EXPLICIT CONTENT IMAGE DETECTION

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ABSTRACT

This paper proposes a system gives for explicit content image detection based on Computer Vision Algorithms, pattern recognition and FTK software Explicit Image Detection. In the first stage, HSV color model is used for the input images for the purpose of discriminating elements that are not human skin images. Then the image is filtered using skin detection. The output image only contains the areas of which it is composed. The results show a comparison between the proposed system and the company software Access Data called Forensic Toolkit 3.1 Explicit Image Detection isperformed.

KEYWORDS

Skin Detection, HSV Color Model, Explicit Content, Pattern Recognition, Computer Vision

1. INTRODUCTION

With the development of Internet, dramatically falling costs of data storage and advances in coding technology are generating a dazzling array of photography, animation, graphics sound and video [1]. Nowadays it is easy to have access to a computer with an Internet connection where there is currently a large amount of adult images for free downloading. This kind of media is also available for children and is an increasingly problem for many parents.

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 despite being a tool of computer forensic, helps to detect images with explicit content.

The name of this tool is FTK Explicit Image Detection, which comes in the “FTK 3.1”version. There are some papers on this subject such as: the paper carried out by Forsyth and Fleck who designed software to detect naked people [3], Wiederhold and Wang design an algorithm for recognition of images with doubtful content [4], and Li Chen *et al* design a skin detector based-on Neural Network [5].

There are some investigators who carried out papers about adult image detection as: Xiaoyin Wang *et al*. [6] who proposed an algorithm to detect adult images, Yue Wang *et al*. [7] who proposed a way to help the algorithms to detect objectionable images using nipple detection, Huicheng Zheng *et al*. [8] designed a filtering system to adult images, Wonil Kim *et al*. [9] design a neural network based adult image classification, Jiann-Shu Lee *et al*.[10]proposed an algorithm to naked image detection based on adaptive and extensible skin color model.

In this paper a new algorithm to detect explicit images is proposed. It is based on Computer Vision algorithms and pattern recognition techniques. First the images are changed from the color model to discriminate objects in the image of no interest. In the next part of the proposed system the image is filtered using skin detection, with the aim to segment a person or people within the image. Then we can estimate the probability of the image as an image with explicit content, by counting all pixels with some skin tone.

The paper is organized as follows. An introduction of color models RGB and HSV, and the representation of skin detector used for the system are presented in the section 3 and 4 respectively. Section 4 presents a brief description of the proposed system, and in section 5 are the results. Finally the conclusions are given.

2. COLOR MODELS

2.1. RGB Color Model

The RGB color model 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.

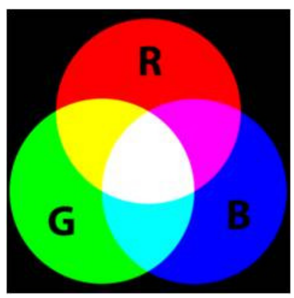


Figure 1. RGB Color Model

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.

2.2. HSV Color Model

HSV color model (Hue, Saturation, and Value) is a no lineal transformation of the RGB space color, and the colors are a combination of the three values: the Hue (H), Saturation or color quantity (S), and itself value (V). These values are represented in a circular diagram, as shown in Figure 2.

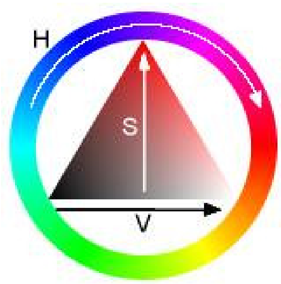


Figure 2. HSV Color Model

The three magnitudes can have the following values

- Hue: The type of color (e.g. red, green, or yellow). These are represented as a degree of angle whose possible values range from 0 to 360° (although for some applications are normalized from 0 to 100%).

- Saturation: Is represented as the distance from the axis of the black-white glow. The possible values range from 0 to 100%.

- Value: Represents the height in the black-white axis. The possible values range from 0 to 100%. 0 is always black. Depending on the saturation, 100 could be white or a more or less saturated color.

Using this color model as an input image is converted using the mathematical expressions (1) to (3) that are shown below.

$$H = \arccos \frac{\frac{1}{2}\left[(R-G)+(R-B)\right]}{\sqrt{\left[(R-G)^2+(R-B)(G-B)\right]}} \quad (1)$$

$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B} \quad (2)$$

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

Once the transformation of the input image was made, it was observed that the skin tone of a person could be seen in a different color from those seen from different objects within the same image. An example of this is shown in Figure 3, which is a sample of conversion to the HSV color model of an image in RGB color model.

(a) (b)

Figure 3. (a) RGB Image (b) HSV Image

As mentioned, an advantage of using this particular color model is that we can rule out many objects using a simple filter, in this case we use skin detection to get only the areas of skin which are the most important for our objective.

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 [11] constructed a color model using histogram-learning techniques at RGBcolor space. Yang and Auhuja [12] 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.* [13], Kakumanu *et al*.[14], Kelly *et al*. [15].

In this paper a novel solution using the HSV color model, which is very similar to the RGB color model, is proposed.

Once the change of color model 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.

To determine the threshold it was necessary to make an analysis of the histograms in the HSV color model. As observed in Figure 4 an image of the face of a girl identified with major clarity the threshold that we need.

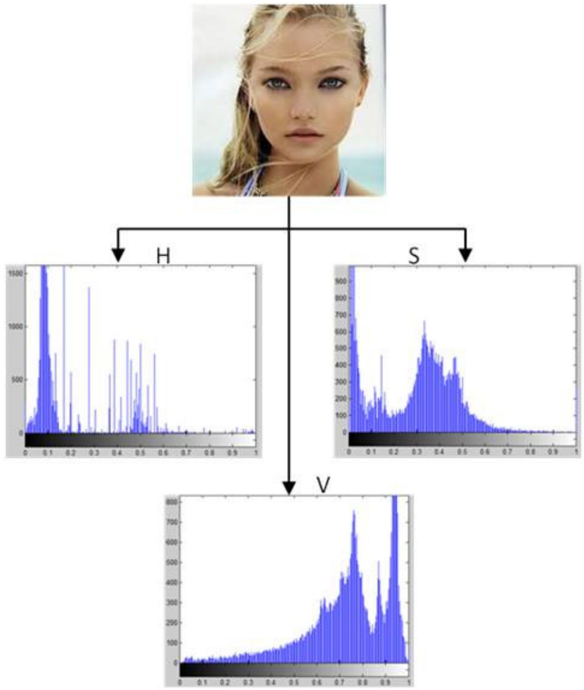


Figure 4. Histograms of HSV Color Model

The histograms observed in Figure 4 helps to have an idea of the values, which could be taken to choose a threshold able to take the skin values. This would be correct if only detecting people with the same skin color of the girl used as reference is desired but in Internet there exists a large amount of images that not only contain people with a specific skin color, but also people with different skin color, so after exhaustive analysis the threshold decided was the following:

$$H > 0 \text{ and } H < 0.25$$

$$S > 0.15 \text{ and } S < 0.9$$

$$V > 0.2 \text{ and } V < 0.95$$

Where H,S,V are in the range from 0 to 1.

With the purpose of finding naked people, there are other kinds of features such as the percentage of pixels detecting similar skin color. Based on these features, a procedure of segmentation is carried out in color images. Some examples are illustrated in Figure 5 which shows people with different skin color and can be seen that the threshold used works appropriately.

(a) (b)

(c) (d)

Figure 5. Skin Color Segmentation

(a) and (c) Original Images, (b) and (d) Segmented Images

The proposed threshold in this section was able to detect skin color zones effectively.

The method proposed for skin detection can find skin areas, but to decide which of a comprehensive set of images contain naked people is still a great challenge.

4. PROPOSED SYSTEM

In the Figure 6 shows the proposed system, which has one part: a classifier.

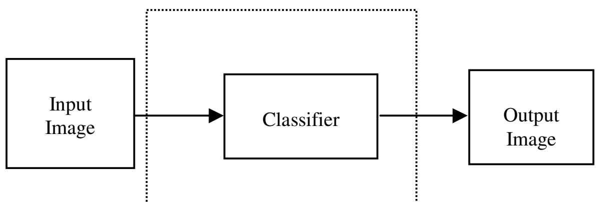


Figure 6.Proposed System

The proposed system is created a classifier, using the HSV color model, which allows us to recognize texture within the image, and this way can detect skin to know if there are pixel areas with some skin tone, and the value of the likelihood that the input image was an image with explicit content can be estimated.

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 prove the performance of the algorithm was used 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 with explicit content people Asians, Caucasian, Europeans, Latin Americans and a little amount of people with black skin can be found. In natural images there are different kinds of images such as: dressed people, animals, plants, cars, cartoons, landscapes and others were also obtained from Internet.

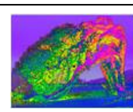
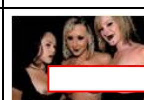
First the input image is transformed from the RGB to the HSV color model. Next stage using the threshold that is proposed in section 3 the image is filtered usingthe skin detection to identify the areas that contain some skin color, and in this way only get the image of the person or people within the input image.

At this point, all skin areas detected are taken, and proceed to count the amount of pixels that there are within the image to estimate the likelihood that this image is classified as an image with explicit content or not. The results obtained are shown in Table 1.

To be able determine if the input image has explicit content, a mathematic expression is proposed, described in (4), 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 to have objectionable content.

$$skin\ percentage = \frac{\#skin\ color\ pixels}{\#image\ pixels\ in\ total} \times 100 \quad (4)$$

Table 1. Classification results using the proposed system

Input Image	Images Classification		
	HSV Image	Proposed Classifier	Skin Percentage
			27.74 %
			26.10%
			58.17%
			64.78%

The Table 1 shows four images of the set, which the proposed system was proved, in this results can be observed that the third and the fourth image are classified as an image with explicit content.

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 people 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.

Also software was used from Access Data called Forensic Toolkit 3.1, to make the comparison between the proposed system and its system to detect images. It makes a forensic image of the device that have to analyze, after the analysis began with three algorithms to determine the percentage of explicit content of an image. The description of the three algorithms used for evaluate the images was obtained from [16] and was shown in the Table 2:

Table 2. Explicit Image Detection Profile Types

Profile Name	Level	Description
X- DFT	Default (XS1)	This is the most generally accurate, It is always selected.
X-FST	Fast (XTB)	This is the fastest. It scores a folder by the number of files it contains that meets the criteria for a high likelihood of explicit material. It is built on a different technology than X-DFT and does not use “regular” DNAs. It is designed for very high volumes, or real-time page scoring. Its purpose is to quickly reduce, or filter, the volume of data to a meaningful set.
X-ZFN	Less False Negatives (XT2)	This is a profile similar to S-FST but with more features and with fewer false negatives than X-DFT. Apply this filter after initial processing to all evidence, or to only the folders that score highly using the X-FST option. Check-mark or highlight those folders to isolate them for Additional Analysis.

To test its system, the same set of input images was used using the three profiles that have. The results of the software are shown in the Table 3.

Table 3. Results obtained with FTK 3.1

Input Image	Algorithms used		
	X-FST	X-DFT	X-ZFN
	99%	0%	99%
	99%	21%	99%
	99%	99%	99%
	0%	0%	0%

The software from Access Data is used only to help the users take decisions whether the images have or lack explicit content, as can be observed in the Table 3. There is a discrepancy between the percentage that gives the result and the content of original image.

6. CONCLUSIONS

This paper proposed an algorithm to detect images with explicit content in color images, using the HSV color model 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.

HSV color model is an important method to be able to decrease all the lighting problems that the image could be had; moreover, using this color model is more visible the skin tone than the RGB color model, for this reason is used HSV color model to be able to do skin detection.

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 image or not, due to explicit content image in most part has color skin pixels.

The importance of the comparison between the proposed system and the software Forensic Toolkit 3.1 was done to know if the proposed system could do the same work, and this way know whether the input image is an explicit content image or not, at final could prove that the system proposed carry out effectively.

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