FUZZY SKIN DETECTION

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ABSTRACT

The robustness of web technologies allows huge collection of information to be available through internet. Among this information, some of them are unhealthy and undesirable. This kind of harmful information will make bad impact on human development especially to children and teenagers. Therefore, an explicit image filtering method based on skin detection is proposed in this project. Skin detection is a popular image processing technique that has been applied in many areas such as video-surveillance, cyber-crime prosecution and face detection. It is well known technique to detect the human appearance within image. However, it faces several drawbacks when using color as cue to detect skin. First, the similarity between skin and background color within an image. Second, the skin appearance of human under different lightning condition also adds the complexity in skin detection. Third, different camera characteristics also influence the performance of skin detection. Therefore in this project, fuzzy theory is proposed to improve the skin detection performance by solving the first problem. By improving the first problem, we can increase the classification accuracy when discriminate human and animal skin images which was tested in this project. The complexity of applying fuzzy theory in skin detection is based on the highly similarity between skin and non-skin pixels as a clear description of the skin color set is needed for processes. Hence, the rules need to be explicitly enough in order to achieve better performances. Finally, experiment has been conducted to test the applicability of fuzzy classification. Although the classification result is lower than comparison method, fuzzy theory has been proved to be able to discriminate human and animal skin.

ABSTRAK

Perkembangan teknologi web membenarkan maklumat yang berjumlah besar dihantar melalui. Antara maklumat yang dihantar antara web ini, sebahagian adalah dalam bentuk gambar yang tidak sihat. Gambar-gambar ini menjejaskan kesihatan dan perkembangan manusia, terutamanya kepada kanak-kanak dan remaja. Oleh itu, satu kaedah untuk menapiskan gambar-gambar tidak sihat diperkenalkan dalam projek ini. Teknik pengesahan kulit manusia melalui gambar merupakan salah satu teknik popular. Teknik ini digunakan dalam banyak bidang seperti video pengawasan dan pendakwaan jenayah siber. Bagaimanapun, beberapa masalah wujud semasa menggunakan teknik ini. Masalah pertama yang ditemui ialah kesamaan antara warna kulit manusia dengan warna latar belakang gambar. Selain itu, warna kulit manusia berbeza apabila dalam keadaan cahaya yang berbeza. Pada masa yang sama, ciri-ciri kamera yang berlainan juga akan mempengaruhi prestasi ketepatan untuk mengesahkan kewujudan kulit manusia dalam gambar. Dalam projek ini, Teori Fuzzy telah digunakan untuk menyelesaikan masalah pertama. Selain itu, Teori Fuzzy juga digunakan untuk membezakan gambar manusia dengan gambar haiwan dalam projeck ini. Kesusahan untuk melaksanakan Teori Fuzzy dalam projek ini ialah membezakan warna kulit manusia dengan warna kulit haiwan yang mempunya nilai serupa. Peraturan Fuzzy yang jelas diperlukan untuk mencapai prestasi yang lebih baik semasa mengesahkan kewujudan kulit manusia dalam gambar. Walaupun prestasi ujikaji adalah lebih buruk daripada kaedah dibandingkan, Teori Fuzzy telah dibuktikan dapat membezakan gambar kulit manusia dengan gambar haiwan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

With fast-growing World Wide Web and more simplified way to access Internet, people are easier and have more choices to find and locate information. Many of this information available in Internet are in the form of images such as photo, videos etc. As most people want to understand the image contents before they locate it, the importance of image processing increases. So, various image processing methods have been proposed to achieve this objective. One of the important techniques of image processing is the skin detection technique. As a popular technique, it proposes a way to detect human and human-body parts in images using skin value. It has been used in various applications such as video surveillance, human-machine interface, cyber-crime prosecution, gesture recognition, hand detection, teleconference. The application of skin detection in video surveillance, hand detection and cyber-crime prosecution will be discussed in Section 1.1.1, Section 1.1.2 and Section 1.1.3.

1.1.1 Application of Skin Detection in Video Surveillance

The application of video surveillance allows users to identify, alert, analyse and respond to the threat such as theft and terrorism. This is where the skin detection comes in as it can be used to detect the face of the people in the video who may be the person involve in stealing if theft happened or the culprit that commit a criminal. It provides help for police to deal with criminals and find the culprits. Various approaches have been proposed by researchers to improve the application of skin detection in video surveillance. T. Kim et al (2005) had used an integrated approach of multiple face detection techniques to improve the performance of skin detection in video surveillance. Then, Robertson et al (2006) used the skin detection method to estimate the direction of the head in order to help to determine human behaviour.

1.1.2 Application of Skin Detection in Hand Detection

The hand detection is implemented to measure the length and shape of fingers and knuckles. Optical camera and light-emitting diodes that have mirrors and reflectors are used to take two orthogonal, two dimensional images of the back and side of hands. Skin detection technique is applied in hand detection to improve the performance of the hand detection. Based on the research by K¨olsch and Turk (2004), the best detection they obtained achieved outstanding performance in practical application, indoors and outdoors with the combination of skin color verification.

1.1.3 Application of Skin Detection in Cyber-crime Prosecution

Although the robustness of information available within the Internet provides people a better way to acquire information, it also exposes people to the illegal and harmful content such as violent and nude image. There is a need to block and filter this undesirable content from the web especially from children. To fulfil this

requirement, some companies such as NetNanny and SuftWatch operate by maintaining lists of URL's and newsgroups and require constant manual updating. Due to the rapid changing and growing of Internet, this approach is not enough to cope with all these evolving web contents. By taking advantage of the strong relationships between adult images and images with large patch of skin, a skin detector can be developed in order to provide an efficient and effective way to detect adult images. Several researches have been done to fit the skin detection in web content filtering. Zhang et al (2004) suggested that the adult images can be blocked by using statistical skin detection. They build a first order model which imposes constraint on color gradients of neighbouring pixels.

The application of skin detection in various fields shows its popularity within image processing technique. It is computationally effective and robust information against rotation, scaling and partial occlusions. However, this skin color modeling is not perfect yet, as there are still problems to be solved to achieve high accuracy and effective skin detection method.

1.2 Problem Background

Skin detection has been a popular technique to classify or detect the skin pixels within an image. Several advantages have been provided by skin detection. First, it is fast in processing due to its low level processing. Then, Stern and Efros (2002) stated that it is also invariance against rotations, partial occlusions and poses change. However, a survey conducted by Kakumanu et al (2007) has shown several factors need to be considered to apply skin detections which are illumination, camera characteristic and ethnicity.

The illumination factor related with the lightning condition when an image is taken which including indoor, outdoor, highlights, shadows and non-white lights. The transformation of lightning condition in an environment will produce a change

on the skin color that leads to color constancy problem. This color constancy problem will seriously affect the performance of the skin detection system

The camera characteristic is difference from one camera to other camera depending on the camera sensor characteristic. Although under same lightning condition, the performance of the skin detection system will still be variant depend on the camera characteristic.

Although the skin color differences which vary from one region to another region can be identified using human eyes, the differentiation and variation of skin color becomes difficult when it comes to computation. For example, the skin color of people between different ethnicity from Caucasian to Asian and African ranges from white to yellow and black. Besides that, the color value of human skin pixel and other pixels within an image may fall within the same color boundary which makes the computation complicated. For example, the color value of lion pixel value may have similar RGB value as human skin value.

The problems that have been encountered in visual spectrum can be solved by applying non-visual spectrum such as infrared and spectral imaging which is stated by Terrillon et al (1998). Skin color in non-visual spectrum method is invariant to changes in illumination conditions, ethnicity, and make up and shadow. However, the performance of non-visual spectrum method was decreased by the tiresome setup procedure and high cost equipments. Therefore, there is still much room to be improved in the area of skin detection.

1.3 Problem Statement

To solve the color likelihood problem between human skin pixels and background pixels, the skin color boundary need to be determined which can be achieved by building a skin color model. This identified skin color boundary will be used as references in fuzzy classification later to classify a pixel as skin or non-skin pixels. So, this project examines the following questions

How the color likelihood problem of human skin pixel and background pixel can be solved by building a skin color model? How the fuzzy logic can be used to classify skin and non-skin pixels based on the identified skin color model?

Then, this project intends to classify human and animal images using Fuzzy Logic. Therefore, another question is

How fuzzy rules can be used to classify human and animal images? What is the performance of fuzzy logic when classifying human and animal images?

1.4 Project Aims

This project will use RGB colorspace to extract color features. These extracted color features will be used to build skin color model. Types of existing colorspaces include Red Green Blue (RGB), normalized RGB, Hue Saturation Intensity (HIS) and YCbCr.

In this project, suitable skin color modelling method that works well with RGB colorspace will be identified. The skin color modelling method will help to discriminate the human skin and animal skin images. The available skin modelling methods are explicitly defined skin region, nonparametric skin distribution modeling, parametric skin distribution modeling and dynamic skin distribution method.

The images will be subtracted in order to acquire object of interest. Then, the subtracted images will be processed with fuzzy method in order to solve problem in skin detection method. In the end, an algorithm that can classify human skin and animal images with high true positive rate and low false positive rate is desirable.

1.5 Objectives

The objectives of this project are as follows:

1. To propose a new set of fuzzy rules in discriminate human skin and skin-like pixels.
2. To study human and animal skin images using fuzzy classification.
3. To evaluate and compare the classification result with simulation result of explicitly defined skin region and Takagi-Sugeno Fuzzy Inference System

1.6 Project Scopes

This project is focus on the skin color extraction and classification. The performance of fuzzy classifier is evaluated. This project covers the following area:

1. Asian skin region: Only skin color information of Asian people will be covered in this project.
2. Image format: Images in JPEG format will be used to perform skin detection
3. RGB colorspace will be used for feature extraction: This project will use RGB colorspace to represent the skin color information.
4. Fuzzy classification for skin detection: Fuzzy logic will be used in this project for the classification of skin and non-skin pixels.
5. This project will be conducted by using vb.net as programming language.

1.7 Significance of Study

This study evaluates the performance of skin detection based on fuzzy classification. The result is compared to the result acquired from previous skin detection technique to check whether this approach can achieve better classification performance. The result of the evaluation will help to solve the problems faced when discriminating human skin pixels and pixels that have similar color information as human skin. This approach could be used to the development of a methodology that will be of value in filtering adult images within web.

1.8 Conclusion

In conclusion, the report consists of 5 chapters. Chapter 1 presents the introduction of the study, problems background, objectives and scopes of the project. Chapter 2 gives literature reviews on the existing colorspace and skin detection technique. Project methodology is discussed in Chapter 3 and Chapter 4 exhibits the experimental results. The conclusion and suggestion for future work will be explained in Chapter 5.

REFERENCES

A. Diplaros, T. Gevers and N. Vlassis (October 2004). Skin Detection Using The EM Algorithm with Spatial Constraints. *IEEE International Conference*, Vol 4, 3071 – 3075.

A. Soria-Frisch, R. Verschae and A. Olano (2007). Fuzzy Fusion for Skin Detection. *Fuzzy Sets and Systems*, 325 – 336.

C.N. R. Kumar and A. Bindu (2006). An Efficient Skin Illumination Compensation Model for Efficient Face Detection. *IEEE*.

D. Brown, I. Craw and J. Leithwhite (2001). A SOM Based Approach to Skin Detection with Application in Real Time Systems. *BVMC01*.

D. Chen and Z. Liu (2003). A Novel Approach to Detect and Correct Highlighted Face Region in Color Image. *Proceedings of the IEEE Conference on Advanced Video and Signal Based Surveillance, AVSS'03*.

D. Hong and W. Woo (2003). A Background Subtraction for a Vision-based User Interface. *ICICS-PCM*.

D. H. Anderson and L. O. Hall (1999). MR FIS: Mamdani Rule Style Fuzzy Inference System. *IEEE International Conference on* Vol 5, 238-243.

H. Stern and B. Efros (2002). Adaptive Colorspace Switching for Face Tracking in Multi-Colored Light Environment. *Fifth IEEE International Conference on Automatic Face and Gesture Recognition*.

H. Zheng, M. Daoudi_and B. Jedynak (2004). Blocking Adult Images Based on Statistical Skin Detection. *Electronic Letters on Computer Vision and Image Analysis* 4(2):1-14.

J.C. Terrillon, M. David and S. Akamatsu (1998). Detection of Human Faces in Complex Scene Images by Use of A Skin Color Model and of Invariant Fourier-Mellin Moments. *ICPR98*, 350-1355.

J. Kovac, P. Peer and F. Solina (2003). Human Skin Color Clustering for Face Detection. *EUROCON2003*.

J. Ruiz-del-Solar and R. Vershae (2004). Robust Skin Segmentation using Neighborhood Information. *IEEE Internet. Conf. on Image Processing*, Vol. 1, 207-210.

K. Nallaperumal, S. Ravi, C. N. K. Babu, R. K. Selvakumar, A. L. Fred, C. Seldev and S. S. Vinsley (2007). Skin Detection using Color Pixel Classification with Application to Face Detection: A Comparative Study. *International Conference on Computational Intelligence and Multimedia Applications 2007*.

L. A. Zadeh (1965). *Fuzzy Sets*. Department of Electrical & Engineering Research Laboratory, University of California, Berkely, California.

L. Jordao, M. Perrone, J. P. Coasteira and J. Santose-Victor (1999). Active Face and Feature Tracking. *In Proceedings of the 10th International Conference on Image Analysis and Processing*. 572 -577.

L. Mostafa and S. Abdelazeem (2005). Face Detection Based On Skin Color Using Neural Network. *GVIP 05 Conference, CICC, Cairo, Egypt*.

M. B. Hamid and Y. B. Jemma (2005). Fuzzy Classification, Image Segmentation and Shape Analysis for Human Face Detection. *ICSP2006 Proceedings*.

M. H. Kim, J. B. Park and Y. H. Joo (2005). New Fuzzy Skin Model for Face Detection. *AI 2005*, 557-566.

M. J. Jones and J. R. Rehg (1999). Statistical Color Models with Application to Skin Detection. *CVPR99*.

M. K¨olsch and M. Turk (2004). *Robust Hand Detection.* Department of Computer Science, University of California, Santa Barbara, CA 93106.

M. R. Girgis, T. M. Mohamoud, T. Abd-El-Hafeez (2005). An Approach To Image Extraction And Accurate Skin Detection From Web Pages. *International Journal of Computer Science and Engineering*, Vol. 1, Number 2.

N. Robertson, I. Reid and M. Brady (2006). *Behaviour Recognition and Explanation for Video Surveillance.* University of Oxford, Dept. Engineering Science.

P. Kakumanu, S. Makrogiannis and N. Boubakis (March 2007). A Survey of Skin-color Modeling and Detection Methods. *Pattern Recognition*, Vol. 40, Issue 3, 1106 – 1122.

R. Hsu, M. Abdel-Mottaleb and A. K. Jain (2002). Face Detection in Color Images. *IEEE Trans, Pattern Analysis and Machine Intelligence*, 696 – 706.

S. L. Phung, A. Bouzerdoum and D. Chai (January 2005). Skin Segmentation Using Color Pixel Classification: Analysis and Comparison. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol.27, Number 1.

T. Fawcett (2007). An Introduction to ROC Analysis. *Pattern Recognition Letters 27*, 861 – 874.

T. Kim, S. Lee, J. Lee, S. Kee and S. Kim (February 2005). *Integrated Approach of Multiple Face Detection for Video Surveillance Human.* Computer Interaction Lab, Samsung AIT, KOREA.

Y. Chahir and A. Elmoataz (2006). Skin-color Detection using Fuzzy Clustering. *ISCCSP 2006*.