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ALGORITHMS AND METHODS USED IN SKIN AND FACE DETECTION SUITABLE FOR MOBILE APPLICATIONS

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Face detection is one of the most important issues in the identification and authentication systems that use biometric features. In this paper we present algorithms for detecting skin colour. The selection and implementation of an algorithm for automated authentication system and face detection can significantly improve the effectiveness of such a system. In the paper we examine several algorithms and methods that can be used in mobile application for authentication purpose i.e. NFC payments.

Keywords: face identification, authentication, biometrics, detection of skin colour

1. Introduction

Authentication and identification systems are now being used increasingly. Nowadays more and more popular become NFC transactions like mobile payments. We want to protect our resources against unauthorized access to the compromised. The commonly used authentication using login and password appear to be insufficient and too easy, which are exposed to a high risk of attack. There is therefore a need to develop alternative methods which seem most promising biometric methods using individual human characteristics. Biometric methods can use a variety of physical characteristics such as fingerprints, hand geometry, ear and facial geometry, iris of the eye [6]. Among these features face as our individual identifier seems to be the most interesting and gives new features research [1, 2, 3].

Face area is now one of the most interesting elements of the image to the research on its location in the image, the appointment of facial symmetry, finding the significant points [15], searching for similarities between several images and compared the skin colour detection. Locating faces in the image using its search algorithms need to be able to work on the details and provides a basis for further research in the diagnosis of skin colour [6].

Searching for skin colour is much simpler than the other much more complex elements of the image. Skin colour is indicative - it is not a physical phenomenon from different angles as light colour will have a different degree of saturation, colour is determined by perception. Facial image captured by the camera in motion is changed due to weather conditions such as sunny or cloudy weather, the exposure of an object or its movement. Image captured by the camera may have different tolerances of colour, through which can recognize different skin colour for one object.

2. Skin colour classification

Study of image content and classification of skin colour in the image gained popularity through active research [11]. It is thanks to research it became possible to determine the distribution of points in the image and operation face. Locating faces and the use of colour information in the face is often the first step to locate her. Classification of colour is important. The research resulted in the creation of colour histograms.

2.1. Skin colour detection – histograms

Histograms show range of colours that identify the colour as your skin. In the first skin colour models used in the base images that have been taught by the elimination of noise in the picture, which property has a skin test and what it is not. It then examines the effectiveness of the photos. Working with photos to create database used in the applications give impressive results. However, histograms created from images did not give satisfactory results in the study of new unidentified photos. Therefore, new, created from the image recording systems based on RGB, YCbCr, HSV, HSI and TLS [7, 8, 9, 10].

2.2. Colour and its models in skin detection

RGB it is the most well-known and widely described method of storing digital images. Yet it is not very accurate because of the colour analysis. This model mixes colours in outdoor conditions such as exposure to cloudy weather.

Nevertheless, it is relatively simple and inexpensive to operate. In addition, recording of images taken for treatment of the following on each computer is in this system [7, 19].

HSV is describing the video recording using saturation and colour intensity. It determined the dominant colour in the image considered in relation to its brightness. This model is to represent the colours with numbers whose values describe what type and size of the image is hidden beneath it [16, 17, 18, 33].

YCrCb [8] is a non-linearly encoded RGB commonly used by television studios and used to work with image compression.

The simplicity of the transformation and a clear separation of components of images, such as exposure and saturation makes this type of recording is becoming very attractive for further studies [10, 17, 20, 21, 22].

TSL means the hue, saturation and exposure. In this case the transformation was made intuitively by using the following formula:

$$S = [9/5(r'^2 + g'^2)]^{1/2}$$

$$T = \begin{cases} \arctan(r'/g')/2\pi + 1/4, g' > 0 \\ \arctan(r'/g')/2\pi + 3/4, g' < 0 \\ 0, g' = 0 \end{cases}$$

$$L = 0{,}299R + 0{,}587G + 0{,}114B$$

where $r' = r - 1/3$, $g' = g - 1/3$ and the rig are calculated using the formula for the normalization of RGB

$$r = \frac{R}{R+G+B} \quad g = \frac{G}{R+G+B} \quad b = \frac{B}{R+G+B}$$

There are defined another possible delegated classifications of skin colour also: YES [24], YUV [25] and YIQ [26], [27]. CIE-xyz [14] it is very rarely used.

3. Skin colour detection algorithms

Recording an image in one of these models offers the possibility of further processing. Skin models are formed on the basis of qualifications of pixels contained in the test image, and eliminate those that belong to the skin, and those that do not belong there. Classification of pixels is followed by image storage systems.

Below there are the RGB values to classify areas as skin test pictures.

$$\begin{aligned}
&(R,G,B) \textit{ is classified as skin if}: \\
&R > 95 \textit{ and } G > 40 \textit{ and } B > 20 \textit{ and} \\
&\max\{R,G,B\} - \min\{R,G,B\} > 15 \textit{ and} \\
&|R - G| > 15 \textit{ and } R > G \textit{ and } R > B
\end{aligned}$$

Classification of the skin is followed by separating the pixel that was identified. Then pass the standardization process, which resulted in the imposition of a mask on the image and then the image has been subjected to binarization.

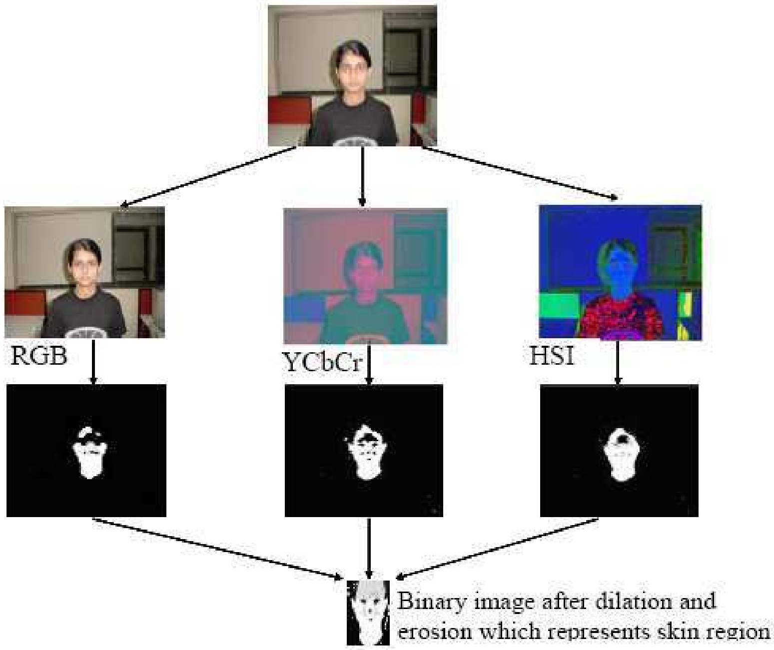


Figure 1. Processing of the sample image for a particular system by normalization and binarization. The result finds skin component images in the test image

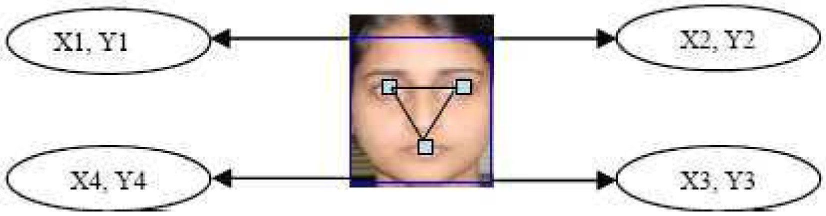
3.1. Singh's algorithm [4]

Normalization of pixel colour is based on saving images using the mask. Pixels create colours' histograms we are interested in identifying the picture. The following example illustrates the process of normalization $r + g + b = 1$ calculated using the following procedure in the image in RGB mode controlled entry.

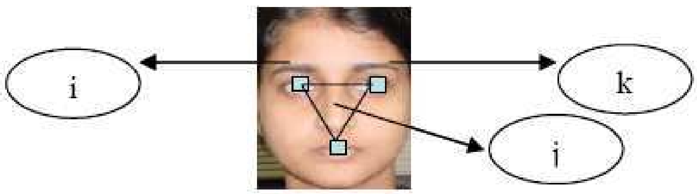
$$r = \frac{R}{R+G+B} \quad g = \frac{G}{R+G+B} \quad b = \frac{B}{R+G+B}$$

It gives us the opportunity to study pictures, build algorithms by which we can classify the test area as the skin [17, 23, 32].

This method made it possible to locate the face in the test image using an algorithm and comparing the pixel colour histograms. The area in which the face becomes a field of research is between the coordinates (X1, Y1), (X2, Y2), (X3, Y3) and (X4, Y4)



identified by points of the eyes and mouth.



The algorithm was formulated for the calculation of the frontal regions of the skin to picture the assumption of symmetry of the face varies from 90-110°

X1 and X4 are deployed at the same coordinate (Xi – 1/3 d (k));

X2 and X3 are deployed on the same coordinate (X k +1 / 3D (k));

Y1 and Y2 are deployed at the same coordinate (Yi + 1 / 3D (k));

Y3 and Y4 deployed on the same coordinate (Yj – 1 / 3D (k));

The results achieved on the basis of the classification of HSI in conjunction with the proposed algorithm for finding faces in images yielded results of 90% of the classification of the skin in the test images. The database consists of 1100 images and the authors [4] obtained the following results for the different colour spaces.

Table 1. Performance of Singh algorithm

Criterion	RGB	YCbCr	HIS	Singh algorithm [2]
Photo frontal	56.46%	83.91%	82.27%	96.01%
Photo rotated	54.57%	80.14%	80.09%	92.42%
Profile photo	47.84%	80.11%	79.92%	91.29%
Image with complex background	42.62%	73.72%	71.19%	95.18%
Time [s]	2.09	3.46	3.52	6.38

3.2. Tomaz algorithm [5]

Method using TSL (hue, saturation, luminance), distance Mahalanobis (search skin in images), based on the Gaussian model. It seeks to eliminate parts of the image containing the skin. Scaling and Calibration values are input to the algorithm taken from each test pixel after normalization in the range [0, 1.0] [14]. The Mahalanobis distance is applied:

$$S = (S - MinS)/ (MaxS - MinS)$$
$$T = (T - MinS)/ (MaxT - MinS)$$

Input filter, which was used in the calculation of the algorithm relates to the classification of pixels: RGB values are represented by 0 to 255.

```
if (((B> 1 60 && R <180 && G <180) || // too much blue
(G> 1 60 && R <180 && B <180) || // too much green
(B <100 && R <100 && G <100) || // too dark
(G> 200) || // Green
(R + G> 400) || // a lot of red and green (yellow)
(G> 150 && B <90) || // yellow
(B / (R + G+ B)> .40) || // too much blue in contrast with other colours
(G / (R + G+ B)> .40) || // too much green in contrast with other colours
(R <102 && G> 100 && B> 110 && G <140 && B <160)) //
```

For skin segmentation Gaussian model was used:

$$S = \sqrt{\frac{9}{5(r'^2 + g'^2)}} \qquad T = \begin{cases} \dfrac{\tan^{-1}\left(\dfrac{r'}{g'}\right)}{\pi} + 0,5 & g' \neq 0 \\ 0 & g' = 0 \end{cases}$$

where

$$r' = \frac{R}{R+G+B} - 1/3 \text{ and } g' = \frac{G}{R+G+B} - 1/3$$

The class definition describing the skin colour is determined by the formula:

$$C_s = \begin{bmatrix} \sigma^2 M_t & \sigma T M_s \\ \sigma T M_s & \sigma^2 M_s \end{bmatrix}$$

using the formula Mahalanobis of the distance

$$v_m = \left[M_t \quad M_s\right]^T.$$

Pixel distance in the vector v_m calculated using the formula

$$\left|\lambda_{i,j}^2\right| = \left[X_{i,j} - v_m\right]^T C_s^{-1}\left[x_{i,j} - v_m\right]$$

It gives the results

$$\lambda_{i,j}^2 = \left(\frac{T_{i,j} - M_t}{\sigma^2 M_t T_{i,j}^2 M_s} - \frac{S_{i,j} - M_s}{\sigma T_{i,j}\left(\sigma^2 M_t - T_{i,j}^2 M_s\right)}\right)\left(T_{i,j} - M_t\right) +$$

$$\left(\frac{-\left(T_{i,j} - M_t\right)}{\sigma T_{i,j}\left(\sigma^2 M_t - T_{i,j}^2 M_s\right)} + \frac{\left(S_{i,j} - M_s\right)M_t}{M_s\left(\sigma^2 M_t - T_{i,j}^2 M_s\right)}\right)\left(S_{i,j} - M_s\right)$$

This method first calculates the pixel values using the formula above values are then subjected to normalization by $\lambda^2_{i,j}$/cons. If the values are greater than 0.7 are identified as skin and this method works quite well. This method detects skin in test images but as every method has errors and is prone to blur the image by clothes and other disturbances.

4. Mixture of gaussian classifiers

Another method based on the RGB system, and my e s a colour Strait Gaussian model is to compare the values of pixels in the histogram of the skin and the skin. Gaussian model is defined by the formula:

$$P(x) = \sum_{i=1}^{N} w_i \frac{1}{(2\pi)^{\frac{3}{2}}\left|\Sigma_i\right|^{\frac{1}{2}}} e^{-\frac{1}{2}(x-\mu_i)^T \Sigma_i^{-1}(x-\mu_i)}$$

where x is defined by a vector of RGB, and - the share of the Gauss-scalar value in the vector, u - diagonal diagonal matrix E.

This system gives the possibility of their qualifications. Characterized by the following formulas

$$P(rgb|skin) = \frac{s[rgb]}{T_s}, \quad P(rgb|-skin) = \frac{n[rgb]}{T_n}$$

where s [rgb] is the pixel value of the skin an [RGB] - not leather, T respectively, the amount of all pixels in the image test.

The skin is determined by formula (the most important factor in the equation is the value of the equation for the skin):

$$\frac{P(rgb|skin)}{P(rgb|-skin)} \geq \Theta ,$$

where the detection threshold is set in

$$0 \leq \Theta \leq 1$$

and P is equivalent to the formula

$$P(skin) = T_s / (T_s + T_n)$$

The method gives good results provided clarification image recognition of the skin in the test images. The performance of the algorithm defined by calculation ROC curve [14].

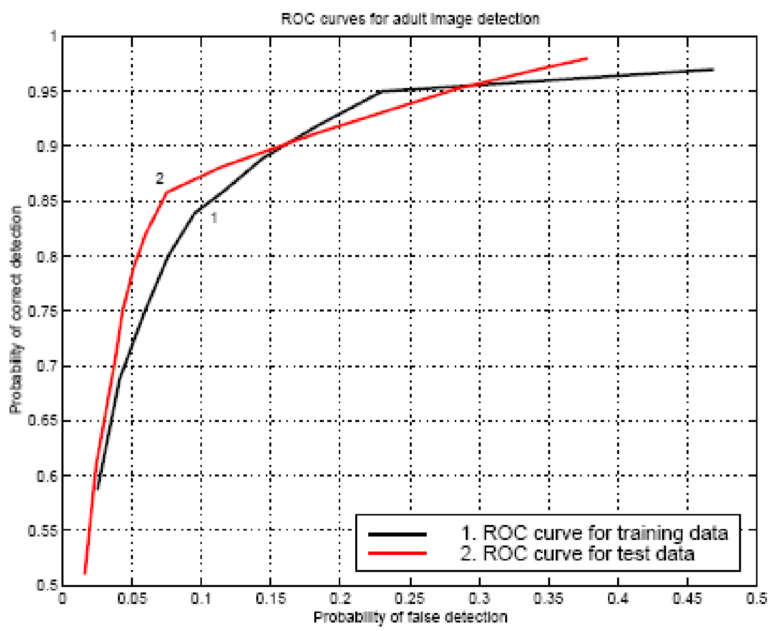


Figure 2. The effectiveness of the algorithm

The method gives good results provided classification image recognition of the skin in the test images. The effectiveness of the algorithm described in the following Table 2, where the authors used the 4999 and 1909 test shots respondents.

Table 2. Performance of Jones' method [26]

	Images correctly classified as human beings	Correctly classified images that are not human beings	The total number of correctly classified images
Test images	83.0% (2488/2999)	70.6% (1412/2000)	78.0% (3900/4999)
Examined images	83.2% (835/1004)	71.3% (645/905)	77.5% (1480/1909)

5. The algorithm based on morphological filters

Another algorithm based on HSV system and the morphological filters [28, 29] used a picture after binarization. Image Filer used, which aims to eliminate noise in an image - such as too small faces, unidentified areas. Given the irregularity of the outline of the face to the location of the image used in the test structure of diamond. Then the hole that was present after filtration was filled with original picture to recover the nose, mouth or eyes. If you change the filter results were inspiring

$$H = H.* Filter$$
$$S = S.* Filter$$
$$V = V.* Filter$$

There was proposed algorithm based on a table that identifies the skin colour and created by Garcia [30]. For any value of X * Y pixels in the image below algorithm to be more efficient:

$$O_p(XY) + O_m(XY) + O_f(XY)$$

where the O_p - evaluation of pixels, O_m - morphology filter, and O_f - filter pixels.

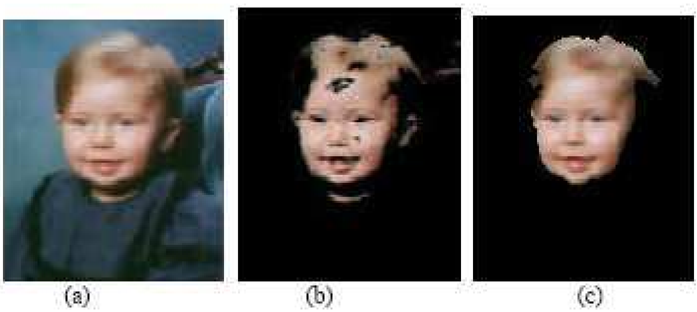


Figure 3. (a) The original photograph, (b) the result of the algorithm [31], (c) the result of the proposed algorithm

The method can be described as highly efficient method in the location of the face in the image. Due to the identification of the skin and comparison of pixels of the histogram one should use colourful pictures for the tests.

6. Conclusion

In this paper we presented the first part of the algorithms and methods for detecting sets pixels that can represent the human skin. Selected methods have high recognition performance areas of skin such as the face. And an extra characteristic feature is the simplicity and therefore do not require large computing power of the device, which will be applied. These algorithms can be used successfully in the face authentication system complains act on mobile devices on the client side.

Most of the currently available mobile devices such as smartphones have enough computing power to use one of the presented algorithms. These devices can perform the necessary calculations in a sufficiently short time. Therefore, it can be used in applications using face recognition and authentication of users [6, 15] i.e. contactless payment verification using NFC.

Based on the article table can be concluded that the percentage is about 80%. Because most faces were randomly distributed in the pictures, and facial image taken with the smartphone can be restricted to a certain area, their effectiveness in such defined conditions will increase significantly.

Of course, the implementation of these algorithms and methods will not provide transaction security. By forwarding photos of people in front of the camera can easily fool such applications. Therefore, such an application would be strengthened by comparing the series of images of 3D human being [12] or tracking the gaze [13].

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