Explicit Image Detection using YCbCr Space Color Model as Skin Detection

JORGE ALBERTO MARCIAL BASILIO[1], GUALBERTO AGUILAR TORRES[2], GABRIEL SÁNCHEZ PÉREZ[3], L. KARINA TOSCANO MEDINA[4], HÉCTOR M. PÉREZ MEANA[5]
Sección de Estudios de Posgrados e Investigación
[1]Escuela Superior de Ingeniería Mecánica y Eléctrica Unidad Culhuacan
Santa Ana #1000 Col. San Francisco Culhuacan, Del. Coyoacán C.P. 04430
MEXICO CITY
jmarcialb0300@ipn.mx[1], gaguilar@ipn.mx[2], gsanchez@ipn.mx[3], ltoscano@ipn.mx[4], hmperezm@ipn.mx[5]

Abstract: - In this paper a novel way to detect explicit content images is proposed using the *YCbCr* space color, moreover the color pixels percentage that are within the image is calculated which are susceptible to be a tone skin. The main goal to use this method is to apply to forensic analysis or pornographic images detection on storage devices such as hard disk, USB memories, etc. The results obtained using the proposed method are compared with Paraben's Porn Detection Stick software which is one of the most commercial devices used for detecting pornographic images. The proposed algorithm achieved identify up to 88.8% of the explicit content images, and 5% of false positives, the Paraben's Porn Detection Stick software achieved 89.7% of effectiveness for the same set of images but with a 6.8% of false positives. In both cases were used a set of 1000 images, 550 natural images, and 450 with highly explicit content. Finally the proposed algorithm effectiveness shows that the methodology applied to explicit image detection was successfully proved vs Paraben's Porn Detection Stick software.

Key-Words: - Skin Detection, YCbCr Color Space, Pattern Recognition, Explicit Content

1 Introduction

The information on the Internet is becoming more and more plentiful. The juveniles should be prevented from getting access to adult information, such as adult images, so the development of adult image recognizing technology is urgently desired. However, it is difficult to recognize adult image accurately. So far, adult images can be divided into three categories, which are images of nude body, close-up images of erotogenic parts, and images having pornographic action [1].

Filtering images with adult classified content is very important for searching principal Internet browser programs to avoid offensive content. Nowadays there are some ways to stop pornographic images on computers, such as blocking unwanted sites or identifying images that show explicit content. There are some programs in the foreign market that allow blocking sites on Internet with offensive or explicit content such as: CyberPatrol, ContentProtect, NetNanny, Family.net and K9 Web Protection [2]. All these programs provide parental control to safeguard their children using the Internet. There are some others programs which detect pornographic images within the computer such as: SurfRecon that offers a program for this purpose and other tool is that the company Paraben offers which its name is Porn Stick Detection [3].

There are some papers on this subject such as: the paper carried out by Forsyth and Fleck who develop software to detect naked people [4], Wiederhold and Wang proposed an algorithm for doubtful content images recognition [5], and Li Chen *et al* design a skin detector based-on Neural Network [6].

In this paper a novel algorithm to detect explicit images is proposed. It is based on image processing, skin detector, and pattern recognition techniques. First the image is transformed to *YCbCr* color space to discriminate all objects into the image that are not of interest. Next the threshold used for skin detection is calculated using this threshold the image is filtered to segment a person or people shape within the image. Finally the image likelihood is estimated to know whether an image with explicit content is or not.

The paper is organized as follows. An introduction of *RGB* and *YCbCr* color spaces and the skin detector method used in this system are shown in sections 2 and 3 respectively. Section 4 shows the proposed system and in the section 5 the results are shown as a comparative with Paraben's Porn Detection Stick. Finally the conclusions are given.

2 Color Spaces

2.1 The RGB Color Space

The *RGB* color space is an additive color model in which the primary colors red, green, and blue light are added together in various ways to reproduce a broad array of colors. The name comes from the initials of the three colors Red, Green, and Blue. The RGB color model is shown in the Figure 1.

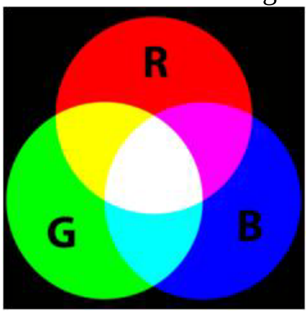

Fig. 1 *RGB* Color Model

The main purpose of the *RGB* color model is for sensing, representation, and display of images in electronic systems, such as televisions and computers.

The *RGB* color model is an additive in the sense that three light beams are added together to make a final color. To form a color with *RGB*, three colored light beams (one red, one green, and one blue) should be superimposed. Each of the three beams is called a component of that color, and each can have arbitrary intensity, from fully off to fully on, in the mixture. Zero intensity for each component gives the darkest color (no light, considered the black), and full intensity of each gives a white.

A color in the *RGB* color model is described by indicating how much of each of the red, green, and blue is included in each component which can vary from zero to a defined maximum value which depends of the application. In computing, the component values are often stored as integer numbers in the range 0 to 255.

2.1 The *YCbCr* Color Space

The *YCbCr* color space is widely used in digital video, image processing, etc. In this format, luminance information is represented by a single component, *Y*, and color information is stored as two color-difference components, *Cb* and *Cr*. Component *Cb* is the difference between the blue component and a reference value, and component *Cr* is the difference between the red component and a reference value.

The *YCbCr* color model was developed as part of ITU-R BT.601 during the development of a world-wide digital component video standard. *YCbCr* is a scaled and offset version of the *YUV* color model. *Y* is the luma component defined to have a nominal 8-bit range of 16 – 235; *Cb* and *Cr* are the blue-difference and red-difference chroma components respectively, which are defined to have a nominal range of 16 – 240.

The transformation used to convert from *RGB* to *YCbCr* color space is shown in the equation (1):

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

In contrast to *RGB*, the *YCbCr* color space is luma-independent, resulting in a better performance. The corresponding skin cluster is given as [7]:

$Y > 80$
$85 < Cb < 135$
$135 < Cr < 180$,
Where $Y, Cb, Cr = [0, 255]$.

Chai and Ngan [8] have developed an algorithm that exploits the spatial characteristics of human skin color. A skin color map is derived and used on the chrominance components of the input image to detect pixels that appear to be skin. Working in this color space Chai and Ngan have found that the range of *Cb* and *Cr* most representatives for the skin–color reference map are:

$$77 \leq Cb \leq 127 \quad \text{and} \quad 133 \leq Cr \leq 173$$

However due to that our purpose is to find human skin from different races, the thresholds given above works only with a Caucasian people skin because the first threshold only finds people with white skin, and the second threshold segments people of different places of the world but some pixels are detected as skin but really not. For this reason is proposed a new skin threshold to segment people within the image regardless skin color, so after exhaustive image histogram analysis, the optimal range threshold was:

$$80 \leq Cb \leq 120 \quad \text{and} \quad 133 \leq Cr \leq 173$$

Some examples of segmentation of people shape using the three thresholds are shown in the Table 1. Kukharev and Novosielski proposed the first threshold, Chai and Ngan proposed the second one, and the third one is proposed in this paper.

Table 1 Comparison between the three thresholds

Original Image	1st Threshold	2nd Threshold	3rd Threshold
			
			

3 Skin Detection

Skin detection can help detect a human limb, torso, or face within a picture. Lately many methods of skin identification within a digital image have been developed. Skin color has proved to be a useful and robust method for face detection, localization and tracking. There have been a number of researchers who have looked at using color information to detect skin. Jones and Rehg [9] constructed a color model using histogram-learning techniques at *RGB* color space. Yang and Auhuja [10] estimated probability density function of human skin color using a finite Gaussian mixture model whose parameters are estimated through the EM algorithm. There are other researchers who have developed papers about the different models of skin detection as Vezhnevets *et al.* [11], Kakumanu *et al.*[12], Kelly *et al.* [13].

In this paper a novel solution using the modified *YCbCr* color space threshold, which is very similar to the *RGB* color space is proposed.

Once the color transformation has been made, the next stage is to proceed to pixel detection with human skin. This was achieved by observing several images, which are a threshold where most people with different skin color within the image can be segmented using the histograms techniques.

To determine the optimal threshold it was necessary to do a histogram analysis in the *YCbCr* color space of many images. The results expressed in Figure 2 and 3 shows the histograms values which help to decide the optimal threshold for different people who have different skin color.

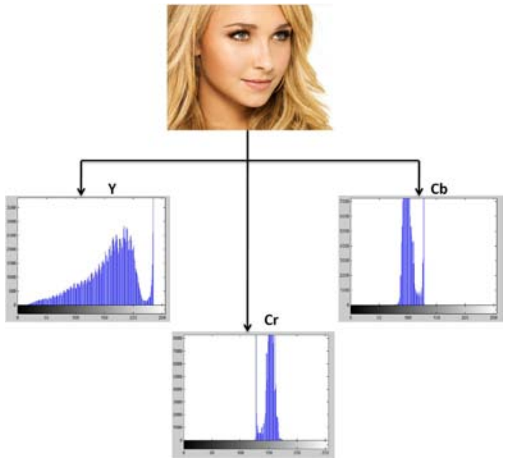

Fig. 2 White Skin Girl

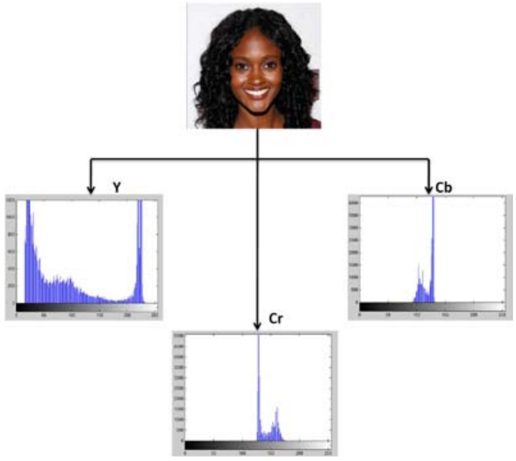

Fig. 3 Black Skin Girl

As observed in the images above, the luminance *Y* histogram is so different for both cases white and black skin because the energy is concentrated in opposite of the histogram, so only the *Cb* and *Cr* chrominance histograms are used to propose a new threshold which includes people with different skin color from white to black skin.

4 Proposed System

Figure 4 shows the proposed system, which has five stages: the image transformation from the *RGB* to *YCbCr* color space is done in the first stage. Next the threshold calculation is done using the chrominance *Cb* and *Cr* histograms analysis. Filter stage or classifier is obtained using the skin detection with the threshold that was obtained in the previous stage.

After the Skin Pixel Quantifier count the pixels number with human skin. Finally the decision stage classify the images by the percentage of skin that the image content.

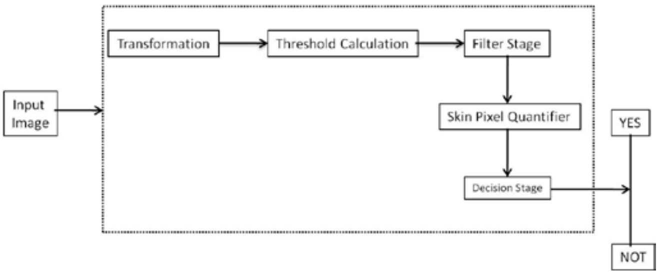

Fig. 4 Proposed System

Skin detection can be used as the basis for detection of the images with explicit content because there is a considerable relationship between the images with large areas of skin and pornographic images or with explicit content.

5 Results

A test to see the performance of the proposed system was using different images from Internet. The system can process different kind of images, as images in different lighting conditions and images with different size.

The input images for testing are classified in: a) images of naked people or with explicit content and b) natural images. In the images of naked people Asians, Caucasians, Europeans, Latin Americans and a little amount of people with black skin can be found. A natural image is one that by its nature does not contain explicit or pornographic content. In the set of natural images there are different kinds of images such as: dressed people, animals, plants, cars, cartoons, landscapes and others were also obtained from Internet.

First the input image is converted from the RGB color space to the YCbCr color space. This discriminates the objects in which we have no interested from the input image. After this stage, skin detection is used to identify the areas that contain some skin tone, and in this way only get the image of the person or people within the input image.

At this point, all skin areas detected are taken, and proceed to count the amount of pixels that there exists within the image to estimate the likelihood that this image is classified as an image with pornographic content or not. The results obtained are shown in Table 2.

To be able determine if the input image has pornographic content, a mathematic expression is proposed, described in (2), and in this way obtain the percentage of amount of skin that there are in the input image. If the percentage is more than 50% it is considered as to have objectionable content.

$$skin\ percentage = \frac{\#\,skin\ color\ pixels}{\#\,image\ pixels\ in\ total} x100 \qquad (2)$$

Table 2 Classification results using the proposed system

Input Image	Images Classification		
	YCbCr Image	Proposed Classifier	Skin Percentage
			60.458 %
			54.049%
			19.765%
			3.323%

For this experiment the set was used had 450 adult images which the majority of images are naked people and a little amount of close-up images of erotogenic parts; and 550 natural images.

Using the system proposed can be proved that it could recognize the 88.8% of all images with 5% of false positives.

This system is used as reference to know if the analyzed images have a certain quantity of pixels with skin color. This is a factor to determine if the image has naked people, as the majority of images that have undressed people are made up of skin zones that take up most of the image.

Within the results, it can be observed that the selected threshold for the image segmentation works efficiently in people with white skin, although to brown or black people, this threshold does not segment the total of skin areas. However, we can estimate its naked people likelihood with the fact that details are not lost detecting such things.

As mentioned in the section 1, also software was used from Paraben's called Porn Stick Detection, to make a comparison between the proposed system and its system to detect images. It works with a software that is within the USB device, only the user select the threshold to start the search within the computer, the threshold is the following: 0 Fewer False Positives and 100 More False Positive; this software search all the images no matter that have been deleted. The images are classified of two different ways: a) Images Highly Suspect, and b) Images Suspect. For these experiment three tests was done using different threshold for every experiment. The results obtained are shown in the Table 3.

Table 3 Results obtained with Paraben's Porn Stick Detection

	1st Experiment	2nd Experiment	3rd Experiment
Threshold	50	65	75
Recognize	64.30%	75.40%	89.10%
False Positive	2.6%	4.9%	6.2%

6 Conclusions

This paper proposed an algorithm to detect images with explicit or pornographic content in color images, using the YCbCr color space and a method of skin detection which works effectively although in some images it could find some errors, due to the image lighting conditions when taken, another factor that can be by a bad interpretation of the system.

The YCbCr color space is an important method to be able to decrease all the lighting problems that the image could be had; this is achieved using the components of chrominance Cb and Cr only.

The proposed system gives an output image that only shows color skin pixels within the image, in basis to this can be known the likelihood that the image is an explicit content or not, due to explicit or pornographic content image in most part has skin color pixels.

The importance of comparison between the proposed system and the tool Paraben's Porn Stick Detection was done to know whether the proposed system could do the same work, and this way know whether the input image is a pornographic image or not, at final could prove that the proposed system carry out effectively, although the tool has a wide threshold that the proposed system. The proposed system achieved a 88.8% for explicit images detection, compared with 89.1% of Paraben's Porn Detection Stick which is one of the commercial software used for this purpose. It was concluded that the proposed system is reliable and can be used for this purpose.

References:

[1] Xiaoyin Wang; Changzhen Hu; Shuping Yao; "An Adult Image Recognizing Algorithm Based on Naked Body Detection", Computing, Communication, Control, and Management 2009. (CCCM 2009). ISECS International Colloquium on, pp. 197 – 200, 2009.

[2] C. Habis, and F. Krsmanovic, "Explicit Image Filter," Stanford Univ., 2005.

[3] (2010) The Paraben's Porn Stick Detection website. [Online]. Available: http://paraben-sticks.com/porn-detection-stick.html.

[4] D. A. Forsyth. M. Fleek, and C. Bregler, "Finding naked people", Proc.Forth European Conference on Computer Vision. pp 593-602, 1996

[5] G. Wiederhold and J. Z. Wang, "WIPE (TM): Wavelet Image Pornography Elimination; A System for Screening Objectionable Images".

[6] Li Chen, J. Zhou, Z. Liu, W. Chen and G. Xiong, "A Skin Detector Based on Neural Network", In IEEE 2002 International Conference on Communication, Circuits and Systems and West Sino Expositions, vol. 1, 615 – 619, 2002.

[7] G. Kukharev, A. Novosielski, "Visitor identification elaborating real time face recognition system", In Proc. 12th Winter School on Computer Graphics (WSCG), Plzen, Czech Republic, pp. 157 – 164, Feb. 2004.

[8] D. Chai, and K.N. Ngan, "Face segmentation using skin-color map in videophone applications". IEEE Trans. on Circuits and Systems for Video Technology, 9(4): 551-564, June 1999.

[9] M. J. Jones and J. M. Regh, "Statistical color models with application to skin detection", In Proc. Of the CVPR '99, vol. 1, 274-280, 1999.

[10] M. H. Yang and N. Ahuja, "Detecting human faces in color images ", In International Conference on Image Processing (ICIP), vol 1, 127-130, 1998.

[11] V. Vezhnevets, V. Sazonov, A. Andreeva, "A Survey on Pixel-based Skin Color Detection Techniques", In Proceedings of the GrapiCon, 85-92, 2003.
[12] P. Kakumanu, S. Makrogiannis, N. Bourbakis, "A survey of skin-color modeling and detection methods", In *Pattern Recognition*, Vol. 40, pp. 1106-1122, 2007.
[13] W. Kelly, A. Donnellan and D. Molloy, "Screening for Objectionable Images: A Review of Skin Detection Techniques", In Machine Vision and Image Processing Conference (IMVIP '08), 151 – 158, 2008.

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