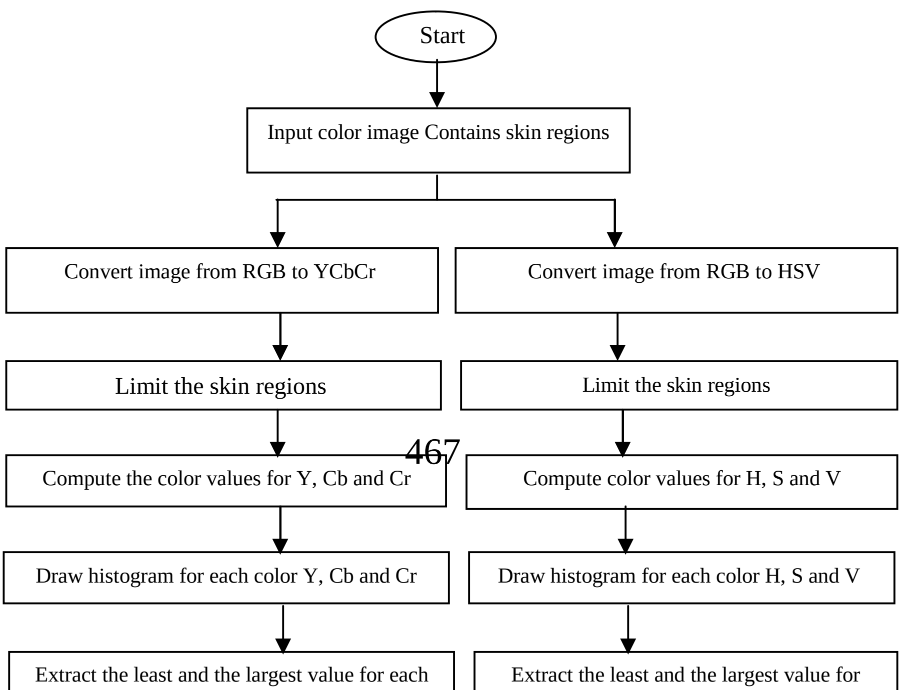
Orientation is nothing but the aspect ratio Dx Dy (height and width) of the box surrounding the region.

$$Orientation = \frac{D_y}{D_x} \qquad \text{K K} \quad (5)$$

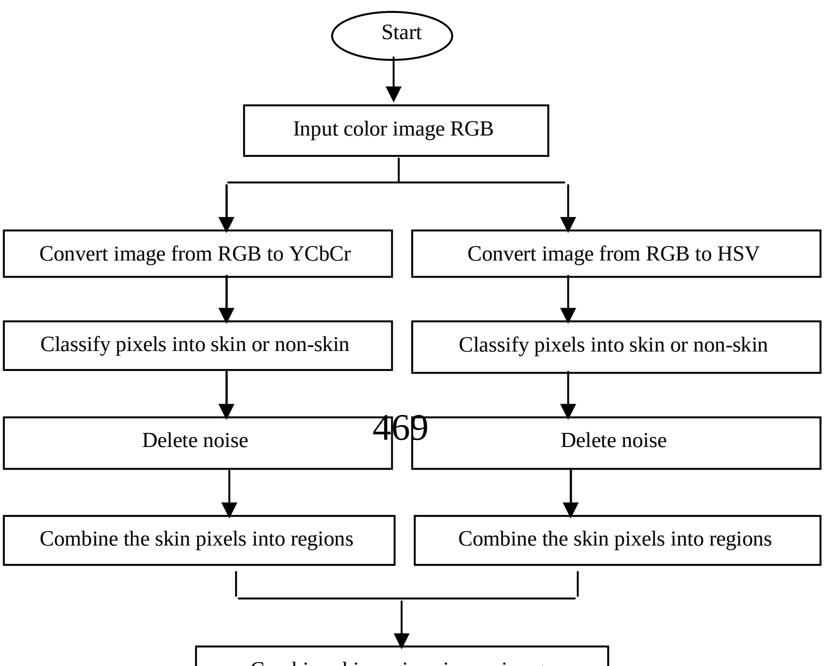
It is assumed that normally face region have orientation within a certain range **(0.90 to 2.10)**. This range is found out based on observation on a number of images. If a region's orientation falls out of this range, the region is eliminated. A lot of non-face regions that have solidity and compactness of a face region can be removed using orientation operator. For example, using orientation, a face component can be separated from an elongated pipe component, a horizontal elliptic component etc. The remaining unwanted components are removed using Normalized Area. It is the ratio of the area of the connected component to that of the largest component that remains after the application of the above three operators [10].

4- System Overview:

This work consists of two stages; rules extract and face detection. In the rules extract stage, a group of rules extracted through training a set of images. Two commonly known color spaces YCbCr and HSV are used to construct the proposed hybrid model. Bounding planes or rules for each skin color space are constructed from their respective skin color distributions, as illustrated in figure (1).

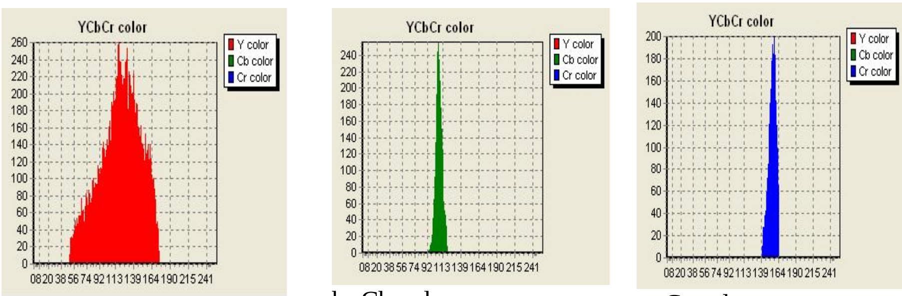


In the face detection stage, entering colored image RGB and convert it to YCbCr and HSV color space using equation 1 and 2 respectively, bounding rules are used to classify the pixels into skin or non-skin color, medium filter used to remove the random pixels may appear after classifying the pixels. Gathering the skin pixels into regions expected to be face candidates, and combining the detected regions from the two images to extract one image containing the face candidates. Examining the face in the localized skin regions obtained by using three operators (Compactness, Solidity, and Orientation) to detect the face region. Finally, labels the face in the image, as illustrated in figure (2).



4-1- Skin Color Bounding Rules

From the skin color subspace analysis, a set of bounding rules is derived from two color spaces, YCbCr and HSV, based on our training observations. All rules are derived for intensity values between 0 and 255, based on the observation that the YCbCr subspace is a strong discriminate of skin color, we formulated 4 bounding planes from it, as shown in Figure (3).



a- Y color   b- Cb color   c- Cr color

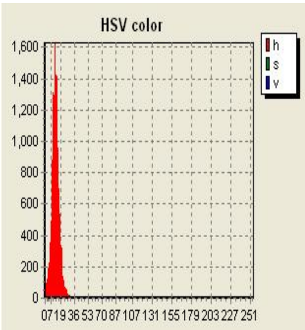
Figure (3) Distribution of Y, Cb and Cr

The 4 bounding rules that enclosed the YCbCr skin color region are formulated as below:

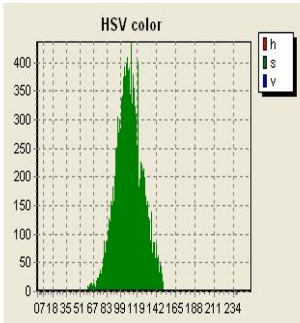
$$\begin{aligned}&(Y > 50)\ \mathit{and}\ (Y < 175)\ \mathit{and}\\&(Cb > 90)\ \mathit{and}\ (Cb < 120)\ \mathit{and}\\&(Cr > 140)\ \mathit{and}\ (Cr < 165)\ \mathit{and}\\&(Cr > Cb)\ \mathit{and}\ (Cr - Cb > 15) \qquad \text{K K K K (6)}\end{aligned}$$

Therefore, each pixel that fulfills **equation 6** is classified as a skin color pixel.

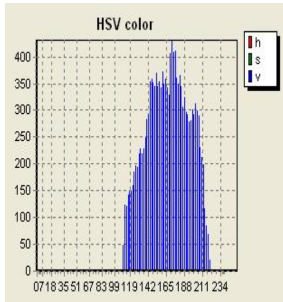
In the HSV space, the hue values exhibit the most noticeable separation between skin and non-skin regions. We estimated three cutoff levels as our H, S and V subspace skin boundaries, as shown in Figure (4).



a- h color



b- s color



c- v color

Figure (4) distribution of H, S and V

The 3 bounding rules that enclosed the HSV skin color region are formulated as below:

$$(H > 0)\ \mathit{and}\ (H < 25)\ \mathit{and}$$
$$(S > 70)\ \mathit{and}\ (S < 150)\ \mathit{and}$$
$$(V > 90)\ \mathit{and}\ (V < 220) \qquad \text{K K K K (7)}$$

Therefore, each pixel that fulfills **equation 7** is classified as a skin color pixel.

4-2 Face candidates

First step includes entering color image (RGB), as illustrated in figure (5).

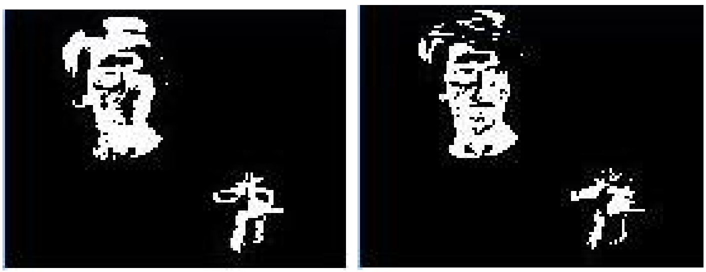
Figure (5) color image

After that, converting the input image into two images one for YCbCr and the other for HSV color space, as illustrated in figure (6).

a- YCbCr image b- HSV image

Figure (6) image after converting

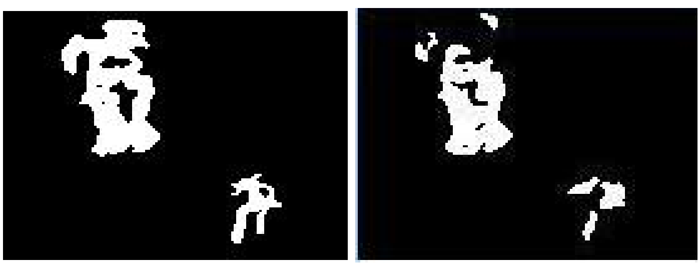
Using the bounding rules (equation 6 and 7) that extracted in the first stage to classify the pixels of the two images into skin or non-skin color. The result of this step is two images containing skin color pixels and some pixels may have skin color but they are not skin, as illustrated in figure (7).



a- Skin pixels YCbCr b- Skin pixels HSV

Figure (7) image after classify pixels

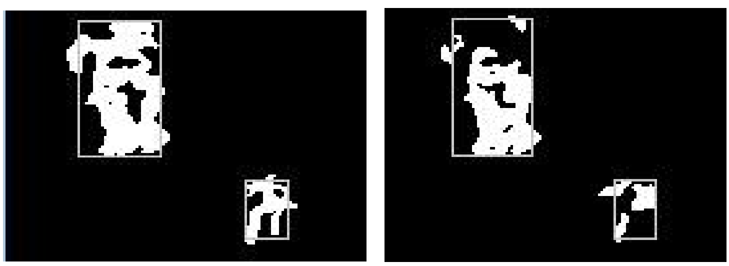
Medium filter used to remove the noise pixels that may appear a ot skin and to enhance the image, as illustrated in figure (8).



a- Delete noise YCbCr b- Delete noise HSV

Figure (8) image after delete noise

Combining the skin pixels into different groups so that they will represent something meaningful as a group, (i.e. face, hand, etc.). Since we have to form meaningful groups of pixels by grouping them by 8-connected neighborhood (i.e. if a skin pixels has got another pixels in any of its 8-neighboring places, then both the pixels belong to the same region). At this stage, different regions are gained in the two images. as illustrated in figure (9).



a- Combine skin pixels YCbCr

b- Combine skin pixels HSV

Figure (9) combine skin pixels in each image

The skin regions of the two images are combined in one image, as illustrated in figure (10). These skin regions will represent face candidates.

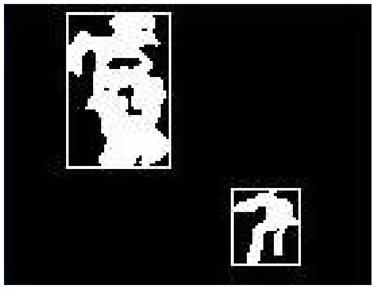


Figure (10) image after combine the skin regions

4-3 Face detection

The next step is to search for the face in the localized skin regions obtained in the above process. Searching method includes examining each region by using three operators (Compactness, Solidity and Orientation) to decide whether this region represents the face or not, by using equations 3, 4 and 5 respectively (these operators are mentioned previously). In this example two regions appear, as illustrated in figure (11).

After applying these equations (3, 4 and 5) on the first region we get the following results:

Area= 1421 Perimeter = 141 Height = 57 Width = 38

Compactness = 0.071

Solidity = 0.656

Orientation = 1.5

After applying these equations (3, 4 and 5) on the second region we get the following results:

Area= 335 Perimeter = 61 Height = 28 Width = 25

Compactness = 0.090

Solidity = 0.478

Orientation = 1.12

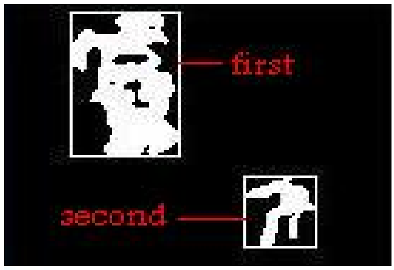


Figure (11) face candidate

After examining the results of the first and second regions it's noticed that the fist region is agreeable in three operators (Compactness, Solidity and Orientation) while the second region failed in one of the operators which is (Solidity), therefore the first region represents the face region. Finally after detecting the region that represents the face, draw a box around it to make it clear, as illustrated in figure (12).

Figure (12) face detection

5- Conclusion

In this paper, we have presented a novel model to detect human face in color image by using different color space. Skin region segmentation was performed using a combination of YCbCr and HSV color spaces, which demonstrated evident discrimination between skin and non-skin regions. The experimental results showed that our new approach in modeling skin color was able to achieve a good detection successful rate. It can be noticed that the model is able to separate the skin regions from the back grounds. In future we'll develop this work in order to use it to track the face in sequence color images.

6. Experimental Result

Figure (13, 14 and 15) shows the sample result of the proposed model and make clear work steps respectively.

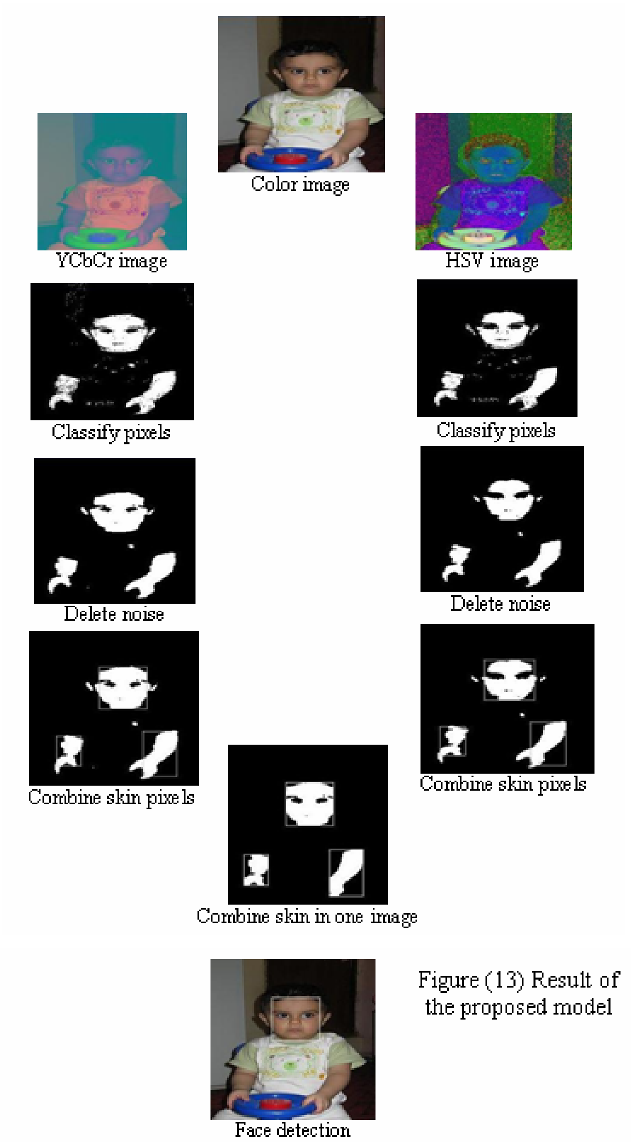


Figure (13) Result of the proposed model

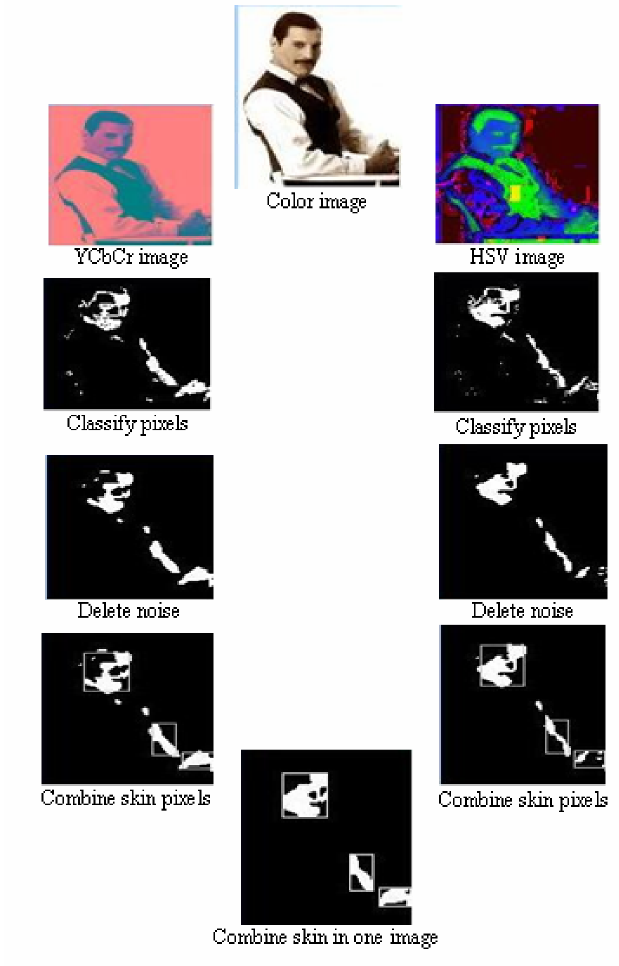
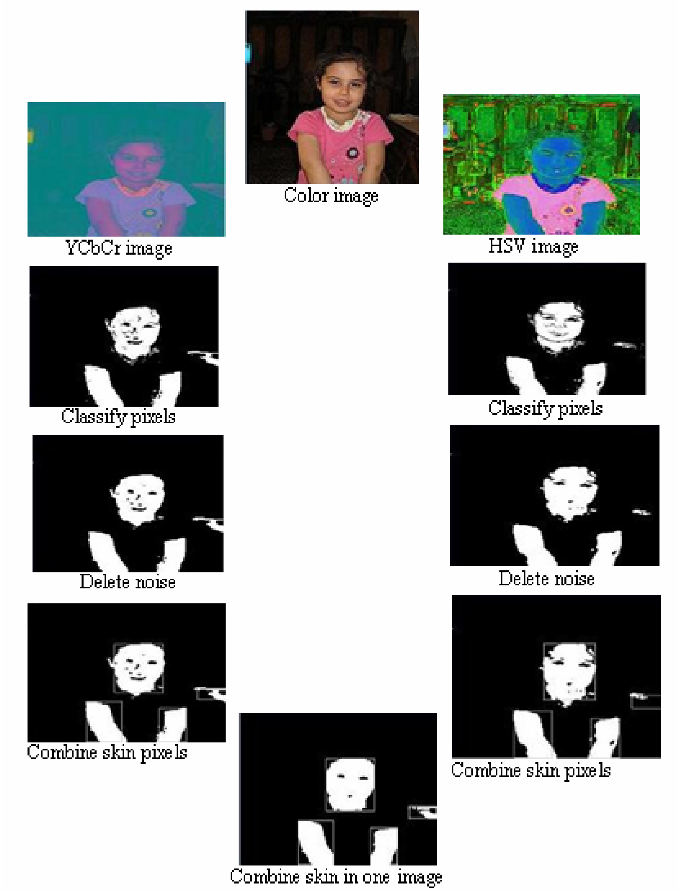


Figure (14) result of the proposed model



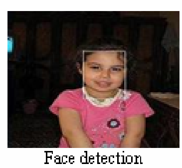


Figure (15) Result of the proposed model

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