UNIVERSITI PUTRA MALAYSIA

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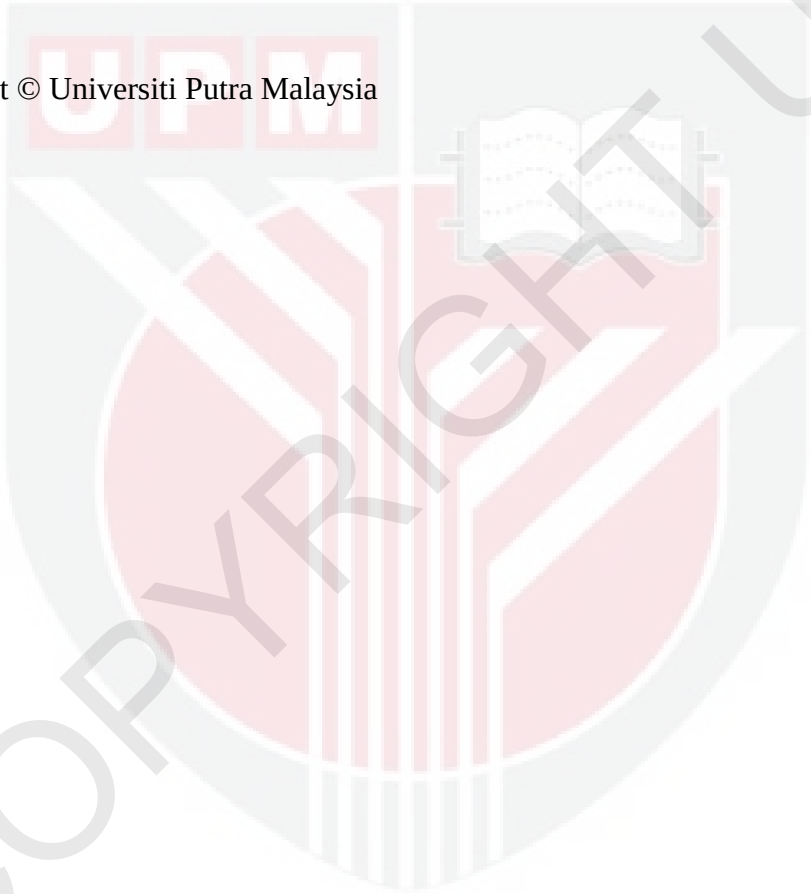

AGE CLASSIFICATION USING HIERARCHICAL SUPPORT VECTOR MACHINE BASED ON CHARACTERISTICS OF UPPER FACIAL AREA

By

HADI AFFENDY BIN DAHLAN

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

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AGE CLASSIFICATION USING HIERARCHICAL SUPPORT VECTOR MACHINE BASED ON CHARACTERISTICS OF UPPER FACIAL AREA

By

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May 2013

Chair: Syamsiah Mashohor, PhD

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Facial aging classification is a growing research in pattern recognition area, where it can be used in many applications. Most of the digital image feature extractor needs the whole facial area to be used for the age classification. This however causes disadvantage to the people who may unable to show their full face because of a certain condition such as Muslim woman who wears 'purdah' to cover their 'aurah'. Furthermore, only a few have performed feature extraction on the upper facial area, which an approach that may improve feature used and classification performance. Additionally, not many researchers have study the classification effect on different genders when using the features on the upper region. This study aimed to classify age that focused on wrinkle features at the Region of Interest (ROI) on the upper facial area using specific orientation of Gabor wavelet filter. The region is detected using a robust eye detection method. The Gabor wavelet filter is used for the wrinkle extractions together with the employed 2-step Hierarchical Support Vector Machines (SVM) as the classifier. The first step

of the method classifies the sample between age groups 20-39 and above 40, while the second step classified it again into more specific age groups whether the sample is between 20-29 and 30-39 or 40-49 and above 50. The captured facial image of Malaysian database is used in this study, as to compare with the normal use of the Caucasian databases. For the Malaysian database using the hierarchical-SVM on the upper region, the best results obtained for the overall average accuracy and Mean Absolute Error (MAE) for the male were 59.34% and 0.5968 respectively when using the 3 upper regions in both stage; while the female obtained 59.08% and 0.5308 respectively when using the 5 upper regions for both stage. To gained better performance, modification were made in the final test, by combining the used of the full facial region in the first stage and the 3 upper region in the second stage of the hierarchical-SVM classification. The final results obtained were 62.96% for the male and 62.09% for the female in the overall average accuracy; while the MAE obtained for the male is 0.4573 and 0.4857 for the female. The result for the Malaysian database has shown that the full facial ROI usage does provide good age classification in the first step. However, for distinguishing specific age group in the second step, the full ROI will not be effective anymore. It is more appropriate to use the upper facial ROI to distinguish the more senior age. The main finding in this study suggests that age classification for different gender can be detected using upper facial wrinkle, which thus complements the biometric information field.

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

MENGKLASIFIKASI UMUR MENGGUNAKAN HIERARKI VEKTOR MESIN SOKONGAN PERPANDUKAN PADA CIRI-CIRI BAHAGIAN ATAS MUKA

Oleh

HADI AFFENDY BIN DAHLAN

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Klasifikasi umur menggunakan gambar muka adalah penyelidikan yang semakin membangun di bidang pengecaman pola, di mana ia boleh digunakan dalam pelbagai aplikasi. Kebiasaannya, keseluruhan wajah muka diperlukan untuk mengestrak ciri-ciri umur muka bagi bertujuan pengelasan umur. Ini bagaimanapun, telah membawa permasalahan kepada sesetengah individu yang berkemungkinan tidak dapat mempamerkan keseluruhan wajah mereka kerana sebab-sebab tertentu seperti wanita muslim yang memakai purdah untuk menutup auratnya. Malah, terdapat segelintir penyelidik telah memperkenalkan cara mengelas umur dengan hanya menggunakan ciri-ciri bahagian atas muka sahaja, yang berkemungkinan dapat memantapkan lagi cara penggunaan ciri-ciri dan juga prestasi pengelasan umur. Tambahan, tidak ramai juga pertimbangkan kesannya pada jantina yang berbeza apabila mengklasifikasi umur menggunakan ciri-ciri bahagian atas muka. Tujuan kajian ini adalah untuk mengelaskan umur menggunakan kedutan tua yang tertumpu pada bahagian-bahagian

penting (ROI) di kawasan atas muka dengan menggunakan penapis riak Gabor dengan orientasi tertentu. Bahagian-bahagian ini dikesan dengan menggunakan fungsi pengesan mata. Penapis riak Gabor digunakan sebagai pengestrak kedut tua manakala 2-langkah Hierarki Vektor Mesin Sokongan (SVM) digunakan sebagai pengelas. Peringkat pertama hierarki-SVM mengklasifikasikan sampel antara kumpulan umur 20-39 dan 40 tahun ke atas, manakala pada peringkat kedua pula, sampel diklasifikasi lagi ke dalam kumpulan umur yang lebih khusus antara umur 20-29 dan 30-39 atau 40-49 dan 50 tahun keatas. Imej muka yang digunakan dalam kajian ini adalah imej pangkalan data Malaysia yang ditangkap, ini untuk dibandingkan dengan kebiasaan penggunaan pangkalan data Kaukasia. Bagi pangkalan data Malaysia yang menggunakan cara hirarki-SVM pada bahagian atas imej ini, hasil terbaik yang diperolehi untuk keseluruhan purata ketepatan dan ralat mutlak min (MAE) bagi lelaki adalah 59.34% dan 0.5968 masing-masing apabila 3 bahagian atas ROI digunakan pada kedua-dua peringkat; manakala perempuan pula memperolehi 59.08% dan 0.5308 masing-masing apabila menggunakan 5 bahagian atas ROI. Untuk memperolehi prestasi yang lebih baik, pengubahsuaian telah dibuat pada ujian terakhir, dengan menggabungkan penggunaan keseluruhan muka pada peringkat pertama dan 3 bahagian atas ROI pada peringkat kedua. Keputusan akhir yang diperolehi adalah 62.96% untuk lelaki dan 62.09% untuk perempuan bagi keseluruhan purata ketepatan; manakala MAE yang diperolehi bagi lelaki adalah 0.4573 dan 0.4857 bagi perempuan. Hasil yang diperolehi apabila menggunakan pangkalan data Malaysia telah menunjukkan bahawa umur diklasifikasikan dengan baik apabila menggunakan ROI muka penuh pada peringkat pertama hierarki-SVM. Walau bagaimanapun, untuk membezakan kumpulan umur yang lebih terperinci dalam langkah kedua, ROI penuh tidak akan berkesan lagi. Adalah lebih sesuai menggunakan ROI atas muka untuk membezakan

umur yang lebih tua. Penemuan utama dalam kajian ini mencadangkan bahawa klasifikasi umur untuk jantina yang berbeza boleh dikesan dengan hanya menggunakan kawasan atas muka, sekali gus melengkapi bidang maklumat biometrik.

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I certify that a Thesis Examination Committee has met on 7th Mei 2013 to conduct the final examination of Hadi Affendy Bin Dahlan on his thesis entitled "**Age Classification using Hierarchical Support Vector Machine Based on Characteristics of Upper Facial Area**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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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 Universiti Putra Malaysia or other institutions.

HADI AFFENDY BIN DAHLAN

Date: 7 May 2013

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LIST OF ABBREVIATIONS

AAM	Active Appearance Model
AGES	Aging Pattern Subspace
ASM	Active Shape Model
ARSM	Adapted Retinal Sampling Method
BERC	Biometric Engineering Research Center
BGC	Burlington Growth Center
BIF	Biologically-Inspired Features
BMI	Body Mass Index
CAM	Contourlet Appearance Model
CS	Cumulative Score
DCT	Discrete Cosinus Transformation
DWT	Discrete Wavelet Transform
FG-NET	Face and Gesture Recognition Research Network
GHPF	Gaussian High Pass Filter
HOIP	Human and Object Interaction Processing
IAD	Internet Aging Database
IHPF	Ideal High Pass Filter
LAR	Least Angle Regression
LBP	Local Binary Pattern
LDA	Linear Discriminant Analysis
LGBP	Local Gabor Binary Pattern
LOPO	Leave One Picture Out
LSDA	Locality Sensitive Discriminant Analysis
MAE	Mean Absolute Error
MASM	Modified Active Shape Model
MDA	Multiple Discriminant Analysis
MFA	Marginal Fisher Analysis
MLP	Multilayer Perceptrons

MORPH	Craniofacial Morphology
NSCT	Nonsubsampled Contourlet Transform
OAPFD	One Age Per-Person Face Database
PAL	Productivity Aging Laboratory
PCA	Principal Component Analysis
RMIR	Robust Multi-Instance Regression
ROI	Region Of Interest
SOM	Self Organizing Map
SVM	Support Vector Machine
SVR	Support Vector Regression
ULTP	Uniform Local Ternary Patterns
VLF	Vietnamese Longitudinal Face
YGA	Yamaha Gender and Age

CHAPTER 1

INTRODUCTION

1.1 Introduction

Age estimation or classification is one of the growing researches in which it can be integrate in many real world applications. Currently, there is a need of new age classification method that can help improve the process of classifying age, a method that classifies age using only the upper facial part. The approach may benefit people who unable to show their full facial because of certain condition such as the Muslim woman who wears the 'purdah'. The benefit of having an understanding of these age classification methods is that it can be applied in the machine expert that will help reduce human error. This age estimation function can be used in many different areas such as in biometric field, medical field, and even in the criminology field.

Researchers have come up with different approaches in extracting aging features from the facial images. Nevertheless, most researchers tend to concentrate on the overall region of the face in determining a person's age. However, there were several works reported that age can be estimated using particular part of the face [1, 2]. The main advantage of specific area extraction is that it reduces extracting unwanted aging features that may affect the age classification. Hence, it can also, to some extent, increase the speed of the classification process which is desirable particularly for real time response. Additionally, Lantis [1] and El Dib and Onsi [2] reported that

the upper facial region of the face (from the nose to the forehead) has the most prominent aging features that affect the overall age classification or estimation performance. Thus, hypothesis is made that the inclusion of features with low estimation capability, will consume less computational resources, and reduce error rate. Moreover, question on whether different gender would give different result when classifying the age using partial facial is needed to be studied.

Previous studies that used the upper facial region, mostly used the holistic approach when analyzing the entire upper facial region segment for the aging feature extraction. Holistic approach is a method that extracts not only the aging signature, but also other facial characteristics such as face geometric structure, expression, gender, ethnic and others. The downside of using the holistic approach is that one of its process is to dimensional reduce the feature that they have extracted. This in result creates loss on special aging characteristics (e.g. wrinkles features) that they have extracted before, which may help improve significantly in age classification. Moreover in their research, none have study on specific upper region that significantly shows important aging progression, and none also study its effects on different gender and race. Thus, an approach for age classification using the special aging signature at the specific upper facial region is proposed. The aging signature that will be using is the wrinkle. This is because the wrinkle is the most commonly use by people to estimate age, and also one of the common features used by researchers since it shows special aging characteristics that can be used for estimation [3-5]. In addition, the test will also be studying the proposed method effects when applying on different gender. Furthermore, as to compare with the normal Caucasians database used by researchers, the experiment will be done on the self obtained Malaysian

database. The method will use the Gabor filter as the wrinkle extractor and two Support Vector Machine (SVM) methods employed as the classifier, namely the multi-SVM and the hierarchical-SVM. The reason behind employing the two classifier methods is to seek which classifier method will give better age classification performance.

1.2 Understanding Aging

Facial aging are attributes of changes on the facial features, shape, texture and other biological factors. In the progress of the human aging, two biophysical change or growth happen on the face [3-5]. The first one is the craniofacial bony aging [3-6, 49, 50], where changes in bone expansion and loss on the cranium happen due to time. The bone expands when the body is growing and causes tightening on the skin, giving a younger complexion. However, when reaching adulthood, the bone will stop growing and later recede, causing less supports to the skin. The second is change due to texture and elasticity of the skin [3-6, 49, 50]. Like all other organ systems, the skins also undergo some changes proportional with time; getting less elastic when reaching seniority. Overall, people have predetermined aging progression pattern. However, some of them may age progressively fast, and others may be slower. The reason behind this is the effect of secondary factors that contribute to fast or slower aging progression. The first main factor is the intrinsic aging, which is an irregularity change inside the person's body. Examples of intrinsic factors are genetic disorder, age related disease or even cancer.

Second main factor is the external factor, which is aging cause by environmental changes such as the result from repetitive environmental stimulation or insult. Examples of common external factors that help make the facial looks older are: the gravity's acting on the skin, which progressively making the skin thinner, drier, less elastic and downward [6, 49, 50]; long exposure to the sun (photoaging), which occurs mostly on baby boomers [6, 50]; and excessively smoking, where Koh et al. [7] claimed that the older the person smokes, the more severe wrinkle will appear on the face of the smoker, creating an older complexion.

However, even though the external factors can cause the face to look older, there are some examples such as makeup and plastic surgeries that can make the face look younger. Another example is the body mass index (BMI) of a person, where, when a person starts gaining weight, they perceive to look younger because of the stretched out skin. Considering all these factors in facial aging, a proper age classification method is needed.

As for the age classifications to be applied to the system, one must know the types of data needed for the process. These data are the facial signatures that show the aging process of the human being, which can be the bone structure and the face texture. As mentioned before in the introduction, the wrinkle will be used as the aging features. Considering the wrinkles start to form in the adult stage, subjects use would be in the range of 20 years old and above.

1.3 Problem statement

Current information technology needs age estimation software for security purpose. Since most laptops or computers nowadays can equip with a camera, the image captured can be used for the authentication process. However, the problem occurs if certain people with different culture (e.g. woman wear purdah) or condition (e.g. wear flu mask), in which they unable to open their face cover. How would the age be estimate if only the upper facial part is available?

1.4 Aim and Objectives

The aim of this research is to classify age by focusing on the wrinkle features on the Region of Interest (ROI) located at the upper facial area using specific orientation of Gabor wavelet filter for extraction. The objectives of this study are:

1) To propose significant characteristics of upper facial area for age classification.
2) To develop a Gabor filter based features extraction system for upper facial area.
3) To employ two support vector machines for age classification using the features extracted in the second objective.
4) To compare classification on different gender and ethnic using the Malaysian, FG-NET and SCFile databases.

1.5 Thesis Outlines

The thesis content is organized as follows: The Literature Review (Chapter Two) reviews the literature of past studies about face aging and age classification works on still images. Research Methodology (Chapter Three) explains the process of the proposed method. The Results and Discussion (Chapter Four) shows results of the preliminary and final experiment. Lastly, the Conclusion (Chapter Five) concludes the overall thesis, and give suggestions on the future works of the study.

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