

Detection of Human Faces in Color Nature Image

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Abstract: We present an approach for face detection based on skin color segmentation and unification. The proposed approach composed of three steps: the skin color segmentation step where an input image is segmented by using vector quantization (VQ) clustering algorithm, the skin color unification step where the cluster centers of the VQ results are integrated to generate candidate face regions in considering the Hue color component distribution of skin color in each cluster, and the verification step where the face candidate regions are verified with facial features. Comparisons with the existing face detector show that our method gives 5 ~ 10% more accurate detection rate.

1. Introduction

The face detection from an image is an important issue that is usually used in a wide range of applications such as face recognition, security and multimedia retrieval system. An excellent survey of the relevant literature can be found in [1]. The methodologies vary, but the research mainly centers around three different approaches such as template matching approaches, feature based approaches and appearance based approaches. It is noted that skin color feature based face detection approaches have several advantages compared to others such as fast processing of feature extraction and robustness in geometric variations of face patterns.

Utilizing the skin color information, the proposed skin color segmentation and unification approach more improves the performance of the face detection.

2. Skin Color Segmentation

The skin color segmentation is to segment an input image into meaningful skin color regions by using a vector quantization (VQ) clustering algorithm.

A skin color classifier [2] in RGB color space is applied to coarsely classify the pixels in the image into skin and non-skin colors as shown in Figure 1. And then, to reduce the size of input feature vectors, RGB color space is transformed into a HSV color space only for remaining skin color pixels.

Accordingly, morphological closing operator with 3×3 size structure elements is applied to the skin color pixels. Moreover, for the data simplification of input vectors as well as for the reducing of the color sensitivity to the noises, we quantize the HSV color components into 36 bins for Hue color component, and 3 bins for both of Saturation color component and Value color component, resulting in regions shown in Figure 2. that is represented with quantized skin color pixels in RGB color space.



Figure 1. The results of skin color classifier

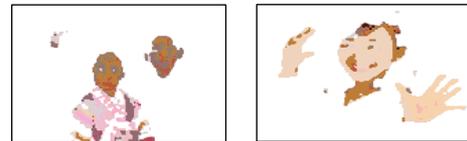


Figure 2. The quantized skin color pixels

These quantized HSV color components are taken as input feature vectors to the VQ clustering algorithm. Note that it does not need for the VQ clustering to take all pixels in the image due to the similarity of colors between neighboring pixels. Thus, we sample every two other pixels in the horizontal and vertical dimensions for the VQ clustering.

In the skin color segmentation, we can significantly reduce not only the number of input feature vectors but also the required clustering time for VQ clustering where we can flexibly obtain the representative of skin color features from the HSV quantized color image. Figure 3(a) shows the pixels corresponding to each cluster obtained from the result of VQ.



(a) Pixels corresponding to each cluster obtained from the result of VQ



(b) Integrating selected cluster and generating face candidate regions

Figure 3. Skin color segmentation and unification

3. Skin Color Unification

The skin color unification integrates cluster centers to generate face candidate regions by considering Hue color component distribution of skin color in each cluster. In HSV color space, a skin color can be identified by the presence of a certain set of Hue color component that are narrowly distributed from 0 degree to 50 degrees. The Hue color component histograms are extracted from all cluster and then the coefficient of Hue color (C_{Hue}) is calculated as follows:

$$C_{Hue} = 0.1 \times h_1 + 0.2 \times (h_2 + h_5) + 0.25 \times (h_3 + h_4) \quad (1)$$

where, h_1, h_2, h_3, h_4 and h_5 are the number of pixel in the quantized Hue color component histogram bins for 10 degrees, respectively (h_1 : 0~10°, h_2 : 11~20°, h_3 : 21~30°, h_4 : 31~40°, h_5 : 41~50°).

If the C_{Hue} of each cluster greater than or equal to the predefined threshold Th , the cluster is selected and merged into a merged cluster that includes face candidate regions as following:

$$Merged\ cluster = \bigcup_{i=1}^N P_i, \text{ if } C_{Hue}^{(i)} \geq Th, i \in [1 \dots N] \quad (2)$$

where, P_i is the set of pixels corresponding to i^{th} cluster center and $C_{Hue}^{(i)}$ is the set of coefficients to i^{th} cluster center. In Figure 3(a), Clusters marked with a red triangle are selected by considering skin color distribution of Hue color component.

To locate face candidate regions from the integrated cluster as shown in Figure 3(b), two methods are applied: one is the *region growing algorithm* to exclude the small regions and the other is horizontal and vertical *projection histograms* to estimate the boundary of the face.

From the experimental results, the size of face candidate region must be at least 30×30 pixels, otherwise the extraction of facial features and the verification procedure can not be performed.

4. Face Verification

Not all face candidate regions contain faces since there are regions that represent exposed part of the body such as hands and neck, and even objects with similar color to the skin color.

The most common approach is to find various facial features within the skin region such as the eyes, the nose and the mouth.

Our face verification procedure relies on the detection of the eyebrows, the eyes and the mouth in the face candidate region. Facial features can be determined by searching for maxima in the pixel value relief, which is simply obtained from the projection of gradient pixel values [3]. Face verification results are shown in Figure 4.



Figure 4. Face verification results

5. Experimental Results and Conclusion

For a data set of 1,490 images with 3,534 faces, an 83.4% detection rate is obtained. Results are presented in Table 1. The faces that were missed due to the following reasons: (1) The face regions are broken into small pieces due to inhomogeneous skin color; (2) Two or more faces are so close to each other that they merged into one; (3) The faces are merged with other parts of body or background with similar color.

Table 1. Detection results of the proposed method

	390 images captured by us	1,100 images from Internet
Total number of faces	894	2,640
Number of correct detections	737	2,228
Number of false detections	104	268
Number of miss detections	157	412
Detection Accuracy (83.4%)	81.8 %	84.6 %
False Positive (10.9%)	11.6 %	10.2 %
False Negative (16.6%)	17.6 %	15.6 %

In addition, we compared the proposed method with the well known face detector developed by Rowley et al.[4] and Viola et al.[5]. Comparison for a data set of 218 images with 281 faces show that our method gives 5 ~ 10% more accurate detection rate. Comparison rate results are described in Table 2.

Table 2. Comparison results with other methods

	Our method	Method[4]	Method[5]
Total number of faces	281	281	281
Number of correct detections	232	218	204
Number of false detections	23	5	2
Number of miss detections	49	63	67
Detection Accuracy	82.6%	77.6%	72.6%
False Positive	8.2%	1.7%	0.7%
False Negative	17.4%	22.4%	27.4%

References

- [1] M.H. Yang, D.J. Kreigman, N.Ahuja, T.A. Jones, "Detecting faces in images: a survey," *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol. 24, pp.34-58, 2002.
- [2] M. Fleck, D.A. Forsyth, C. Bregler, "Finding naked people," *European Conference on ComputerVision*, Vol. 2, pp.592-602, 1996.
- [3] G. Bebis, S. Uthiram, M. Georgiopoulos, "Face detection and verification using genetic search," *International Journal of Artificial Intelligence Tools*, Vol. 20, pp.225-246, 2000.
- [4] H.A. Rowley, S. Baluja, T. Kanade, "Neural network based face detection," *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol.20, pp.23-28, 1998.
- [5] P. Viola, M. Jones, "Robust real time object detection" *International Journal of Computer Vision*, Vol.57, pp.137-154, 2004.