Use of Deep Learning Approach in Predicting the Gender using Fingerprints

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Abstract: A fingerprint has been considered as one of the unique identities connected with every person. Fingerprints are imprints left by the papillary ridges at the tips of all fingers. Every human finger has a unique ridge arrangement that does not change as they get older. As a result, these are employed in forensics to identify suspects personally. The fingerprint ridge patterns of arches, loops, and whorls are compared to store data. Latest research studies have shown that the fingerprint data can be used for predicting the gender of the suspect. This made the forensic department do the first level of classification about the suspect at the basic level. This paper has a focus on predicting the gender and the age of the suspect. The training models have shown that the derived results have given better accuracy of 87% percent.
Keywords: Fingerprint, imprints, ridge pattern, forensic, classification

I. INTRODUCTION

Human fingerprints are very precise, unique, impossible to alter, and long-lasting, making them ideal for use as long-term identification markers. They can be used by police or other authorities to identify people who prefer to remain anonymous, as well as those who are incompetent or deceased and so unable to be identified, such as in the aftermath of a natural disaster.

Fingerprint of a person remains unique identity throughout the lifespan as it does not change with the age. It is hard to modify and hence it s considered as unique identity of a human being. Hence these identities are used by investigation departments and police force for identifying the suspects in crime incidents as primary level of decision making .Fingerprints can be captured on a typical fingerprint card or uploaded to the FBI for comparison digitally and electronically. Officials can establish irrefutable proof of a person's presence or identity by comparing fingerprints found at a crime scene with fingerprint databases of probable suspects. Detectives can use fingerprint identification to track down a criminal's history, including past arrests and convictions, and to decide the level of punishment to be given bounded with law. Since decades, experts from forensic department have been using the fingerprints as one of the most effective method of identification in criminal investigations. According to a study, male fingerprints exhibit lower ridge density than female fingerprints. Male fingerprints have a ridge density of fewer than 13 per 25mm^2, whereas female fingerprints have more than 14 per 25mm^2.

This has been demonstrated using the thickness value of the ridges. Figure 1 depicts male and female fingerprint samples.

Fig. 1 Male and female fingerprint images

The migration of chloride ions from fingerprints can provide a rough estimate of the age of a fingerprint. Law enforcement agencies all around the world legally acknowledged fingerprint identification as a genuine personal identifying method, and it became a common process in forensic medicine and research.

II LITERATURE SURVEY

Niberia and Yaba Lagos [1] have studied the properties of fingerprints and found that the breadth of the ridges in fingerprints of male is higher than the fingerprints of females. Later Abdullah et al. [5] have found that Ridge Thickness to Valley Thickness Ratio (RTVTR), if high in female fingerprints than the male fingerprints. This helped in prediction of gender based on RTVTR. Hong L. et al [9] have discussed how The ridge density on region of interest is analyzed for classifying the gender. Samta Gupta et al. [10] have proposed a method based on ridgeline patterns for ridgeline density estimation in fingerprint images, for the identification of the gender. For the identification of gender, frequency domain analysis of fingerprints [11] yields a high classification rate. An univariate decision tree [12], has been used by the authors to predict gender classification. Based on the research approaches that different researchers have discussed, still there is an ample space for the research by applying various artificial intelligence approaches which could identify depth of the ridge/valley and enhance the accuracy in gender prediction. We have implemented a deep learning approach using Convolution Neural Networks (CNN) for classification of gender based on the fingerprint images from NIST DB4.

III. PROPOSED METHOD

The fingerprint picture is initially acquired using the suggested system. The information of the fingerprint picture is then reconstructed using a combination of two image enhancement procedures (DFT and Histogram equalization) ; the methodology for these processes are shown as some blocks in Fig 1.

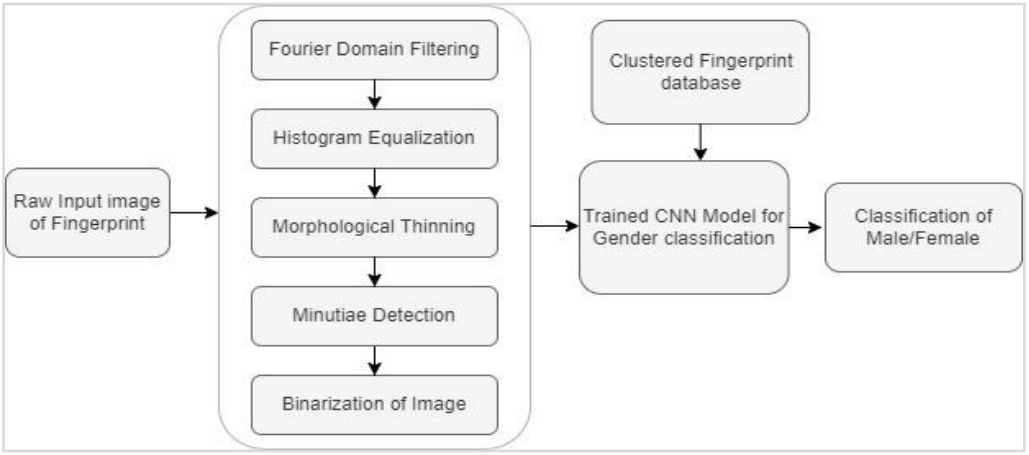

Fig.2 Proposed approach

Collected fingerprints may vary in the quality of the image. The first step is to enhance the quality of the image using the Fourier transform approach. Individual image is divided into 'm x n' blocks and then fitted into frequency domain F(u,v) in Eq.1..

$$F(u,v) = \sum_{x=0}^{m-1}\sum_{y=0}^{n-1} i(x,y)exp\left\{j^2\pi\left(\frac{ux}{m}+\frac{vy}{n}\right)\right\} \quad (1)$$

This Fourier transform has been multiplied by its power spectrum by raising it to power 'i'. The enhanced image has been derived by applying inverse Fourier transform on the above image as shown in Eq.2.

$$Img(x,y) = F^{-1}\{F(u,v) * |F(u,v)|^i\} \quad (2)$$

The output of the FDT has been supplied to Histogram Equalization. This method improves the overall contrast of a large number of images, particularly when the data of the image is represented by near contrast values. This allows regions with lower local contrast to obtain higher contrast without affecting overall contrast. This is accomplished with the help of histogram equalisation, which efficiently spreads out the most common intensity values.The fingerprint picture quality has improved following DFT and histogram equalisation. The two-stage cascading enhancements technique produces significantly superior results. The step by step images are displayed in Fig 2.

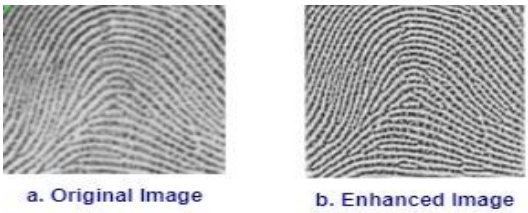

Fig. 2. Histogram equalization of fingerprint image.

The term "histogram equalization" refers to a mapping of grey levels p to grey levels q with a uniform distribution of grey levels q [16]. The probability density function of a pixel intensity level r_k is given by Eq.3

$$p_r\left(r_k = \frac{n_k}{n}\right) \quad (3)$$

Where $0<=0 \leq r_k \leq 1, k = 0,1,2,\ldots,255, n_k$ is the pixels at intensity level r_k and n is the number of pixels. The histogram is derived by plotting $p_r(r_k)$ against r_k. A new intensity s_k of level k is defined as given in Eq.4.

$$s_k = \sum_{j=0}^{k} \frac{n_j}{n} = \sum_{j=0}^{k} p_r\left(r_j\right) \quad (4)$$

Enhanced image is hen supplied for image binarization process. In order to process the acquired fingerprints, we need to apply binarization of the fingerprint image. Rides and valleys have been given with bit-0 and bit-1 respectively. In the grayscale image, the ridges are highlighted by black color and the valleys by white color. Binary zero or one value would be decided based on the intensity of the pixel. Once converted into grayscale fingerprint image, only the region of interest has been taken for image processing. Extracted image has been processed by using complex filters to perform ridge thinning by removing the redundant pixels across the ridges by keeping the ridge width one pixel. Thinned image is processed by crossing number concept for minutiae extraction. Ridge ending is generally called as minutiae point and pattern. This will be unique in nature with every person. We carried out binarization using adaptive threshold approach. Each pixel is assigned a new value according to the mean intensity in a local neighborhood as given in Eq.5.

$$I_{new}(n1, n2) = \begin{cases} 1 \; if \; I_{old}(n_1, n_2) \geq Local\ Mean \\ 0 \; ot\square erwise \end{cases} \quad (5)$$

Morphological thinning operation is used for thinning the ridgelines in the original image.

In the implementation, we have used Convolutional neural network (CNN) model for gender categorization based on fingerprint photos in this article. From the input pictures, the convolutional layers extract features. A rectifier linear unit shapes the output of each convolutional layer (ReLU). The feature resolution is reduced using the sub sampling layer. The max-pooling layer subsamples the outputs provided by the preceding convolutional layers. NIST DB4 is a well-known public domain fingerprint database that we used to test the system. It contained 4000 images, 3200 of which were training images and 800 of which were testing images. The CNN model is used to train and test on 4000 images.

Table 1. Experimental results.

Activation Function	Epoch	Accuracy	F1 Score
Relu	10	89.50%	88%
	15	87%	87%
Tanh	10	85%	86.60%
	15	87.10%	87.30%

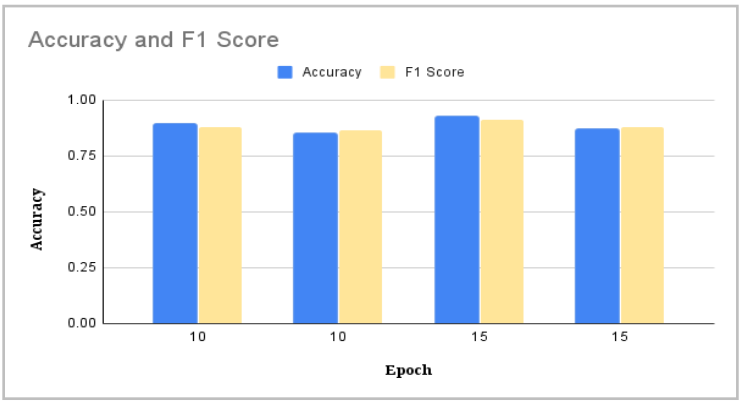

Fig.3 Accuracy in the gender classification using Relu and Thanh activation functions.

Table-1 shows the results of the suggested approach's performance measures. The activation function of Relu successfully categorized the image with an accuracy of 88% and an accuracy of 87% for Tanh by training the network model for 20 epochs.

IV CONCLUSION

Conclusion We present a gender categorization model in this research, which is simple for people but difficult for robots. To categories gender based on fingerprint photos, CNN, one of the most extensively used image classification models, was applied. For epochs ranging from 10 to 20, we used pictures from NIST DB4 to train the convolutional model using the activation functions ReLu and Tanh. At the 20th epoch, the Relu activation function performed at its best, with a 87 percent accuracy. In other applications like identification and authentication, this paradigm may be utilised to minimise search space. Future research will concentrate on gender prediction using palm prints and hand photos.

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