# Common and Few Not-so-common Usages of Fingerprints And Multimodal Hybrid Biometrics

**Samayita Bhattacharya**
Department of Computer Science & Engineering,
University of Kalyani, Kalyani, West Bengal, India

**Kalyani Mali**
Department of Computer Science & Engineering,
University of Kalyani, Kalyani, West Bengal, India

**Abstract—** Biometrics is one of the biggest tendencies in human identification. The fingerprint is the most widely used biometric. Fingerprint identification is one of most popular and accurate Biometric technologies. Nowadays, it is used in many real life applications. Here we have discussed few usages of Fingerprints which are not much practiced. Fingerprints do have the potential to be used as a way to find if someone is addicted to drugs (or about a person's daily medications). It can even be used for gender determination, using the chemical composition of fingerprints, along with the features extracted from the fingerprint images.

**Keywords-Fingerprints;** Drug use detection; Gender detection; Hybrid Biometrics, Multimodal Biometrics; Embedded system; Soft Computing; Data Fusion

## I. INTRODUCTION

To uniquely identify a single person, different types of information can be used with other sources. This concept is ancient, and it has become much more important as information technology and the Internet have made it easier to collect identifiable documents. To uniquely identify a person, the recent trend is to use biometric. Different biometric features can uniquely identify a person unless there are identical twins. In case of identical twins many biometrics fail to distinguish them as separate person, but fingerprint still can distinguish as two different persons. Fingerprint images, considered as a class, are an attractive choice for identification. Fingerprints and analysis of their properties has been an area of great historical interest, dating back to early cave drawings of finger ridge patterns, though until the recent advent of experimental automated systems, all fingerprint analysis has of course been done by human beings.

Here we are discussing few possible systems for gender determination using fingerprints, and also few other not so widely used applications of fingerprints such as drug abuse detection. In the second part of this paper, we have discussed how in recent technology more than one biometric feature is also being used in a combination to have more robust indentifying system. Several research projects have shown that multimodal biometrics (e.g. fingerprints and voiceprints combined) can improve the performance and the reliability of biometric authentication.

## II. FINGERPRINT

Fingerprint is one of the wonders in the biometric and forensic science. Fingerprint images are considered as a class. Fingerprints are an effective choice for recognition. Fingerprints and analysis of fingerprint images' properties have been an area of great historical interest, dating back to the age of early cave drawings of finger ridge patterns. Until the recent advancements of experimental automated systems, all fingerprint analysis had been done by human beings.

Human fingertips contain ridges and valleys which together forms distinctive patterns. These patterns are fully developed under pregnancy and are permanent throughout whole lifetime. Prints of those patterns are called fingerprints. Injuries like cuts, burns and bruises can temporarily damage quality of fingerprints but when/if fully healed, patterns will be restored. Fingerprints have long been used for personal identification. It is assumed that every person possesses unique fingerprints and hence the fingerprint matching is considered one of the most reliable techniques of people identification.

A fingerprint image exhibits a quasiperiodic pattern of ridges (darker regions) and valleys (lighter regions). The local topological structures of this pattern together with their spatial relationships determine the uniqueness of a fingerprint. Fig. 1 shows a sample fingerprint and fig. 2 shows different fingerprint types.

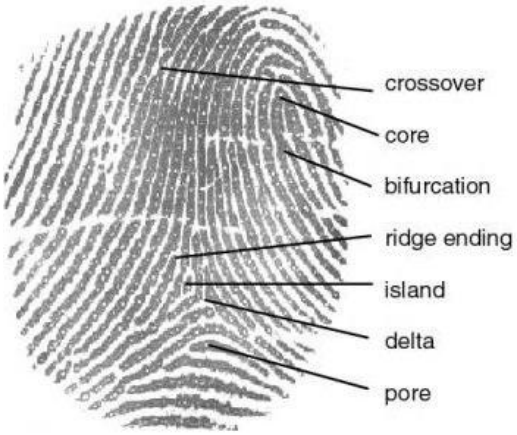


Fig 1: A fingerprint sample

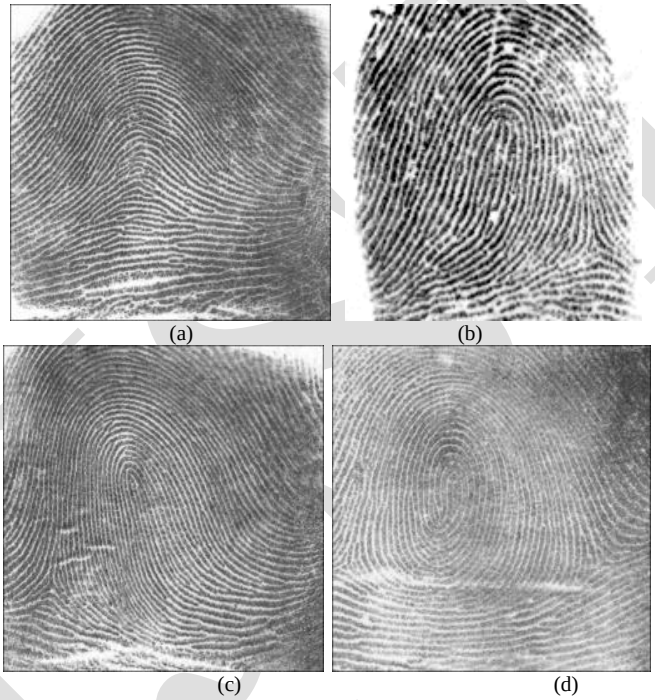


Fig 2: Fingerprint types: (a) Arch, (b) Left Loop, (c) Right Loop, (d) Whorl

A fingerprint in its narrow sense is an impression left by the friction ridges of a human finger. In a wider use of the term, fingerprints are the traces of an impression from the friction ridges of any part of a human or other primate hand. A print from the foot can also leave an impression of friction ridges. Finger ridge configurations do not change throughout the life of an individual except due to accidents such as bruises and cuts on the fingertips. This property makes fingerprints a very attractive biometric identifier. Fingerprints of an individual have been used as one of the vital parts of identification in both civil and criminal cases because of their unique properties of absolute identity. Fingerprint-based personal identification has been used for a very long time. Owning to their distinctiveness and stability, fingerprints are the most widely used biometric features. Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity.

## III. FINGERPRINT RIDGE

In Fig. 3, a fingerprint is depicted. The information carrying features in a fingerprint are the line structures, called ridges and valleys. In this figure, the ridges are black and the valleys are white.
There are more than 100 different types of local ridge structures that have been identified.

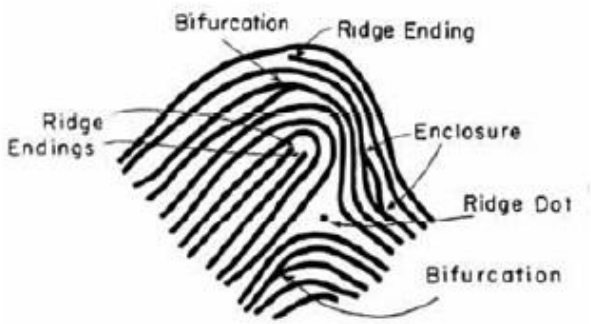


Fig 3: Fingerprint image showing different ridge features

## IV. COMMON USE

Fingerprint identification is one of most popular and accurate Biometric technologies. Nowadays, it is used in many real life applications. Fingerprint is one of the wonders in the biometric and forensic science.

To uniquely identify a person, the recent trend is to use biometric. Different biometric features can uniquely identify a person unless there are identical twins. In case of identical twins many biometrics fail to distinguish them as separate person, but fingerprint still can distinguish as two different persons. Fingerprint images, considered as a class, are an attractive choice for identification. Fingerprints and analysis of their properties has been an area of great historical interest, dating back to early cave drawings of finger ridge patterns, though until the recent advent of experimental automated systems, all fingerprint analysis has of course been done by human beings.

Human fingertips contain ridges and valleys which together forms distinctive patterns. These patterns are fully developed under pregnancy and are permanent throughout whole lifetime. Prints of those patterns are called fingerprints. Injuries like cuts, burns and bruises can temporarily damage quality of fingerprints but when/if fully healed, patterns will be restored. Fingerprints have long been used for personal identification. It is assumed that every person possesses unique fingerprints and hence the fingerprint matching is considered one of the most reliable techniques of people identification. A fingerprint image exhibits a quasiperiodic pattern of ridges (darker regions) and valleys (lighter regions). The local topological structures of this pattern together with their spatial relationships determine the uniqueness of a fingerprint.

A fingerprint in its narrow sense is an impression left by the friction ridges of a human finger. In a wider use of the term, fingerprints are the traces of an impression from the friction ridges of any part of a human or other primate hand. A print from the foot can also leave an impression of friction ridges.

Finger ridge configurations do not change throughout the life of an individual except due to accidents such as bruises and cuts on the fingertips. This property makes fingerprints a very attractive biometric identifier. Fingerprints of an individual have been used as one of the vital parts of identification in both civil and criminal cases because of their unique properties of absolute identity. Fingerprint-based personal identification has been used for a very long time. Owning to their distinctiveness and stability, fingerprints are the most widely used biometric features. Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity.

## V. CHEMICAL COMPOSITION

The chemical nature (composition) of fingerprints might be (and currently being) analysed to ascertain whether differences in chemical composition or the existence of chemical markers can be used to determine personal traits, such as age, gender, and personal habits. This type of information could be useful for reducing the pool of potential suspects in criminal investigations when latent fingerprints are unsuitable for comparison by traditional methods.

Fingerprints at crime scenes are crucial in identifying suspects. However, if the fingerprints are smudged or are only partial prints, they may not be suitable for Automated Fingerprint Identification System (AFIS) processing. If there were a way to characterize the individual who left the fingerprint, such as age, gender, ethnic background or personal habit, the list of suspects might be reduced.

Whether such information, specifically gender determination, can be extracted from fingerprint residue is the basis of this report. It should be noted that these experiments were performed on unprocessed fingerprint residue to determine whether any differences could be detected before studying what effects visualization processing might have on these results.

Lipids on the skin surface originate from the sebaceous gland and the epidermis. The palm and fingertips primarily have eccrine glands, although the material found on these areas is usually contaminated with sebaceous gland secretions due to frequent contact with regions rich in this gland, such as the face. The eccrine-glands produce inorganic components (chlorides, metal, phosphate) and amino acids. Sebaceous glands produce components such as squalene, fatty acids, and alcohols. It is believed that slight variations in the composition of the sebaceous fatty acid mixtures give individuals a unique scent. It is this compositional variation that is believed to provide trained dogs the ability to track an individual. We hypothesized that if this were true, then there is a possibility that general differences in chemical residue from fingertips could be used to distinguish between males and females and various age groups.Initial experiments in this area are going on, on studying the chemical composition of children and adults' fingerprints. This study showed children's fingerprints (pre-pubescent) had less non-volatile components, such as long chain fatty acid esters, than adult fingerprints due primarily to inactive sebaceous glands.

## VI. DRUG USE DETECTION

A very interesting feature of fingerprint is that it can help to detect drug use. The secretions, skin oils and dead cells in a human fingerprint contain residues of various chemicals and their metabolites present in the body. These can be detected and used for forensic purposes. For example, the fingerprints of tobacco smokers contain traces of cotinine, a nicotine metabolite; they also contain traces of nicotine itself. Caution should be used, as its presence may be caused by mere contact of the finger with a tobacco product. By treating the fingerprint with gold nanoparticles with attached cotinine antibodies, and then subsequently with a fluorescent agent attached to cotinine antibodies, the fingerprint of a smoker becomes fluorescent; non-smokers' fingerprints stay dark. The same approach, as of 2010, is being tested for use in identifying heavy coffee drinkers, cannabis smokers, and users of various other drugs [5], [6]. In 2008, British researchers developed methods of identifying users of marijuana, cocaine and methadone from their fingerprint residues [7].

## VII. GENDER DETERMINATION

In an experiment, Fingertip residue that has been deposited onto a bead was extracted with a solvent such as chloroform. Samples were analyzed by gas chromatography/mass spectrometry. The chemical components identified include fatty acids, long chain fatty acid esters, cholesterol and squalene. The area ratios of ten selected components relative to squalene were calculated for a small preliminary experiment that showed a slight gender difference for three of these components. Although this work did not find compositional variations that could be used to surely distinguish between genders, it is possible that there are other distinguishing components in fingerprints.

Using image processing techniques also we can achieve gender determination; and analyzing ridge Pattern, orientation, thickness and gaping can be the key features of this study.

The science of fingerprint has been used generally for the identification or verification of person and for official documentation. Based on the varieties of the information available from the fingerprint we might be able to process its identity along with gender, age and ethnicity.

The primary dermal ridges (ridge counts) are formed during the gestational weeks 12-19 and the resulting fingerprint ridge configuration (fingerprint) is fixed permanently [11-12].

Variations in ridge dimensions and sex differences in ridge breadth have been reported [13-14]. Ridges and their patterns exhibit number of properties that reflect the biology of individuals. Dermatoglyphic features statistically differ between the sexes, ethnic groups and age categories [14]. Studies so far carried out in gender determination were used the inked fingerprints and their findings are based on the spatial domain analysis of ridges [8], [10], [15-16]. On general, ridge related parameters are fingerprint ridge count, ridge density, ridge thickness to valley thickness ratio and ridge width.

Gender Identification Using Fingerprint through Frequency Domain Analysis and fingerprint patterns and pattern types can be used for gender determination. All the methods proposed based on the fingerprint ridges has given insight about the ridge parameters mentioned about but fails to give accurate method of measuring the parameters [8], [10], [15-16]. This may be due to the measurement made on the inked fingerprint impressions and manual measurements of the parameters where human error and recklessness is inevitable. Poor impressions are unavoidable due to one or more of the following reasons. Poor, thin or coloured ink, poorly maintained inking apparatus, fingers of foreign substances, failure to roll fingers fully, smears and blurred fingerprint due to finger slip or twist while enrolling and poor cooperation of subject. Also, the ridge thickness depends on the pressure applied and may provide false results on gender identification.

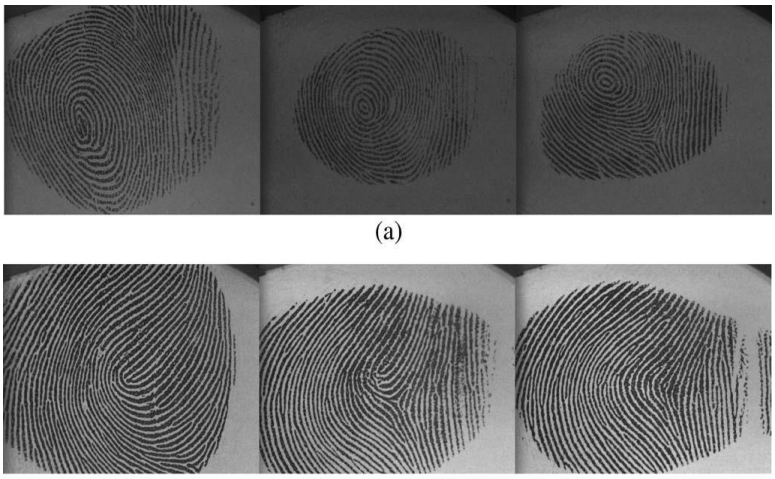

Fig 4: Example 800-dpi fingerprint images in our established database. (a) From a female. (b) From a male. From left to right: thumb, index finger, and middle finger.

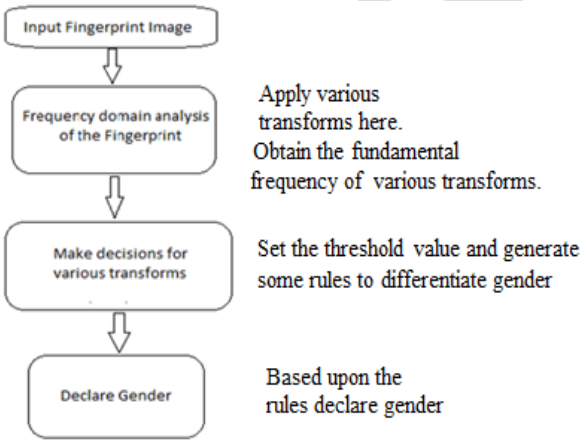


Fig 5: Steps for gender determination using frequency domain analysis

## VIII. FREQUENCY DOMAIN

Also studying is going on if fingerprint on frequency domain give a result of the print belongs to a male or female finger. In their study, P. Gnanasivam and S. Muttan showed an automatic gender recognition system by frequency domain analysis of the Fingerprint [9]. They obtained the fundamental frequency of various transforms and use them for gender Classification; Frequency domain calculations were made using FFT, DCT and PSD and compared with predetermined threshold and gender is determined. With the frequency domain, significant improvement in performance compared to that of spatial domain counterparts was achieved. Few values were found to have abnormal deviation from the desired value. By simultaneous comparison with all the transform values, this problem was alleviated and decision was made more accurately.

Fourier transform plays a vital role in image processing applications. It contains most of the information of the spatial domain image. DCT transforms an image from the spatial domain to the frequency domain and provide better approximation of image. DCT transforms a set of data which is sampled at a given sampling rate to its frequency components.

## IX. RIDGE PATTERN ANALYSIS

Many studies have been conducted on ridge count but, mainly for race determination and genetic inheritance of ridge pattern. Recently studies are being conducted to broaden the horizon of ridge count i.e. sex determination by finger print ridge density. In his study to establish a relationship between sex and fingerprint ridge density, Dr. Sudesh Gungadin showed with experiments that males of Indian Origin in the Southern part of India do have significantly lesser ridge density as compared to females. It shows similar trends in sex difference

as the other studies of the past conducted on other races. It also shows that this trend is universal among all races [8].

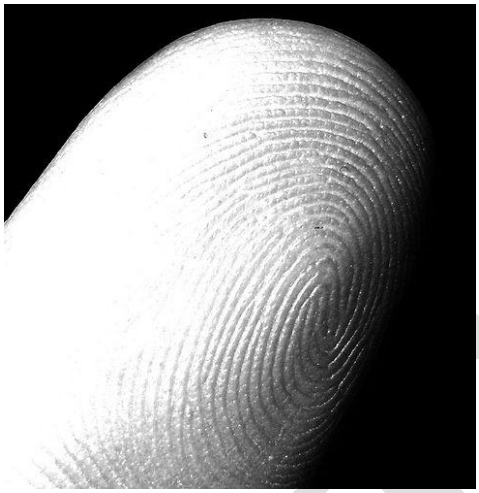

Figure 6: Human Fingertip

## X. DATA FUSION

Data fusion is the process of integration of multiple data and knowledge representing the same real-world object into a consistent, accurate, and useful representation. Low level data fusion combines several sources of raw data to produce new raw data. The expectation is that fused data is more informative and synthetic than the original inputs. In simpler terms, we can get more effective set of data by fusing data acquired by different means, or by fusing different set of data of different aspects of same entity and get more effective set of final data.

In fingerprinting system, we can do data fusion of chemical nature of a particular fingerprint and the fingerprint image acquired, to get a new set of data.

## XI. MULTIMODAL BIOMETRICS

Multimodal biometrics can improve the performance and reliability of biometric authentication. Each body part is unique and Biometrics uses your unique identity to enable a purchase activate something or unlock something. Other than fingerprints, Biometrics encompasses Voice, Vein, Eye, Facial recognition and more. In recent technology more than one biometric feature are being used in a combination to have more robust indentifying system. Several research projects have shown that multimodal biometrics (e.g. fingerprints and voiceprints combined) can improve the performance and reliability of biometric authentication.

Unimodal biometric systems have to contend with a variety of problems such as noisy data, intra-class variations, restricted degrees of freedom, non-universality, spoof attacks, and unacceptable error rates. Some of these limitations can be addressed by deploying multimodal biometric systems that integrate the evidence presented by multiple sources of information.

Criminals have been known to remove fingers to open biometric locks, Biometrics requires a lot of data to be kept on a person, these systems are not always reliable as human beings change over time if you are ill; eyes puffy, voice hoarse or your fingers are rough from labouring for example it may be more difficult for the machinery to identify you accurately [19], multimodal biometrics having the option to customise the biometrics features to be used at a time can be used to solve few of these disadvantages.

## XII. EMBEDDED SYSTEM AND HYBRID BIOMETRICS

Works are also going on in the field of embedded system. Fingerprint operated locks are no more a new concept. Now what about a lock which opens with no other separate sensor but with the sensor attached to the lock handle itself, and senses your fingertips when you press your finger to hold it! Ok, now let's make it more secure with a lock attached with a keypad where the keypad senses your fingertips when you actually type the secure access PIN there. Does this hybrid system sound nice?

Figure 7: Fingerprint Operated Locks

## XIII. SOFT COMPUTING

There are many methods in the literature for fingerprint identification using minutia as a feature. But there is not much work done using soft computing tool such as neural network. Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind. The guiding principle of soft computing is: Exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness and low solution cost. Soft computing may be viewed as a foundation component for the emerging field of conceptual intelligence. Few soft computing tools are: Fuzzy Systems, Neural Networks, Evolutionary Computation, Machine Learning and Probabilistic Reasoning.

Fuzzy logic is a form of many-valued logic derived from fuzzy set theory to deal with reasoning that is fluid or approximate rather than fixed and exact. Artificial neural networks may either be used to gain an understanding of biological neural networks, or for solving artificial intelligence problems without necessarily creating a model of a real biological system. Real life applications and the tasks which can be solved using artificial neural networks include classification, including pattern and sequence recognition; novelty detection and sequential decision making. In the field of artificial intelligence, neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic.

Human brain recognition system for biometrics works neuro-fuzzily. Therefore, implementing a system, with added neuro fuzzy features, or implementing a neuro-fuzzy system for biometrics (here in our case for fingerprints), will improve the efficiency of the recognition system.

Automatic fingerprint identification system (AFIS) can be made more accurate using soft computing tools. The most used fingerprint recognition system in current days depends on minutia extraction. Different soft computing tools can be used in different phases of fingerprint feature extraction, classification and matching.

Noise is a big issue in fingerprint extraction and matching. Wavelets can be used in removing noise from the fingerprint image. In the minutia extraction phase only extracting minutia does not help to get enough information about the minutia, so aligning minutia becomes a necessary step. Fuzzy techniques can be used in minutia alignment. For the hierarchical classification of fingerprints neural network can be used. We can set four classes for hierarchical classification i.e. arch, left loop, right loop and whorl as shown in figure 2 [17].

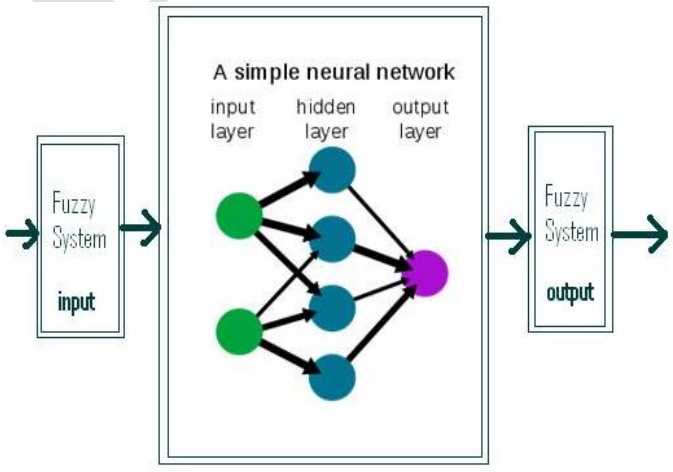


Figure 6: Simplified version of our algorithm

In our project, we have used back propagation neural network for fingerprint identification with fuzzy techniques incorporated for hierarchical classification and minutia detection [18].

## XIV. CONCLUSION

Fingerprinting remains the best to establish personal identification and tracking criminals. Identification by fingerprints is foolproof and now with the help of this study it will be further helpful to the fingerprint expert to direct their search to a particular gender and eventually the investigating officers would save time in going through the list of suspects.

The chemical composition of fingerprints holds much information that could be useful in criminal investigations.

## REFERENCES

[1] H. C. Lee and R. E. Gaensslen, Eds., *Advances in Fingerprint Technology*. New York: Elsevier, 1991.
[2] Rafeal C. Gonzalez, Richard E. Woods, "Digital Image Processing," Pearson Education Asia, 2002.
[3] Nicolaides N. Skin lipids: Their biochemical uniqueness. Science 1974; 18:19–26.
[4] M. Acree, "Is there an gender difference in fingerprint ridge density?" *Forensic Sci. Int.*, vol. 102, no. 1, pp. 35–44, May 1999
[5] Paul Marks (18 May 2007) "New fingerprint analysis identifies smokers," New Scientist (on-line version).
[6] Tom Simonite (3 April 2006) "Fingerprints reveal clues to suspects' habits," New Scientist (on-line version).
[7] Everts, Sarah (December 2008). "Fingerprints Reveal Drug Use," Chemical & Engineering News 86 (51): 34.
[8] Dr. S. Gungadin, "Sex determination from fingerprint ridge density", INTERNET JOURNAL OF MEDICAL UPDATE, ISSN: 1694-0423,VOLUME 2, NUMBER 2 AND JULY-DECEMBER 2007.
[9] P. Gnanasivam and S. Muttan, "Gender Identification Using Fingerprint through Frequency Domain Analysis", European Journal of Scientific Research, ISSN 1450-216X Vol.59 No.2 (2011), pp.191-199.
[10] G. G. Reddy, Finger dermatoglyphics of the Bagathas of Araku Valley (A.P.), American Journal of Physical Anthropology Volume 42, Issue 2, pages 225–228, March 197.
[11] John J. Mulvihill, David W. Smith, "The genesis of dermatoglyphics,"the journal of pediatrics, vol 75(4), pp. 579-589, October 1969
[12] Babler W. Embryologic development of epidermal ridges and their configurations. In: Plato CC, Garruto RM, Schaumann BA, editors. 1991; Dermatoglyphics: Science in Transition. Birth Defects. Original Article Series; vol. 27. Wiley- Liss, New York, pp. 95-112.
[13] Harold Cummins, Walter J. Walts, and James T McQuitty," The breadths of epidermal ridges on the finger tips and palms: A study of variation." American Journal of Anatomy, vol 68(1), pp. 127-150, January 1941.
[14] KRÁLÍK M., NOVOTNÝ V. 2003. Epidermal ridge breadth: an indicator of age and sex in paleodermatoglyphics. Variability and Evolution, Vol. 11: 5–30, Tabs. 5, Figs. 9. Adam Mickiewicz University, Faculty of Biology, Institute of Anthropology, Poznan.
[15] M.D. Nithin, B. Manjunatha, D.S. Preethi and B.M. Balaraj, "Gender differentiation by finger ridge count among South Indian population," Journal of Forensic and Legal Medicine, vol 18 (2), pp. 79-81, Feb 2011.
[16] Yvonne K. Dillon, Julie Hayne S and Macie J Hennerberg [8]," The relationship of the number of Meissner's corpuscles to dermatoglyphic characters and finger size," journal of anatomy, vol 199, pp. 577-584, November 2001.
[17] Kalyani Mali and Samayita Bhattacharya, "Soft Computing Approach towards Fingerprint Recognition", Proc of National Conference on Recent Trends in Soft Computing (NCRTSC 2011), ISBN 978-93-81006-03-0, pp 95-99.
[18] Samayita Bhattacharya and Kalyani Mali, "SCIFI-A Project Proposal: Soft Computing for Identification of Fingerprint Image", Proc. Of International Conference on Emerging Technologies (*ICET-2012*): International Journal of Scientific and Engineering Research Special Issue, ISSN: 2229-5518.
[19] Samayita Bhattacharya and Kalyani Mali, "Security, Forgery and Fingerprints: Advantages, Drawbacks and Limitation of Biometrics", International Journal of Computer Information Systems, May Issue, ISSN: 2229-5208, Vol. 4, No. 5, 2012, pp 6-10.