Pornography Detection Based on Morphological Features

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Abstract

This paper proposes a new pornographic image detection system. The system is divided into several major components to perform skin color segmentation, texture analysis, and pornographic image detection. Some effective features such as holes and clothes inside chest area are utilized to exclude bikini pictures. The mug shots can be effectively eliminated based on the ratio of face skin area to total all skin area. The experimental results show that the proposed method can achieve correct classification rate 92.86%.

1. Introduction

In this information explosion era, people can access any kind of information through Internet unprecedentedly. While people are experiencing and enjoying the benefit from text-based information to any type of multimedia brought by the World Wide Web, some have taken advantage of its uncontrollable weakness and provided harmful materials for people who are not eligible to access them. Pornographic materials are one of such examples. More than decades ago, researchers [1-3] have begun the study of pornographic detection technique in order to prevent juvenile to get access to adult materials which they are not allowed to.

In general, the core mechanism of pornographic image detection system can be divided into two stages, the first stage is skin area detection and the second stage is feature detection from skin area. With features detected, an input image can be classified as pornographic image by some trained classifier. Using Input-Process-Outputmodel, there are three phases during detection process, which needs to be taken care of.

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For input phase, an input image may contain adult or non-adult contents. Furthermore, an adult image may be taken under special lighting, or it may contain different skin color of different races, whereas a non-adult image could be mug shots, normal bikini pictures or pictures of natural scenes such as desert or building's color is similar to skin color. For the process phase, it can be further divided into three stages. The first stage of the process phase is the skin area segmentation. The second stage of the process phase is texture verification of skin region. With the aid of texture analysis, the false positive can not only be reduced, but also affect the true positive. The third stage of the process phase is morphological features extraction from skin region. The most commonmorphological features are low-level features such as eccentricity, compactness and rectangularity and high-level features such as normal moment and Zernike moments [4]. Besides these features, the size of skin region, color histogram, and low-level features based on color or textures have also been considered during features extraction process. For output phase, classifiers such as *K-NN* [5], Support Vector Machine (SVM) [6], or *AdaBoost*[7-8] have been used for image classification tasks.

Most existing pornography detection methods can not well handle the over detection problem for bikini pictures and mug shots. In this paper, we propose a new pornography detection scheme that can effectively exclude the interference of bikini pictures and mug shots. Most pornographic images contain figures of naked persons and usually expose a lot of skin color. Hence, the skin area occupation rate is an important clue for the presence of a pornographic image. For low-level geometrical constraints, we introduce several morphological features to further eliminate bikini images or mug shots that frequently cause false positive for pornography detection.

The remainder of this paper is organized as follows: In Section 2, we describe in detail the proposed design methodology for the system, and in Section 3, we present several outcomes of experiments that are conducted by using the proposed methodology. Finally, the conclusions are made in Section 4.

2. The Proposed Method

The proposed system can be divided into three subsystems: Skin Segmentation Subsystem *(SSS)*, Texture Analysis Subsystem *(TAS)* and Pornographic Image Detection Subsystem *(PIDS)*. The SSS is used for separating image colors into skin clusters and non-skin clusters. The actual skin regions in image will be verified by *TAS*. Finally, the *PIDS* will eliminate mug shots and bikini pictures and perform features extraction with respect to skin regions in order to form feature vectors, which are then used to classify pornographic image by a SVM classifier. The design of each system will be described in detail in the following sections.

2.1. Skin Segmentation

In this paper, we adopt *YCbCr* as color space for skin color detection. It has been shown that the *YCbCr* color space is not sensitive with respect to varied lighting conditions, and it also provides compact distribution for human skin colors incertain ranges. To further deal with

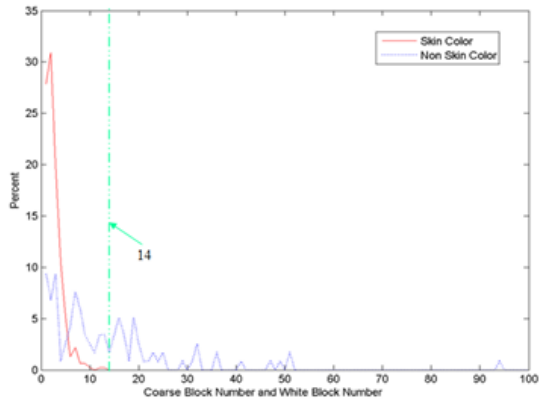

Figure 1: The statistics of CWR for skin color and non-skin color, respectively.

the chromatic deviation coming from special lighting without increasing false alarm, we adopt the learning based chromatic distribution-matching scheme proposed by Lee et al. [8] that consists of the online sampling mechanism and the one-class-one-net neural network. The skin regions detected by this subsystem are denoted as *SR*.

2.2. Texture Analysis

Using the *SR* obtained from above step, we will conduct texture analysis for the input image. First, the *SR* will be divided into many non-overlapping blocks. The size of each block is 5 by 5. Here we only consider the all white pixels blocks which corresponds to candidate skin region of the original image. After we obtain all white pixels blocks, the variance of luminance will be calculated. If the luminance value is greater than the predefined threshold TH_{var} , this region will be marked as coarse region; otherwise we consider it as smooth region. This statisticsis is obtained according to the following rules:

$$P_{skin}(V) = Num(S|V)/Num(TotalBlock) \quad (1)$$

$$P_{nonskion}(V) = Num(NS|V)/Num(TotalBlock) \quad (2)$$

where $P_{skin}(V)$ denotes the probability of skin color with variance V and $P_{nonskin}(V)$ denotes the probability of non-skin color with variance V , $Num(S|V)$ denotes the number of skin color blocks with variance V and $Num(NS|V)$ denotes the number of non-skin color blocks with variance V , and $Num(TotalBlock)$ denotes the total number of blocks for all skin blocks and non-skin blocks. Here, we adopt 105 as the threshold for variance TH_{var} .

After knowing the coarse region, the ratio of coarse block number to white block number (*CWR*) will be calculated. Figure 1 shows the percentage relation of *CWR*.Without affecting skin color image, the threshold TH_{CWR} of *CWR* is set to 14. Therefore, if the value of *CWR* is greater than TH_{CWR} , we will conclude that the image is a non-skin image. Figure 2 shows some testing results forapplyingthis procedure.

2.3. Pornographic image detection

In general, most adult images contain great amount of skin regions, so if we know about the ratio of skin area to image area, we could eliminate images with small skin region beforehand. At the end, we first investigate this ratio from our adult images database and non-adult images database. This database contains 340 adult images and 242 non-adult images. In our study, we find that when the ratio is close to 10%, the percentage of adult image is almost 0 and non-adult image is close to 87% (Figure 3). This information tells us that for most non-adult images, the skin region doesn't occupy a lot of image area. On the contrary, there are a lot of skin regions occupied in adult images. Also, we find that when the area of the skin region takes up 10% of the total image area, it indicates that the image could be an adult image. In order not to miss any adult image, we can detect the threshold TH_{SALAR} set to 10%.

From observation, we see that in most of adult images, the number of skin regions is small and we define this quantity as skin area number (*SAN*). The statistics of *SAN* for adult images, non-adult images and bikini pictures from our database tells us two thresholds TH_{SAN1} and TH_{SAN2} for *SAN* (Figure 4). If the value of *SAN* lies outside TH_{SAN1} and TH_{SAN2}, the image is considered as non-adult image.

If an input image can still pass above two verifications steps, we can conclude that at this point, the input image possesses large area of skin region. And this image could be an adult image, bikini picture, ormugshot. To handle mug shots, we employed face detection method in order to eliminate mug shot. There are many researches and implementations for face detection and face tracking,and in this study, we use the open source software OpenCV [9] and Haar face detection method used in [10].It is easy to seethatthere is some regularityin mug shots.

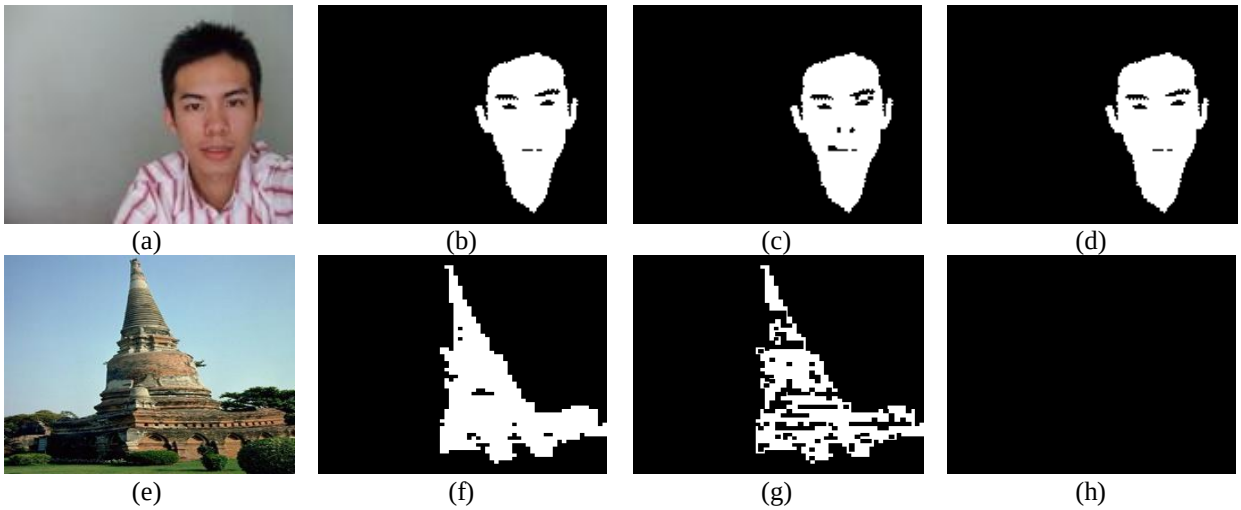

Figure 2:(a)(e) Original images (b)(f) Binary images after skin detection (c)(g) Coarse region (d)(h) Texture analysis results.

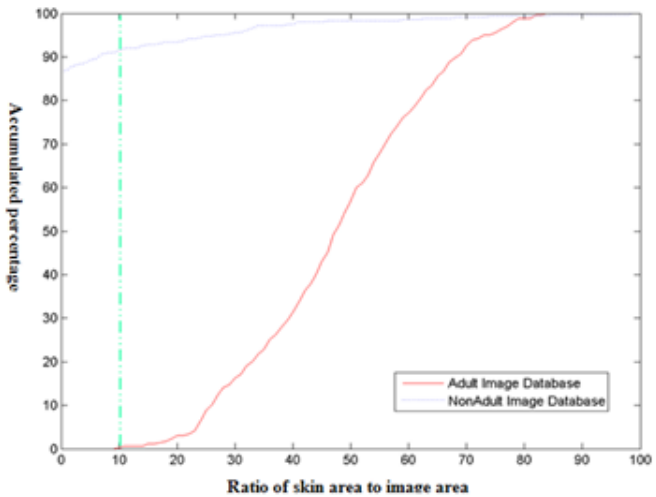

Figure 3: The accumulated percentage for the ratio of skin area to image area for adult and non-adult images database respectively.

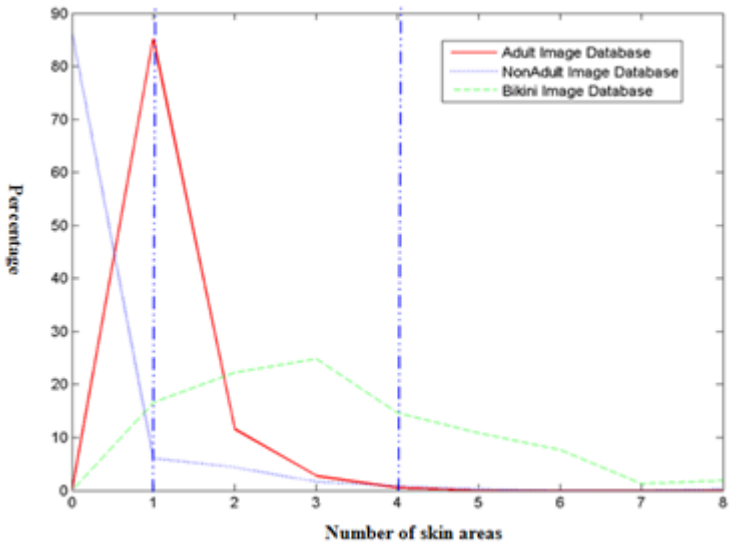

Figure 4: The statistics information for the number of skin areas for adult, non-adult, bikini pictures.

For example, the face usually takes up large amount of area with respect to the area of mug shot itself. Hence, we define *FAR* as the ratio of face skin area (*FSA*) to total all skin area (*ASA*) [8]:

$$FAR = FSA / ASA$$

The threshold TH_{FAR} for *FAR* is set to 0.4 (Figure 5). If TH_{FAR} is greater than 0.4, the input image will be considered as mug shot; otherwise, it is considered as image with great amount of skin color area.

In order to take care of bikini pictures, we see that most bikini pictures containholes in its binary image.But

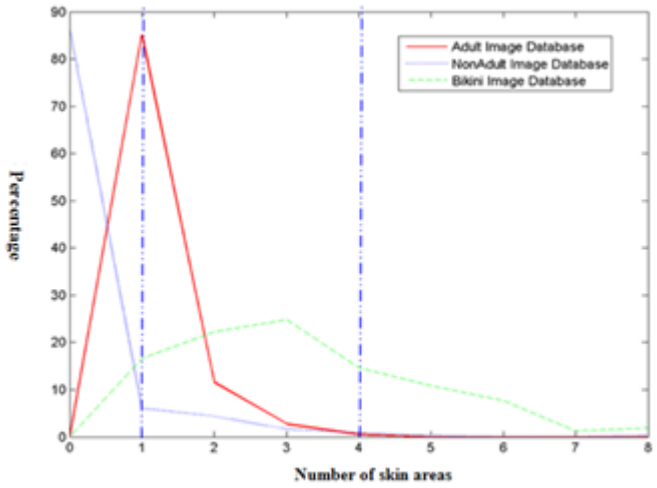

Figure 5: The statistics of FAR for mug shots and adult images in database, respectively.

(a) (b)

Figure 6: The difference between the binary images of adult image and bikini image.

for adult images, the binary images do not reveal this kind of shape appearance. Figure 6 illustrates an example of this case. Therefore, we define a morphological property called the circumference to area ratio *(CAR)* for the largest skin region as follows:

$$CAR = circumference / area$$

We choose 0.14 as the threshold TH_{CAR} of *CAR* (Figure 7).

If we further investigate the remaining 70% of bikini pictures carefully, we can find that the poses are mostly standing and facing front. Also, there are clothes covering in front of chest. Therefore, we can continue on using the Haar face detection in previous section to first construct a bounding box for face area, then using the centroid of face area as the starting position, then move the box downward to the place which is 1.2 times the height of the face bounding box. This position will be marked as the center of chest area. Then, the chest area is defined as the rectangle with length same as face bounding box and width twice the size of face bounding box. This is shown in Figure 8. After the chest area is found, we can define a proper threshold to check whether there is any clothes inside this area. The decision criterion is based on the ratio of the non-skin area *(NSA)* in chest area and chestregion area *(NCAR)*:

$$NCAR = NSA / CRA$$

We choose the threshold TH_{NCAR} for *NCAR* to be 0.2 (Figure 9). That is, if the value of *NCAR* of the input image is greater than 0.2, the image is considered as bikini image.

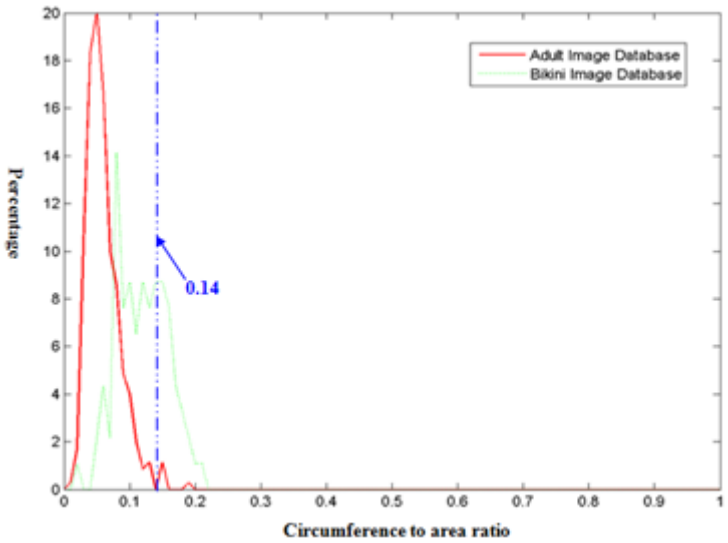

Figure 7: The statistics of CAR for adult images and bikini images in database, respectively.

(a) (b)

Figure 8: (a) Original image (b) Chest bounding box.

For remaining images, we will further extract information about position and morphological features in order to make the system more robust. For position feature, we calculate the distance between the centroid of skin region and center of input image. The reason is that for a meaningful adult image, the skin region is most likely to locate around the center of the image. For morphological features, we consider two features in this study: one is the ratio of long axis to short axis for skin region, and another is the ratio of skin region area to its bounding box area. The reason for the first consideration comes from the fact that the human body structure maintains certain aspect ratio. And the reason for the second consideration is that for the area that we are interested in an adult image, the area of skin region and that of interested area must maintain some appropriate ratio. Figure 10 illustrates morphological features that an adult image won't possess. After extracting position and morphological features from skin region, a feature vector PV will be form as follows:

PV ={distance, long/short axis ratio, area ratio}

The feature vectors will be extracted from our training image database for adult images and non-adult images. And they are used to train a SVM classifier for adult image classification.

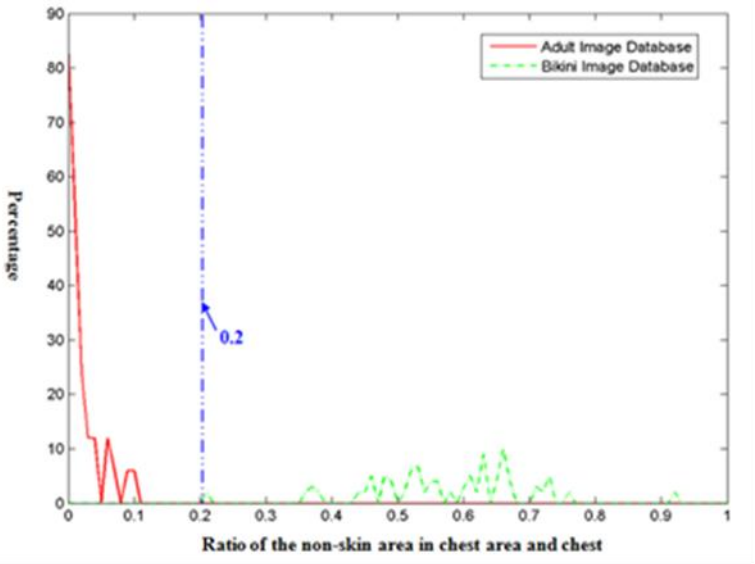

Figure 9: The statistic of *NCAR* for adult images and bikini images in database

(a) (b)

Figure 10:Morphological features that an adult image won't possess.

3. Experimental Results

The image dataset consists of 970 naked images and 692 non-naked images, in which 35% images were adopted as the training data. The remains were treated as the test data. We conducted serial experiments to see the performance of our pornographic image detection system based on the morphological features. There are 6 thresholds used and they are TH_{SALAR} , (TH_{SAN1} and TH_{SAN2}), TH_{FAR}, TH_{CAR} and TH_{NCAR} with value 0.1, (1, 4), 0.4, 0.14 and 0.2. Table 1 shows the experimental results for each step described in section 2.3. The results revealthat our method can detect pornography in accuracy 92.86%. Table 2 shows the performance of using different combination of features such as distance, long/short axis ratio, and skin area/bounding box ratio. The results show that each feature contributes specific information so that combining all of them can provide the best performance. Table 3 shows the performance of using the above three features for detecting pornographic images and bikini images. We can see that the true positive rate for bikini images detection is greater than 90%. The accuracy for discriminating pornographic images and bikini images is 95%. This result reveals that our method can effectively cope with the interference coming from bikini images.

Table 1. Performance of each step for pornographic image detection.

Condition	TP	FP	Acc
Area of Skin Region	99.52%	17.34%	91.19%
Number of Skin Region	98.45%	15.85%	91.80%
Circumference and area ratio	98.07%	15.22%	91.84%
Area of Face Area	98.07%	14.97%	92.05%
Non-Skin Color in Chest Area	98.07%	13.96%	92.70%
SVM	97.42%	12.80%	92.86%

Table 2. Performance of different feature selections.

Feature Selection	*TP*	*FP*	*Acc*
Distance (Feature 1)	96.77 %	13.80 %	92.05 %
Long/Short Axis Ratio (Feature 2)	91.29 %	20.80 %	85.89 %
Skin Area/Bounding Box Ratio (Feature 3)	94.52 %	24.80 %	85.89 %
{Feature 1, Feature 2}	97.58 %	13.60 %	92.59 %
{Feature 1, Feature 3}	97.10 %	13.60 %	92.32 %
{Feature 2, Feature 3}	92.90 %	10.00 %	87.14 %
{Feature 1, Feature 2, Feature 3}	97.42 %	12.80 %	92.86 %

Table 3. Performance of using {Feature 1, Feature 2, Feature 3} for detecting pornographic images and bikini images.

Original Image → Detection Result	Percentage
Pornographic Image →Pornographic Image	95.56 %
Pornographic Image → Bikini Image	4.44 %
Bikini Image →Pornographic Image	7.76 %
Bikini Image → Bikini Image	92.24 %

4. Conclusions

In this paper, a new pornographic image detection method is proposed. This method can eliminate pictures containing head only or swimming suit. The remaining pictures consist of images with great amount of skink color. A feature extraction process is applied to those pictures based on position and morphological features. A SVM classifier is used to classify whether the input image is a pornographic image. The experimental results show that our method is a currently outperformed method.

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