UNIVERSITI PUTRA MALAYSIA

FACE DETECTION TECHNIQUE BASED ON SKIN COLOR AND FACIAL FEATURES

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By

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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

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Dedicated

to

My Parents, Wife, Brothers and Sisters

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

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December 2005

Chairman: **Khairi Bin Yusof, PhD**

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Face detection is an essential first step in face recognition systems with the purpose of localizing and extracting the face region from the background. Apart from increasing the efficiency of face recognition systems, face detection technique also opens up the door of opportunity for application areas such as content based image retrieval, video encoding, video conferencing, crowd surveillance and intelligent human computer interfaces.

This thesis presents the design of face detection approach which is capable of detecting human faces from complex background. A skin color modeling process is adopted for the face segmentation process. Image enhancement is then used to improve the face candidate before feeding to the face object classifier based on Modified Hausdroff distance. The results indicate that the system is able to detect human faces with reasonable accuracy.

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

TEKNIK PENGESANAN MUKA BERDASARKAN WARNA KULIT DAN CIRI.CIRI MUKA

Oleh

KHALID MOHAMED ALAJEL

Disember 2005

Pengerusi: Khairi Bin Yusof, PhD

Fakulti: Kejuruteraan

Pengesanan muka merupakan langkah pertama yang penting dalam pengecaman muka dengan tujuan melokalisasikan dan mengeskstrakkan bahagian muka daripada latar belakang. Selain meningkatkan keberkesanan sistem pengecaman muka, teknik pengecaman muka juga membuka peluang kepada bidang.bidang aplikasi seperti pengeluaran imej berdasarkan kandungan, pengenkodan video, pengawasan dan antara muka manusia.komputer bestari.

Tesis ini mempersembahkan reka bentuk pendekatan pengesanan muka yang mampu mengesan muka manusia dalam latar belakang kompleks. Sistem pemodelan warna kulit digunakan untuk sistem segmentasi muka. Penambah baikan imej juga kemudian digunakan untuk meningkatkan calon muka sebelum membekalkan kepada pengelas objek muka berpandukan jarak Modified Hausdorff. Keputusan yang diperoleh menunjukkan sistem ini mampu mengesan muka manusia dengan ketepatan yang munasabah.

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LIST OF ABBREVIATIONS

HCI	: Human Computer Interaction
PDM	: Point Distributed Models
PPED	: Projected Principal Edge Distribution
RFM	: Relational Face Model
PCA	: Principal Components Analysis
SVM	: Support vector machine
OCSVM	: One.Class SVM
BDF	: Bayesian Discriminating Features
SEW2HD	: Spatially Eigen.Weighted 'Doubly' Hausdorff Distance

CHAPTER 1

INTRODUCTION

1.1 Background

Face detection is a necessary first step in face recognition systems with the purpose of localizing and extracting the face region from the background. Apart from increasing the efficiency of face recognition systems, face detection technique also opens up the door of opportunity for application areas such as content-based image retrieval, video encoding, video conferencing, crowd surveillance and intelligent human-computer interfaces. (Hjelmas and Low, 2001; Seo *et al.,* 2000).

Early efforts in face detection started as early as the beginning of the 1970's. In those researches, simple heuristic and anthropometric techniques are used and are largely due to various assumptions such as plain background, frontal face. Any change of image conditions would usually bring about fine-tuning of the whole system or even complete redesign.

Human face is a dynamic object and displays high degree of variability in appearance. In real life situations, different illuminations and distance from imaging device, occlusion and rotation of head in different axis are bound to happen and this causes massive challenge to the detection algorithm. Most systems assume certain orientation of the face to simplify the problem such as frontal or near frontal face orientation. (Liu, 2003;

Samal and Lyengar, 1992; Kotropoulos and Pitas, 1997; Kim *et al.,* 2002; Suzuki and Shibata, 2004).

Generally speaking, face detection techniques can be classified to two schools of philosophy which is: (i) image based techniques and (ii) feature based techniques. Image based techniques address face detection as a general recognition problem whereby pattern recognition is applied to the whole image which has undergone certain transformation. The face knowledge is therefore implicit to the users and mapping and training schemes are utilized to achieve what is known as recognition. Feature based technique on the other hand has an explicit knowledge on the face detection problem whereby features representing face as defined by the designer are first extracted from images. Face detection are thus achieved by verifying to a certain degree of confidence that features extracted from images represent face.

Color analysis on images has long been used as a technique which can give additional dimension to image compared to grey scale image. Classification is easier to handle in color space compared to gray scale. It is a known fact that skin color of different races tend to cluster in close proximity in normalized color space or chromaticity space. This has also brought about the possibility of modeling skin color distribution as Gaussian distribution. Using this skin color model, skin candidate region is identified based on certain threshold value.

The problem of matching two images has been an active topic of research in computer vision and target track for the last two decades. Image matching methods can be well used to find correspondence between a template and given portion of an image having the most partial similarity. The partiality stems from many factors, such as different time, viewing condition, occlusion, noise, etc. In the past, there were various methods that can be well used for locating a model in an image and be divided into two categories: area based matching and feature based matching. (Zhijia. Z., *et al*, 2003).

The use of variants of the Hausdorff distance has recently become more and more popular in the image matching application. Hausdorff distance is a robust technique used in image matching problem. It has the advantage of being scale invariant, illumination invariant and robust in complex background. Given two images *A* and *B*, Hausdorff distance between the two images can be formulated as follow:

$$H(A, B) = \max\left(h(A, B), h(B, A)\right)$$

$$\text{where} \quad h(A, B) = \max_{a \in A} \min_{b \in B} \|a-b\| \tag{1.1}$$

h(A, B) is known as the directed Hausdorff distance from set *A* to set *B*. In other words, Hausdorff distance is the maximum shortest distance between points on *A* and *B* respectively. In order to minimize the effect due to outliers, a modified Hausdorff distance is used instead.

1.2 Problem Statement

Skin color has long been used for detecting skin color region and even in head detection system for searching head region. The major problem with using skin color model however is that it is subject to variation in illumination and hence not robust enough in detecting head candidate. One more prominent problem is that most of the time, object which appears to have skin color is not necessarily the human face, worse, it may not even be part of the human skin. It is therefore impossible to rely solely on skin color alone as an effective face detection strategy.

Hausdorff distance is a robust technique in image matching. Traditionally, it has always been used in gray scale image to locate image candidate which is a closest match to an object. In order to search for the possible image candidate, the system generally needs to scan through the whole image until it reaches the targeted candidate. As the image size grows, so does the computing power needed to locate the image candidate.

It is therefore believed that using skin color filter along with Hausdorff distance will target the shortcomings of both these strategies. Skin color filter will help identify the image candidate so that Hausdorff distance will be able conserve computing power on the image candidate while Hausdorff distance will verify the validity of the image candidate which is not possible by using skin color filter alone.

1.3 Objectives

Face detection is a complex task which consists of a series of structured steps. The aim of this thesis is to research the necessary steps needed to construct a system which will lead to successful detection of human face from any input images either downloaded or captured using an imaging device.

The primary objective of this thesis is to produce a face detection approach which is robust enough to be used in images or video with complex background and scale invariant. It should also be robust enough to detect multiple faces which could occur within a single image.

The secondary objective is to improve on the general detection rate of the proposed Hausdorff detection method and to reduce false detection rate at the same time.

1.4 Thesis Outline

This thesis is organized in five chapters. Chapter one consists of introduction, which covers background of research problem, research objectives and thesis outline. Chapter two consists of literature review which discuss on the various prior works done in face detection using different approaches, while the third chapter consists of the methodology. The fourth chapter consists of the result obtained within this study. Finally, the fifth chapter summarizes the research finding and suggests potential work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Face detection is the necessary first step in face recognition system (Hjelmas and Low 2001; Seo *et al.*, 2002). It carries the objectives of localizing face region and to extract it out of an image. Successful face detection will enable face recognition to be carried out smoothly and more efficiently and at the same time reduce false recognition. Human can do this almost effortlessly but for a computer, sophisticated algorithm with efficient computation is the only solution to this problem. Face detection is also applied to other areas which are equally important such as content based image retrieval, video conferencing, crowd surveillance and intelligent Human Computer Interaction (HCI).

Human face is a dynamic object and displays high degree of variability in appearance. In real life situations, different illuminations and distance from imaging device, occlusion and rotation of head in different axis are bound to happen and this causes massive challenge to the detection algorithm. Most systems assume certain orientation of the face to simplify the problem such as frontal or near frontal face orientation (Liu 2003; Samal and Lyengar 1992; Kotropoulos and Pitas 1997; Kim *et al.*, 2004; Suzuki and Shibata 2004).

Early efforts in face detection started as early as the beginning of the 1970's. In those researches, simple heuristic and anthropometric techniques are used and are largely due to various assumptions such as plain background, frontal face. Any change of image conditions would usually bring about fine-tuning of the whole system or even complete redesign.

2.2 Previous Work on Face Detection

Face detection has become one of hottest topics in the field of computer vision and pattern recognition in the past decades because of its potential applications, such as biometrics, intelligent human computer interaction, and so on. Face detection is a key step of automatic face analysis. The purpose of face detection is to look for and locate face patches in given images, and its performance has great effect on face tracking, face recognition, expression analysis and human gesture analysis. In recent years, a lot of face detection methods have been published.

Menser and Muller (1999) presented a face detection algorithm for color images with complex background. This algorithm includes color information into a face detection approach based on principal components analysis (PCA). A skin color probability image is generated by doing a color analysis and the PCA is performed on this new image instead of the luminance image. The presented face detection algorithm combines a skin color analysis with an eigenspace approach. The incorporation of color information reduces the influence of the image background and improves the detection performance especially in images where the size of the facial area is relatively small. This work focused on the adjustment of the error criterion and the

automatic adaption of the global detection threshold only. The algorithm can be extended to face tracking in image sequences. Experiments show that color information improves the robustness of the detection significantly.

Balasuriya and Kodikara (2000) attempted to unravel the classical problem of automated human face recognition. A near realtime, fully automated computer vision system was developed to detect and recognise expressionless, frontal view human faces in static images. In the implemented system, automated face detection was achieved using a deformable template algorithm based on image invariants. The natural symmetry of human faces was utilised to improve the efficiency of the face detection model. The deformable template was run down the line of symmetry of the face in search of the exact face location. Once the location of the face in an image was known, this pixel region was extracted and the test subject was recognized using principal component analysis, also known as the eigenface approach.

Prem Kuchi *et al.* (2000) developed an algorithm to detect and track human face(s) in a color image sequence. The algorithm starts with human skin color modeling and uses it in isolating skin pixels (probable face regions). Skin color is found to be a powerful feature for isolating potential face candidates. It is also useful for detecting multiple human faces in an image. It is orientation independent. Connected Component Operators are applied on the thresholded skin probability image to isolate the final face components. The combination of the six operators used proved to be very effective. Skin color analysis followed by the use of shape based Connected Operators makes the system invariant to change in scale. For a higher detection performance, the structuring element used during open/close operations

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