PERFORMANCE EVALUATION OF BIOMETRIC SYSTEM

YOUNIS ELMADANY HAMED

A project report submitted in partial
fulfillment of the requirement for the award for the Degree of
Master of Engineering
(Electrical-Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

APRIL 2007

Dedication to my parents my Dad, Elmadany Hamed

Mum, Amina Haid

Brothers and sisters

Thank you for your love, support, prayers,

and encouragement.

ACKNOWLEDGEMENTS

By the name of ALLAH and precious prayer on his profit Mohamed, I grateful ALLAH to give me the ability to reach this level of knowledge by making good people helps me, support me, and guide me in this work and gave me the advices to make this work as good as possible my supervisor: Prof. Ir. Dr. Sheikh Hussain Shaikh Salleh and Amar K. Arief, and all my lecturers during my master course.

I acknowledge sincerely with thanks the many contributions of all those who have helped in the preparation of this thesis.

ABSTRACT

Since biometrics may used to ensure that a person accessing information is authorized to do so, interest in biometrics for information assurance has increased recently. New biometric applications are constantly being announced while at the same time new spoofing technology is being developed to defeat them. One approach to overcoming the problem of spoofing is the use of multimodal biometric fusion. Most current research is focused on overcoming the deficiencies of a single biometric trait or reducing the false acceptance rate, both without any emphasis on the false rejection rate. Multimodal biometric fusion combines measurements from different biometric traits to enhance the strengths and diminish the weaknesses of the individual measurements. In this project we considered three types of biometrics techniques are fingerprint, hand-scan, and voice-scan. This project examines the use of cost function to set the threshold point such that an optimization of false acceptance and false rejection rate can be achieved. Other minimum cost thresholds with different setting of FA and FR prior probabilities and costs are also shown to be better than EER in terms of total cost. The experimental results for voice-scan show that the minimum cost is better than EER in term of combination digits, also the experiments also show that by using cost function the new threshold be more accurate and by that one could be able to find new FR and FA which provide a new EER, for example the EER=5.29% for 6 digits in normal case and by using cost function the EER became 5.28%. The experimental results on the digits combination show the cost becomes less whenever the number of combination digits becomes bigger. For 2 digits combination the min-cost is 12.5 while it is 5.287 for 6 digits combination. On the hand-scan and fingerprint-scan the experimental results were perfect by the methods were used in these tasks. Hence, by considering the cost function as one way to calculate the cost for any multimodal biometric system, the different costs depending on the application, become easier to provide.

ABSTRACT

Sejak teknologi biometrik telah diterimapakai dalam memastikan pengguna yang mendapatkan sesuatu maklumat adalah pengguna yang sah, minat terhadap teknologi ini sentiasa meningkat. Aplikasi baru teknologi ini sentiasa muncul dan dalam masa yang sama, teknologi untuk mengalahkan sistem ini turut dibangunkan oleh sesetengah pihak. Salah satu cara untuk mengelakkan usaha ini ialah dengan menggunakan gabungan biometrik. Kebanyakan penyelidikan terkini tertumpu pada usaha mengatasi kelemahan sistem biometrik tunggal atau mengurangkan ’false acceptance rate’ (FAR), tanpa memberi penekanan pada ’false rejection rate’ (FRR). Dalam projek ini, 3 sistem biometrik telah digunakan iaitu pengecaman jari, pengecaman tangan dan pengecaman suara. Projek ini mengkaji penggunaan fungsi kos untuk menetapkan nilai ambang (’threshold’) bagi membolehkan FAR dan FRR yang optimum diperolehi. Nilai ambang daripada kos minimum dengan pelbagai kos dan kebarangkalian awalan FA dan FR memberikan keputusan yang lebih baik dari EER dari segi jumlah kos. Keputusan eksperimen untuk pengecaman suara menunjukkan kos minimum adalah lebih baik daripada EER untuk kombinasi digit. Eksperimen juga menunjukkan bahawa dengan menggunakan fungsi kos, nilai ambang yang diperolehi adalah lebih tepat. Seterusnya nilai FR dan FA yang baru boleh diperolehi, yang memberikan EER yang baru. Sebagai contoh, EER bagi kombinasi 6 digit ialah 5.29% manakala menggunakan fungsi kos, nilai EER yang baru ialah 5.28%. Nilai kos akan semakin berkurang apabila bilangan kombinasi digit bertambah. Untuk kombinasi 2 digit, kos minimum ialah 12.5 manakala bagi kos minimum bagi kombinasi 6 digit ialah 5.287. Keputusan bagi pengecaman tangan dan jari memberikan keputusan yang sempurna berdasarkan kaedah yang digunakan dalam projek ini. Oleh itu, dengan menggunakan fungsi kos sebagai cara

mendapatkan kos bagi mana-mana sistem gabungan biometrik, kos yang berbeza berdasarkan aplikasi boleh ditetapkan dengan mudah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATIONS

$\mu / \bar{x}$	-	Mean
B	-	Boy
$B_{i/}$ B_k	-	Biometric Trait
C	-	Codebook
CCD	-	Charge-coupled device, an electronic light sensor used in digital

		cameras
CER	-	Cross-over Error Rate
CM	-	Cross Match
C_m	-	Cepstral coefficients
C1&C2	-	Client Cost & Imposter Cost
$\tilde{c}_m$	-	Weighted cepstral coefficients
3-D	-	Three dimension picture
DET	-	Detection Error Trade-off
DFT	-	Discrete Fourier transform
D_j	-	Distortion in vector quantization
DTW	-	Dynamic Time Warping
EER	-	Equal Error Rate
$E_{n\,=}$ EER	-	Square prediction error
FA	-	False Acceptance
FAR	-	False Acceptance Rate
FBAS	-	Full Multibiometric Adaptive System
FIR	-	False Identification Rate
FR	-	False Rejection
FRR	-	False Rejection Rate
FMR	-	False Match Rate
FNMR	-	False Non-Match Rate
FTA	-	Failure to Acquire
FTE/FER	-	Failure to Enroll
G	-	Girl
GFAR	-	Generalized False Acceptance Rate
GFRR	-	Generalized False Rejection Rate
GMM	-	Gaussian Mixture Model
H_0	-	Input Biometric Not From the Same Biometric
H_i	-	Input From Same Biometric
HMM	-	Hidden Markov Model
I	-	claimed identity

L	-	Lengths of frame of speech
LPC	-	Linear Predictive Coding
LPCC	-	Linear Predictive Coding Cepstral Coefficients
M	-	Similarity measure between two Fingerprint Images
M	-	Man
MAP	-	Minimum Adapted System
MFCC	-	Mel-Frequency Cepstrum Coefficients
MMER	-	Multi-Modal Error Rate
MS	-	Multiple similarity
MVE	-	Minimum Verification Error
N_m	-	Number of Templates of Database
NN	-	Nearest Nighbors
P( )	-	Probability
Q	-	Number on input vector to be quantized
Q_{NO}	-	Prior Probability
QRR	-	=(FTA) Failure to Acquire
ROC	-	Receive Operating Characteristic
ROCA	-	Receive Operating Characteristic Area
RSI	-	Recognition System Inc
σ	-	Standard deviation
S_k	-	Normalized Matching Score
SI	-	Speaker Identification
SV	-	Speaker Verification
th	-	Threshold Parameter
T_i	-	EER Threshold
t_i	-	Training vector in vector quantization
TV	-	Television
$v_{i,j}$	-	Codebook vectors in vector quantization
VQ	-	Vector Quantization
VQ-CM	-	Combination of Vector quantization and cross match technique
W	-	Women

ω_0	-	True Imposter Class
ω_1	-	True Enrollee Class
ϖ_0	-	Corresponding True Imposter Class
ϖ_1	-	Corresponding True Enrollee Class
w_m	-	Weighting function
W_k	-	Weight Associated With a Biometric Trait
X_i	-	Score
Z	-	Scores
η	-	Matching Threshold

LIST OF APPENDICIES

CHAPTER I

PROJECT BACKGROUND

1.0 INTRODUCTION

On the basis of media hype alone, you might conclude that biometric passwords will soon replace their alphanumeric counterparts with versions that cannot be stolen, forgotten, lost, or given to another person. But what if the performance estimates of these systems are far more impressive than their actual performance? To measure the real-life performance of biometric systems, and to understand their strengths and weaknesses better, we must understand the elements that comprise an ideal biometric system (P. Jonathon *et al*., 2000).

Biometrics are automated methods of recognizing a person based on a physiological or behavioral characteristic. Among the features measured are face, fingerprints, hand geometry, handwriting, iris, retinal, vein, and voice. Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. As the level of security breaches and transaction fraud increases, the need for highly secure identification and personal verification technologies is becoming apparent.

Biometric-based solutions are able to provide for confidential financial transactions and personal data privacy. The need for biometrics can be found in federal, state and local governments, in the military, and in commercial applications. Enterprise-wide network security infrastructures, government IDs, secure electronic banking, investing and other financial transactions, retail sales, law enforcement, and health and social services are already benefiting from these technologies.

Biometric-based authentication applications include workstation, network, and domain access, single sign-on, application logon, data protection, remote access to resources, transaction security and Web security. Trust in these electronic transactions is essential to the healthy growth of the global economy. Utilized alone or integrated with other technologies such as smart cards, encryption keys and digital signatures,

Here we focus on biometric applications that give the user some control over data acquisition These applications recognize subjects from voice recognition hand-scan geometry, and scanned fingerprints

The data collection in this project was done by using the set of available devices. For collect the voice data had done by using Multispeech System (CSL model 4500) with normal microphone (Shure dynamic lo). In hand-scan experimental the data was collected by using Recognition System Handkey II. Lastly for the fingerprint part, the data was collected by using a FIU81/PERS (Puppy suite from Sony).

1.1 Problem statement

A potentially more serious security concern occurs when someone uses the same biometric in many systems or when many user biometrics are stored on a single system. Specifically, once an attacker acquires the original biometric, he can use it to compromise the security of many different systems. This potential, for identify theft is much more serious for biometrics than passwords since if a password is stolen, it can be easily changed. A biometric such as a fingerprint if is stolen it is difficult or impossible to change. (Emin Martinian *et al.*, 2005).

By using different biometrics, hand-scan and voice-scan together will reduce this chance and make the system more secured.

Under the voice-scan biometric category the best (optimum) threshold setting will be the one that gives the lowest FA or FR rate. Our task will be to solve this problem i.e. optimize the FA and FR as possible by using an expected misclassification cost (Masters, 1993). False acceptance errors are the ultimate concern of high security can be traded off for a higher false rejection rate [Cample, 97]. Since we know the cost of FA or FR error rate, the cost function can be used to find the optimum threshold so that the minimum (lowest) total expected cost will be achieved.

1.2 Project Objectives

- To find the threshold which gives the optimum (best) FR & FA errors rate for speaker recognition task using cost function.
- To compare the performance of the obtained optimum threshold setting with EER threshold setting.
- Analyze the recognition performance when word combinations are used as an input to the speaker recognition system.
- Analyze performance when system is combined with hand-scan and fingerprint biometrics.

1.3 Project Scope and Methodology

- The training task will use all digits while one digit or combination of several digits will be used in recognition task.
- Data base which consists of single digit and combination digits are designed based on TIDIGIT data base.
- The recognition system will use MFCC-derived spectrum and HMM algorithm to create client and impostors model in pattern matching process.
- The enrollment and testing sessions are carried out in normal room environment.
- Hand scan data and Fingerprint will be collected from same number of clients and impostors.

1.3.1 Methodology

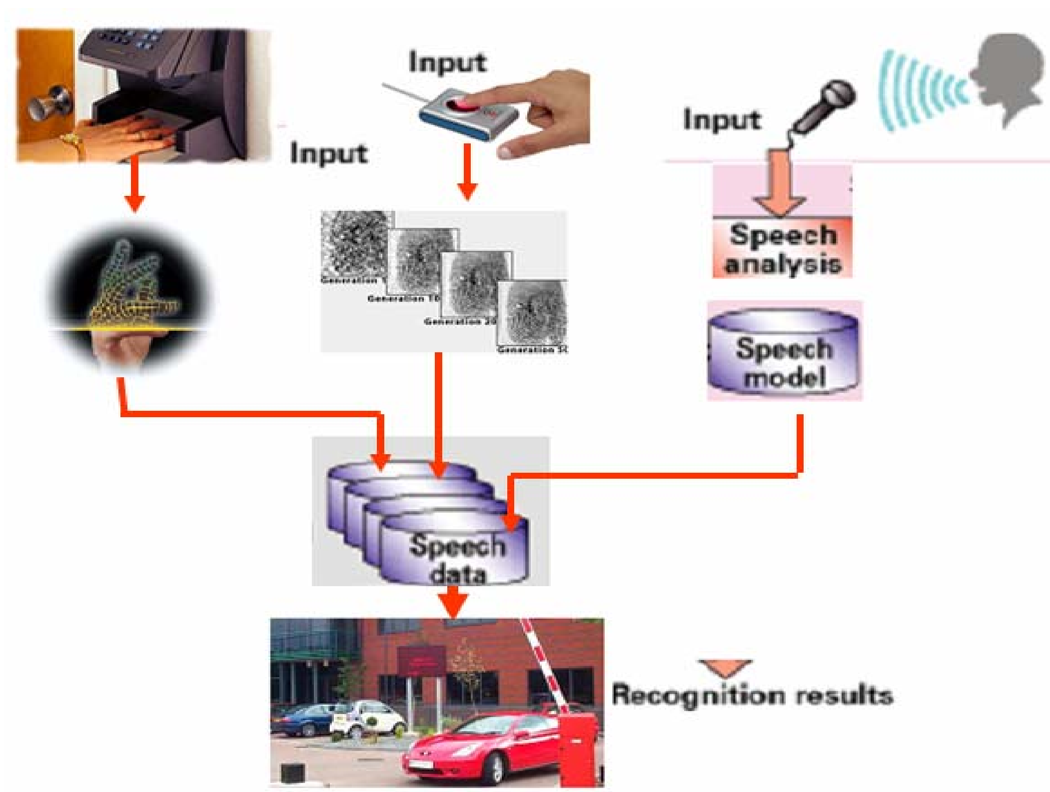

Figure 1.1 Multi-modal method.

REFERENCES

A. .K. J. A. Ross and J. Z. Qian. (2001). "*Information fusion in biometrics,*" *'in Proc. 3rd International Conference on Audio- and Video-Based Biometric Person Authentication*, Halmstad, Sweden, pp. 354-359, June 2001. http://citeseer.nj.nec.corn/rossOlinformation.h tml.

A. K. Ariff, Arief Ruhullah, M. Alwi, Sh-Hussain,Salleh. (2004) Centre for Biomedical Engineering Faculty of Electrical Engineering Universiti Teknologi Malaysia 81310 Skudai, Johor, Malaysia

Atal, B.S. (1976). "Automatic Recognition of Speakers from Their Voices". Proceedings of the IEEE. Vol 64, No 4, April 1976. Pp 460-475.

Anil K. Jain and Arun Ross (2002). Appeared in Proc. International Conference on Image Processing (ICIP), Rochester, New York

Arun Ross and Anil Jain (2007) www.biometrics.msc.edu/ Hand_proto.html. updated By Feb 2007.

Becchetti C., Ricotti L. P.(2002). Speech Recognition Theory and C++ Implementation. West Sussex: John Wiley & Sons Ltd. 122-301; 2002

Blight, Richard C. (1989). An exegetical summary of 1 & 2 Thessalonians. Dallas: Summer Institute of Linguistics. 291 p.

Dr. Bhavani Thuraisingham (2005).The University of Texas at Dallas Biometric Technologies: Some Physiological Biometrics October 5, 2005

Emin Martinian, Sergey Yekhanin, and Jonathan S.(2005). Yedidia Secure Biometrics Via Syndromes 43rd Annual Allerton Conference on Communications, Control, and Computing, (Monticello, IL) October 2005 28-

Fakotakis, N.; Dermatas, E.; and Kokkinakis, G. (1986). "Optimal Decision Threshold for Speaker Verification", Signal Processing III: Theories and Applications, Elsevier Science Publishers B.V (North-Holland), 1986. Pp. 585-587.

Hong, K. S.(2001). Implementation of Speech Recognition Using Hidden Markov Models. Bachelor Thesis. Universiti Teknologi Malaysia. 1-120 ; 2001

Higgins, A., Bhaler, L.; Porter, J. (1993). "Voice Identification Using Nearest Neighbor Distance Measure". Proc. IEEE Int. Conf. Acoustics, Speech, and Signal Processing, Minneapolis, MN. Pp 375-378.

Hermansky, H., Morgan, N. RASTA processing of speech. IEEE Transactions on Speech and Audio Processing. Oct 1994. 2(4): 578 –589.

J. Kittler and E. F.(2001). Roli, Decision-level fusaon in fingerprint uerification. Springer Verlag, 2001.

J. W ang, Q . Z hang, K.(2001). Ren, M ulti-scaling hierarchical structure analysis.

Joseph P. Campbell , Jr. ,Senior member IEEE.(1997). Speaker Recognition. A tutorial, 27-June-1997.

Jittiwarangkul, N. et al.(1998). Thai Syllable Sementation for Connected Speech Based on Energy. IEEE Asia-Pacific Conference on Circuits and Systems.

24-27 Nov 1998. Thailand: IEEE, 1998. 169-172.

L. H. A. K. Jain and Y.(1999). Kulkarni, “A multimodal biometric system using fingerprint, face, and speech,” *in Proc. 2nd International Conference on Audio- and Video- Based Biometric Person Authentication,* Halmstad, Sweden, pp. 182-187, March 1999. http://www.cse.msu.edu/cgiuser/
web/tech/document?NUM=98-32.

Master work.(2006). IMPLEMENTATION OF FINGERPRINT BIOMETRIC TEMPLATE SYSTEM University technology Malaysia 2006.

Masters, T. (1993). “Practical Neural Network Recipes in C++”, Academic Press Inc., Canada.

Rabiner, L.R. (1989). “A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition”. Proc. IEEE, Vol 77, Feb 1989. Pp 257-286.

Rabiner, L. and Juang, B. H.(1993). Fundamentals of Speech Recognition. Englewood Cliffs, N.J.: Prentice Hall. 69-481 ;1993

Rosenberg, A.E.; Siohan, O.; Parthasarathy, S. (1998). “Speaker Verification Using Minimum Verification Error Training”. Acoustics, Speech and Signal Processing, 1998. Proceedings of the 1998 IEEE International Conference on, Vol:1, 1998. Pp. 105-108.

R. W. Frischholz and U.(2000). Dieckmann, “Bioid: A multimodal biometric identification system,” IEEE Computer, vol. 33, pp. 64-68, February 2000.

R. Brunelli and D. Falavigna. (1995). “Person identification using multiple cues,” IEEE Transactions on PAMI, vol. 17, pp. 955-966,
October 1995.

P. Jonathon Phillips Alvin Martin C.L. (2000). Wilson Mark Przybocki
National Institute of Standards and Technology .2000

Paper EEL 6586- Final project. (2002). A speaker aidentification and Verification System. By Zhongmin Lin,. Qizhang Yin , and Weimin Zhang. In 04-24-2002.

Pierrot, J.B; Lindberg, J.; Koolwaij, J.; Hutter, H.P.; Genoud, D.; Blomberg, M.; Bimbot, F. (1998). "A Comparison of a Priori Threshold Setting Procedures for Speaker Verification in the Cave Project". Acoustics, Speech, and Signal Processing, 1998. Proceedings of the 1998 IEEE International Conference on, Vol:1, 1998. Pp. 125-128.

Parsons, T.W. (1987). "Voice and Speech Processing". McGraw-Hill Inc. New York, USA.

Quran Karem. Surah Al-Qiyamat (75:3-4).

Shochet, E. and D. Connolly, (Jan., 1981). "An Investigation into the Effects of Dialectical Variation on Flight Plan Filing by Machine Recognition", Interim Report, FAA-RD-80-115

S. K. Dahel and Q. Xiao .(2003).Accuracy Performance Analysis of Multimodal Biometrics Information Assurance United States Military Academy,
West Point, NY June 2003

www.bromba.com/faq/biofaqe.htm#ROC Updated by Mar 2007.

www.biometricsinfo.org/ copy right Mar 2007

www.oninonin.com/fp/fmiru ..chinese_day-seal/jpg Updated in Fep. 2007