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Human Age and Gender Determination Using Fingerprints

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Abstract

We present a review of technologies to determine human age and gender using fingerprints. Broadly two methodologies are reviewed i.e. Ridge based human age and gender determination and Image based human age and gender determination. Ridge based techniques uses ridge information with its variant statistics measures for classification of a human fingerprint into different classes of age groups and male/female distinction. These methods do not involve separate classifiers for classification rather determines different thresholds for different classes for classification. On the other hand, Image based techniques uses image processing concepts both in spatial and frequency domain like image transformation in frequency domain. These methods also need separate classifier like KNN (K-Nearest Neighborhood) classifier, SVM (Support Vector Machine) etc. to determine age and gender of a specific human fingerprint. Considering the two approaches different research papers are reviewed and their accuracy is stated for the difference. In the end advantages and disadvantages are concluded for both methodologies along with the future scope in this field.

Keywords: Fingerprints, ridge based classification, image based classification, KNN, SVM, gender determination

INTRODUCTION

Biometrics device has emerge as an necessary a part of humans' day after day life. From smart phone's passwords to security check-in cards, everybody is using the Biometrics technology. In other words Biometrics is a revolutionary step in today's world. The Greek words "Bios" (which means life) and "metron", which means measurement, make up the phrase biometrics' [1]. It means to use human lively characteristics, both behavioural and physiological characteristics (e.g. fingerprints, face, hand geometry, signatures, ear/lip motion, skin reflection, body odour/shape, gait, dental etc.), which are commonly known as biometric identifiers to recognize a person. In short, Biometrics is a study of automatic recognition of a person's identity using the information of the person's distinguished characteristics with accuracy. Biometrics identify people by measuring some issue of individual's anatomy or body structure together with hand geometry or fingerprint which incorporates a sample of interleaved ridges and valleys. Human imaginative and prescient gadget is self-enough and superb in figuring out the demographical attributes of humans inclusive of age, gender, voice, accessory etc. [2, 3]. Among all biometric features, fingerprints are the oldest, proved and most reliable feature for identification and recognition processes. Fingerprint and different pores and skin ridges are known as dermatoglyphics. The distinctive function of fingerprint pores and skin ridges allows for gender differentiation [4, 5]. It is most widely used biometrics feature in forensics and crime

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investigation along with security purposes due to its persistence and individuality (distinctiveness) property. By definition, fingerprints represent the epidermis or uppermost layer of the fingertip with arrangements of black and white lines [6, 7, 8, 9]. In fingerprint representation, black lines are called ridges and white lines formed between the ridges are called valleys [10, 11, 12]. Ridges and valleys are formed due to the combination of genetic and environmental factors [13, 14, 15, 16].

Today, in the century of engineering and automation, automatic human age and gender determination is an important tool in a variety of applications like security, marketing and advertisements, gender and age mediated Human Computer Interaction (HCI), surveillances systems (video and passive), forensics, face recognition etc. With the high use of Internet and social media, intensity of cyber-crimes is also increasing so there is a need of automatic and accurate authorization and authentication system. For this purpose, automatic age and gender recognition systems can be very Fruitful [17, 18]. In crime investigation, the age/gender recognition methods are used to identify a missing person or reducing the search space [19, 20]. Many traditional methods were used to identify the age or gender of the person but those methods needs bones, teeth, and identifiable body parts. But it isn't feasible to be to be had each time. It is required to have a method which should be easily available and uniquely identifies a person's age and gender [21]. So fingerprints with the uniqueness quality can be used to determine human age and gender.

There can be two approaches to determine human age and gender:

1. Ridge Based Method
2. Image Based Methods

Ridge Based Methods to determine Human Age and Gender

These methods uses ridge based information and parameters for classification. They are used to determine a classification threshold for each class. The not unusual place parameters used on this technique are Ridge count (RC), Ridge thickness to valley thickness ration (RTVTR), Ridge density (RD), Ridge width (RW), Fingertip size (FS) etc. as shown in Figure 1.

Ridges

Ridges are frictional lines carved on a fingertip because of vein pattern, genetic and environmental factors. There are three different kinds of ridges: whorls, loops, and arches [10].

Arches

These are the simplest type of ridges with a pattern of entering from one side of finger and leaving from other side. They can be plain or tented [10].

Loops

These are the maximum not unusual place kind of ridges with a sample of getting into from one facet of finger and leaving from the identical facet. They can be radial or ulnar and left loop or right loop [10].

Whorls

They follows the pattern of having one ridge making a complete circuit. They have two delta points [10].

Delta Point

It is a factor where three ridges coming from three directions (120 degrees apart) either meets (bifurcated) or diverge (divergence) [10].

Core: It is a ridge surrounded by a field of ridges and turns back at 180 degree [10].

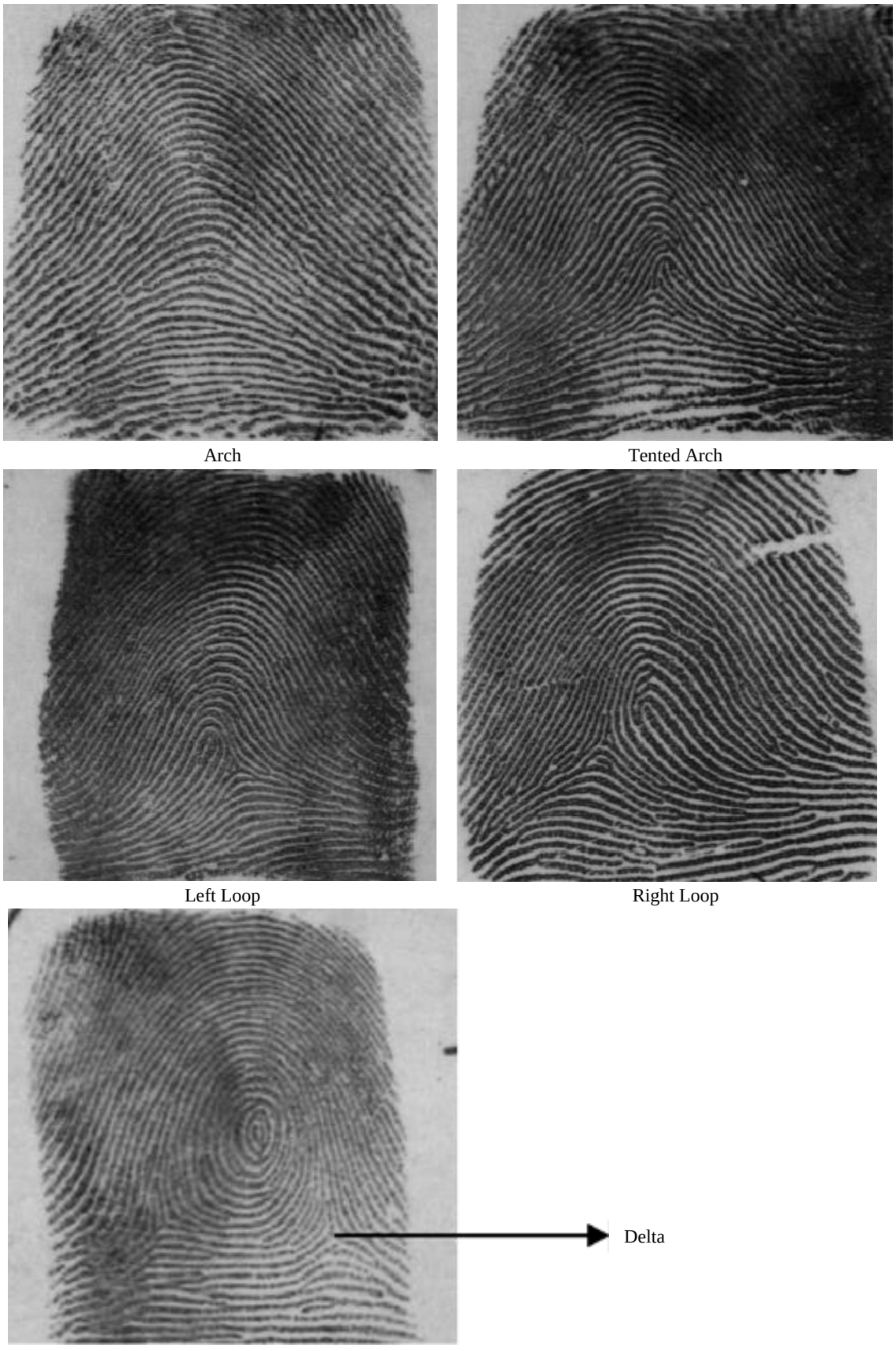

Figure 1. Types of ridges.

Optimal Score Assignment [11]

It is a method to assign an optimal score to each ridge based parameters value for each class. By combining the score associated to each value, fingerprint is classifies into specific predefined class. The optimal score is ranking number x (1<= x <=10) associated with the probability of occurrence of each parameter value in its separate class. This method involves two phases: training phase and testing phase.

Training Phase

- *Step 1:* Calculate ridge parameters like ridge count (RC), ridge width (RW), fingertip size (FS) for all samples of known classes.
- *Step 2:* Assign the optimal scores as follows:
  - i Measured parameter values are arranged in ascending order.
  - ii Frequency of occurrence of each measured value is counted.
  - iii Probability of occurrence of a particular parameter value is calculated as: Prob. of occurrence= (number of frequency/total number of samples)* 100
  - iv A maximum score of 10 is assigned for the parameter value of each finger which has the maximum probability of occurrence.
  - v Scores for the remaining parameter value can be determined by: Score = (Prob. of occurrence of parameter value * maximum score)/(maximum prob. of occurrence)
  - vi This process is repeated for all 10 fingers.

Ridge Count (RC): Number of ridges between core and delta.

Instead of calculate ridges only between core and delta but of whole fingertip. Process to calculate ridge count is:

- *Step 1:* An imaginary line is drawn among middle and delta and an imaginary line is drawn at 135 degree (principal diagonal) and 45 degree (other diagonal) from core points upwards.
- *Step 2:* In the thinned image, number of white pixel on the line is the ridge count.
- *Step 3:* Let ridge count between core and delta is “a”, ridge count on principal diagonal is “b”, and ridge count on other diagonal is “c”. Then RC will be

$$RC = a + (b+c)/2$$

Ridge Width (RW): The thickness of the ridge was computed by counting the number of pixels between consecutive maxima points of the projected image**.**

Similar to RC, adding colors to Ridge width can be computed as:

- *Step 1:* In the thinned image, along the required line of interest, the number of black pixels divided by the ridge count gives the average ridge width.
- *Step 2:* Let A, B, C, D and E be the average ridge width along core to delta points, along principal diagonal, along other diagonal, along the horizontal line with respect to core and along the horizontal line with respect to delta. RW is calculated by:

$$RW = (A + B + C + D + E)/5$$

Image Based Methods to determine Human Age and Gender

These methods use image information and parameters for classification. They used separate classifier for each class to be classified. These methods use frequency based energy features. High frequency components changes rapidly considering edge components. Low frequency components include large features of the image. The common parameters used in this method are Fourier Transformation, Discrete Cosine Transformation, Single Value Decomposition (SVD) and Discrete Wavelet Transformation etc. For classification KNN (K-Nearest Neighbourhood) and SVM (Support Vector Machine) (Figure 2) [10].

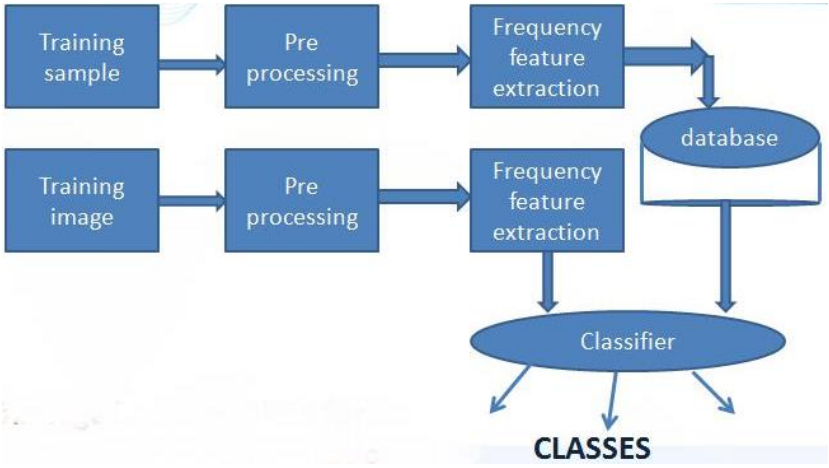

Figure 2. Image based determination.

DISCRETE WAVELET TRANSFORMATION (DWT) AND SINGLE VALUED TRANSFORMATION (SVD)

Discrete Wavelet Transformation

Due to its thorough theoretical foundation, flexibility in choosing bases, and low computational complexity, the wavelet transform is a well-liked tool for image processing and computer visualisation [21, 22, 23].

Two-dimensional DWT splits the image into separate small bands located locally (Horizontally, vertically, diagonal). Low-Low (LL), Low-High (LH), High-Low (HL), and High-High are the four decomposed sub-band images that result from a picture's 2-D wavelet decomposition (HH). Each of those sub-bands represents special picture properties. Typically, maximum of the strength in photographs is withinside the low frequencies and for this reason decomposition is commonly repeated at the LL sub-band only (dyadic decomposition). For ok stage DWT, there are (3*ok) + 1 sub-bands available (Figure 3–5).

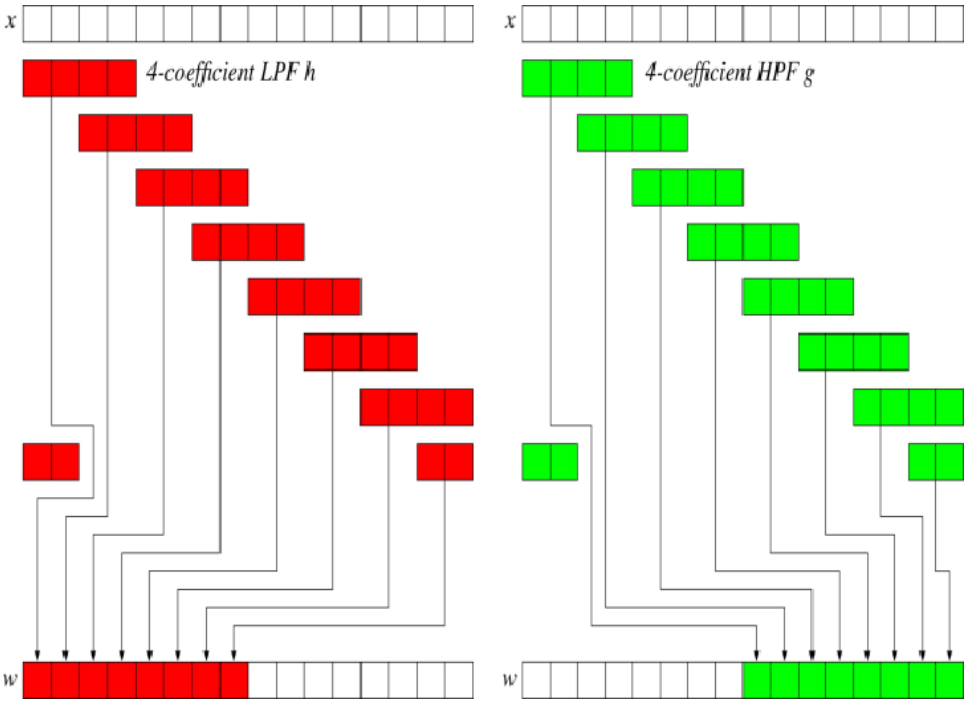

Figure 3. DWT with low pass filter (LPF) and high pass filter (HPF).

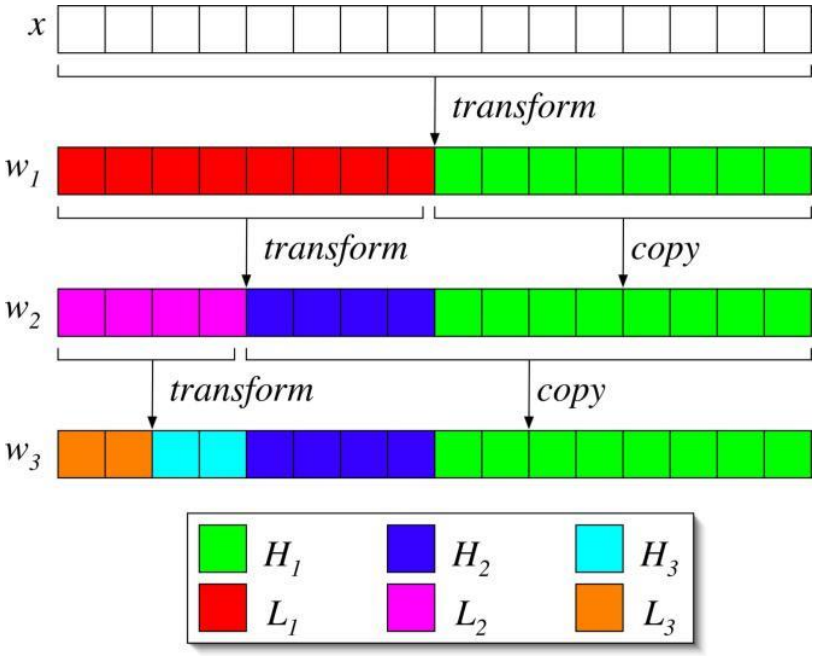

Figure 4. LL, LH, HL, HH from LPF, HPF.

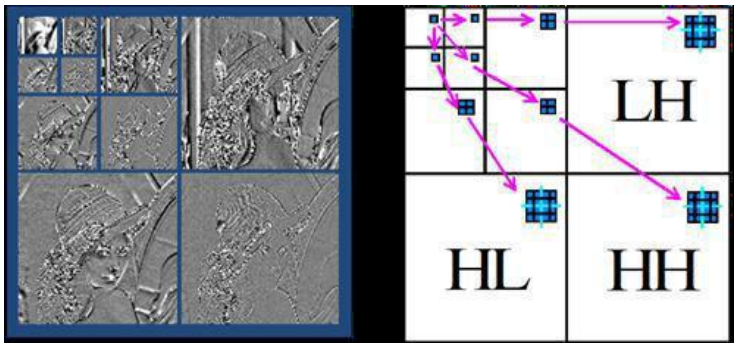

Figure 5. LL, LH, HL, HH.

The electricity of all of the sub-band coefficients is used as function vectors in my opinion that's referred to as sub-band electricity vector (E). The electricity of every sub-band is calculated via way of means of using Equation:

$$E_k = \frac{1}{RC}\sum_{i=1}^{R}\sum_{j=1}^{C}|x_k(i,j)|$$

Where x_k (i, j) is the pixel value of the kth sub-band and R, C are width and height of the sub-band, respectively.

Singular Value Decomposition

Any square matrix can be factored into a matrix created from three separate matrices using the algebraic technique known as singular value decomposition (SVD). Any good X p matrix is factored into three matrices called SVD, each of which has important features [21, 22, 23]. That is, any square matrix A of okay rows with the aid of using p columns may be factored into U, S and V by eq.

A = US(trans(V)); U =A((trans)A) and V = ((trans)A)A

KNN Classifier (K-Nearest Neighborhood)

In sample recognition, the okay-nearest Neighbour algorithm (KNN) is the usually used approach for classifying gadgets primarily based totally on closest schooling examples withinside the

characteristic space. KNN classifies times primarily based totally on their similarity to times withinside the schooling data. In KNN, an item is assessed via way of means of a majority vote of its neighbours, with the item being assigned to the magnificence maximum not unusual place among its okay nearest neighbours (okay is an advantageous integer, commonly small).

Learning Phase [22]:

1. Apply DWT to decompose the fingerprint.
2. Calculated the sub-band energy vector (Ek)
3. Calculate the Eigen vector (V)(SVD)
4. To create the feature vector for a specific fingerprint, concatenate the vectors Ek and V.
5. Add this feature vector, the known class, and the known target as training input.
6. Train KNN classifier using known inputs and targets.
7. Repetition of the aforementioned processes for each sample

The feature vector V, 1x260 in size, was produced via SVD. The sub-band energy vector Ek of size 1x19 (level-6) obtained by DWT. The feature vector is created by adding the features together, and it is then used in the learning phase. The resulting feature vector is of the size 1x279 (1x260 +1x19).

Classification Phase [22]:

1. Apply DWT on the given unknown fingerprint.
2. Determine the sub-band energy vector in (Ek).
3. Calculate the Eigen vector (V)
4. Combine the Ek and V vectors to create the feature vector for the supplied unidentified fingerprint.
5. Using the database created during the learning phase, apply the KNN classifier to determine the age range of the unknown fingerprint.

LITERATURE REVIEW

In "Comparison between Feature Extraction Techniques for Fingerprint Based Gender Classification Using KNN Classifier", Ritika Dadhwal and Ajmer Singh [6] compare several feature extraction methods (image-based methods) for gender classification using KNN classifier. They displayed the comparison using:

1. *Memory requirements:* Lesser the feature length the lesser the memory requirement. DWT has efficient memory requirement due to lesser feature length followed by DCT. Then DWT and SVM have less feature length than DWT and PCA which has the more memory.
2. *Speed of the system:* Lesser the time requirement the better the speed and performance of the system. DWT has better speed followed by DCT. Then DWT and SVM have less time requirement than DWT and PCA which has the more time.
3. *Accuracy:* DWT and SVD grouping has most noteworthy exactness (88.28%) out of the parcel followed by DWT and PCA based arrangement whose precision rate is 70%. The DWT based order can be viewed as better then, at that point, block-based characterization since last option involved enormous data set still exactness for the previous framework which is around 60% is higher than last option whose precision is around 55.25%.

CRITICS: Ridge based methods are more efficient than image based methods.

Alok Chauhan et al. [10] in "Study of Ridge Based and Image Based Approach for Fingerprint Gender Classification" compares the ridge based classification and image based classification. Ridge based is more accurate than image based but is more complex than image based. Ridge based classification methods requires good knowledge of mathematics and computer graphics algorithms.

CRITICS: The method does not provide an efficient threshold assignment method in ridge based classification.

In "Fingerprint gender classification using wavelet transform and singular value decomposition", Gnanasivam, P., and Dr. S. Muttan [21] developed a method of gender classification employing image fusion of DWT and SVD with KNN classifier. This method is tested with an internal database of 3570 fingerprints of which 1980 was a male fingerprint and 1590 were a female fingerprint. The clever sex distinction is achieved by 94.32% of the left index finger of women and 95.46% by the index finger of the left hand of men. The sex segregation of any male finger tested reached 91.67% and 84.69% in females respectively. A total separation rate of 88.28% achieved.

Gnanasivam, P., and Dr S. Muttan [23], "Estimation of age through fingerprints using wavelet transform and singular value decomposition" proposed a method of age classification using image fusion approach of DWT and SVD with KNN classifier. This technique is experimented with the inner database of 3570 fingerprints wherein 1980 had been male fingerprints and 1590 had been woman fingerprints. Tested fingerprints are divided into one of the following five categories: up to 12, 13–19, 20–25, 26–35, and 36 and above. By the proposed technique, fingerprints had been categorised as it should be with the aid of using 96.67%, 71.75%, 86.26%, 76.39% and 53.14% in 5 businesses respectively for male and with the aid of using 66.67%, 63.64%, 76.77%, 72.41% and 16.79% for woman.

Gnanasivam, P., [22], "Gender Classification and Age Estimation Using Fingerprint and Ear Features." proposed a new method OSA (optimal score assignment) for gender classification and SVD, DWT, KNN for age classification. The population samples of internal database consist of 403 males and 410 females. All 10 hands of every difficulty had been scanned and hence in total, 8130 fingerprint had been used. The fingerprints were categorized into four age groups, viz., 8 to 12, 13 to 18, 19 to 25 and above 25.they calculated the accuracy of 87.80% (8–12), 72.73% (13–18), 82.32% (19–25) and 85.85% (>25) in age of male and 88.64% (8–12), 70.13% (13–18), 79.27% (19–25) and 76.40% (>25) in age of female. For gender classification accuracy of 89.24% and 87.15% for male and female respectively is obtained.

CRITICS: Method is computationally complex.

T. Arulkumaran et al [24], "Fingerprint Based Age Estimation Using 2D Discrete Wavelet Transforms and Principal Component Analysis". proposed a method of age classification using image fusion approach of DWT and SVD with PCA classifier. This approach is experimented with the inner database of four hundred fingerprints. The tested fingerprints are divided into the following categories: 15–20, 21–25, 26–30, 31–35, 36–40, 41–45, 46–50, and so on. By the proposed method, the overall success rate is 68%.

This method is tested with an internal database of 3570 fingerprints of which 1980 was male and 1590 female fingerprints. The smart gender divide is achieved by 94.32% of the left index finger of women and 95.46% by the right index finger of the male. The sex ratio of any male tested finger reached 91.67% and 84.69% for women respectively. A total dividend of 88.28% achieved.

ADVANTAGES AND DISADVANTAGES

Advantages

Image Based Determination

1. Takes less time.
2. Calculations become easier by Fixed length feature.

Ridge Based Determination

1. More accurate.
2. No extra classifier required.

Disadvantages

Image Based Determination

1. Threshold is required.
2. Dependency on classifier.
3. Needs optimum database.

Determination Based on Ridge

1. Extraction of ridges from fingerprint and locating distance among them is tedious.
2. Require more time.
3. The function vector received in those strategies is of various period and makes the calculations difficult.

RIDGE BASED GENDER DETERMINATION

Ridge based gender determination using Optimal Score Assignment (OSA) is more accurate than Image based determination gender. In Image based age determination, DWT and SVD with level-6 is more accurate than FFT, DCT or DWT <level-6 (Table 1 and 2).

Table 1. Comparison (Gender Based Determination)

Paper	Technique used	Accuracy
[22]	OSA	92.98% (M)
		89.80(F)
[22]	FFT, DCT, PSD	84.51%
[22]	DWT, PSD, KNN	89.24% (M)
		87.15% (F)
[21]	DWT, SVD, KNN	91.67% (M)
[6]	DCT	55.25%
[6]	DWT, SVD	>80%
[6]	DWT	Around 60%
[6]	DWT, PCA	70%

Table 2. Comparison (Age Based Determination)

Paper	Technique	Accuracy (male)	Accuracy (female)
[23]	DWT, PSD, KNN	96.67% (<12)	66.67% (<12)
		71.75% (13–19)	66.67% (<12)
		86.26% (20–25)	63.64% (13–19)
		76.39% (26–35)	76.77% (20–25)
		53.14% (>35)	72.41% (26–35)
[22]	DWT, SVD, KNN	87.80% (8–12)	88.64% (8–12)
		72.73% (13–18)	70.13% (13–18)
		82.32% (19–25)	79.27% (19–25
		85.85% (>25)	76.40% (>25)
[24]	DWT,PCA, KNN	68% (12–20, 21–25, 26–30, 30–35, 36–40, 41–45, 46–50)	68% (12–20, 21–25, 26–30, 30–35, 36–40, 41–45, 46–50)

CONCLUSION

This project has presented a model for identifying gender from reprint data. The technical method used to process the input photos, find the graphic symbols, map the fingerprint, and train the network to find a collection of desirable corresponding images to the input images has been explained. Results were obtained by training fingerprint samples on age and gender, ridge-to-valley thickness ratio, and

ridge number using a multi-layer perceptron (MLP) modeling approach. In comparison to males, we found that females have a larger ridge thickness to valley thickness ratio. There is no discernible association between subject age and fingerprint pattern, with males having slightly more burrs than females (only by chance or as a result of mutation).

FUTURE SCOPE

1. An overall success rate of 91.39% was achieved using ridge count, ridge width and fingertip size. By adding some more ridge parameters like the Euclidean distance between core and delta, angle between core and delta, ridge orientation, etc., and using OSA method, false identification of gender could be reduced.
2. While acquiring the fingerprint from various subjects, like students, people working in different kinds of jobs and doing business and subjects holding different positions, it was identified that their characters are in alignment with particular fingerprint patterns. For example, studious and high IQ student's most of the fingers are of whorl type. Thus, research on character analysis could be carried out using fingerprint patterns and their spatial characteristics.

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