# AGE INVARIANT FACE RECOGNITION SYSTEM USING AUTOMATED VORONOI DIAGRAM SEGMENTATION

**NIK NURUL AIN BINTI NIK SUKI**

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requirements for the award of the degree of
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**Advanced InformaticSchool**
**Faculty of Computer Science and Information Systems**
**Universiti Teknologi Malaysia**

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I declare that this thesis entitled "*Age Invariant Face Recognition System Using Automated Voronoi Diagram Segmentation* " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :.....

Name :.....

Date :.....

*To my beloved family*.

## ABSTRACT

One of the challenges in automatic face recognition is to achieve sequential face invariant. This is a challenging task because the human face undergoes many changes as a person grows older. In this study we will be focusing on age invariant features of a human face. The goal of this study is to investigate the face age invariant features that can be used for face matching, secondly is to come out with a prototype of matching scheme that is robust to the changes of facial aging and finally to evaluate the proposed prototype with the other similar prototype. The proposed approach is based on automated image segmentation using Voronoi Diagram (VD) and Delaunay Triangulations (DT). Later from the detected face region, the eyes will be detected using template matching together with DT. The outcomes, which are list of five coordinates, will be used to calculate interest distance in human faces. Later ratios between those distances are formulated. Difference vector will be use in the proposed method in order to perform face recognition steps. Datasets used for this research is selected images from FG-NET Aging Database and BioID Face Database, which is widely being used for image based face aging analysis; consist of 15 sample images taken from 5 different person. The selection is based on the project scopes and difference ages. The result shows that 11 images are successfully recognized. It shows an increase to 73.34% compared to other recent methods.

# ABSTRAK

Salah satu cabaran pemadanan muka secara automatik adalah untuk mencapai turutan muka yang tidak berubah mengikut masa. Faktor utama yang menyumbang kepada permasalahan ini adalah kerana wajah manusia mengalami banyak perubahan sepanjang proses peningkatan usia. Kajian ini akan member tumpuan kepada ciri-ciri pada wajah manusia yang tidak berubah mengikut umur. Objektif kajian ini adalah untuk menyiasat ciri-ciri pada wajah yang tidak berubah mengikut umur dan boleh digunakan untuk memadankan muka, objektif kedua adalah untuk membina prototaip system pemadanan wajah yang teguh kepada perubahan penuaan wajah dan akhir sekali adalah untuk menilai prototaip yang dicadangkan dengan prototaip lain yang hampir serupa. Kajian yang dicadangkan mengunakan segmentasi imej secara automatik menggunakan *Voronoi Diagram (VD)* dan *Delaunay Triangulations (DT)*. Kemudian daripada imej wajah yang dikesan, mata akan dikesan menggunakan *Template Matching* bersama-sama dengan DT. Hasilnya, iaitu lima koordinat, akan digunakan untuk mengira jarak cirri-ciri penting dalam muka manusia. Kemudian antara jarak-jarak ini akan dikira. *Difference Vector* akan digunakan dalam kaedah yang dicadangkan untuk melaksanakan langkah-langkah pengiktirafan muka. Dataset yang digunakan di dalam kajian ini merupakan imej-imej yang dipilih dari Pangkalan Data Penuaan FG-NET dan Pangkalan Data Wajah BioID, yang secara meluas diterima pakai bagi analisis imej muka berasaskan penuaan. 15 imej sampel yang diambil daripada 5 orang yang berbeza. Pemilihan adalah berdasarkan skop projek dan perbezaan umur. Hasilnya menunjukkan bahawa 11 imej berjaya dicam. Ia menunjukkan peningkatan kepada 73,34% berbanding dengan kaedah lain baru-baru ini.

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## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| 2D | - | Two dimensional |
| 3D | - | Three dimensional |
| DT | - | Delaunay Triangulations |
| EU | - | Euclidean |
| FEBFRGAC | - | Extraction Based Face Recognition, Gender And Age Classification |
| FERET | - | The Facial Recognition Technology Database |
| FRVT 2002 | - | Face Recognition Vendor Test 2002 |
| FRVT 2006 | - | Face Recognition Vendor Test 2006 |
| GB | - | Giga Byte |
| GOP | - | Gradient Oriented Pyramid |
| GWT | - | Gabor Wavelet Transform |
| HDD | - | Hardisk |
| HP | - | Hewlett Packard |
| HSI | - | Hue Saturation Intensity value |
| ICAO | - | International Civil Aviation Organization |
| JPG/JPEG | - | Joint Photographic Experts Group |
| LDA | - | Linear Discriminant Analysis |
| MBE 2010 | - | Multiple Biometric Evaluation |
| MFDA | - | Multi Features DiscriminatAnalysis |
| MLBP | - | Multi scale local binary pattern |
| NIST | - | National Institute of Standards and Technology |

| | | |
|---|---|---|
| PCA | - | Principle Component Analysis |
| RFID | - | Radio Frequency Identification |
| RGB | - | Red, Green and Blue |
| SFS | - | Shape From Shading |
| SIFT | - | Scale Invariant Feature Transfer |
| SVM | - | Support Vector Machine |
| UDP | - | Unsupervised Discriminant Projection |
| VD | - | Voronoi Diagram |
| WLBP | - | Walsh-Hadamard transform encoded local binary patterns |

# CHAPTER 1

# INTRODUCTION

Personal verification and identification is an actively growing area of research nowadays. Face, voice, lip movements, hand geometry, odor, gait, iris, retina, fingerprint are the most commonly used authentication methods. These physiological and behavioral characteristics are known as biometrics, contributed significant advantages compared to the traditional authentication techniques (Ramesha *et al*., 2010). The high demand of the progress in this field is due to the growing role of the technology in the modern society. As a result, numbers of application appeared in daily tasks such as online electronic commerce, automated factory machines and building security system.

Face recognition is one of the biometrics approaches to identify individuals by the features of the face. Research in this area has been conducted for more than 30 years but only become famous for the past 10 years (Li *et al*., 2011); therefore, currently the face recognition technology is well advanced. Wide range of applications has been using this approach such as security and surveillance system, human computer interaction, image retrieval, criminal identification, etc. In general, the approach will be using a pre-stored image database where later the face

recognition system will be able to identify or verify the person from the captured image or another source of images to the one in the database. The age and gender of a person are grouped by visual observation of still images where it is difficult for the computer vision. Hence, there comes the need to discover the age and gender related area for further studies. However, in this project, we will be focusing only on age related issues.

## 1.1 BACKGROUND OF THE PROBLEM

Face recognition across the ages is a significant problem and has many applications such as passport photo verification, image retrieval, surveillance (Ling *et al*., 2007), etc. This is a challenging task because the human face undergoes many changes as a person grows older. Each person has different facial features in many aspects, including facial texture (e.g. wrinkles), shape (e.g. weight gain), facial hair, presence of glasses, and exposure to sunlight (Ling *et al*., 2010), that make us different to each other. In addition, the image acquisition environments also have an effect on the images captured.

The performance of face recognition systems cannot challenge with the sequential changes over a period of time. Law enforcement agencies such as crime and record bureau regularly require matching a probe image with the individuals in the missing person database (Singh *et al*., 2007), or a customs need to compare new photo to the previous photo during the passport renewal process. In such applications, there are many significant differences between the facial features of probe and gallery image due to age variation. For example, if the age of the probe image is 15 years old and the gallery image of the same person is 5 years old, an existing matching system

is ineffective and might not produce the expected result. Figure 1 shows several typical images with different age gaps.

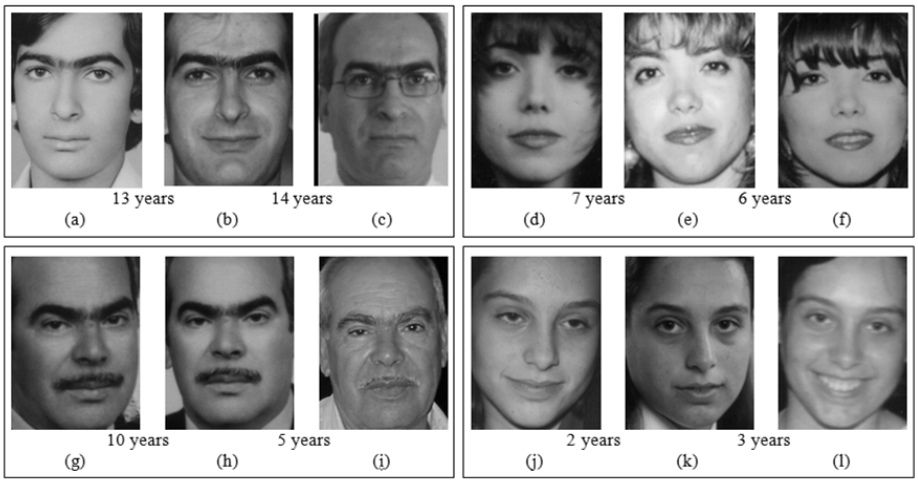


**Figure 1.1** Typical images with age differences. Source images are from the FG-NET Aging Database, http://www.cut.ac.cy/members/fgnet.

One way to overcome this challenge is to regularly update the database with recent images or templates (Singh *et al.*, 2007). However, this method is not suitable for applications such as border control, homeland security and missing person identification. To address this issue, researchers have proposed several techniques which later we will discuss in Chapter 2.

## 1.2 PROBLEM STATEMENT

Determining age-invariant features of a human face is a difficult task since human face facing significant changes across time. Still this task is necessary in many applications, especially those that require checking whether the same person have issued multiple government documents (e.g. passport, identification card and driving license) that include facial images (Li *et al*., 2011).

In this project, we will study on standard features or also being referred as age-invariant features of a human face which later can be used as target points for face recognition process. To recognize the face, we will come out with a prototype to determine whether the images come from the same person, in whom an individual is identified from a large gallery of individuals; in this project we will be using FG-NET Aging and BioID face database as our dataset.

## 1.3 PROJECT OBJECTIVES

The objectives of the project are:

1. To investigate age-invariant features of a human face;
2. To develop a prototype for face recognition system based on the selected features; and
3. To test and evaluate the accuracy of the proposed prototype by comparing with other similar face recognition prototypes.

## 1.4 RESEARCH QUESTIONS

The main questions this research motivates to answer are as follows:

1. What are the features of human face that are not changing across age?
2. How to develop a prototype of the face recognition system?
3. What is the effectiveness of the proposed prototype with other similar face recognition prototype?

## 1.5 PROJECT AIMS

The aim of this study is to investigate the age-invariant features of a human face and later develop a prototype of face recognition systems implementing the selected features. The prototype will be tested using FG-NET Aging and BioID face database as datasets in our experiments.

## 1.6 SCOPES OF THE STUDY

The scopes for this study focus on:

1. Only three (3) age-invariant features will be implemented in the prototype;
2. Image format use for this project will be in Joint Photographic Expert Group (.jpg and .jpeg) only;
3. Images sample will be a face image with frontal faces only; and
4. The prototype can dealt with color and grayscale images;
5. Sample face images will be taken from FG-NET Aging and BioID face databases;
6. Age group of the sample images is 18 years old and above.

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