Minimizing false detection of skin color by using background subtraction

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Abstract – Detecting skin color from image sequences has played an important role in many computer vision applications, such as face detection and tracking. Even though there are a number of approaches for skin color detection, most of the existing algorithms produce false positives when non-skin pixels have similar color to skin color. To overcome this problem, this paper proposes a method that combines skin color detection with background subtraction. In experiment, we quantitatively evaluated three existing skin color detection methods with mixture of Gaussian-based background subtraction. Experimental results show that the proposed approach significantly reduces false positives.

I. Introduction
Skin color detection plays an important role in a wide range of applications, such as face detection and tracking [1]. There have been many skin color detection approaches and most of the approaches consist of two steps: color space selection step and skin color modeling and classification step [2]. In skin color space selection step, several color spaces have been used, such as RGB, normalized RGB, CIE-XYZ, HSV and YCbCr. In skin color modeling and classification step, skin color pixels are modeled to decrease the overlap between skin and non-skin pixels.

Even though there have been a number of skin color detection approaches, most of the existing algorithms produce false positives when non-skin pixels have similar color to skin color. To overcome this problem and improve skin color detection performance, this paper proposes an approach that combines skin color detection with background subtraction. Figure 1 gives a brief overview of the proposed method. In this method, skin color detection method and background subtraction method produce a skin color region and foreground region, respectively. After that, those two results are combine by using AND operation. In experiment, we quantitatively evaluated three existing skin color detection methods with mixture of Gaussian-based background subtraction, and the results show that the proposed approach significantly reduces false positives.

II. Proposed Method
The proposed method combines skin color detection with background subtraction to reduce falsely detected skin pixels. In this paper, we implemented three skin color detection methods [3-5] and one background subtraction method [7]. This method applies skin color detection and background subtraction to image sequences, and then two results are combined via AND operation. We briefly introduce each method in following sections.

2.1 Skin color detection method
2.1.1 YING DAI’s method
YING DAI’s method in [3] detects skin color pixels by using I component of YIQ color space. This method is based on the knowledge that many Asian people have yellow component in their skins and I component well expresses this. In this paper, a pixel is classified as a skin pixel if its I component value is between 1 to 50.

2.1.2 Rein-Lien Hsu’s method
Rein_Lien Hsu’s method in [4] detects skin color pixels by using illumination compensation and nonlinear color transformation of YCbCr color space. Firstly, this method compensates illumination by using white patch approach, and then nonlinearly transforms YCbCr color space. Finally, it classifies skin color pixels via piecewise linear boundaries.

2.1.3 Abbas Cheddad’s method
Abbas Cheddad’s method in [5] mapped RGB color space to a particular 1D space. After that, skin color is modeled in...
this 1D space with Gaussian mixture model by using expectation maximization (EM) method.

2.2 background subtraction method

Many background subtraction algorithms have been presented in recent years [6]. Among them, a mixture of Gaussians using online K-means approximation [7] is on of the most popular methods. Therefore, we use this method for background subtraction to extract foreground pixels.

III. Experimental results

The performance evaluation and comparison were conducted using image sequences acquired by webcam (Microsoft Vx-3000). All experiments were run in C++ using a 2.4GHz Core2 Quad CPU. Resolution and frame rate of image sequences are 360x240 and 15 frames per second, respectively. Figure 2 shows the image sequences used for the experiment and their foreground extraction results.

Figure 2: Sample images of video sequences (first row) and their foreground extraction results (second row).

Figure 3 shows skin color detection results acquired by three different methods. The upper, middle and lower rows show the skin color detection results from YING DAI’s method, Rein-Lien Hsu’s method and Abbas Cheddad’s method, respectively. Figure 4 shows skin color detection results obtained by the proposed method with three different skin color detectors. It can be easily noticed that the proposed method significantly reduced false detection of skin color pixels by comparing Figure 3 and 4.

Figure 3: Results of skin color detection. The first, second and third rows show the results of YING DAI’s method, Rein-Lien Hsu’s method and Abbas Cheddad’s method, respectively.

The proposed method was quantitatively evaluated with three different skin color detectors in Table 1. For this task, we manually segmented the skin pixels 20 frames per each image sequence. We used two criteria: false positive rate (FPR) and false negative rate (FNR). This evaluation shows that the proposed method significantly reduced FPR while increasing small amount of FNR regardless of which skin color detection method is used.

Three skin color detection method were also evaluated in terms of processing time in Table 1. As shown in this table, YING DAI’s method and Abbas Cheddad’s method are much faster than Rein-Lien Hsu’s method.

<table>
<thead>
<tr>
<th>Method</th>
<th>Processing time (second)</th>
</tr>
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<tbody>
<tr>
<td>YING DAI[3]</td>
<td>0.0032</td>
</tr>
<tr>
<td>Rein-Lien Hsu [4]</td>
<td>0.0582</td>
</tr>
<tr>
<td>Abbas Cheddad [5]</td>
<td>0.0047</td>
</tr>
</tbody>
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Table 1. Performance evaluation

As an application of the proposed method, we tried to detect faces by using the results of this method. In this
procedure, a face is detected by applying a morphological filtering and connected component labeling. Figure 5 shows the face detection results from YING DAI’s method, Rein-Lien Hsu’s method and Abbas Cheddad’s method, respectively.

Figure 5: Results of face detection. The upper, middle and lower rows show the results of YING DAI’s method, Rein-Lien Hsu’s method and Abbas Cheddad’s method.

IV. Conclusions
This paper proposes an approach to improve the performance of the skin color detection using by background subtraction. Experimental results show that the proposed method can significantly reduce falsely detected skin color pixels. By summing up the performance evaluation, Rein-Lien Hsu’s method with background subtraction shows the best results. However, other skin color methods are also attractive when considering their computational costs.

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References