Human Skin Detection in Color Images Using Deep Learning

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ABSTRACT

Human skin detection is an important and challenging problem in computer vision. Skin detection can be used as the first phase in face detection when using color images. The differences in illumination and ranges of skin colors have made skin detection a challenging task. Gaussian model, rule based methods, and artificial neural networks are methods that have been used for human skin color detection. Deep learning methods are new techniques in learning that have shown improved classification power compared to neural networks. In this paper the authors use deep learning methods in order to enhance the capabilities of skin detection algorithms. Several experiments have been performed using auto encoders and different color spaces. The proposed technique is evaluated compare with other available methods in this domain using two color image databases. The results show that skin detection utilizing deep learning has better results compared to other methods such as rule-based, Gaussian model and feed forward neural network.

Keywords: Auto Encoder, Deep Learning, Face Detection, Face Recognition, Neural Networks, Skin Detection

1. INTRODUCTION

Human skin detection is an active area of research in computer vision. Skin color is an indication of race, health, age, etc. (Fink et al., 2006). In video images, skin color shows the existence of humans in media; therefore, in recent years significant research efforts have been focused on skin detection in images (Elgammal et al., 2009). Skin detection has numerous applications, such as identifying and filtering nude pictures on the internet (Felck et al., 1996), detecting anchors in TV news videos (Abdel-Mottaleb et al., 1999), face detection (Das et al., 2015; Gondaliya et al., 2015; Hajiarbabi, 2014), etc. There are several factors that make the skin detection problem a challenging one. These include issues such as the similarity between human skin color and other entities like color of sand, walls, etc. (Alshehri, 2012), differences of illumination between

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images, images being taken by different cameras with different lenses, the ranges of human skin
colors due to ethnicity, and others.

The first step in human skin detection is choosing a color space. The most common color
spaces that can be used are RGB, YCbCr, and HSV (Singh et al., 2003). The color spaces can
be used individually or the information of the color spaces can be combined (Hajiarbabi, 2014).

Deep learning methods are a type of neural network. In Neural Networks when the number
of hidden layers increases, the back propagation algorithm often does not train the network
well. Deep learning methods introduced advanced methods for training a neural network with
multiple hidden layers. Neural networks have several parameters such the number of nodes in
the hidden layer, the random initial weights, etc... that make neural network to be very flexible
unlike other methods used for skin detection. The results show that deep learning outperform
other methods that have been used in skin detection in case of precision and accuracy and have
comparable results in terms of recall and specificity relative to other methods.

This paper is organized into 5 sections. In Section 2 Gaussian method and rule based meth-
ods are discussed, which are two popular methods in skin detection. In Section 3 deep learning
is described and in Section 4 skin detection using deep learning is presented. The experimental
results are included in Section 5.

2. METHODS FOR SKIN COLOR DETECTION

Different methods have been used for detecting human skin in images. Among them Gaussian,
rule-based, and neural networks are some of the more popular approaches.

The Gaussian model (Wu et al., 2008) uses the YCbCr color space. The density function
for Gaussian variable is used to make a decision of whether or not a pixel belongs to human
skin. The parameters of the density function are calculated using training images. If the probabil-
ity is more than a given threshold then that pixel is considered as human skin. The density func-
tion for Gaussian variable $X = (Cb \ Cr)^T \in R^2$ is:

$$f(Cb \ Cr) = \frac{1}{2\pi|C|^{1/2}} \exp\left\{-\frac{1}{2}(X - \mu)^T C^{-1} (X - \mu)\right\}$$

Where $X = \begin{pmatrix} Cb \\ Cr \end{pmatrix}$, $\mu = \begin{pmatrix} \mu_{Cb} \\ \mu_{Cr} \end{pmatrix}$, $C = \begin{pmatrix} C_{CbCb} & C_{CbCr} \\ C_{CrCb} & C_{CrCr} \end{pmatrix}$, and the parameters are:

$$\mu_{skin} = \begin{pmatrix} 112.1987 \\ 151.3993 \end{pmatrix}, \ C_{skin} = \begin{pmatrix} 89.3255 & 32.2867 \\ 32.2867 & 252.9336 \end{pmatrix}$$

Chen et al. (2008) used conditional probability density function and Bayesian classification in
order to define some rules for detecting human skin. RGB was used as color space. The rules are:

$$r(i) > \alpha, \ \beta_1 < (r(i) - g(i)) < \beta_2, \ \gamma_1 < (r(i) - b(i)) < \gamma_2$$
A Review of Non-Minutiae Based Fingerprint Features
www.igi-global.com/article/a-review-of-non-minutiae-based-fingerprint-features/201462?camid=4v1a

Analog Circuit of Light Detector for CMOS Image Sensor
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