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Block Based Skin Color Detection for Automated Video Surveillance System

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ABSTRACT

Automated video surveillance systems are an important component for Infocom Technology (IT) Industry. These systems play an important role in a wide range of image processing applications ranging from face detection, face tracking, gesture analysis, and to various human computer interaction domains. Skin color detection provides a useful and robust cue to all these applications. Therefore, skin color detection is one of the important research areas for automated video surveillance systems. Real-time requirements are the major issue for these systems. In this paper, a robust and efficient block based skin color detection technique is proposed. It is capable of detecting skin color regions in an image in real-time and a performance improvement of 3.58 times is achieved without loss of accuracy in results. The presented algorithm is implemented in C language on a standard WindowXP machine using Dev-C++ (Version 4.9.9.2) compiler. For reading and displaying of image/video Intel OpenCV library functions are used. The algorithm yield good results. The experimental results have established the effectiveness of the approach.

KEYWORDS

Skin Color Detection, Automated video surveillance systems, Resolution of image, Block based technique, FPGA

1 INTRODUCTION

There are immediate needs for automated video surveillance systems in commercial, law enforcement, and military applications [1]. In addition to the obvious security applications, video surveillance technology has been proposed to measure traffic flow, detect accidents on highways, and so on. The numerous military applications include patrolling national borders, measuring the flow of refugees in troubled areas, and providing secure perimeters around bases and embassies [1]. Skin color detection provides a useful and robust cue to a wide range of image processing applications ranging from face detection, face tracking, gesture analysis, and to various human computer interaction domains [2]. These all are important features of automated video surveillance systems and real-time requirements are the major issue for all these application. Therefore, real-time skin color detection is one of the important research areas for automated video surveillance system. Various skin color detection techniques have been presented in literature and a survey can be found in [2]. The work presented in this paper is motivated by [3]. Instead of pixel by pixel computing, the block level computing is performed for an input image and for each block flag value is set or reset based on skin or non-skin region computation for each block. This results in reduced computational resource requirements and improved performance. The algorithm is implemented in C Language.

The paper is organized as follow: In ALGORITHM section, the block based skin color detection scheme is explained. The experimental results are presented in section RESULTS. Finally, the conclusions are drawn and future work is discussed in CONCLUSION AND FUTURE WORK section.

2 ALGORITHM

The input image from camera is in RGB color space. Each input image is partitioned into 4x4 blocks. Each block contains centroid value and the flag value. The centroid is computed by averaging the color value of the block. This results in an image of ¼ resolution of an input image. This process is shown in Figure 1.

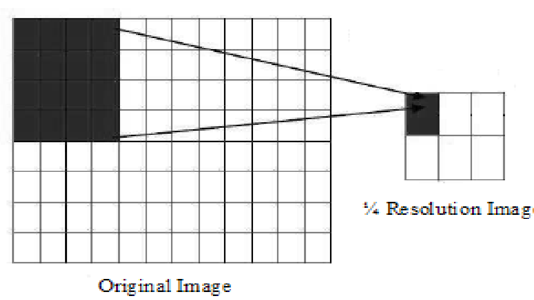

Figure 1. Generating ¼ Resolution Image

Although there exist many color spaces, in this work YCrCb color space is opted because its effectiveness in skin

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detection has been shown previously in literature. In YCrCb, the RGB components are separated into luminance (Y), chrominance blue (Cb) and chrominance red (Cr). The standard relation between YCrCb and RGB color space is given below.

$$\begin{bmatrix} Y \\ C_r \\ C_b \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.4810 & 128.5530 & 24.9660 \\ -37.7745 & -74.1592 & 111.9337 \\ 111.9581 & -93.7509 & -18.2072 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

From RGB to YCrCb color space transformation is performed on the ¼ resolution image. This saves 16 times the computational resources required for color space transformation required on original image. The skin color detection condition for YCrCb color space [4] is given below.

$$Y > 80$$
$$85 < Cb < 135$$
$$135 < Cr < 180$$

The skin color detection is performed on this ¼ resolution image using YCrCb method. The corresponding flag value is set to 1 or 0 based on skin pixel or non skin pixel in ¼ resolution image. The major steps involved in the algorithm are as follow:

- Each RGB image is partitioned in 4x4 blocks.
- For each block the centroid is computed by averaging color value.
- Result is an image of ¼ resolution of input image.
- Skin color detection is performed for this resulted ¼ resolution image using YCrCb Method.
- Set the flag value for each skin pixel as 1.
- Set the flag value for each non-skin pixel as 0.
- If flag value is 1 then write the original pixels from input image to output image for that block.
- If flag value is 0 then write black color i.e. 0 for all pixels of the corresponding block in output image.

Figure 2 shows the flow chart for the algorithm.

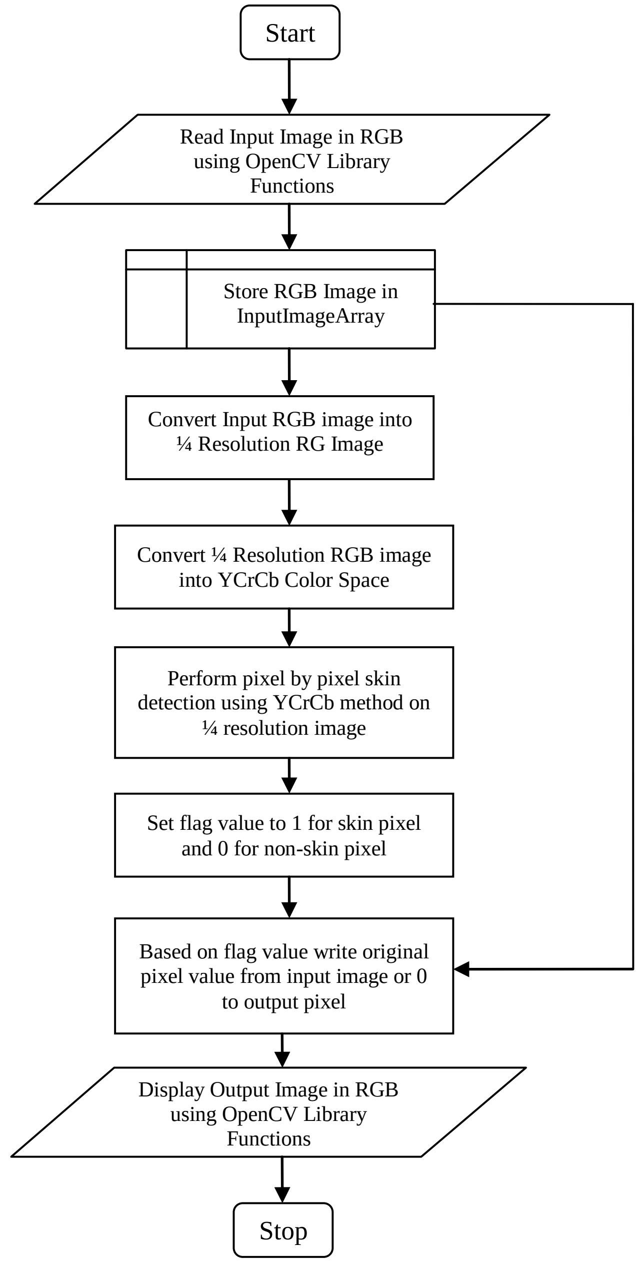
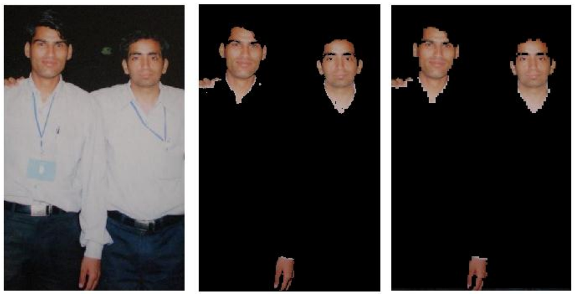


Figure 2. Algorithm Flow Chart

3 RESULTS

The presented algorithm is implemented in C language on a standard WindowXP machine using Dev-C++ (Version 4.9.9.2) compiler. For reading and displaying of image/video Intel OpenCV [5, 6] library functions are used. The presented algorithm robustly and efficiently distinguishes between skin and non-skin regions in an image in real-time. It is evaluated for more than 100 images of different size. Figure 3 and 4 shows the result comparisons between of the proposed scheme and original YCrCb.



(a) (b) (c)

Figure 3. Output result comparison (a) input image (b) YCrCb (c) proposed method

(a) (b) (c)

Figure 4. Output result comparison (a) input image (b) YCrCb (c) proposed method

Since RGB to YCrCb color transformation is performed on ¼ resolution image, therefore it saves 16 times the computational resources required for color space transformation required on original image and hence results in 16 times faster color space transformation. All the operations involved in the algorithm are integer operations except color space transformation so each operation can be performed in single clock cycle on current generation processors. Table 1.1 gives the comparison of number of clock cycles required for YCrCb method and the proposed scheme. The number of clock cycles required is reduced 3.58 times for 640x480 image size as compared to YCrCb method without loss of accuracy in results. Therefore, a performance gain of 3.58 is achieved in proposed scheme.

Operations(640x480 Image Size)	**YCrCb**	**Proposed**
Addition x No. of Clock Cycle	0 x 1	921600 x 1
Division x No. of Clock Cycle	0 x 1	57600 x 1
Comparison x No. of Clock Cycle	4608000 x 1	307200 x 1
Total Clock Cycles	**4608000**	**1286400**

Table 1.1. Number of clock cycles required for skin detection

4 CONCLUSION AND FUTURE WORK

Robust and efficient skin color detection algorithm, which is one of the important components of automated video surveillance systems, has been presented. The presented algorithm is implemented in C language on a standard WindowXP machine using Dev-C++ (Version 4.9.9.2) compiler. For reading and displaying of image/video Intel OpenCV library functions are used. The presented algorithm robustly and efficiently distinguishes between skin and non-skin regions in an image in real-time and a performance gain of 3.58 times is achieved as compared to YCrCb method without loss of accuracy in results. It is evaluated for more than 100 images of different size. The experimental results have established the effectiveness of the approach. Future work will look at sharpening the skin region output at edges of skin detected regions and the application of the presented algorithm for face detection and facial expression analysis.

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