# ON FEATURE EXTRACTION USING GABOR FILTER AND FEATURE RELATION GRAPH FOR OFFLINE SIGNATURE VERIFICATION

SAEED JAMALI

A dissertation submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computer Science and Information Systems
Universiti Teknologi Malaysia

MAY 2012

To

my mother and father for your love and encouragement

To

my beloved wife for your love and inspiration

# ACKNOWLEDGEMENT

First and foremost, I would like to express heartfelt gratitude to my supervisor **Prof. Dr. Ghazali Bin Sulong** for his constant support during my study at UTM. He inspired me greatly to work in this project. His willingness to motivate me contributed tremendously to our project. I have learned a lot from him and I am fortunate to have him as my mentor and supervisor

Besides, I would like to thank the authority of Universiti Teknologi Malaysia (UTM) for providing me with a good environment and facilities such as Computer laboratory to complete this project with software which I need during process.

# ABSTRACT

The most important and difficult stage of each offline signature verification system is feature extraction stage. The performance of the system mainly depends on effectiveness of the feature extraction algorithm. Current methods in this domain make use of different feature extraction and classifications approaches like Radon Transform, VQ, Gabor filter, SVM, KNN, MD, and etc. However, accuracy is still the main issue in this field. The final aim of this study is to implement an offline signature verification system to verify the originality of the test signature images and distinguish the skilled and random forgery from genuine. This project combines Gabor filter, XGabor filter, and gravity center point as a novel feature extraction algorithm and uses FRG (Feature Relation Graph) classifier for classification phase. The proposed system is validated using GDPS signature database, where it achieved equal error rate of 7.66% which is outperformed the latest works in this field.

# ABSTRAK

Tahap paling penting dan sukar dalam setiap sistem pengesahan tandatangan luar-talian adalah tahap pengekstrakan fitur. Prestasi sistem terutamanya bergantung kepada keberkesanan algoritma pengekstrakan fitur. Kaedah semasa dalam domain ini menggunakan pendekatan pengekstrakan fitur dan klasifikasi yang berbeza seperti Transformasi Radon, VQ, penapis Gabor, SVM, KNN, MD, dan sebagainya. Walau bagaimanapun, ketepatan masih menjadi isu utama dalam bidang ini. Matlamat akhir kajian ini adalah untuk melaksanakan sistem pengesahan tandatangan, untuk mengesahkan keaslian imej tandatangan ujian dan membezakan pemalsuan mahir dan rawak dari yang tulen. Projek ini menggabungkan penapis Gabor, penapis XGabor, dan titik pusat graviti sebagai algoritma pengekstrakan fitur baru dan menggunakan pengelas FRG (Feature Relation Graf) untuk fasa klasifikasi. Sistem yang dicadangkan disahkan dengan menggunakan pangkalan data tandatangan GDPS, di mana ia mencapai kadar kesilapan kesamaan sebanyak 7.66% yang mengatasi kerja-kerja terbaru dalam bidang ini.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| EER | - | Equal Error Rate |
| FAR | - | False Acceptance Rate |
| FRG | - | Feature Relation Graph |
| FRR | - | False Rejection Rate |
| GCP | - | Gravity Center Point |
| KNN | - | K-Nearest Neighbor |
| MD | - | Mahalanobis Distance |
| SVM | - | Support Vector Machine |

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

In terms of identification and verification, many studies have been done by scientists and engineers in the field of Computer Science. These studies are particularly focuses on human biometrics. The human biometric is the most commonly defined as measurable physiological features such as finger print, DNA, iris of eye and behavioral characteristics of the individuals like handwriting, signature, voice, and gait.

## 1.2 Background of Problem

The style of a person's handwriting is a biometric feature that can be used for authentication. The researches in this field have been started from 1970s till now and it is still the fastest growing field to explore. Various methods for various types of classification also have been investigated. However, most of them are not extendable to other languages, because every language has their own specific characteristics and several writing styles. One of the biggest problems that they encounter to find a language-independent method is the features dissimilarity for different languages (Helli and Moghaddam, 2010).

Signature is another behavioral biometric that is mostly like handwriting and is very useful for individual authentication, but there are some characteristics that make it different from handwriting (Shanker and Rajagopalan, 2007). For instance most of the signature styles are independent of the language of person who sign, in some cases they are just a painting consists of curved shape lines mixed with somehow name writing. This could be both the advantageous and the disadvantage of starting a research on new methods for signature verification. The advantage point is that, it will help us to focus our research on algorithms which are in independent-language classification. It means that we will not have any problem indifferent language signatures and we can increase the compatibility of applications on this issue without any specific situation like other methods. However, due to these characteristics, those persons who don't follow exact rules in their signatures and it makes it difficulties to find a new method for extracting the signature features which could be expandable to other languages.

In general, signature verification systems can be categorized into two main classes: offline like (Samuel and Samuel, 2010; Shanker and Rajagopalan, 2007; Wen et al., 2007) and online systems (Khalid et al., 2009; Yanikoglu and Kholmatov, 2009). Due to available dynamic information such as pressure, acceleration, stroke orders, angle and etc, online verification systems are more accurate. Thus, an online classification task considered to be less difficult than offline one.

## 1.3 Statement of Problem

Because of the importance of offline signature verification on discriminating the genuine signature from the forgery, and the usefulness application in bank service and forgery detection, the existence of accurate person identification method based on signature is necessary. In this research we want to propose an offline, language-independent signature verification method. Our feature extraction and data representation are all new in field of signature verification and they have not been presented before in this domain.

Moreover, our feature extraction filter is a novel filter based on Gabor filter with combination by gravity center point that has been used in literatures frequently but separately for pattern based features extraction. In addition, in data representation, we use a feature relation graph (FRG) that can be generated in a specific way by using fuzzy relations between extracted features. This also can be used with graph similarity algorithms to do the classification phase. We hope our method can verify all signatures with high level of accuracy and performance.

## 1.4 Purpose and Objectives

Automatic signature verification remains as an interesting area of study for researchers to date. Generally speaking, due to high level of acceptance and usage of signature verification systems like automatic check clearing system in banks, this kind of systems are strongly desirable in applications. Unfortunately, because of the sensibility of handwritten signatures to forgeries, it is hard to achieve an offline system with high performance and accuracy. Many researchers are trying to find better feature extraction methods; therefore, this effort, encourage us to start a new study on a new accurate offline signature method.

The objectives of this study are:

1. To develop a novel filter based on a combination of Gabor filter and gravity center point to extract pattern features of signature data.
2. To propose a new data representation method and FRG (feature relation graph) algorithm in data classification stage based on fuzzy relationship between features.
3. To verify and implement a whole accurate language independent offline signature verification system for skilled and random forgery detection.

## 1.5 Research Questions

1. How can we design a new filter based on Gabor filter and gravity center point to extract accurate pattern features of signature data in an offline signature verification system?
2. What is the FRG (feature relation graph) algorithm and how can we use FRG based on fuzzy relationship between the features in our data classification stage of the signature verification method?
3. How can we implement a whole accurate language independent offline signature verification system for skilled and random forgery detection?

## 1.6 Significance of the Study

The most important output of this study is an offline signature verification system with some specific advantages such as: our system can be used to discriminate the genuine signature from skilled or random forgery one with high performance and accuracy in a very short time. This achievement is due to our new feature extraction method with low rate of errors and the optimal FRG algorithm in a classification level of systematic learning. And the other advantage is that our system is able to work for every author with different languages, because it is a language-independent system.

## 1.7 Scope of the Study

In order to test the performance of the system, we will use GPDS signature database as our signature resource for learning and testing individual identification. GPDS is one of the most popular databases which is used for performance estimation, and it contains signature samples of 960 individuals.

More details about this dataset are explained in chapter 3. However in case of special characteristics, different orientation of sample signatures is beyond the GPDS

Signature dataset. The only issue that should be concerned in this case is the varying size of signature images which is covered in GPDS. Some signature image samples are shown in Appendix C.

## 1.8 Organization of the Dissertation

This chapter discussed the general idea of the project and shows that this domain is still viable and interested among researchers. In the following chapters more in-depth idea of proposed method will be discussed.

This project is organized as follows: in chapter two some recent methods and literatures are presented in order to become more familiar and help to understand better this domain. Chapter three explains the whole methodology and algorithms are used to implement our method. Experimental results and discussions are presented in chapter four and finally chapter 5 contains the conclusion and possible future works in this field.

## REFERENCES


Ahmad, S. M. S., Shakil, A., Faudzi, M. A., Anwar, R. M., and Balbed, M. A. M. (2009). A Hybrid Statistical Modelling, Normalization and Inferencing Techniques of an Off-Line Signature Verification System. *2009 WRI World Congress on Computer Science and Information Engineering*, 6-11. IEEE.

Ali Abdalla, A. A., and Zhirkov, V. F. (2009). Offline Signature Verification Using Radon Transform and SVM/KNN Classifiers, *27*(1), 148-53.

Almazan, J., Fornes, A., and Valveny, E. (2011). A Non-Rigid Feature Extraction Method for Shape Recognition. *International Conference on Document Analysis and Recognition (Rochester, N.Y.)*, 987-991.

Ammar, M. (1991). Progress in Verification of Skillfully Simulated Handwritten Signatures. *IJPRAI, 5*(1-2), 337-351.

Blondel, V. D., Gajardo, A., Heymans, M., Senellart, P., and VanDooren, P. (2004). Ameasure of Similarity Between Graph Vertices: Applications to Synonym Extraction and Web Searching. *SIAM Review*, 647–666.

Cheng, G., and Wei, F. (2009). The Methods of Personal Features Selection Using ACOGA and Geometric Extrema Characteristics for Chinese Online Signature Verification. *Network Infrastructure and Digital Content, 2009. IC-NIDC 2009*, 562 - 565.

Cheriet, M., El-Yacoubi, M. A., Fujisawa, H., Lopresti, D. P., and Lorette, G. (2009). Handwriting recognition research: Twenty years of achievement... and beyond. *Pattern Recognition*, 3131-3135.

Ferrer, Miguel A., Alonso, Jesus B., and Travieso, Carlos M. (2005). Offline Geometric Parameters for Automatic Signature Verification Using Fixed-Point Arithmetic. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 27*(6), 993-997.

Guru, D. S., and Prakash, H. N. (2009). Online Signature Verification and Recognition: An Approach Based on Symbolic Representation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *31*(6), 1059-1073.

Helli, B., and Moghadam, M. E. (2008). Persian Writer Identification Using Extended Gabor Filter. *Lecture Notes in Computer Science*, *5112/2008*, 579-586.

Helli, B., and Moghaddam, M. E. (2010). A Text-independent Persian Writer Identification Based on Feature Relation Graph ( FRG ). *Pattern Recognition*, *43*(6), 2199-2209. Elsevier.

Kekre, H. B., Bharadi, V. A., and Sarode, T. K. (2010). Signature Recognition Using Vector Quantization. *Proceedings of the International Conference and Workshop on Emerging Trends in Technology - ICWET '10*, (Icwet). New York, New York, USA: ACM Press, 11-18.

Khalid, M., Mokayed, H., Yusof, R., and Ono, O. (2009). Online Signature Verification with Neural Networks Classifier and Fuzzy Inference. *Third Asia International Conference on Modelling and Simulation*, 236-241.

Madasu, H., Yusof, M. H. M., and Krishna, M. V. (2005). Off-line signature verification and forgery detection using fuzzy modeling. *Pattern recognition*, *38*, 341-356.

Melnik, S., Garcia-Molina, H., and Rahm, E. (2002). Similarity Flooding: A Versatile Graph Matching Algorithm and its Application to Schema Matching. *Proceedings 18th International Conference on Data Engineering*, 117-128. IEEE Comput. Soc.

Nguyen, V., Blumenstein, M., and Leedham, G. (2009). Global Features for the Off-Line Signature Verification Problem. *International Conference on Document Analysis and Recognition*, 1300-1304.

Prasad, V. S. N., and Domke, J. (2005). Gabor Filter Visualization. *Technical Report, University of Meryland*.

Ramachandraa, C., Rao, J. S., Raja, K. B., Venugopla, K. R., and Patnaik, L. M. (2009). Robust Offline Signature Verification Based On Global Features. *IEEE International Advance Computing Conference (IACC)*, 1173-1178.

Ruiz-del-solar, J., Devia, C., Loncomilla, P., and Concha, F. (2008). Offline Signature Verification using Local Interest Points and Descriptors. *Image (Rochester, N.Y.)*, 22-29.

Samuel, D., and Samuel, I. (2010). Novel Feature Extraction Technique for Off-line Signature Verification System. *International Journal of Engineering Science*, *2*(7), 3137-3143.

Shanker, A. P., and Rajagopalan, A. N. (2007). Off-line signature verification using DTW. *Pattern Recognition Letters*, *28*(12), 1407-1414.

Vargas, J. F., Ferrer, M A, Travieso, C M, and Alonso, J B. (2011). Off-line signature verification based on grey level information using texture features. *Pattern Recognition*, *44*(2), 375-385. Elsevier.

Vargas, J. F., Ferrer, Miguel A, Travieso, Carlos M, and Alonso, Jesús B. (2008). Off-line Signature Verification Based on High Pressure Polar Distribution. *International Conference on Frontiers in Handwriting Recognition*, 373-378.

Wen, J., Fang, B. I. N., Tang, Y. Y. A. N., Zhang, T. A. I. P., and Chen, H. X. I. N. (2007). Offline signature verification based on the gabor transform. *2007 International Conference on Wavelet Analysis and Pattern Recognition*, 1173-1176. IEEE.

Wen, J., Fang, B., Tang, Y. Y., Wang, P. S.-P., Cheng, M., and Zhang, T. (2009). Combining Eodh and Directional Gradient Density for Offline Signature Verification. *International Journal of Pattern Recognition and Artificial Intelligence* (*IJPRAI*), 1161-1177.

Yanikoglu, B., and Kholmatov, A. (2009). Online Signature Verification Using Fourier Descriptors. *EURASIP Journal on Advances in Signal Processing*, *20*, 1-14.