GENDER CLASSIFICATION BASED ON FINGERPRINT IMAGES USING MACHINE LEARNING

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ABSTRACT

Fingerprints are a unique biological feature of the human body that contain a wealth of gender information. Despite the significance of this information, academic exploration on fingerprint gender characteristics is still in its early stages, with limited standardization exploration available. To address this gap, we propose a more robust system for rooting valid gender information from fingerprints: the Dense Dilated Convolution ResNet (DDC-ResNet). We evaluated the efficiency of the DDC-ResNet in three ways. First, we compared our approach to six typical methods of automatic feature extraction coupled with nine mainstream classifiers. Our experimental results demonstrate that our approach outperforms other combinations in terms of average delicacy and separate-gender delicacy, achieving 96.5% for average accuracy and 0.9752 (males) /0.9548 (females) for separate-gender delicacy. Alternate, we delved the effect of fritters on gender bracket and set up that the ring cutlet achieved best performance. Eventually, we explored the effect of specific features and observed that circles and whorls (position 1), bifurcations (position 2), and line shapes (position 3) are connected with gender.

Keywords: Finger print, convolutional neural network (CNN), gender identification.

INTRODUCTION

Fingerprint gender identification is a process that aims to prize gender-related features from an unidentified fingerprint to determine the gender of the existent. This process can be divided into two stages: extracting and classifying. The former stage is of great significance as the effectiveness of gender identification is primarily determined by the adequacy of gender-related features.

Currently, fingerprints can be classified into three levels, as shown in Figure 1. Classifying ridge-related features that are manually uprooted has achieved fairly good results, with an overall accuracy of 90% for average individualities. Still, high performance depends explosively on the manual extraction of features from well-named regions, which has major failings such as high error, weak robustness, and high labor consumption.

With the growing fashionability of machine literacy and deep literacy, automatic feature extraction has become a major focus. Experiments such as Abdullah et al. [2017 a, b], Gnanasivam and Muttan [2013], Gupta and Rao [2014], Mishra and Maheshwary [2018], Rekha et al. [2019], Shinde and Annadate [2016], and Wedpathak et al. [2019] have made significant contributions in this area.

In conclusion, fingerprint gender identification is an important process that can be bettered through the use of automatic feature extraction. This will lead to more accurate and effective gender identification, which can have significant counter accusations in various fields similar as law enforcement and healthcare.

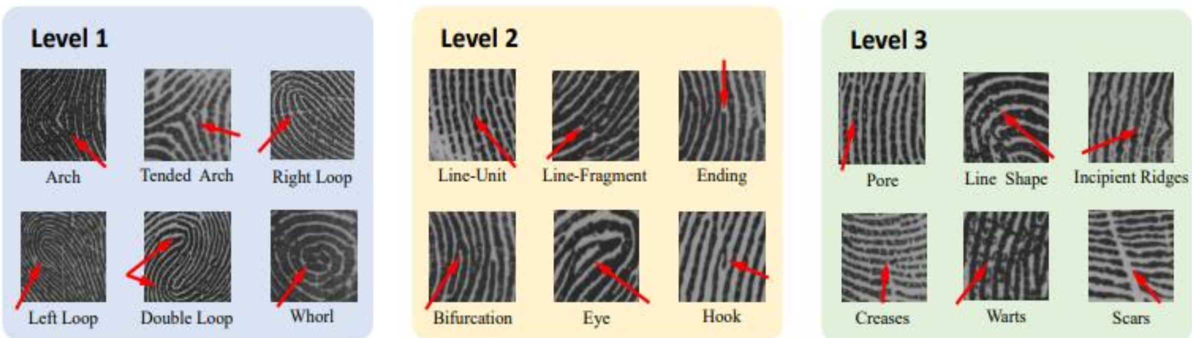


Figure 1: Three levels of fingerprints

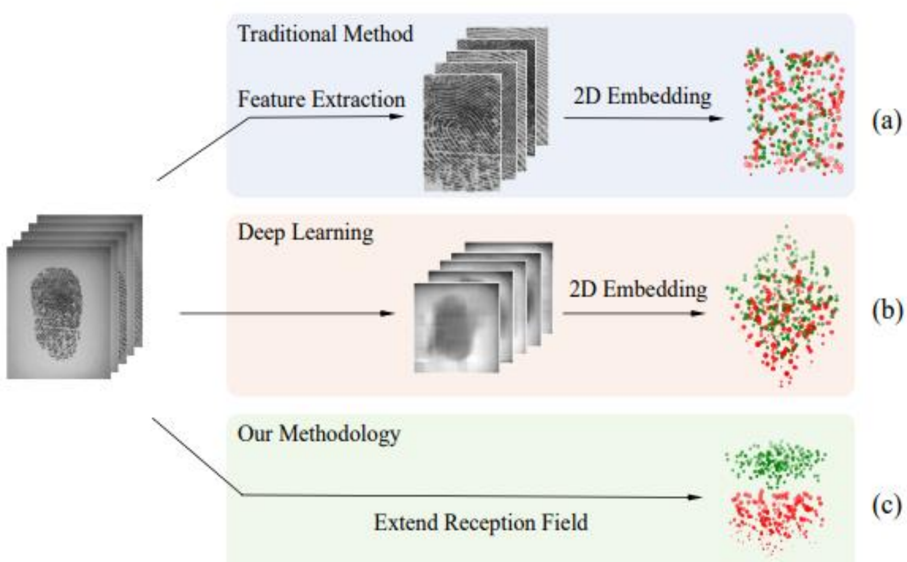


Figure 2: General automatic gender classification style exercise. (a) shows embedding and feature extracted by traditional system, which are delicate to distinguish; (b) shows deep learning method, and it is easier to identify than (a); and (c) is the result of our trial and it performs best.

To realize the automatic feature extraction, considerable work has been done. In machine learning, methods such as DWT, SVD, PCA as well as FFT are considerably used Gnanasivam and Muttan, Kaur and Mazumdar, Marasco et al. For deep learning-based methods, including deep autoencoder neural networks such as VGG and ResNet, etc have been delved Chen et al.

Despite the many algorithms proposed for gender classification, there are still two major challenges that need to be addressed. Originally, traditional approaches bear excessive labor consumption and warrant robotization. Secondly, the automatic feature extraction method lacks robustness as it only considers regions rather of the global field.

To illustrate this point, Figure 2 shows the difference between the normal automatic feature extraction method and the deep neural network with global event consideration. The ultimate can divide the feature space normatively, making it more effective and accurate.

Also, private datasets with distant data distributions and sizes can directly impact the delicacy of gender classification. thus, to overcome these challenges, we propose a global feature extraction method that improves the efficiency of gender classification. This method takes into account the entire feature space, making it more robust and accurate.

In conclusion, our proposed global feature extraction method addresses the challenges faced by traditional approaches and automatic feature extraction methods, making gender classification more effective and accurate.

Role of this paper:

i. We propose a new system for extracting features from fingerprints that takes into account global features. In order to give a fair comparison with existing automatic feature extraction and classification methods, we have conducted a comprehensive analysis with detailed perpetration details

ii. We conduct a thorough comparison to assess the effectiveness of our system. We identify the finger with the most prominent gender-related features using the most effective fashion. Subsequently, we utilize the selected method to visualize the concentrations, highlighting the areas with the most significant contributions and their corresponding specific features in the gender identification process.

iii. We are pleased to advertise that we will be releasing our dataset as open-source. This decision was made due to the limited availability of open-source datasets for fingerprint gender classification.

RELATED WORK

The proposed work for the gender classification is done by the following methodologies.

Fingerprint Image Enhancement (Image improvement):

To enhance the fingerprint images we have image processing methods like RGB to Gray, Thinning and segmentation method.

Segmentation:

In Computer vision segmentation means partitioning the image into multiple parts. The end and thing of segmentation is to partition the image into multiple parts like line, curves, angles etc.

Gabor filters:

During image processing, a Dennis Gabor filter is a linear filter utilized for texture analysis. This filter primarily analyzes whether there is any specific frequence content within the image in specific directions within a localized region around the point or region of interest.

Binarization:

Image binarization is the system converting RGB image into Gray Scale that is Black and White Image.
This is so what called as Image thresholding which may produce affair of two levels of gray.

Thinning:

Thinning may be a morphological operation that's used to take down chosen foreground pixels from binary pictures, somewhat like erosion or gap. It may be used for numerous operations, still is helpful for skeletonization.

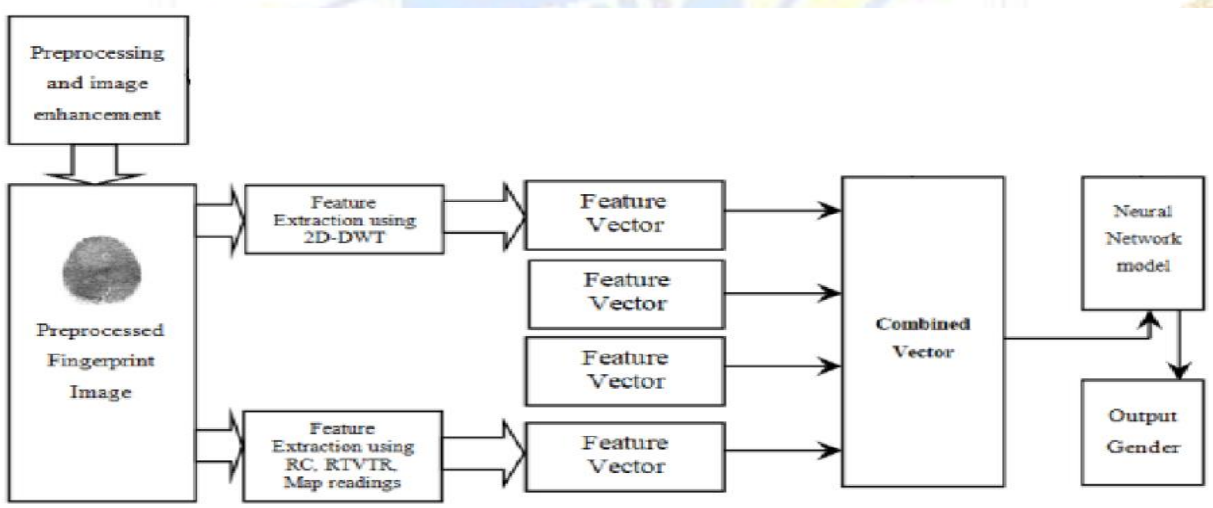
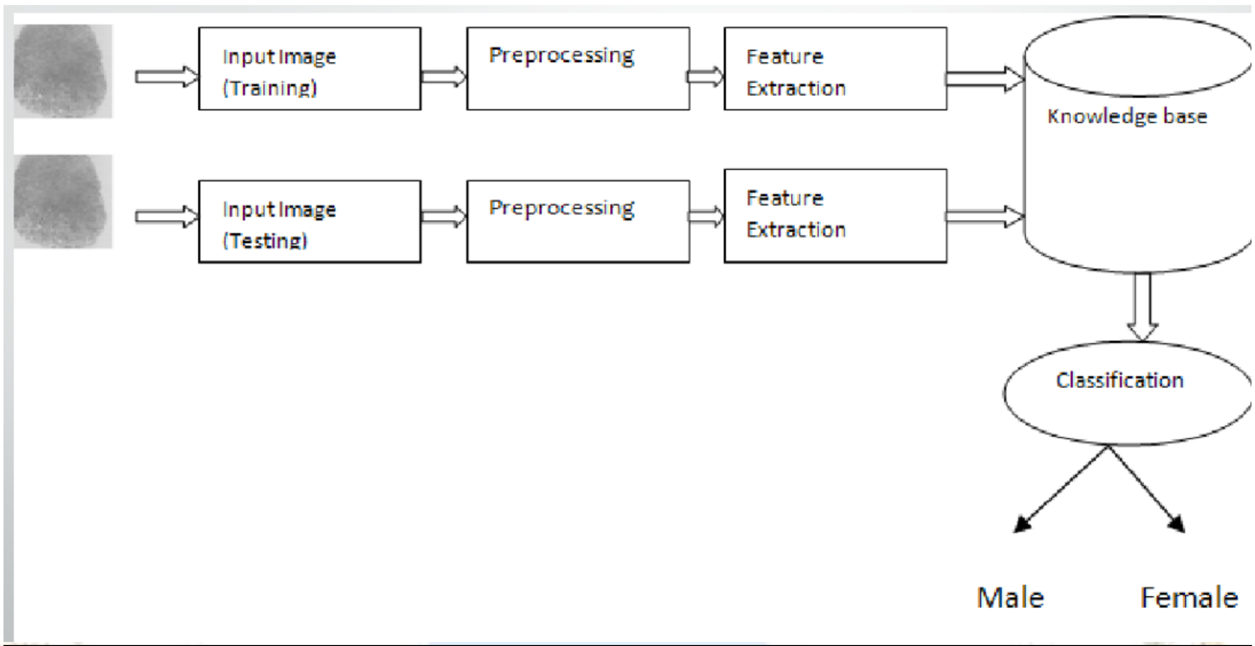


Fig1. Proposed System Architecture

Sub-System Architecture:



Experimental Result and Analysis:

In this report, we will be agitating the results of our gender recognition system. Our system was tested using the well-known public domain fingerprint database, Sokoto Coventry Fingerprint.

To begin, we will provide an overview of the databases used and the experimental setup for each. For our evaluation, we employed the Sokoto Coventry Fingerprint dataset, which is a large fingerprint dataset containing 6000 images of size 512*512.

To showcase the different features of the dataset, we have included sample fingerprint images for Arch(A), Right loop (RL), Left loop (LL), Whorl(W), and Tented arch(T) in Figure 5.

Our trials were conducted on two classes, manly (male) and womanly (female), from the Sokoto Coventry Fingerprint dataset using a CNN model. The CNN model was trained and tested with 6000 images using Tensor Flow on a Core i7 CPU 2.6 GHz, 1-TB hard disk, and 8-GB RAM.

To give a better understanding of our training process, we have included sample training male and female fingerprint images in Figure 6.

Overall, our gender recognition system has shown promising results and has the implicit to be employed in different applications.

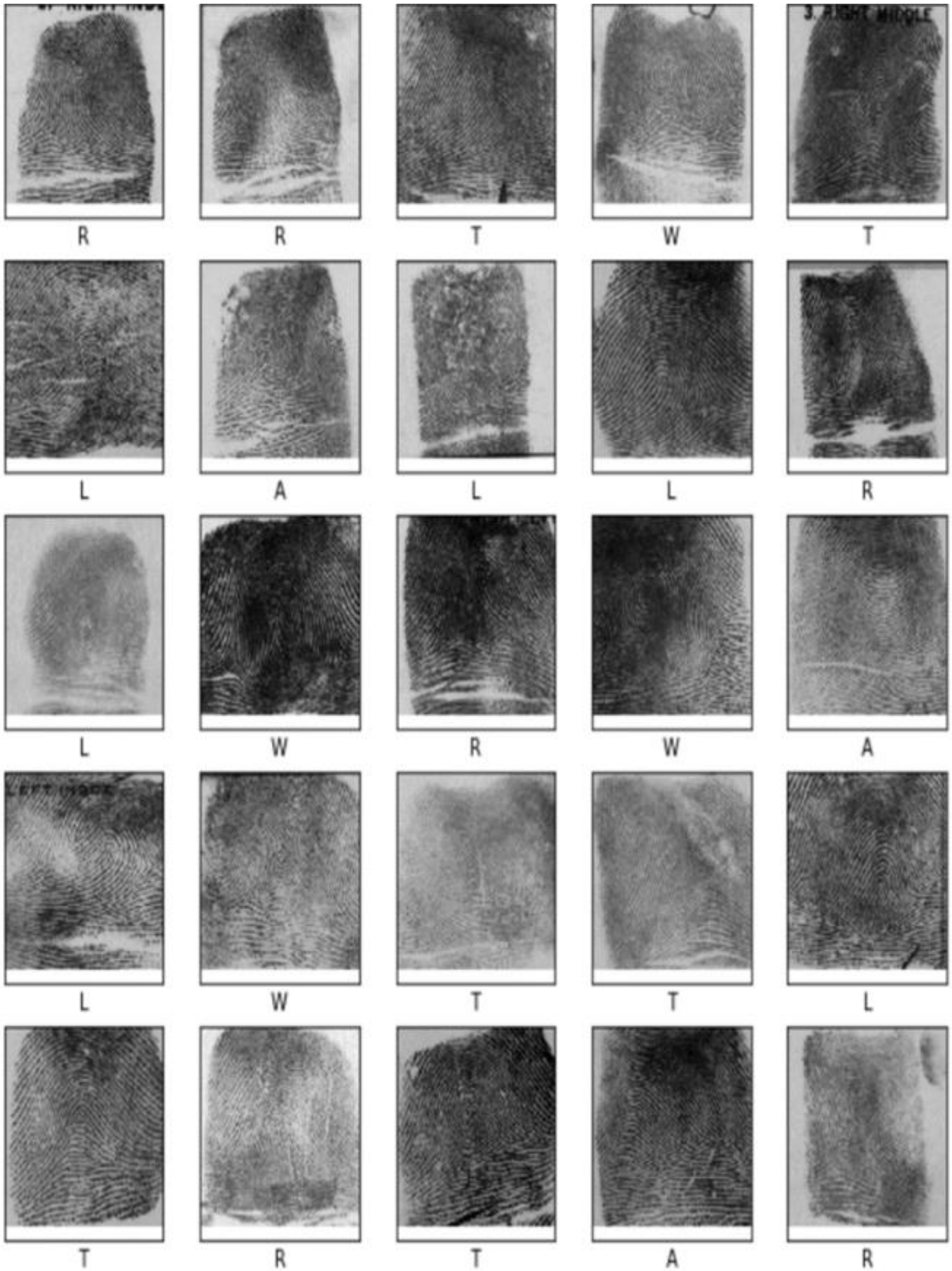


Figure-5

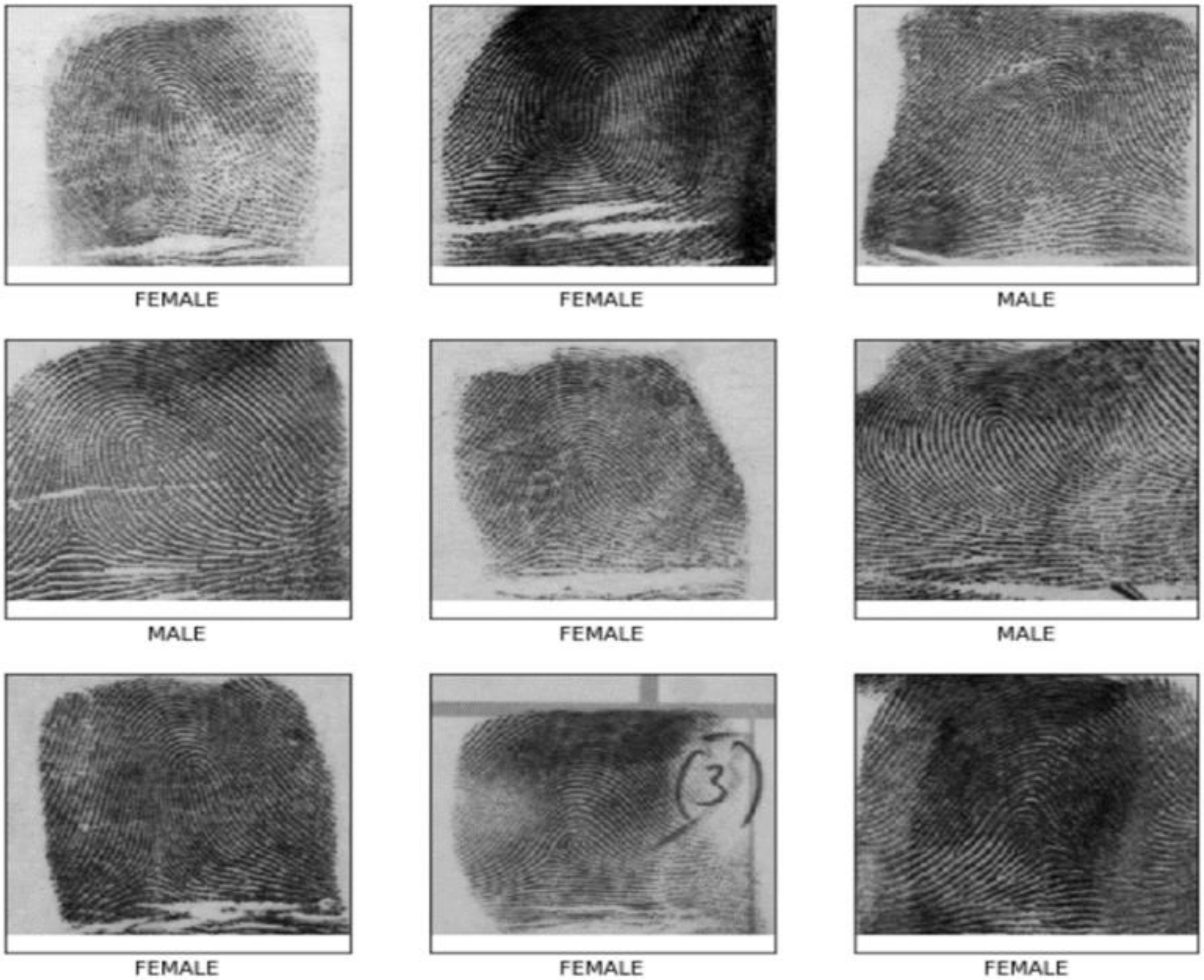


Figure-6

We evaluated the performance of our proposed framework by utilizing four combinations of predicted and actual values: TP, FP, TN, and FN. TP, or true positive, indicates that the system has correctly identified a positive as positive. TN, or true negative, means that the system has correctly identified a negative as negative. FP, or false positive, predicts a negative as positive, while FN, or false negative, predicts a positive as negative.

Accuracy is defined as the ratio of the number of genders correctly classified to the total number of genders, as shown in equation 1. To provide a more comprehensive illustration of the results, we also utilized Precision, Recall, and F-measure, which are defined by equations 2, 3, and 4, respectively. F-measure serves as an evaluation metric for measuring the regression performance of our proposed approach. A higher F-measure value indicates a higher classification rate.

In summary, our evaluation of the proposed framework involved analyzing the four combinations of predicted and actual values, as well as utilizing accuracy, precision, recall, and F-measure to provide a more detailed understanding of the results.

$$\boldsymbol{Accuracy} = \frac{\textbf{Total no. of correct prediction}}{\textbf{No. of input samples}}$$

$$\textbf{PRE}_i = \frac{\textbf{TP}_i}{\textbf{TP}_i + \textbf{FP}_i}$$

$$\textbf{REC}_i = \frac{\textbf{TP}_i}{\textbf{TP}_i + \textbf{FN}_i}$$

$$\mathbf{F}_1^i = \frac{\mathbf{PRE}_i * \mathbf{REC}_i}{\mathbf{PRE}_i + \mathbf{REC}_i}$$

The table below showcases the performance metrics of the proposed approach, while Figure 7 provides a corresponding chart. The performance metrics table clearly indicates that the proposed approach, which utilizes the Relu activation function, is highly efficient in image classification, achieving an accuracy rate of 99%. In comparison, the Tanh activation function resulted in an accuracy rate of 74.5% after training the network model for 20 epochs. It is evident that the proposed approach with Relu activation function outperforms the Tanh activation function in terms of accuracy.

Activation function	Epochs	Accuracy	Precision	Recall	F1-score
ReLu	10	88.5%	87.7%	88.2%	88%
	20	99%	99%	99%	99%
Tanh	10	85.2%	85.1%	84.8%	85%
	20	87.6%	87.3%	87.2%	87%

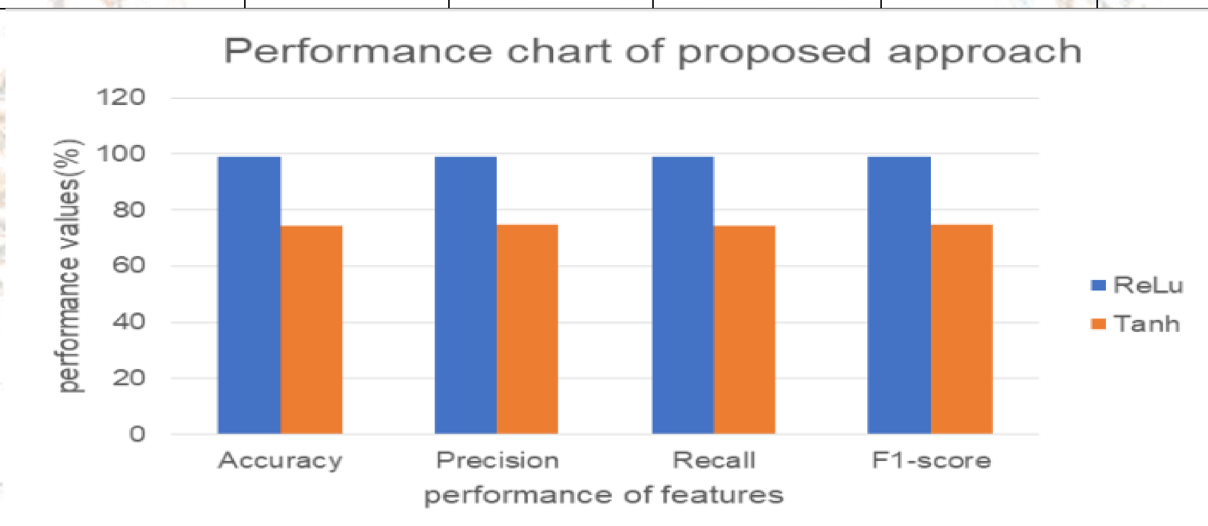


Figure-7

CONCLUSION

This model proposes a gender classification model that is a simple task for humans but challenging for machines. To address this, we employed a Convolutional Neural Network (CNN), which is a widely used model for image classification, to classify gender based on fingerprint images. We trained the convolutional model using images from Sokoto Coventry Fingerprint dataset and utilized the activation functions ReLu and Tanh for epochs ranging from 10 to 20. Our results showed that the optimal performance was achieved with a 99% accuracy rate using the ReLu activation function at the 20th epoch.

This model has the potential to reduce search space in various applications, including identification and authentication. Our future work will focus on analyzing the performance of other deep learning classifiers to further improve the accuracy of gender classification.

Overall, this research provides a promising approach to address the challenge of gender classification in machine learning and has practical implications for various fields.

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