FEATURE-BASED FACE RECOGNITION SYSTEM USING UTILIZED ARTIFICIAL NEURAL NETWORK

by

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ABSTRAK

SISTEM PENGECAMAN MUKA BERASASKAN ORGAN MUKA DENGAN MEMPERGUNAKAN CIPTAAN RANGKAIAN SARAF

Matlamat projek ini adalah untuk mengurangkan masalah yang telah membelenggui prestasi sistem pengecaman muka manusia sejak dahulu lagi seperti kelebihan keterangan, reaksi muka, gaya rambut, kehadiran misai dan janggut. Sumbangan utama projek ini ialah penciptaan algoritma automatik untuk pengesanan mulut, pemotongan organ muka dan pengecaman muka manusia. Pertama, algoritma ini akan mengesan muka dan iris manusia. Kawasan mulut dapat dianggar dengan menggunakan ukuran geometri berasaskan kedudukan iris yang telah dikesan. Algoritma yang dicadangkan telah menggabungkan pegautomatikan warna RGB dan teknik pengesanan sudut untuk mendapatkan kedudukan sudut mulut yang tepat. Selepas itu, system pemotongan organ muka akan memotong keluar iris dan mulut yang dikesan secara automatik. Maklumat raut wajah yang didapati akan dimasukkan ke dalam rangkaian saraf ulang-balik. Senibina rangkaian saraf ini dibentukkan oleh dua lapisan rangkaian saraf. Rangkaian saraf yang kedua merangkumi keputusan-keputusan dari teknik pencontoh pemadanan dan rangkaian saraf pertama. Penggabungan ini berperanan untuk menurunkan pengecaman yang salah dan meningkatkan prestasi rangkaian saraf. Algoritma pengecaman muka automatik berasaskan organ muka yang dicadangkan dalam tesis ini mempunyai kecekapan melebihi 95% walaupun berdepan dengan syarat-syarat kritikal yang dibincangkan. Semua keputusan eksperimen telah dikaji untuk membuktikan kualiti dan keistimewaan penyelidikan ini.

ABSTRACT

This project aims to reduce the effect of critical conditions such as excessive illumination, facial expressions, hairstyles, beard and moustache which have affected the performance of face recognition since ages ago. The main contributions of this project are the automatic algorithms for mouth detection, facial features cropping and face classification. First, the algorithm will detect a human face and irises. Second, the mouth region is estimated by using geometric calculation based on the irises positions. A proposed algorithm which combines RGB color map and corner detection techniques will detect the mouth corners. Then, the proposed features cropping system will crop the detected iris and mouth automatically. These features are fed into the backpropagation neural network. The proposed architecture contains two neural networks. The second network merges the results from template matching and first neural network to reduce wrong recognition rate and improve the performance of neural network. The proposed automatic feature-based face recognition system has efficiency more than 95% under the stated critical conditions. All the experiment results are studied to prove the quality and uniqueness of this research.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces artificial intelligence, computer vision and their impact on face recognition. Besides that, much emphasis is put on face as an important biometric system, related applications and the fundamental knowledge in developing a face recognition system. This chapter includes project objectives, limitation and problem statement faced in this project. Last but not least, the chapter concludes with the organization of this thesis.

1.2 Impact of Artificial Intelligence and Computer Vision in Face Recognition

Artificial Intelligence (AI) is the study of the abilities for computers to perform tasks which currently are better done by humans. AI is an interdisciplinary field where computer science intersects with philosophy, engineering and other fields. Human makes decision based upon experience and intuition. The essence of AI is the integration of computers to mimic this learning process, simply known as artificial intelligence integration. AI can be explained as computer representation of human behavior. The two fundamental notions that involve computers and human behavior are expert systems and neural network. Expert systems are intelligent computer programs which done by human expertise (Schalkoff, 1997). Artificial neural network is a

programming structure with the similar function as human brain. It is trained in this research to recognition different types of human faces.

Computer Vision is concerned with modeling and replicating human vision using computer software and hardware. It combines knowledge in various fields in order to understand the operation of human vision system. Computer vision is the study and application of methods which allow computers to understand image content in general. From the view of image understanding, computer vision is a discipline that studies how to reconstruct, interpret and understand a three-dimensional (3D) scene from its two- dimensional (2D) images in terms of the properties. Computer vision is able to extract specific features from the image data such as image processing and features data extraction to be applied in robots and autonomous vehicles. It is able to study and describe technical vision system which is implemented in software or hardware by learning methods.

1.3 Face and Biometrics

Face is a biometric. Biometrics technologies are now the foundations of highly secure identification and personal verification solutions. Compared with conventional methods based on Personal Identification Number (PIN), biometrics technologies offer some unique advantages. Biometric is individualized traits while passwords might be stolen. It is inexpensive and convenient since there is nothing to carry or remember. Among all biometrics, face biometric is unique because face belongs to both physiological and behavioral categories. Physiological biometric is the innate traits while behavioral biometric is mannerism that is learned. Face biometric has advantages

over other biometrics because it is natural, non-intrusive and easy-to-use. It is ranked first in the compatibility evaluation of a Machine Readable Travel Document (MRTD) system on the basis of six criteria: enrollment, renewal, machine-assisted identity verification requirements and performance (Li & Jain, 2005).

Nowadays, many airports are in consideration to install the face recognition cameras as one of the security measure. The United States Visitor and Immigrant Status Indicator Technology (US-VISIT) program requires visitors to provide fingerprints and a digital photograph. US-VISIT is interfaced with the Automated Biometric Identification System (IDENT) database to check if the visitor is a "person of interest". Face recognition technology has found to be useful in detecting terrorists in United States. Similarly, the Real Identity (ID) Act of 2005 would include an integrated computer chip in driver's license which contains a digital photograph for facial recognition purposes (Jebara, 2000). In Malaysia, face recognition system can be launched in certain area to reduce the criminal rate such as snatch thefts and rape cases.

1.3.1 Future Implementation of Face Recognition System

Human faces recognition systems have been applied in various applications such as personal identification, surveillance, access control, login authentication and law enforcement. However, the strong demand for user-friendly system which can secure our properties and protect our privacy is obvious. Although extremely reliable methods of biometric personal identification exist such as fingerprint analysis and iris recognition, these methods have yet to gain acceptance by general population. For example, there was a case where the driver’s thumb had been cut by the robbers to cope the fingerprint car security system. A personal identification system based on frontal

images of the face is non-intrusive and user-friendly. Moreover, personal identity can be ascertained without the person’s assistance.

Besides that, face recognition is also useful in human-computer interaction, virtual reality, database retrieval and computer entertainment. "Smart Home" is a new wave of technologies that aims to aid elders at homes electronically. Nowadays many elderly folks are left alone at home, while their children are busy with their hectic work load. This system can be used to monitor visitors and avoid intruders from entering the house (Zuo & de With, 2005). It aims to help those handicapped people, old folks and kids who are left at home alone. Face recognition system can be integrated with other biometric system such as fingerprint to form a more perfect smart home concept.

1.3.2 The Growth and Development of Face Recognition

Over the past decade, face recognition has attracted substantial attention from various disciplines and seen a tremendous growth in the research. Humans are good at face identification but machine recognition is never an easy task. Facial recognition system is a computer-based security system that is able to automatically detect and identify human faces. These systems depend on recognition algorithms. The first step for a facial recognition system is to detect a human face and extract it from the scene. The system may measure nodal points on the face, such as the distance between the eyes to match with the nodal points computed from different database. New technologies are able to create three-dimensional models of a person's face to create more nodal points for comparison. However, this research is still under development and is inherently susceptible to error given that the computer is extrapolating a three-dimensional model from a two-dimensional photograph.

Automatic face and facial features detection have become crucial for face recognition. Since most recognition techniques can estimate the positions of the facial features, accurate location of the features is another essential step in face recognition process. The eye and mouth are salient and stable features compared with other facial features. These features are important facial landmarks which significantly affect the performance of face recognition. The research of this project is based on the design and development of a features-based face recognition system which is fast, simple and accurate. The proposed algorithm is developed using the combination of C and MATLAB programming language. The proposed algorithm performed well under normal and external lighting environment, various facial expressions, controlled head orientation angles, different hairstyles and noises such as moustache and beard in color images.

1.4 Problem Statement

Human recognition system is very difficult to develop because human faces are complex, multidimensional and vary according to environmental changes. Human face recognition is confronted to various problems such as face identity, face variation, aging, illumination and viewing direction. In order to study and analyze some of these problems, all the images are downloaded from online AR face database (Martinez & Benaventa, 1998).

Today, different facial expressions, hairstyles, appearance of moustache and beard, head tilts, and illumination changes are the major challenges for face recognition. Artificial Neural Network has been suggested to learn the variation of angles and face

expressions (Rizon & Firdaus, 2006). A new model which combines the neural networks and template matching as classification technique has been proposed in this project. Suitable image processing steps can reduce the effect from environmental and illumination changes. A new algorithm is proposed to detect the mouth corners. It is able to cope with moustache, beard and various facial expressions. Aging is another problem facing by real-time face recognition system. In an offline system, this problem can be eliminated by uploading the face images to the face database from time to time. Anyhow, the possibility of false matches and other technological shortcomings of current facial recognition systems might still happen in real-time.

1.5 Project Objectives

The objective of this research is to develop a simple yet robust algorithm for feature-based face recognition system. The proposed algorithm detects and extracts facial features information automatically for human face classification. The focus of the developed algorithm is to reduce the effects of excessive illumination, moustache, beard, facial expressions and head tilts for different individuals. This project involves the implementation of theoretical techniques such as image processing, corner detection, feature extraction, template matching and artificial neural network.

1.6 Limitations

1. The foreground of the image is limited to head-shoulder with plain background.
2. Head tilt is controlled within $\pm 30°$.

3. Real time camera is not supported as the images are chosen from online AR database (Martinez & Benaventa, 1998).
4. Supported images with moustache, beard, various hairstyles and facial expressions.
5. As complexity of computational and hardware requirement, only 15 individuals are tested in the thesis.

1.7 Report Organization

The report is divided into five main chapters. Chapter 1 (Introduction) gives a brief review on the background and importance of face recognition, problems, objectives and limitations of the project. The structural organization of the complete thesis is identified in this chapter.

Chapter 2 (Literature Review) investigates previous and existing literature materials related to face recognition. This chapter covers the techniques and researches developed for face recognition system. The theories for image processing, feature extraction, neural network and other methods which are related to the proposed algorithm are previewed.

In Chapter 3 (Methodology), the procedures and methods chosen to develop the project are presented. This chapter focuses on the research work done in developing the face recognition system. The equations and theories used in the proposed algorithm are discussed. Problems-solving explanations are provided in this chapter.

Chapter 4 presents the results and discussion of the project. Thorough analysis and explanations have been done in this chapter. The results are reviewed through graphs, tables and figures. Problems and development involved in all the stages in this algorithm are discussed.

Chapter 5 concludes the report by summarizing the outcome of the project, project contributions and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review of the project is based on face recognition, facial features detection and extraction techniques and Neural Network in general. The applications of face recognition system are also reviewed in this chapter.

2.2 History of Face Recognition

Research in face recognition generally falls into two categories, holistic (global) methods (Beymer, 1994; C.M. Li, Y.S. Li, Zhuang & Xiao, 2004) and feature-based methods (Chellappa, Wilson & Sirohey, 1995; Brunelli & Poggio, 1993; Gu, Su & Du, 2003; Song, He, Zhou, Liu & Li., 2004). Feature-based methods rely on the identification of certain nodal points on the face such as the eyes (Ryu & Oh, 2001), nose, mouth (C.M. Li, Y.S. Li, Zhuang & Xiao, 2004; Sobottka & Pitas, 1998) and ears. The location of those points can be determined to analyze surrounding region locally. Independent processing of the eyes, nose and other parts is performed and combined for face recognition. This system is robust to position variations in the image since detection of feature points is the main technique. Holistic methods treat the face as a whole or two dimensional patterns without attempting to localize individual points. These techniques do not destroy any information by exclusively processing certain parts

of a face. However, these methods are sensitive to variations in position and scale which restricts their use to frontal mug shot images (Chellappa, Wilson & Sirohey, 1995) and large samples of training data are required. New technologies are currently in development to create three dimensional models of a person's face. These methods can create more nodal points for comparison. However, such technology is inherently susceptible to error while computer is extrapolating a three dimensional model from a two-dimensional photograph.

Early attempts at face recognition were mostly featured-based. These include Kanade's (1973) work where a series of nodal points are detected using relatively simple image processing techniques such as edge maps and signatures. More sophisticated feature extraction algorithms were proposed by Yuille, Cohen and Hallinan (1989) by using deformable template. Mostly, these techniques use a knowledge-based system to restrict the search space with geometrical constraints. Unfortunately, such energy minimization methods are computationally expensive. Certain tolerance must be given to the models since they can never perfectly fit the structures in tested images. Brunelli and Paggio (1993) and Beymer (1994) located facial features using template matching. The template is moved along the image, a patch of sub-image with the best match is selected as the region of interest.

Pentland, Moghaddam and Starner (1994) used eigenspace to locate facial features. Sub-images are projected onto the eigenspaces to compute their matching errors. However, template matching and eigenspace method require normalization of the face for variation of size and orientation. A large number of templates are needed to accommodate varying pose. These algorithms can only detect patterns similar to the

model. Then, Nixon (1985) proposed the use of Hough transform techniques to detect structures more efficiently. Anyhow, the problem remains and the algorithm is still insensitive to the minute variations needed for recognition. Automatic localization had generated poor results due to lower precision. In fact, even the most precise deformable template matching algorithms such as technique developed by Roeder (1995) generally have significant errors in detection. Essentially, current automatic systems are not accurate enough to obtain high recognition rates exclusively based on simple geometrical statistics of the localization.

Holistic techniques have been popularized and generally involve the use of transforms to make the recognition robust to variation in the image. Manjunath (1992) uses a wavelet transform to extract feature points and perform recognition on the basis of Gabor wavelet jets. Pentland, Moghaddam and Starner (1994) used Karhunen-Loeve decomposition to generate optimal basis to map the faces into a lower-dimensional representation for recognition. This technique has also been applied by Akamatsu, Sasaki, Fukamachi, Masui and Suenaga (1992) on Fourier-transformed images instead of the original intensity images. These techniques have yielded very high recognition rates and popularity but do not fare well under pose changes or dealing with natural face images. In most holistic face recognition algorithms, the face needs to be either segmented or surrounded by a simple background, roughly frontal and well-illuminated for recognition to remain accurate. Thus, performance degrades under non-linear illumination variation, 3D orientation changes and background clutter.

2.3 Research in Facial Features Detection and Classification

A popular method used to detect facial features is the use of vertical and horizontal projections. The projections can be employed on the first derivative of the image (Brunelli & Poggio, 1993) or directly on the intensity values. Projection-based methods (Ryu & Oh, 2001; Baskan, Bulut & Atalay, 2002; Chen & Tiddeman, 2007; Lanzarotti, Campadelli & Borghese, 2001) have been used particularly to find coarsely the position of the facial features. However, some weaknesses identified from the previous researches using projection-based methods include: inefficiency in detecting mouth from individuals with beard (Chen & Tiddeman, 2007; Ryu & Oh, 2001), training and testing database only consists of images with no facial expressions (Lanzarotti, Campadelli & Borghese, 2001) and face region needs to be extracted manually before using projection-based methods for facial features detection (Baskan, Bulut & Atalay, 2002). Such limitations need to be overcome in order to fully utilize the potential of projection-based methods in the effort of automatic facial features detection.

In order to detect and extract facial features, projection method is used more effectively by developing algorithms which combine this technique with other techniques such as template matching and color space. The combination of projection method and template matching (Yang & Yuan, 2000) has achieved 90% accuracy in extracting facial features. However, template matching has shortcomings that need to be solved for it to be used effectively in face recognition systems: overcoming the variation caused by facial expressions such as open or closed mouth by increasing the number of training templates. Projection method has also been combined with color space (Sobottka & Pitas, 1998). By using color space, face region can be detected automatically. The combination of edge map and projection method has also been

attempted (Li et al., 2004; Guizatdinova & Surakka, 2005). These researches have considered face images with beard, glasses and facial expressions but achieved relatively low efficiency, achieving only 50% to 87% for mouth feature detection.

Efforts have been placed in mouth detection by using Active Shape Model (Moran & Pinto-Elias, 2007). Using information of vertical projection and horizontal projection of the mouth area, the lips region is first established before using Active Shape Model. This combination has flexibility in detecting the shape of mouth, however, the success rate can be affected by illumination and poor contrast between lips and the skin surrounding the lips. Genetic Algorithm (Wong, Lam & Siu, 2001; Yen & Nithianandan, 2002) has also been applied for facial feature extraction. This technique is effective in extracting regions of interest but is limited to images captured under controlled lighting and the ineffectiveness in detecting mouth where beard and moustache are present has not been overcome. Clustering of Gaussian derivative responses (Gourier, Hall & Crowley, 2004) is effective and robust to illumination achieving around 94% to 98% in detecting facial features but this technique can be affected when the head is tilted and when moustache and beard are present. Gabor filter (Shih & Chuang, 2003) is applied on face boundaries extracted using projection method. Gabor technique is computationally expensive and difficult in adjusting parameters. In addition to that, the technique is only proven successful in face images captured in frontal view without glasses and the head is not tilted or rotated. In conclusion, projection-based methods are easily affected by intensity variation and the appearance of beard or moustache. This may cause wrong or inaccurate region extraction.