

Patch-Based Skin Color Detection and Its Application to Pornography Image Filtering

Haiqiang Zuo^{†,‡} Weiming Hu[†] Ou Wu[†]

[†]National Laboratory of Pattern Recognition, Institute of Automation, CAS, Beijing, China

[‡]China University of Petroleum, Qingdao, China
 { hqzuo, wmhu, wuou }@nlpr.ia.ac.cn

ABSTRACT

Along with the explosive growth of the World Wide Web, an immense industry for the production and consumption of pornography has grown. Though the censorship and legal restraints on pornography are discriminating in different historical, cultural and national contexts, selling pornography to minors is not allowed in most cases. Detecting human skin tone is of utmost importance in pornography image filtering algorithms. In this paper, we propose two patch-based skin color detection algorithms: regular patch and irregular patch skin color detection algorithms. On the basis of skin detection, we extract 31-dimensional features from the input image, and these features are fed into a random forest classifier. Our algorithm has been incorporated into an adult-content filtering infrastructure, and is now in active use for preventing minors from accessing pornographic images via mobile phones.

Categories and Subject Descriptors

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval – *Information filtering*.

General Terms: Algorithms, Security.

1. INTRODUCTION

Over the past few decades, the explosive growth of the World Wide Web is reshaping the nature and environment of pornography at an accelerated pace. An immense industry for the production and consumption of pornography has grown, and pornography has become widely popular and generally distributed. The internet offers nearly free access to pornography uninhibited by previous barriers of time and space. Though the censorship and legal restraints on pornography are discriminating in different historical, cultural and national contexts, selling pornography to minors is not allowed in most cases. Detecting human skin tone is of utmost importance in most of pornography image filtering algorithms, and most of existing skin tone detecting algorithms are pixel-based methods [1], classifying each pixel as skin or non-skin individually. However some attributes of human skin tone, such as textures, are only valid in a region. In this paper, we propose a patch-based skin color detection algorithm that verifies whether all the pixels in a small patch correspond to human skin tone at one time.

2. PATCH-BASED SKIN COLOR DETECTION

We first convert the original image from RGB color space to orthogonal YCbCr color space. The YCbCr space is one of the most popular choices for skin tone detection and has been used by many researchers such as Hsu et al.[2]. Y is the luminance (or intensity) component and Cb and Cr are the blue-difference and red-difference chrominance components. The image is split into small patches, and

according to different patch generation methods, we develop two kinds of skin color detection algorithms.

- ✧ Regular Patch Skin Color Detection. The patches are nonoverlapping sliding rectangle windows (Figure 1 the red rectangles over each image component).
- ✧ Irregular Patch Skin Color Detection. The patches are irregular regions (or superpixels) generated by a common image segmentation algorithm. The last second row in Figure 2 demonstrates the segmentation results of Felzenszwalb algorithm [3].

We extract 19-dimensional skin tone features on each patch. The first set of 15 features are skin tone texture features, and we use a covariance descriptor [4] to model skin texture. We extract image intensity and norm of first and second order derivatives of intensity in both x and y directions. Each pixel is mapped to a 5 dimensional feature space

$$F(x,y) = \left[I(x,y) \left| \frac{\partial I(x,y)}{\partial x} \right| \left| \frac{\partial I(x,y)}{\partial y} \right| \left| \frac{\partial^2 I(x,y)}{\partial x^2} \right| \left| \frac{\partial^2 I(x,y)}{\partial y^2} \right| \right]^T, \quad (1)$$

and each patch can be represented as a 5×5 dimensional symmetric covariance matrix:

$$C_R = \frac{1}{S-1} \sum_{i=1}^S (z_i - \mu)(z_i - \mu)^T. \quad (2)$$

The nonsingular covariance matrices can be formulated as a connected Riemannian manifold, and tangent space projection techniques are used to map the covariance features into a R^m vector space. The tangent space is a $m=15$ -dimensional vector space. Hence normal machine learning techniques can be used with these features. The last 4 features are the mean and standard deviation of patches in the Cr and Cb components respectively. Figure 1 demonstrates the whole skin tone feature extraction processes.

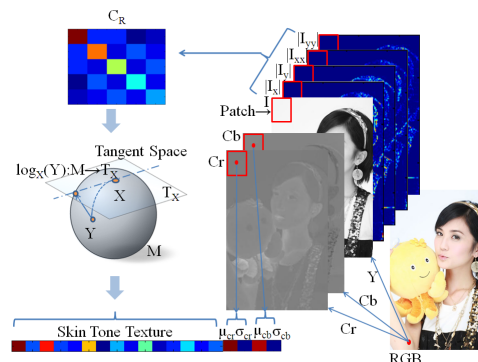


Figure 1. Patch-based skin tone feature extraction process.

For the regular patch skin color detection algorithm, integral images are employed to accelerate the feature extraction procedure. Initially, the patch size is set to 32×32 , and the patch will be split into smaller ones as to 4×4 if the sum of standard deviation of patches in the Cr and Cb components exceeds a predefined threshold.

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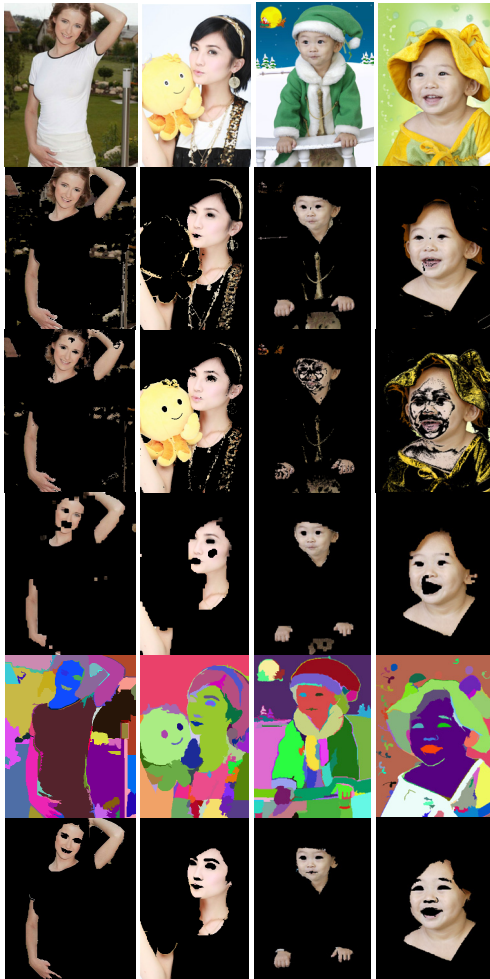


Figure 2. Skin tone detection results: (top row to bottom) original image, result of Hsu [2], result of GMM [5], result of proposed regular patch algorithm, Felzenszwalb image segmentation[3], result of proposed irregular patch algorithm.

We collect 17,812 skin patches and 31,623 non skin patches, and the features extracting from these patches are used to train a random forests [6] classifier. Figure 2 the last third row and the last row demonstrate the results of our regular and irregular patch skin color detection algorithms respectively. The former algorithm is faster, but the obtained skin region boundaries are jagged. The latter algorithm can obtain more satisfactory results.

3. PORNOGRAPHY IMAGE FILTERING

On the basis of skin detection, we extract 31-dimensional features from the input image. The fist 5 features are global image features:

- ✧ The image aspect ratio;
- ✧ The image entropy;
- ✧ The proportion of skin region;
- ✧ The skin region spatial moments (10 dimension);
- ✧ The number of skin region.

The following 4 features are related to human body part detection, and haar-like features [7] are employed. Figure 3 demonstrates the detection results.

- ✧ The number of detected faces;
- ✧ The number of detected breasts;
- ✧ The number of detected vulvas;
- ✧ The ratio of skin area in the detected faces and that in the whole image.

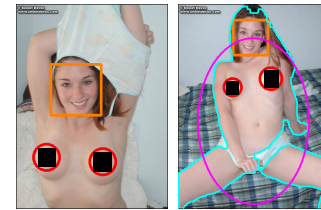


Figure 3. Human body parts detection.

The last 7 features are extracted from the largest skin region (LSR, as shown at the right side of Figure 3, indicated by the aqua line) and its fit ellipse [8] (as shown at the right side of Figure 3, indicated by the fuchsia line) of the input image.

- ✧ The ratio of LSR area and the skin area in the whole image;
- ✧ The distance from the center of fit ellipse to the center of input image;
- ✧ The ratio of the fit ellipse axes;
- ✧ The tilt angle of the fit ellipse;
- ✧ The Hu invariant moments [9] of the LSR (7 dimension);
- ✧ The roundness [10] of LSR;
- ✧ The irregularity [10] of LSR.

Once the features have been computed for an image, they are fed into a random forest [6] classifier. Our training set consists of 13,649 images; and among them, 3,784 were pornography and 9,865 were not. The test set consists of 26,151 images; and 11,809 were pornography and 14,342 were not. At the test set, our algorithm gets a recall 98.8% and precision 96.5%. As there does not exist a public consistent test set, and image quality, resolution, brightness etc. greatly affect experimental results, so comparing with others is of little significance.

4. CONCLUSIONS

We have proposed two patch-based skin color detection algorithms: regular patch and irregular patch skin color detection algorithms. On the basis of skin detection, we have extracted 31-dimensional features from the input image, and these features are fed into a random forest classifier. Our algorithm has been incorporated into an adult-content filtering infrastructure, and is now in active use for preventing minors from accessing pornographic images via mobile phones.

5. ACKNOWLEDGMENTS

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6. REFERENCES

- [1] V. Vezhnevets, V. Sazonov, A. Andreeva. A Survey on Pixel-Based Skin Color Detection Techniques. Graphicon, 2003.
- [2] R. Hsu, M. Abdel-Mottaleb, A. K. Jain. Face Detection in Color Images. PAMI, 2002.
- [3] P. Felzenszwalb and D. Huttenlocher. Efficient graph-based image segmentation. IJCV, 2004.
- [4] O. Tuzel, F. Porikli, and P. Meer. Region Covariance: A Fast Descriptor for Detection and Classification. ECCV, 2006.
- [5] M. J. Jones and J. M. Rehg. Statistical color models with application to skin detection. CVPR, 1999.
- [6] L. Breiman. Random Forests. Machine Learning, 2001.
- [7] P. Viola and M. J. Jones. Rapid Object Detection Using a Boosted Cascade of Simple Features. CVPR, 2001.
- [8] H. Zheng, M. Daoudi and B. Jedynek. Blocking Adult Images Based on Statistical Skin Detection. ELCVIA, 2004.
- [9] M. K. Hu. Visual Pattern Recognition by Moment Invariants. IRE Trans. Info. Theory, 1962.
- [10] C. R. Aragon, D. B. Aragon. A fast contour descriptor algorithm for supernova image classification. SPIE, 2007.