A Study on Various Methods Based on Gender Classification through Fingerprints

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ABSTRACT
This paper is proposed of determining the gender through fingerprints.Finger prints verification is one of the most reliable personal identification method and it plays a very important role in forensic application like criminal investigation. Finger prints has been used as a biometric for the gender identification because of its unique nature and do not change throughout the life of an individual. Estimating the gender of fingerprints is an emerging field and many methods using the fingerprint physical features like the ridge count and the ridge thickness have been used so far. This study highlights various ridge and minutiae related methods which are based on the basis of some features of finger such as ridge count, ridge density, ridge to valley area ratio(RVA) and ridge width for fingerprint identification and gender classification through fingerprints. Different algorithms have analysed for finger prints based gender classification in this paper such as Singular Value Decomposition(SVD), Principle ComponentAnalysis(PCA),Neural Network(NN),Adaptive Resonance Theory(ART),Fuzzy- C Means (FCM), Linear Discriminate Analysis (LDA), k-nearest neighbour (k-NN) classifier . These algorithms provide different recognition rates and performances hence their comparative study can prove useful for the designing of an efficient and robust fingerprint identification system allowing its successful application on security authentication.

To classify a given fingerprint image as male or female, we extracted the most significant features such as RVA and Ridge density from the existing database. These features were then used to train the ANFIS classifier. The experimental results showed that the proposed system can be used as a prime candidate in forensic anthropology with a higher accuracy than NN and Fuzzy individually.

General Terms
Adaptive Neuro Fuzzy Inference System Classifier (ANFIS)

Keywords
k-NN classifier, RVA, LDA, FCM, Neural Network, ART, PCA.

1. INTRODUCTION
Gender identification is important to provide information of unknown persons ,which leads for crime scene investigation. Fingerprints are one of the most mature biometric technologies and are considered legitimate proofs of evidence in courts of law all over the world. Finger prints are one of the many forms of biometrics used to identify an individual and verify the person's identity. Because of their uniqueness and consistency. Fingerprints have been used for over a century, more recently becoming automated (i.e. a biometric) due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition, the numerous sources (ten fingers) available for collection ,and their established use and collections by law enforcement and immigration. Each of our ten fingerprints is different from one another and from those of every other person. Even identical twins have unique finger-prints. A Fingerprint is the representation of the epidermis of a finger. .A fingerprint image acquired by a sensor is shown in the figure(figure 1.1). It consists of a pattern of interleaved ridges and valleys on the surface of the finger. In a fingerprint image the black pixels seen are ridges, and the white pixels seen correspond to valleys. The uniqueness of a fingerprint can be determined by the overall pattern of ridges and valleys as well as the local ridge anomalies. Studies so far carried out in age and gender determination have used generally ridge related parameters such as fingerprint ridge count, ridge density, ridge thickness to valley thickness ration, ridge width and fingerprint patterns.

Fig.1.1 A fingerprint image using an Optical Sensor

The gender of the person can be judged using the fingerprint of that concern person based upon the count of the ridges of the fingerprint. The average ridge count is slightly higher in males than in females, with high standard deviation among subjects of both genders. Epidermal ridges and their arrangement (dermatoglyphic patterns) exhibit a number of properties that reflect the biology of an individual. Dermatoglyphic features statistically differ between the sexes, ethnic groups and age categories .
In this paper we studied the different debates in the literature for the few articles that exist concerning the significance of ridge count, pattern type concordance, ridge count asymmetry, ridge thickness to valley thickness ratio (RTVTR), and white lines count features on the classification performance. We analyzed different features that can be significant in gender classification and different classifiers performances.

2. LITERATURE SURVEY

On the basis of different pattern types Fingerprint identification and classification has been extensively researched in the literature:

Marius Taco et.al in 2001 worked on fingerprint recognition based on features extracted from the wavelet transform. The proposed method has been tested on a small fingerprint database using the *k*-nearest neighbour (*k*-NN) classifier. The very high recognition rates achieved show that the proposed method may constitutes an efficient solution for a small-scale fingerprint recognition system.

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Ahmed Badawi, et al, in 2006 proposed a Gender classification from fingerprints, which is an important step in forensic anthropology in order to identify the gender of a criminal and minimize the list of suspects search. A dataset of 10 - fingerprint images for 2200 persons of different age s and gender (1100 males and 1100 females) was analyzed. Features extracted were; ridge count, ridge thickness to valley thickness ratio (RTVTR), white lines count, and ridge count asymmetry, and pattern type concordance. Fuzzy - C Means (FCM), Linear Discr iminant Analysis (LDA), and Neural Network (NN) were used for the classification using the most dominant features. They obtained results of 80.39%, 86.5%, and 88.5% using FCM, LDA, and NN, respectively. [9]

Manish Verma, et al, in 2008 proposed a method for Gender classification from fingerprints. Features extracted were; ridge width, ridge thickness to valley thickness ratio (RTVTR), and ridge density.SVM is used for the classification. This method is experimented with the internal database of 400 fingerprints in which 200 were male fingerprints and 200 were female fingerprints. They found male - female can be correctly classified up to 91% [7].

Jen feng wang, et al, in 2008 worked on gender determination using finger tip features. He obtained fingerprints from 115 normal healthy adults in which 57 were male fingerprints and 58 were female fingerprints. They have used ridge count,

mean ridge density) below 13, while in Bania, 100% of females have mean ridge density above 14 and 80 % of males – below 14. The study suggested that there are significant differences in epidermal ridge density between males and females within each of the two populations, and also significant differences between the two populations. [6]

Ting Tang et.al in 2012 proposed fingerprint recognition using wavelet domain features. Image-based and minutiae-based are two major methods of fingerprint recognition. A method of fingerprint recognition based on wavelet domain is presented. The fingerprint image is enhanced before extracting features and this can make a substantial improvement of recognition accuracy for recognition method. The computational complexity is low compare to minutiae-based method. The length of feature vector of a fingerprint is 1152 and the feature matching is performed on normalized Euclidian distance.

Experimental results show that the presented method has the better recognition accuracy compared with the previous image-based methods.

ridge density, and finger size features for classification. However, the ridge count and finger size features of left little fingers are used to achieve a classification. The best classification result of 86% accuracy is obtained by using ridge count and finger size feature together [8].

Hopes Gourd et.al in 2010 proposed ART and Modular Neural Network Architecture for multilevel Categorization and Recognition of Fingerprints. ART1 is an efficient technique for grouping fingerprints in to N number of classes, which speedup the process of fingerprint recognition. After classification of fingerprints the key fingerprint class is used for the purpose of fingerprint identification. The key-fingerprint is recognized by using Monolithic and Modular Neural Network and their performance has been compared on the bases of time and accuracy.

Due to modularity, Modular Neural Network gives better performance on the classified databases as compared to Monolithic Neural Network even with poor quality fingerprints.

Drunk's et.al in 2011 proposed a machine learning approach for fingerprint based gender identification. This paper deals with the problem of gender classification using fingerprint images. The attempt to gender identification follows the use of machine learning to determine the differences between fingerprint images. SVM is a learning machine used in this work. It can be used as a tool for data classification, function approximation, etc, due to its generalization ability and has found success in many applications. Each image in the database was represented by a feature vector consisting of ridge thickness to valley thickness ratio (RTVTR) and the ridge density values.

By using a support vector machine trained on a set of 150male and 125 female images, a robust classifying function for male and female feature vector patterns is obtained.

Ramanjit Kaur, Rakesh K. Garg in 2011 with their study provided an aid for the fingerprint examiner in analyzing fingerprint samples as it shows that there is a significant difference in epidermal ridge density between males and females of the two populations. Their study has been carried out to examine ridge density differences in two Northern Indian populations (Sikh Jat and Bania). In their study it has been found that 92% of Sikh Jat females have a mean ridge density above 13, whereas 76% of Sikh Jat males have (a

Dr. Prateek Rastogi, Ms. Keerthi R Pillai, presented that there is an association between distribution of fingerprint patterns, blood group and gender. This prospective study was carried out over a period of 2 months among 200 medical students (100 male & 100 female) belonging to the age group 18 - 25 of Kasturba Medical College, Mangalore, India. Results show that each finger print is unique; loops are the most commonly occurring fingerprint pattern while arches are the least common. Males have a higher incidence of whorls and females have a higher incidence of loops. Loops are predominant in blood group A, B, AB and O in both Rh positive and Rh negative individuals except in O negative where whorls are more common. Thus, they concluded that there is an association between distribution of fingerprint patterns, blood group and gender and thus prediction of gender and blood group of a person is possible based on his fingerprint pattern. [5]

Ritu Kaur et.al, in 2012 have worked on fingerprint based gender identification using frequency domain analysis. The

classification is achieved by analyzing fingerprints using Fast Fourier transform (FFT), Discrete Cosine Transform (DCT) and Power Spectral Density (PSD). A dataset of 220 persons of different age and gender is collected as internal database. Frequency domain calculations are compared with predetermined threshold and gender is determined. They obtained results of 90%, and 79.07% for female and male samples respectively [4].

Ravi Wadhaw et.al (2013) presented the work on age and gender of a person from finger print impression using RVA and duct Coefficients. The novelty in the solution lies in the fact that the identification of age and sex is independent from the pressure i.e. finger prints thickness or ridge/valley thickness.

The age and gender finger prints are classified on the basis of ridge to valley area, entropy and rams value of duct coefficients. [12]

Rijo Jackson Tom, et al, in 2013 have proposed a method for Fingerprint Based Gender Classification through frequency domain analysis to estimate gender by analyzing fingerprints using 2D Discrete Wavelet Transforms (DWT) and Principal Component Analysis (PCA).A dataset of 400 persons of different age and gender is collected as internal database. They have used minimum distance method for classification and achieve overall success rate in gender classification of around 70% [1].

Heena Agrawal et al, in 2014 have proposed a technique on "Fingerprint Based Gender Classification using multi- class SVM" by which have use some features of finger such as ridge thickness, ridge density to valley thickness ratio (RTVTR) and ridge measurement for gender detection. Proposed methodology uses Multi Class SVM as classifier which overcome the problem of SVM (Binary Classifier). They have used multi class SVM method for classification and achieve overall success rate in gender classification is 91%.

Samta Gupta et al, in 2014, have proposed a technique on"Fingerprints based gender classification using Discrete Wavelet Transform and Artificial Neural Network",using two methods have been combined in the proposed work for gender classifications. The first method is discrete wavelet transformation employed to extract fingerprint characteristics by doing decomposition upto 5 levels. The second method is the back propagation artificial neural network algorithm used for the process of gender identification. The overall recognition rate achieved of about 91%.

3. COMPARISON

S. No.	Author/ Title	Method	Classification Method	Result
1	A. Badawi, M. Mahfouz, R. Tadross, and R. Jantz "Fingerprint - based gender classification"[9] 2006.	Features extracted were; ridge count, ridge thickness to valley thickness ratio (RTVTR), white lines count, and ridge count asymmetry, and pattern type concordance	Fuzzy - C Means (FCM), Linear Discr iminant Analysis (LDA), and Neural Network (NN).	results of 80.39%, 86.5%, and 88.5% using FCM, LDA, and NN, respectively.
2	Manish Verma and Suneeta Agarwal.'' Fingerprint Based Male - Female Classification.''[7] 2008.	Features extracted were; ridge width, ridge thickness to valley thickness ratio (RTVTR), and ridge density.	SVM	91%
3	Jen feng wang, et al, "Gender Determination using Fingertip Features". [8] 2008.	Ridge count, ridge density, and finger size.	Structural analysis	86% accuracy is obtained by using ridge count and finger size features together.
4	Ritu Kaur and Susmita Ghosh Mazumdar, "Fingerprint Based Gender Identification using Frequency Domain Analysis" [4] 2012	Frequency domain analysis.	Fast Fourier transform FFT), Discrete Cosine Transform (DCT) and Power Spectral Density (PSD).	results of 90%, and 79.07% for female and male samples respectively.
5	Rijo Jackson Tom, T.Arulkumaran , "Fingerprint Based Gender Classification Using 2D Discrete Wavelet Transforms and Principal Component Analysis"[1] 2013.	Frequency domain analysis.	2D Discrete Wavelet Transforms (DWT) and Principal Component Analysis (PCA).	70%.

6	Heena Agrawal et al, "Fingerprint Based Gender Classification using multi- class SVM",2014	Features extracted were; ridge width, ridge thickness to valley thickness ratio (RTVTR), and ridge density.	Muliclass SVM	91%
7	Samta Gupta et al, "Fingerprints based gender classification using Discrete Wavelet Transform and Artificial Neural Network", 2014	Frequency domain analysis.	DWT & Backpropagation ANN	91.45%

4. CONCLUSION

Gender classification using fingerprints is an emerging field of research in recent years. After reviewing a number of papers related to gender classification using fingerprints we found that various approaches like pattern based , neural network based ,FCM based, machine learning based and wavelet transform based approaches etc. has been implemented so far.

It is concluded that higher recognition rate of gender determination can be achieved if more number of samples in each category (for male and female) is trained.

For better results of gender classification, we are working in collecting huge samples in each category. In addition, our research work will be extended using the spatial parameters of fingerprints. Moreover, it is aimed to use Adaptive Neuro Fuzzy Inference System (ANFIS) as a classifier towards improving the accuracy, precision and computational speeds of classification methods.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] Rijo Jackson Tom, T.Arulkumaran , " Fingerprint Based Gender Classification Using 2D Discrete Wavelet Transforms and Principal Component Analysis ". International Journal of Engineering Trends and Technology, Volume 4 Issue 2, 2013.

[2] P. Gnanasivam & Dr. S. Muttan " Estimation of Age Through Fingerprints Using Wavelet Transform and Singular Value Decomposition" International Journal of Biometrics and Bioinformatics (IJBB), Volume (6) : Issue (2) : pp 58 - 67. 2012.

[3] E.O. Omidiora, O. Ojo, N.A. Yekini, T.O. Tubi "Analysis, design and implementation of human fingerprint patterns system "towards age & gender determination, ridge thickness to valley thickness ratio (RTVTR) & ridge count on gender detection" International Journal of Advanced Research in Artificial Intelligence, Vol. 1, No. 2 , pp 57 - 63, 2012.

[4] Ritu Kaur and Susmita Ghosh Mazumdar, "Fingerprint Based Gender Identification using Frequency Domain Analysis". International Journal of Advances in Engineering & Technology, March 2012.©IJAET ISSN: 2231 – 1963.

[5] Dr. Prateek Rastogi, Ms. Keerthi R Pillai "A study of fingerprints in relation to gender and blood group" J Indian Acad Forensic Med 2011 , 32(1), pp - 11 - 14 ISSN 0971 – 097.

[6] Ramanjit Kaur, Rakesh K. Garg "Determination Of Gender Differences From Fingerprint Ridg e Density In Two Northern Indian Populations" Problems of Forensic Sciences 2011, vol. LXXXV, 5 – 10.

[7] Manish Verma and Suneeta Agarwal.'' Fingerprint Based Male - Female Classification. '' in Proceedings of the international workshop on computational intelligence in security for information systems (CISIS'08), Genoa, Italy, 2008, pp.251 – 257.

[8] Jen feng wang, et al, " Gender Determination using Fingertip Features". Internet Journal of Medical Update 2008 Jul - Dec;3(2):22 – 8.

[9] A. Badawi, M. Mahfouz, R. Tadross, and R. Jantz "Fingerprint - based gender classification" The International Conference on Image Processing, Computer Vision, and Pattern Recognition, June 2006.

[10] Acree, M. "Is there a gender difference in fin gerprint ridge density?" Forensic Science International 1999 May; 102 (1)

[11] Gajanan Pandurang Khetri , Satish L. Padme , Dinesh Ch Jain, Vrushsen P. Pawar "Fingerprint Pattern

Recognition Using Back Propagation Algorithms" International Journal of Electronics and Computer Science Engineering. ISSN 2277-1956/V2N1-225-232

[12]Ravi Wadhwa,ManinderKaur, Dr. K.V.P. Singh "Age and Gender Determination from Finger Prints using RVA and dct Coefficients" IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 8 (August. 2013), ||V5|| PP 05-09.

[13]S. S. Gornale, Geetha C D, Kruthi R "Analysis Of Fingerprint Image For Gender Classification Using Spatial And Frequency Domain Analysis" American International Journal of Research in Science, Technology, Engineering & Mathematics, 1(1), pp. 46-50, June-August, 2013.

[14]Marius Tico, EeroImmonen, Pauli Ramo, Pauli Kuosmanen, and Jukka Saarinen "Fingerprint Recognition Using Wavelet Features" IEEE.

[15]Ahmed Badawi, Mohamed Mahfouz, RimonTadross, Richard Jantz, "Fingerprint-Based Gender Classification." Biomedical Engineering department, University of Tennessee Knoxville. June 2006.

[16]Arun K.S. Sarath"A Machine Learning Approach for Fingerprint Based Gender Identification" 978-1-4244-9477-4/11/$26.00 ©2011 IEEE

[17]Marius Tico, EeroImmonen, Pauli Ramo, Pauli Kuosmanen, and Jukka Saarinen "Fingerprint Recognition Using Wavelet Features" IEEE.