Chapter 73
Human Skin Detection in Color Images Using Deep Learning

Mohammadreza Hajiarbabi
University of Kansas, USA

Arvin Agah
University of Kansas, USA

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.

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

DOI: 10.4018/978-1-7998-0414-7.ch073

similarity between human skin color and other entities like color of sand, walls, etc. (Alshehri, 2012), differences of illumination between 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 methods 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 probability is more than a given threshold then that pixel is considered as human skin. The density function for Gaussian variable $X = \left(Cb\ \ Cr\right)^T \in R^2$ is:

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

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:

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