UNIVERSITI PUTRA MALAYSIA

IMPROVEMENT OF FACE RECOGNITION USING PRINCIPAL COMPONENT ANALYSIS AND MOMENT INVARIANT

ANNIE A/P THOMAS

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By

ANNIE A/P THOMAS

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

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To my beloved father and mother.

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

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Chairman : Associate Professor Mohd. Adzir bin Mahdi, PhD

Faculty : Engineering

Face recognition attracts many researchers and has made significant progress in recent years. Face recognition is a type of biometric just like fingerprint and iris scans. This technology plays an important role in real-world applications, such as commercial and law enforcement applications, from here comes the importance of tackling this kind of research.

In this research, we have proposed a method that integrates Principal Component Analysis (PCA) and Moment Invariant with face colour in gray scale to recognize face images of various pose. The PCA method is used to analyze the face image because it is optimal with any similar face image analysis and it has been employed to extract the global information. The vectors of a face in the database that are matched with the one of face image will be recognized the owner. If the vector is not matched, the original face image will be reconsidered with moment invariant and face colour in gray scale extraction. Then, the face will be rematched.

In this way, the unrecognized faces will be reconsidered again and some will be recognized accurately to increase the number of recognized faces and improve the recognition accuracy as well.

We have applied our method on Olivetti Research Laboratory (ORL) database which is issued by AT&T. The database contains 40 different faces images with 10 each face. Our experiment is done by using the holdout to measure the recognition accuracy, as we divided about 2/3 of the data 280 faces for training, and about 1/3 which is 120 faces for testing. The results showed a recognition accuracy of 94% for applying PCA, and 96% after reconsidering the unrecognized patterns by dealing with pose-varied faces and face colour extraction.

Our proposed method has improved the recognition accuracy with the additional features extracted (PCA + face colour in gray scale) with the consideration of the total time process.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains.

PENAMBAHBAIKAN PENGECAMAN MUKA MENGGUNAKAN PRINCIPAL COMPONENT ANALYSIS DAN MOMENT INVARIANT

Oleh

ANNIE A/P THOMAS

Ogos 2007

Pengerusi : Profesor Madya Mohd. Adzir bin Mahdi, PhD

Fakulti : Kejuruteraan

Pengecaman muka menarik ramai penyelidik dan telah membuat satu kemajuan pada zaman ini. Pengecaman muka adalah satu jenis biometrik sama seperti pengesanan cap jari dan anak mata. Teknologi ini memainkan peranan yang penting dalam aplikasi harian seperti dalam perdagangan dan penguatkuasaan dan ini menunjukkan ada kepentingan untuk membuat penyelidikan jenis ini.

Dalam penyelidikan ini, kami telah mencadangkan satu kaedah yang mengitegrasikan Analisis Komponen Utama (*PCA*) dan Momen tak berubah dengan warna muka untuk mengecam imej muka dalam pelbagai variasi. Kaedah *PCA* digunakan untuk menganalisis imej muka kerana ia adalah optimal dengan mana-mana analisis imej muka yang serupa serta ia digunakan untuk mendapatkan maklumat yang global. Vektor sesuatu muka dalam pangkalan data adalah dinilai dengan salah satu imej muka bagi mengecam orang sebenar. Jika vektor yang dinilai adalah tidak sama, maka imej muka sebenar akan dikaji dengan momen tak berubah dan warna muka. Kemudian, imej muka akan dinilai semula. Dengan cara ini, muka yang tidak dicam akan dinilai semula dan kebanyakkannya akan dicam dengan betul untuk

meningkatkan bilangan muka yang dicam serta meningkatkan tahap pengecaman yang betul.

Kami telah mnggunakan kaedah kami atas pangkala data Makmal kajian Olivetti (*ORL*) yang diperkenalkan oleh AT&T. Pangkalan data ini mengandungi 40 imej muka yang berlainan, dengan 10 imej setiap imej muka. Eksperimen kami dilakukan dengan menggunakan kaedah “holdout” untuk mengukur tahap pengecaman betul dengan membahagikan 2/3 daripada data yang mengandungi 280 imej muka untuk latihan dan 1/3 daripada data yang mengandungi 120 imej muka untuk ujian pengecaman. Keputusan menunjukkan tahap pengecaman betul sebanyak 94% dengan menggunakan kaedah PCA dan 96% selepas dinilai semula imej-imej yang tidak dicam dengan menyelesaikan masalah pelbagai variasi dan warna muka.

Kaedah kami yang dicadangkan telah meningkatkan tahap pengecaman betul dengan penambahan (PCA + warna muka) dengan menilai jumlah masa diproses.

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I would like to acknowledge in particular the continuous support of my parents and family. They have been a consistent encouragement for me throughout my many years of university education.

Special appreciation to Puan Wan Azizun bt. Wan Adnan and also my friends, mainly, Mohammad Said El-Bashir for his encouragement, constant source of ideas, suggestions and for giving me the confidence to complete my research.

Annie Thomas
August 2007

I certify that an Examination Committee has met on …… 2006 to conduct the final examination of Annie on her Master of Science thesis entitles "Face Recognition Improvement Using Principal Component Analysis and Moment Invariant" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be a warded the relevant degree. Members of the Examination Committee are as follows:

Profesor Dr. Mohamad Khazani B. Abdullah
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Profesor Madya Dr. Abdul Rahman b. Ramli
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Dr. Mohammad Hamiruce b. Marhaban
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Profesor Madya Dr. Syed Abdul Rahman Syed Abu Bakar
(External Examiner)

_____

HASANAH MOHD. GHAZALI, PhD
Professor / Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Mohd. Adzir B. Mahdi
Assistant Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

_____
AINI IDERIS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 December 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

Annie A/P Thomas

Date:

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LIST OF ABBREVIATIONS

DLA	Dynamic Link Architecture
FBG	Face Bunch Graph
FE	Feature Extraction
FLD	Fisher Linear DIscriminant
HMM	Hidden Markov Model
ICA	Independent Component Analysis
JPEG	Joint Photographic Experts Group
KLT	Karhunen-Loeve Transform
LDA	Linear Discriminant Analysis
PCA	Principle Component Analysis
PGM	Portable Grey Map
PICS	Psychological Image Collection at Stirling
PC	Personal Computer

CHAPTER 1

INTRODUCTION

1.1 Background

Biometrics is increasingly becoming important in our security-heightened world. Computer face recognition promises to be a powerful tool, just like fingerprint scans.

Automated face recognition is an interesting computer vision problem with many commercial and law enforcement applications. Mugshot matching, user verification and user access control, crowd surveillance, enhanced human computer interaction all become possible if an effective face recognition system can be implemented. However, face recognition is still an area of active research to solve the face recognition problem.

Face recognition is the ability to recognize people by their facial characteristics. Computers can conduct facial database searches and/or perform live, one-to-one or one-to-many verifications with unprecedented accuracy and split-second processing. Users can be granted secure access to their computer, mobile devices, or for online e-commerce, simply by looking into their Web camera.

Just like human beings, computer algorithms to perform face analysis are also divided into detection, recognition and expression understanding. Face detection is about

determining the locations and sizes of faces in an image, separating them from other non-face objects. Recognition, on the other hand, is about establishing the identity of the person from image(s) of his face. This is done with reference to a database of known faces.

In this research, we propose a method to enhance the accuracy of recognizing faces of people available in Olivetti Research Laboratory (ORL) dataset. Our method attempts to recognize face first by applying Principal Component Analysis (PCA). If face is correctly recognized, we stop and finish. But if it has not been recognized, we apply moment invariant, Hu's Equation combined a Decision Tree (DT) to classify the unrecognized faces by first attempt. In this way, we improve the recognition of high complexity on the method.

The method proposed in this research is the integration of PCA with (Moment Invariant + Face Colour) whereby this integration method is to improve the face recognition accuracy over PCA method with less complexity and the face colour in this research is refered to the face colour in gray scale. Some methods such as Phiasai’s et al., 2001 apply moment invariant on some parts of the face, this means that they need to detect that certain part first and then apply the feature extraction on it. In this way, there is some difficulty in not detecting the certain part correctly and end up getting wrong result as well. In addition to that, the detection process increases complexity and time process. In our proposed method, there is no chance for difficulty in detection of certain parts correctly because we

will not be using feature detection but instead we will be using face colour in grey scale which reduces the complexity and also the time process.

- We will be comparing our method with Phiasai's et al. method. Phiasai's et al., 2001 method is using the integration of PCA and (Moment Invariant + Nose Feature). Phiasai's et al., 2001 method for PCA has the recognition accuracy of 92% and for the integration of PCA and (Moment Invariant + Nose Feature) has the recognition accuracy of 96%. Our method is also based on this method and to enhance it.

1.2 Problem Statement

For the pose variation problem, global methods perform satisfactorily as coarse classifier but it is not robust against orientation. For varied-pose face recognition by global analysis, sometime local information has been distorted and it makes the recognition error. In the global analysis, the facial image is analyzed by the PCA method because it is optimal with any similar facial image analysis and it has been employed to extract the global information. The vectors of a face in database that are matched with one of the face image will be identified as the face owner. If it recognizes wrongly, we have proposed to integrate PCA with (Moment Invariant + Face Colour) to consider region of pose variation and colour on facial image to be robust against scaling and translation.

1.3 Scope of the Research

In this research, we are dealing with recognizing faces of human by considering pose variant under scaling, translation and rotation. Our method is using PCA integrated with (Moment Invariant + Face Colour) and applied on ORL database which contains 400 face images with 40 subjects, each subject with 10 face images of different pose, illumination and expression. The subject of our research is classified under pattern recognition of image processing.

The global analysis is analyzed by PCA. Then the global features of tested and trained images are compared to check the minimum error. If the error is less than the threshold, the system will accept the result from PCA. Otherwise, the system will be reconsidered. (Moment invariant + Face Colour) method is applied again on faces that have been rejected and with the combination with a Decision Tree based on decision rules. The rejected faces may be accepted to reduce the number of rejected faces and improve the recognition accuracy of the approach. This process may be shown more clearly in figure 1.1.

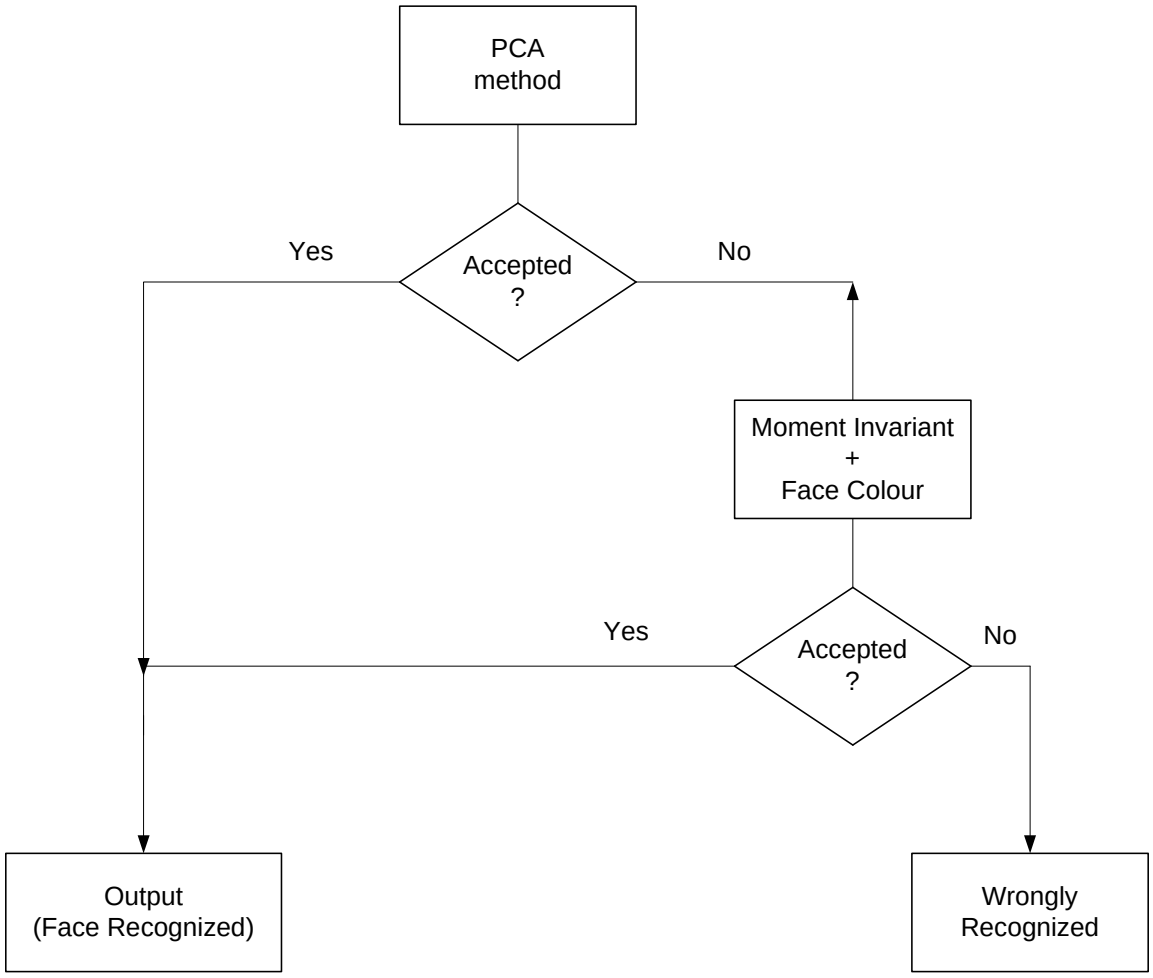

Figure 1.1: Face recognition system

1.4 Research Objectives

Much research has been done on face recognition using several techniques and methods. Many attributes should be considered while developing a system for face recognition. The most important is the recognition accuracy and the other is the time-process. In our research, our objective is to:

- Improve the recognition accuracy of human face using PCA techniques as the base algorithm and further extention whereby (Moment Invariant + Face Colour in grey scale) is applied to enhance the accuracy and speed up the processing time with less complexity.
- Develop a face recognition system with varied pose under scaling and translation.

1.5 Thesis Outline

The rest of the thesis is organized as follows:

Chapter two includes literature review and previous approaches and drawbacks to face recognition are discussed.

Chapter Three describes our methodology which is the development for integration of PCA and (Moment Invariant + Face Colour) method.

Chapter Four is based on the results obtained from the proposed method and discuss on the results of the proposed method and also a comparison with previous work.

Chapter Five contains the conclusion of the work carried out on face recognition with the proposed method and present possible future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Face recognition has been recognized for years and attention has been given to make it more robust because a robust face recognition system would allow computers to interact more intelligently with humans. With careful research and planning, the technology is ready to be deployed in real-world applications, such as access control. Attention should be given when selecting a commercial system, taking note of how system performance is evaluated and reported. National standards, regulated by a government body, are important to making face recognition systems operate smoothly across different algorithms, and acceptable by the general population. Regulators should also address the concomitant privacy issues rather than skirt them.

Face recognition problem is a classification problem where every face in the database represents a class to which the input data is to be mapped. The classification problem is compounded by the high dimensionality of the data.

The problem of machine recognition of faces can be formulated as follows: given still or video images of a scene, identify or verify one or more persons in the scene using a stored database of faces. Available collateral information such as race, age, gender, facial

expression, or speech may be used in narrowing the search (enhancing recognition). The solution to the problem involves segmentation of faces (face detection) from cluttered scenes, feature extraction from the face regions, recognition, or verification. In identification problems, the input to the system is an unknown face, and the system reports back the determined identity from a database of known individuals, whereas in verification problems, the system needs to confirm or reject the claimed identity of the input face.

2.2 Psychophysics / Neuroscience Issues Relevant to Face Recognition

The human recognition processes utilize a broad spectrum of stimuli, obtained from many, if not all, of the senses (visual, auditory, olfactory, tactile, etc.). In many situations, contextual knowledge is also applied, for example, surroundings play an important role in recognizing faces in relation to where they are supposed to be located. Below are some summarized findings of potentially relevant designs of face recognition systems.

—*Is face recognition a dedicated process?*(Biederman and Kalocsai, 1998; Ellis, 1986; Gauthier et al., 1999; Gauthier and Logothetis, 2000):

Traditionally it is understood that face recognition is a dedicated process which is different from other object recognition tasks. Evidence for the existence of a dedicated face processing system comes from several sources (Ellis, 1986). (a) Human remember faces more easily than other objects when presented in an upright orientation. (b) Prosopagnosia patients are unable to recognize previously familiar faces, but usually have