FPGA Implementation of Skin Tone Detection Accelerator for Face Detection

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Abstract

Face detection in image sequence has been an active research area in the computer vision field in recent years due to its potential applications such as monitoring and surveillance, human computer interfaces, smart rooms, intelligent robots, and biomedical image analysis. Face detection is based on identifying and locating a human face in images regardless of size, position, and condition. An algorithm for Skin tone Detection Accelerator has been implemented for colour images in the presence of varying lighting conditions as well as complex backgrounds and it detects skin regions over the entire image, and then generates face candidates based on the spatial arrangement of these skin patches. The algorithm constructs eye, mouth, and boundary maps for verifying each face candidate. The proposed architecture of Skin tone detection Accelerator for Face detection has been designed using Verilog HDL, simulated using ISE simulator and implemented in Xilinx FPGA module. Its performance has been improved when compared with an equivalent software implementation.

Keywords: Face detection, Skin tone, Field Programmable Gate Array (FPGA), Verilog-HDL.
1. Introduction
Face detection plays a vital role in a wide range of applications in image processing such as, Face Recognition, personal identity, personal identification, Content Base Image Retrieval (CBIR) etc. Normally, in order to identify a face in an image, it is essential to check each and every pixel whether it is skin or non-skin. It is very difficult to check hence a skin tone detection has been designed by using which we can easily identify the Face/non-Faces in an image.

2. Proposed Work
In this paper, we have proposed a new skin tone detector for Face detection. Fig 2. Shows the structure of the Face detector using skin tone detector. In the first stage, we have used the skin color detector. It is used to detect the skin or non-skin regions in the images. The output generated from the skin tone detector is given as an input to face detector. Identify the face/non-face from the output of skin tone detector is easy rather than checking each and every pixel in an image. In the skin tone detector, we have used the YCbCr colour space because it is widely used in the digital images. In the YCbCr, Y channel represents the luminance component of the images, and both Cb and Cr represent the chrominance components of the images.

![Block diagram of Face detector.](image)

In this fig 2. First we have applied the input images. All input images are given as an input to skin tone detector. The skin tone detector has to identify the skin regions from the input images. Skin regions have consists the non-faces along with faces, while non-skin regions have not contains any faces. By removing the non-skin region we need to use the skin tone regions. The output of the skin tone detector is applied as an input to the Face detector. Finally, Face detector is used to neglect the non-faces and more accurately identifies the faces from the input image. The block diagram of skintone detector is as show in fig.2.
The input image is given as a input to RGB to YCrCb converter. Here MATLAB is used as a interface between RGB to YCrCb converter and input image. The pixels which are generated is given as a input to RGB to YCrCb Converter. Processing an image in RGB colour space is not effiecient method. To speed up some processing steps may communication techniques use luminance /chrominance colour spaces,such as YCrCb. The output which is obtained from the RGB to YCrCb conveter is given as a input to skin scorer. The skin scorer is used to calculated the skin score of each pixel and compare the skin score of each pixel with the threshold value and then decides whether it is skin or non-skin.

**Skin tone detection:**
Locating and tracking patches of skin-colored pixels through an image is a tool used in many face recognition and gesture tracking systems [8,7]. Skin detection has many challenges like illumination conditions and many objects in the real world might have skin-tone colors [1]. Color is a powerful fundamental cue of human faces, distribution of skin color clusters lay on a small region of the chromatic color space [2, 3].

Skin tone detector is plays a major role in Face detection. It can be used to separate the skin and non-skin regions in an image.First we can choice the suitable colour spaces in skintone detection .There are various color spaces such as, RGB (Red Green Blue), HSV, CMY, YCbCr, YUV,HIS .In digital images and digital videos YCbCr colour space is widely utilizing.In the YCbCr ,Y is the information of luminance ,CB is the difference between the blue component and a reference value and Cr is the difference between the read component and a reference value. The HSI (Hue Saturation Intensity) color space, it is widely used in skin color detection.YIQ and YUV are analog spaces, while YCbCr is a digital color system [5].
3. Colour Space Skin Cluster Method

The skin cluster model is realized in YUV (Y CbCr) colour space [4]. The realization is done in two different ways. While both of them classify the pixels by using only Cb and Cr components, we can mark this color space as 2D (chromatic) colour space. In the first case we describe skin colours with cluster determined by two central curves (the centers) $C_b(Y)$ and $C_r(Y)$ and by deviation curves (spread of the cluster) $W_{Cb}(Y)$ and $W_{Cr}(Y)$. Here we can notice that all curves depend on Y component, which represents the luminance. Equations of mentioned curves are the following:

$$W_{C_i}(Y) = W_{L_{C_i}} + \left(\frac{Y-Y_{\min}}{K_t-Y_{\min}}\right) \left(W_{C_{i_{\min}}}-W_{L_{C_{i_{\min}}}}\right)$$

$$= W_{H_{C_i}} \left(\frac{Y_{\max}-Y}{Y_{\max}-K_h}\right)$$

$$\overline{C}_b(Y) = 108 + 10\left(\frac{K_t-Y}{K_t-Y_{\min}}\right)$$

$$Y_{\min} < K_t, Y < K_h$$

$$= 108 + \frac{10(Y_{\max}-K_h)}{Y_{\max}-K_h}$$

$$K_h < Y$$

$$= 108 \text{; else}$$

$$\overline{C}_r(Y) = 154 + 22\left(\frac{K_t-Y}{K_t-Y_{\min}}\right)$$

$$Y_{\min} < K_t, Y < K_h$$

$$= 154 + \frac{22(Y_{\max}-K_h)}{Y_{\max}-K_h}$$

$$K_h < Y$$

$$= 108 \text{; else}$$

Where $i$ in $W_{C_i}(Y)$ is $b$ or $r$, $W_{Cb} = 46.97$, $W_{L_{Cb}} = 23$, $W_{H_{Cb}} = 14$, $W_{Cr} = 38.76$, $W_{L_{Cr}} = 20$, $W_{H_{Cr}} = 10$, $K_t = 125$, $K_h = 188$, $Y_{\min} = 16$ and $Y_{\max} = 235$. These parameters are evaluated from the training samples of skin patches described in [4]. Each and every pixel in an input image contains Y,Cb,Cr values in order to determine whether it corresponds to skin or not.

4. Results

4.1 Simulated and Synthesis Report:

The simulation results of pixels conversion from RGB colour space to YCbCr colour space is presented in this section. Fig.3 show the simulated results of each and every pixel from RGB colour space to YCbCr colour space.
The simulation results of skin scorer for pixels of an image is presented in this section. Fig. 4 show the simulated results of skin scorer which gives the skin score of each and every pixel.

By using the simulation results of skin scorer generator the Fig. 5 shows the skin score value of the few pixel of an image.

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5. Conclusion
Design and architecture of Skin tone Detector for Face Detection was designed in
verilog and implemented on FPGA has been presented in this paper. The main
advantage is that by using Skin tone detector, Face detection is easy rather than
checking each and every pixel in an image.

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