NUDITY PROHIBITION SYSTEM

Lorenz Tombo Ras[1], Davood Pour Yousefian Barfeh[2]
College of Engineering and Computer Studies
Lyceum of the Philippines University – Laguna, Philippines
[1]lorenz@ywa.com
[2]davoodpb@gmail.com
YWA Human Resource Corporation
Manila, Philippines

ABSTRACT

This research presents a system for prohibiting users from uploading images containing nudity. The system uses face detection, and nudity detection algorithms. These algorithms are used to analyze an image for clues containing nudity. The algorithm performs with 94.779% recall and 5.04% false positive rate on a test set of images consisting of 421 nude images and 635 non nude images.
Due relatively high rate of false positive, a user may appeal the image to the website, and may be subject for manual verification of the image.

Keywords*: nudity, image processing, pornography, skin color, correlation, skin regions*

INTRODUCTION

There are now 7.2 billion people on the planet. There are just over 3 billion active Internet users (45% of the world's internet users). Nearly 2.1 billion people have social media accounts. 3.65 billion mobile users have access to the internet via smartphones and tablets and close to 1.7 billion people have active social media accounts [1]. Given the staggering amount of content self-published by social media users every day, there is no way the site can pre-screen every, or any, post.

But due to the international nature of the Internet, Internet pornography carries with it special issues with regard to the law. There is no one set of laws that apply to the distribution, purchase, or possession of Internet pornography. This means that, for example, even if a pornographer is legally distributing pornography, the person receiving it may not be legally doing so due to local laws, or the other way around.

Cybercrime Laws vary considerably around the world. In general, in most countries, there are no laws which prescribe what clothing is required to be worn. However, the community standards of clothing are set indirectly by way of prosecution of those who wear something that is not socially approved. Those people who wear insufficient clothing can be prosecuted in many countries under various offenses termed indecent exposure, public indecency or other descriptions. Generally, these offenses do not themselves define what is and what is not acceptable clothing to constitute the offense, and leave it to a judge to determine in each case. However, the owner or admin of the site can have its own rule on what content its users share regardless of country rule.

Most clothing laws concern which parts of the body must not be exposed to view; there are exceptions. Some countries have strict clothing laws, such as in Islamic countries. Other countries are more tolerant of non-conventional attire and are relaxed about nudity. Many countries have different laws and customs for men and women, what may be allowed or perceived often varies by gender and age [2].

The current most popular of social media sites, Facebook, has 936 Million daily active users. [3] It is also found that 83% of the 11 to 15 year olds whose internet usage was monitored registered on a social media site with a false age [4]. In Facebook, It relies on users to identify breaches of the community standards. “If you see something on Facebook that you believe violates our terms,” the site implores, “you should report it to us.” [5] It means that an obscene photo for example can be uploaded and be seen by unsuspecting minors before it can be taken down by reports of other users.

For the purpose of this research, the researcher made an account in Facebook containing nudity to test how long it would take Facebook to take down an offensive account. The photos went thru the site’s photo upload system. From day 1, a total of 30 friend request were sent daily. On Day 2, about 200 friend requests came to the account with about 30 messages from men. 12 people who sent messages also contain nudity showing genitals in their account. The account was finally removed on day 4 with 214 friends. The account was public and can be viewed by anyone including children.

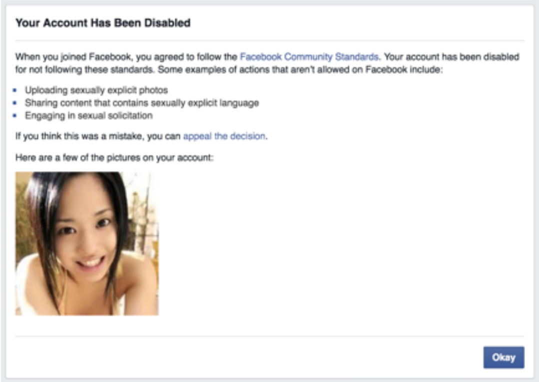

Figure 1 Banned Facebook account

Children often imitate what they've seen, read, or heard. Studies suggest that exposure to pornography can prompt kids to act out sexually against younger, smaller, and more vulnerable children. Experts in the field of childhood sexual abuse report that any premature sexual activity in children always suggests two possible stimulants: experience and exposure. This means that the sexually deviant child may have been molested or simply exposed to sexuality through pornography [6].

Prohibition of nudity from sites accessible especially to children continues to be an active research. Technology companies devoted to image recognition acknowledge that current algorithms in nudity detection are still highly inaccurate. Thus, new system to prohibit nudity from websites is continually being sought.

This paper describes a system for prohibiting users of a website from sharing damaging images, specifically, nudity.

METHODOLOGY

In general the nudity prohibition system consists of the following steps.

1. Face Detection.
2. Classify as non-nudity if most of the picture contains face or else proceed to next step.
3. Use Nudity detection for clues of nudity.
4. If nudity is found, the image is prohibited or the user may appeal for for manual approval.

The method used for Face detection is based on Robust Real-Time Face Detection [7]. It is an approach combining three key contributions for face detection which minimizes computation time while achieving high detection accuracy. The first is called "Integral Image" which allows features used by the detector to be computed very quickly [8]. The second is AdaBoost learning algorithm to select a small number of critical visual features from a very large set of potential features [9]. The third contribution is a method for combining classifiers in a "cascade" which allows background regions of the image to be quickly discarded spending computation on potential face-like regions of the image. Facebook also has its own Facial recognition system called DeepFace. It is also highly accurate as shown in Figure 1.

The system will identify how much area a face occupies in an image image, if the area occupied by the face is about 50%. it will be classified as non-nudity and safe. This is to reduce the computing load for the actual nudity detection.

Figure 2 Facebook face detection.

If the image contains face with less than half of the image or none at all, the system will use a method using nudity detection algorithm by Rigan Ap-apid [10]. The algorithm only has 5.04% false positive rate on a set of images consisting of 421 nude images and 635 non-nude images.

The algorithm used for nudity detection uses a skin color distribution model based on the RGB, Normalized RGB, and HSV color spaces constructed by utilizing correlation and linear regression. The skin color is used to identify and locate skin regions in an image. These regions are then analyzed for clues indicating nudity.

The most important feature that provides clues to image content is color. Color is a low level feature, which makes it computationally inexpensive and therefore suitable for real- time object characterization, detection and localization [11].

Nudity often consists of showing naked persons, special shots of sexual organs, or a picture of sexual intercourse (Lin et al., 2003). These images show a lot of skin and thus, skin color is a basic feature used in nudity detection. A disadvantage of systems using color as a primary feature is that the systems will not work with black and white images.

However, nude images are rarely in black and white.

The simplest methods in skin detection define or assume skin color to have a certain range or values in some coordinates of a color space. Usually, the skin is recognized due to the fact that it is composed of a group of color containing red for the blood and yellow and brown for melanin.

In general, the fairness or darkness of skin depends on the amount of melanin in the skin. Due to the emerging importance of skin detection in computer vision several studies have been made on the behavior of skin chromaticity at different color spaces. Many studies such as those by Yang and Waibel (1996) and Graf et al. (1996) indicate that skin tones differ mainly in their intensity value while they are very similar in chrominance coordinates. Several surveys on the use of color spaces such as those by Zarit et al. (1999) and Vezhnevets et al. (2003) have been made to identify optimal methods for skin detection using different color spaces. While some studies show differences in performance due to the color space used (Terillon et al., 2000), (Vezhnevets et al., 2003), some researchers (Bosson et al., 2002), (Chan et al. 1999) agree that the choice of color space is not critical provided that enough training is done and that an appropriate data set is used. [12], [13],[14],[15],[16]

The main goal of skin color detection or classification is to build a decision rule that will discriminate between skin and non-skin pixels. Identifying skin colored pixels involves finding the range of values for which most skin pixels would fall in a given color space. This may be as simple as explicitly classifying a pixel as a skin pixel if R>G or R>B or both (Brown et al., 2000) or may be as complex as models using neural networks and Bayesian methods (Jones & Rehg, 1999), (Chai & Bouzerdoum, 1999). In general, a good skin color model must have a high detection rate and a low false- positive rate. That is, it must detect most skin pixels while minimizing the amount of non-skin pixels classified as skin [17],[18],[19].

The purpose of a color space is to facilitate the specification of colors in some standard, generally accepted manner. A color space is a specification of a coordinate system and subspace within a system where each color is represented by a single point. Most color spaces today are oriented toward hardware such as color monitors or toward applications where color manipulation is a goal such as the creation of color graphics or animation (Gonzalez & Woods, 2002).

Various color spaces are used for processing digital images. For some purposes, one color space may be more appropriate than others. For skin detection, researchers do not quite agree on whether the choice of color space is critical to the overall performance of the detection system. One obvious reason for this is the lack of a standard set of images that can be used as a benchmark for algorithms using different color spaces.

The RGB color space is one of the most widely used color spaces for storing and processing digital image. However, the RGB color space alone is not reliable for identifying skin-colored pixels since it represents not only color but also luminance. Skin luminance may vary within and across persons due to ambient lighting so it is not dependable for segmenting skin and non-skin regions. Chromatic colors are more reliable and these are obtained by eliminating luminance through some form of transformation. The color spaces Normalized RGB, HSV, and YCbCr are transformations commonly used by studies on skin color [12].

The RGB color space is ideal for hardware implementations. However, it is not well suited for describing colors in terms that are practical for human interpretation. For example, we do not refer to the color of a car in terms of the percentages of each of the primary components composing color. We also do not think of a color image as being the composite of three images. When humans view color objects, we describe them in terms of hue, saturation, and brightness (Gonzalez & Woods, 2002).

The HSV (Hue, Saturation, Value/Intensity/Luminance) color space describes color with intuitive values, based on the artist's idea of tint, saturation and tone. This was introduced when there was a need to specify color properties numerically. Hue defines the dominant color as described by wavelength, for instance the distinction between red and yellow. Saturation measures the colorfulness of an area in proportion to its brightness such as the distinction between red and pink. Value refers to the color luminance, the distinction between a dark red and a light red.

For skin detection, the value component is discarded to eliminate the undesirable effect of uneven illumination. The transformation is defined by

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

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

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

Some studies show that HSV is invariant to highlights at white light sources, to matte surfaces, and ambient lighting. However, hue discontinuities and the computation of the luminance component conflict badly with the properties of color vision. The cyclic nature of Hue-Saturation spaces also makes it inconvenient for parametric skin color models that need a tight cluster of skin performance for optimum performance (Vezhnevets et al., 2003).

The Normalized RGB color space removes the luminance component through the normalization

$$r = \frac{R}{R+G+B}$$

$$g = \frac{G}{R+G+B}$$

$$b = \frac{B}{R+G+B}$$

Since the sum of the three components r, g, and b is 1, the blue (b) component can be omitted to reduce space dimensionality.

In summary, the nudity detection algorithm works in the following manner.

1. Scan the image starting from the upper left corner to the lower right corner.
2. For each pixel, obtain the RGB component values.

3. Calculate the corresponding Normalized RGB and HSV values from the RGB values.
4. Determine if the pixel color satisfies the parameters for being skin established by the skin color distribution model.
5. Label each pixel as skin or non-skin.
6. Calculate the percentage of skin pixels relative to the size of the image.
7. Identify connected skin pixels to form skin regions.
8. Count the number of skin regions. Identify pixels belonging to the three largest skin regions.
9. Calculate the percentage of the largest skin region relative to the image size.
10. Identify the leftmost, the uppermost, the rightmost, and the lowermost skin pixels of the three largest skin regions. Use these points as the corner points of a bounding polygon.
11. Calculate the area of the bounding polygon.
12. Count the number of skin pixels within the bounding polygon.
13. Calculate the percentage of the skin pixels within the bounding polygon relative to the area of the polygon.
14. Calculate the average intensity of the pixels inside the bounding polygon.
15. Classify an image as follows:
    a. If the percentage of skin pixels relative to the image size is less than 15 percent, the image is not nude. Otherwise, go to the next step.
    b. If the number of skin pixels in the largest skin region is less than 35% of the total skin count, the number of skin pixels in the second largest region is less than 30% of the total skin count and the number of skin pixels in the third largest region is less than 30 % of the total skin count, the image is not nude.
    c. If the number of skin pixels in the largest skin region is less than 45% of the total skin count, the image is not nude.
    d. If the total skin count is less than 30% of the total number of pixels in the image and the number of skin pixels within the bounding polygon is less than 55 percent of the size of the polygon, the image is not nude.
    e. If the number of skin regions is more than 60 and the average intensity within the polygon is less than 0.25, the image is not nude.
    f. Otherwise, the image is nude.

False positives cannot be avoided because images have characteristics that are very similar to that of nude images. In which case, a user uploading images who may find pictures wrongly classified by the system may file an appeal for manual classification of the image.

The researcher was not able to obtain data sets aside from the one used by author of the algorithm used in this system.

CONCLUSION

The researcher concludes that prohibition of nudity from websites as big as Facebook is possible with available methods although with some limitations to make it fully automated. For example, the system may let some images containing nudity to go through the site by changing the image's skin colors to trick the system. In this case, the researcher believes that by combining a good report system and available image comparison algorithims, copies or reuploads of the image may also be systematically removed or banned from the site.

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