UNIVERSITI PUTRA MALAYSIA

AN IMPROVED CHROMATIC SKIN COLOR MODEL FOR DETECTING HUMAN SKIN IN JPEG IMAGES

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

June 2005

In the name of God, Most Gracious, Most Merciful

Dedication to

My Parent, My wife, My brothers Nofal, Mohammed and Riadh

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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June 2005

Chairman : Associate Professor Abd Rahman Ramli, PhD

Faculty : Engineering

The detection of the human skin has proven to be a useful and robust technique in computer vision for detecting, segmenting, and tracking faces and hands. It is also used in many different applications in motion capture, human-computer interaction, access control, surveillance, and content-based image retrieval and indexing of image databases.

To build a decision rule that will discriminate between skin and non-skin pixels, a metric has to be introduced to measure the distance of the pixel color to skin tone. The skin color models define the type of this metric.

An improved chromatic skin color model is discussed in this thesis. The model detected the human skin in the Bitmap images with JPEG format. A threshold method and 2D Gaussian model were used to improve the accuracy of the skin region detected.

Good results have been achieved by using the proposed model. Results show that the model detects the human skin with an excellent detection rates for over than 90%. This result shows that this model is more appropriate to avoid false detection areas, while there remains a high degree of correct detection.

This model has been implemented using the MATLAB software, which able to improve the performance and accuracy of skin detection models.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia Sebagai memenuhi keperluan untuk ijazah Master Sains

PENAMBAHBAIKKAN MODEL KROMATIK WARNA KULIT UNTUK MENGESAN KULIT MANUSIA DI DALAM IMEJ JPEG

Oleh

HANI KAID SAIF ALMOHAIR

Jun 2005

Pengerusi : Profesor Madya Abd Rahman Ramli, PhD

Fakulti : Kejuruteraan

Pengesanan kulit manusia telah terbukti amat berguna dan tahan lasak di dalam penglihatan komputer untuk mengesan, membahagi serta menjejaki muka dan tangan. Ia juga digunakan di dalam pelbagai aplikasi di dalam penangkapan pergerakan, interaksi manusia dengan komputer, kawalan capaian, pemantauan, pengambilan imej berdasarkan kandungan dan penyusunan pengkalan data imej.

Pembinaan suatu peraturan keputusan yang akan membezakan di antara piksel yang mewakili kulit dan bukan kulit, memerlukan suatu peuyukur jarak di antara warna piksel dan ton kulit. Model warna kulit mendefinisikan metrik yang dikehendaki.

Suatu model warna kulit yang lebih baik dibincangkan di dalam tesis ini. Model ini mengesan warna kulit manusia di dalam imej bitmap yang mempunyai format JPEG. Kaedah ambang dan model 2D Gaussian telah digunakan untuk meningkatkan kejituan kawasan kulit yang dikesan.

Hasil yang baik telah didapati dengan menggunakan model yang dicadangkan. Hasil ini menunjukkan bahawa model tersebut mengesan kulit manusia dengan kadar pengesanan yang amat baik iaitu melebihi 90%. Hasil ini menunjukkan bahawa model ini adalah lebin sesuai untuk mengelakkan kawasan kesalahan positif, dalam masa yang sama mengekalkan pengesanan pada tahap yang tinggi.

Model ini telah dilaksanakan dengan menggunakan perisian MATLAB yang menambah baikan prestasi pengesanan kulit dan ketepatan yang lebih jitu.

ACKNOWLEDGEMENTS

All praise be to supreme almightly Allah swt, the only creator, sustainer and efficient assembler of the world and galaxies whose blessings and kindness have enabled the author to accomplish this thesis successfully.

The author would like to express gratitude to his supervisor, Associate professor Dr Abdul Rahman Ramli, for accepting him as student. His cheery nature and his unfailing patience has been a great motivation for him to excel in my work. Without this guidance, this thesis would not have been completed successfully. Sincere appreciation is also due to Dr. Elsadig Ahmed Mohamed Babiker and Mr Shaiful Jahari Hashim, members of the supervisory committee for their constructive suggestions, and guidance for execution of the research project as well as critical reviewing of the manuscript.

The author is too much grateful to Computer System Lab. Members of their constructive advice, suggestions, and encouragement in preparation of the research project.
The author is indebted to the Faculty of Engineering and Universiti Putra Malaysia for providing all sorts of facilities to accomplish this thesis.

The author would like to thank his wife for her spiritual moral support and tremendous help to achieve this prestigious degree. The author is indebted to his friends Mohanad and Adel Qadsi for their support and cooperation during the period of study.

The author would like to thank his friend Morad for his immense help to editing this thesis and eliciting any existing English mistakes.

Last but not least, the author would like to thank Dr. Abdul Samad Haza'a who gave him the opportunity to complete his postgraduate studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

cdr	:	Correct detection rates
CRT	:	Cathode-Ray-Tub
fdr	:	False detection rates
FN	:	False Negative
FP	:	False Positive
HSV	:	Hue – Saturation Value
ICSC	:	Improved Chromatic Skin Color
LUT	:	Look Up Table
NN	:	Neural network
JPEG	:	Joint Photographic Experts Group
POS	:	Probability of skin
RGB	:	Red-Green-Blue
r-g	:	Normalized red- green
SCDM	:	Skin color distribution model
TP	:	True Positive
TSL	:	Tint-Saturation light
WWW	:	World Wide Web
2D	:	Two Dimension

CHAPTER 1

INTRODUCTION

1.1 Background

Human skin detection is an interesting and difficult task in computer vision area. This task is the first step in a large number of problems such as human face and hand detection, face recognition or facial expression extraction, sex and race detection and searching and filtering image content on the web. All of these applications are based on the assumption that the areas of human skin are already detected and located (Alaqrabawi, 2000).

Skin color detection also used in many different applications in motion capture, HCI (human-computer interaction), access control, surveillance, and content-based image retrieval and indexing of image databases (Buenaposada *et al*, 2001).

A recent survey on pixel-based skin color detection techniques was introduced by Vezhnevets *et al* (2003). This survey defined the methods used for modeling skin color distributions as follows: explicitly defined skin region, nonparametric skin distribution, and parametric skin distribution.

One of the most common models used for detecting human skin is the chromatic skin color model. This model is adaptive-parametric model and can be easily constructed from training data and capable to deal with different images including Asian, African, American and Caucasian. This approach is the most commonly used, and is employed here.

Skin detection in color images define portions of an image that should be classified as human skin. Due to this classification, it can provide an important first step in a wide variety of other applications in computer vision.

An improved chromatic skin color model has been proposed in this thesis. This model based on the r-g chromaticity color-space, 2D Gaussian model and the optimal threshold method. Databases of Bitmap images with JPEG format are needed to be trained and tested for designing the proposed model.

1.2 Problem Statement

Human skin color varies to great extent from person to another. Besides, images of different races have different shapes, sizes and backgrounds. This can result in a serious difficulty in detecting human skin. In addition, images that contain bright light and shadows can change the apparent color of an image. All these together might reduce the performance of models used for detecting the human skin in color images. On the other hand the skin color detection techniques used Gaussian model for detecting human skin have low correct detection ratio.

1.3 Motivation

Improving the Gaussian model to increase the detection of the human skin regions in color images is the motivation of this study. This improvement is important to achieve a high correct detection ratio and to increase the performance of the skin color detection models.

1.4 Objectives

The aim of this thesis is to improve the skin color detection models used to detect the human skin in color images. Therefore the main objective of this study are as follows:

- To choose the color-space to build the skin color distribution model.
- To improve the skin color distribution model.
- To improve the detection of skin regions in segmented-images.
- To achieve high correct detection rates.

1.5 Scope of Work

In this thesis an Improved Chromatic Skin Color Model (ICSC) has been presented for detecting the human skin in JPEG Images. 2D Gaussian model and optimal threshold method have been used to increase the detection of skin regions. The proposed model will improve the performance of chromatic skin color models by avoiding the non-skin regions to achieve the high correct detection rates. This scheme has been designed using MATLAB software.

1.6 Thesis Organization

The thesis proposes an improved model for detecting human skin, using MATLAB codes as platform.

The theoretical aspect of the chromatic model for detecting human skin is organized into five chapters. Chapter Two gives an introduction to the subject by introducing color and color spaces used in skin detection models, uses of the skin detection in computer vision, and the types of images used in this model. An Introduction and brief summary of skin color modeling and detection presented by the previous authors also included in this chapter.

Chapter Three presents the methodology, which has been used to achieve an improved skin color detection model and all the steps used, with brief contents of the program such as filter, etc, mathematically and practically, supported by working principles pseudocode to give brief explanation to the user. Chapter 4 includes results and discussion, where these results found from the experimental work by generation the proposed model and test it by using testing data set of images. Finally, the conclusion and future work for this thesis is presented in chapter 5.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

This chapter introduces the theoretical background and reviews the state of the art in skin color detection and modeling. This chapter is presented in two sections: first section discussed the background of the skin color detection models, which include the types of color-spaces, types of images, color-spaces and skin and the uses of skin detectors. In this category the features of color-spaces, JPEG images and the uses of skin detection in computer vision are discussed in details. The related works in skin color detection and the resulting images of their works are covered in details in the second section. Finally section 2.7 summarizes the conclusion of this chapter.

2.2 Color

The color is made of two components: chrominance and luminance. The chrominance is property of the object itself that identifies the coloring of that object. The luminance is a property of the lighting environment surrounding the object. Each colored image contains values of both luminance and chrominance. It is obvious that colored objects appear black in the dark and white under extremely bright light. In addition, glass is always transparent under all lighting conditions. It is recognized that the luminance is a major problem in detecting human skin since color varies widely by changing of lighting conditions (Soriano *et al*, 2000).

Luminance and chrominance make human skin colors cover a wide area of the color spectrum. This makes it hard to detect the human skin color based on the RGB color values themselves. Hence, the need for different color spaces that reduce the variance of human skin colors arises (Swain *et al*, 1991).

2.2.1 Color-Spaces

Color space is a method of representing color information obtained for an image. Human skin color tends to cluster in different color spaces. Different color-spaces tend to enhance some characteristics of images on the expense of others. A wide variety of them has been applied to the problem of skin color modeling. In this thesis, we will briefly review the most popular color-spaces and their properties (Moritz , 2004)

2.2.1.1 Linear and Non-linear RGB Spaces

RGB spaces are usually grouped into linear and non-linear; that it is linear to the intensity, whereas a non-linear RGB space (R'G'B) is non-linear to the intensity (Plataniotis and Venetsanoupoulos, 2000; Poynton *et al,* 1996). RGB color-space was used in (Brand and Mason, 2000) and (Jones and Rehg, 1999). Brand and Mason introduced a comparative assessment of three approaches to pixel-level human skin detection. One of these approaches is a 3-D RGB probability map.

RGB space is quantized to 8 bits per color, giving a discrete 3-D space of dimension 2^{24}, the discrete RGB values would themselves form the address for the probability map. Jones and Rehg constructed a general color model using histogram with 256 bins per channel in the RGB color-space, each of the three histogram dimensions is divided into 256 bins, and each bin stores an integer counting the number of times that color value occurred in the entire database of images. This color-space was originated from CRT (or similar) display applications to describe color as a combination of three colored rays (red, green and blue). It is one of the most widely used color-spaces for processing and storing of digital image data. However, high correlation between channels, significant perceptual non-uniformity mixing of chrominance and luminance data make RGB not a very favorable choice for color analysis and color based recognition algorithms. The RGB color space consists of the three additive primaries: red, green, and blue. Spectral components of these colors combine additively to produce a resultant color. Figure 2.1 shows that the RGB model is represented by a 3-dimensional cube with red green and blue at the corners on each axis. Black is at the origin. White is at the opposite end of the cube. The gray scale follows the line from black to white.

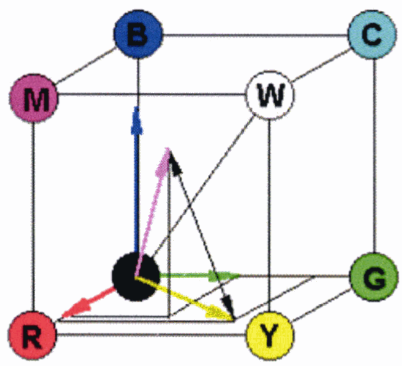

Figure 2.1: RGB color-space