ENHANCING THE ACCURACY OF FINGERPRINT IMAGE USING NOVEL FUZZY LOGIC SYSTEM IN COMPARISON WITH ARTIFICIAL NEURAL NETWORK

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Abstract

Aim: To enhance the accuracy of fingerprint image based on novel fuzzy logic systems and artificial neural network algorithms.
Materials and Methods: Classification is performed by a Novel fuzzy logic system (N=10) over an artificial neural network (N=10). Sample size is calculated using GPower with pretest power as 0.8 and alpha 0.05.
Result: Mean accuracy of Novel fuzzy logic systems (98%) is high compared to artificial neural networks (94%). The significance value for performance and loss is 0.601 (p>0.05).
Conclusion: The mean accuracy of the fingerprint image enhancement system using novel fuzzy logic is better than artificial neural networks.

Keywords: Novel Fuzzy Logic System, Accuracy, Algorithm, Enhancement, Artificial Neural Network, Fingerprint Image.

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1. Introduction

Fingerprint enhancement system is a system which enhances the accuracy of low-quality fingerprint images to high quality fingerprint image (Arada and Dadios 2012). This fingerprint enhancement system uses low-quality fingerprint images and enhances its accuracy in percentage. It is mostly done using machine learning, artificial intelligence, etc (Stojanovic et al. 2014). Here compare Novel fuzzy logic systems and artificial neural network algorithms to find out which has better accuracy percentage rate for fingerprint enhancement ("FINGERPRINT BASED GENDER CLASSIFICATION USING ANN" 2018). A fingerprint image has the subsequent options by that, it is increased victimization acceptable techniques. Ridge Orientation Map is the native direction of the ridge depression that is employed for classification, verification and filtering functions, whereas Ridge Frequency Map is just used for image filtering functions (Mutter 2013). Registration and classification is done on the premise of Singular points within the fingerprint image, where core represents the top a part of arced edge and Delta represents' the purpose wherever 3 ridge flows meet. The applications of this system is that it can be used for identification proof, border control identification, theft control and access control (Petry-Schmelzer et al. 2021).

The fingerprint enhancement system and the fingerprint database are collected from people (Kumar, Bhushan, and Jangra 2021). Fingerprint enhancement has been carried out by various researchers and numerous articles, a total of 84 articles have been published in IEEE Digital Xplore and research gate. Various factors will have an effect on the standard of fingerprint images like dryness/wetness conditions, heterogenous and inconsistent contact, permanent cuts, etc, (Gupta and Kumar 2010). Many of those factors can not be avoided. Therefore, enhancement of the standard and validity of the captured fingerprint image is important and substantive (Ayarzagüena et al. 2021). Many papers in biometric literature address the matter of enhancement fingerprint image quality. But these methods still have some issues and can't be appropriate for all the conditions. Comparison is done between Novel fuzzy logic systems and artificial neural network algorithms. This article determines which algorithm is best suited for a fingerprint image enhancement system – Novel fuzzy logic system or artificial neural network. Biometrics traits also are referred to as life science modalities (Shalaby 2012). From the available biometric modalities fingerprint based mostly authentication has gained a foothold over others because of its highest recognition rate and straightforward acquisition as compared to different life science like face, retinal and iris etc. numerous techniques developed over a time for fingerprint recognition square measure broadly speaking classified as minutiae-based and image-based strategies.

Our institution is passionate about high quality evidence based research and has excelled in various domains (Vickram et al. 2022; Bharathiraja et al. 2022; Kale et al. 2022; Sumathy et al. 2022; Thanigaivel et al. 2022; Ram et al. 2022; Jothi et al. 2022; Anupong et al. 2022; Yaashikaa, Keerthana Devi, and Senthil Kumar 2022; Palanisamy et al. 2022). The existing system features a disadvantage of lesser prediction and accuracy rate. Finding a detection model to precisely enhance fingerprint image depending on raw data is tedious (Menke, Massa, and Koch 2021). The above problem's complexity is going to be reduced once a model is constructed. Despite various undeniable facts that several researchers have discovered numerous enhancement models, several of them are unable to accurately enhance the fingerprint image. The aim of this proposed work is to create a model to enhance the accuracy of fingerprint image based on their database using a novel fuzzy logic System, thereby improving accuracy and precision and reducing time complexity.

2. Materials and Methods

This study setting was done in the Data Analytics Lab, Department of Information Technology, Saveetha School of Engineering. Sample size for this project is 20 (Group 1=10, Group 2=10). In this fingerprint enhancement system, to rectify the problem of low accuracy rate Novel fuzzy logic system and artificial neural network is used (Nagati 2012). The fuzzy system proposed uses only the information stored in the aggregation matrix and an index indicating the current expert looking at the images. The image fuzzification, therefore, plays a pivotal role in all image processing systems that apply any of these components. Mean accuracy of the Novel fuzzy logic system is 98%. Mean accuracy of ANN is 94%. Dependent variables are ridges, pattern, pores, edge contour. Independent variables are accuracy, enhancement and detection. Independent t test is carried out in this research work. Dataset for this article is collected from (https://github.com/utkarsh-deshmukh/Fingerprint-Enhancement) website with 6 attributes and 2134 rows.

The Novel fuzzy logic system proposed uses solely the knowledge stored within the aggregation matrix and an index indicating this skill observing the images (Mutter 2013). The image fuzzification, therefore, plays a crucial role in all image processing systems that apply any of

those elements. A digital image with grey tone suffers from ambiguity and vagueness. This vagueness is outlined using linguistic variables, like 'good contrast', 'light red' etc (Fingerprint Fuzzy Vault: Security Analysis and a New Scheme 2013). An image can be thought of as an array of fuzzy singletons every having a membership operation specifying the varied degree of brightness levels. Pseudocode for Novel fuzzy logic systems is described in Table 1.

The Artificial Neural Network (ANN) is similar to biological systems such as the brain or neurons whereas information is the processing paradigm. Artificial neural network is based on the idea that it receives a group of input (X1, X2……Xn). This set of inputs is increased by a group of weights (W1, W2, and Wn). These weighted values are then summed and also the output is passed through an activation (transfer) function. The information inserted is trained to learn the characteristic, behavior and others in order to ensure the system is able to recognize the input data (Sujitha and Chitra 2019). The pseudocode for an artificial neural network is described in Table 2.

Statistical Analysis

The analysis was done by IBM Statistical Package for the Social Sciences version 21. In SPSS, datasets are prepared using 10 as sample size for both the algorithm, Novel fuzzy logic system and artificial neural network algorithm. Group id is given as 1 for Novel fuzzy logic systems and 2 for artificial neural networks, group id is given as a grouping variable and accuracy is given as a testing variable. The attributes are ridges, pattern, pores, edge contour, colour, image, etc,.

3. Result

In statistical tools, the total sample size used is 20. This data is used for analysis of Novel fuzzy logic systems and artificial neural network algorithms. Statistical data analysis is done for both the prescribed algorithms namely Novel fuzzy logic system and artificial neural network algorithm. The group and accuracy values are being calculated for given filtering systems. These 20 data samples used for each algorithm along with their loss are also used to calculate statistical values that can be used for comparison. Table 3, shows that group, accuracy and loss values for two algorithms Novel fuzzy logic system and artificial neural network algorithms are denoted. Group statistics table shows a number of samples that are collected. Mean and standard deviation obtained and accuracies are calculated and entered.

Table 4, shows group statistics values along with mean, standard deviation and standard error mean for the two algorithms are also specified. Independent sample T test is applied for data set fixing confidence interval as 95%. Table 5, shows independent t sample tests for algorithms. The comparative accuracy analysis, mean of loss between two algorithms are specified. Figure 1 shows comparison of mean of accuracy and mean loss between Novel fuzzy logic system and artificial neural network algorithm.

4. Discussions

The accuracy of a Novel fuzzy logic system is 98% whereas an artificial neural network is 94% with p=0.601 because, a large number of datasets with fewer parameters. which shows that a Novel fuzzy logic system is better than an artificial neural network algorithm. Mean, standard deviation and standard mean values for Novel fuzzy logic systems are 92.2510, 1.82511, 0.57715 respectively. Similarly for artificial neural network algorithms the mean, standard deviation and standard mean values are 82.0130, 1.70336, 0.53865 respectively.

This research increases accuracy for enhancement of fingerprint image systems thereby providing better results in accordance with the data (Chen et al. 2021). With a hybrid database the chances for correct detection is also greatly increased. This model has a slow processing rate with better accuracy (Fan et al. 2020). Slow processing rate is due to usage of a large database but in case of a smaller database, both the processing and accuracy are faster and better. Above problem's complexity will be reduced once a model is built (Gupta and Kumar 2010). Despite various fact that many researchers have discovered various detection models, many of them are unable to accurately enhance the fingerprint image (Sundararajan 2003). Many applications can be developed to predict accurately for sensitivity from various platforms.

The Novel Fuzzy logic system has a disadvantage of not being easy to use and is extremely tedious since it has numerous cycles (Sujitha and Chitra 2019). Which implies that the K Nearest Neighbor calculation is difficult to utilize and takes a great deal of the time preparing the information (Mutter 2013). In future this unique fingerprint image enhancement can be additionally improved by fostering the Novel Fuzzy logic calculation.

5. Conclusion

From this study of fingerprint enhancement systems, the mean accuracy of an artificial neural network algorithm is 94% whereas a Novel fuzzy logic system has a higher mean

accuracy of 98%. Hence, it is inferred that a Novel fuzzy logic system appears to be better in accuracy when compared to artificial neural network algorithms.

Declarations

Conflict of Interest

No conflict of interest in this manuscript.

Authors Contribution

Author RN was involved in data collection, data analysis and manuscript writing. Author RK was involved in conceptualization, data validation and critical reviews of manuscript.

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Tables and Figures

Table 1. Pseudocode for Fingerprint Enhancement system based on Novel Fuzzy Logic system

INPUT: Training dataset for Fingerprint Enhancement

Step 1: Extract the fingerprint data attributes
Step 2: Input fingerprint dataset
Step 3: def __normalise(self, img, mean, std):
if(np.std(img) == 0):
img = cv2.imread('image_path', 0)
out = fingerprint_enhancer.enhance_Fingerprint(img)
cv2.imshow('enhanced_image', out);
cv2.waitKey(0)
normed = (img - np.mean(img)) / (np.std(img))
return (normed)
def __ridge_segment(self, img):
Step 5: Formula for Fuzzy logic system : $\mu E(x) = \sum_{i=1}^{k} [\mu A_i(x)]q$

OUTPUT: Enhanced fingerprint image to obtain accuracy

Table 2. Pseudocode for Fingerprint Enhancement system based on Artificial Neural Network

INPUT: Training dataset for Fingerprint Enhancement
Step 1: Read and test data for enhancement for fingerprint images Step 2: Extract fingerprint attributes for enhancement Step 3: Extract attributes to enhance fingerprint data Step 4: Input fingerprint image Step 5: Apply Artificial Neural Network Step 6:Formula for Artificial neural network $y = f(\sum_{i=0}^{n} (w_i * x_i) + B)$ Step 7: Learn user preferences Step 8: Return accuracy

OUTPUT: Enhanced fingerprint image to obtain accuracy

Table 3. Group, Accuracy and Loss value for Fingerprint Enhancement System

SI.NO	Name	Type	Width	Decimal	Columns	Measure	Role
1	Group	Numeric	8	0	31	Nominal	Input
2	Accuracy	Numeric	8	4	31	Scale	Input
3	Loss	Numeric	8	2	31	Scale	Input

Table 4. Group Statistical analysis for Novel Fuzzy Logic System and Artificial Neural Network Mean, Standard deviation and Standard error mean are determined

	Group	N	Mean	Std Deviation	Std Error Mean
Accuracy	Fuzzy Logic System	10	92.2510	1.82511	0.57715
	Artificial Neural Network	10	82.0130	1.70336	0.53865
Loss	Fuzzy Logic System	10	7.7490	1.82511	0.57715
	Artificial Neural Network	10	17.9870	1.70336	0.53865

Table 5. Independent sample T test is performed on two groups for significance and standard error determination. P value is greater than 0.05 (0.601) and it's considered to be statistically insignificant with 95% confidence interval

	Levene's Test for Equality of Variance	T-Test for Equality of Means

		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Accuracy	**Equal variances assumed**	0.284	0.601	12.968	18	0.000	10.23800	0.78946	8.57941	11.89659
	Equal variances not assumed			12.968	17.915	0.000	10.23800	0.78946	8.57884	11.89716
Error	**Equal variances assumed**	0.284	0.601	-12.968	18	0.000	-10.23800	0.78946	-11.89659	-8.57941
	Equal variances not assumed			-12.968	17.915	0.000	-10.23800	0.78946	-11.89716	-8.57884

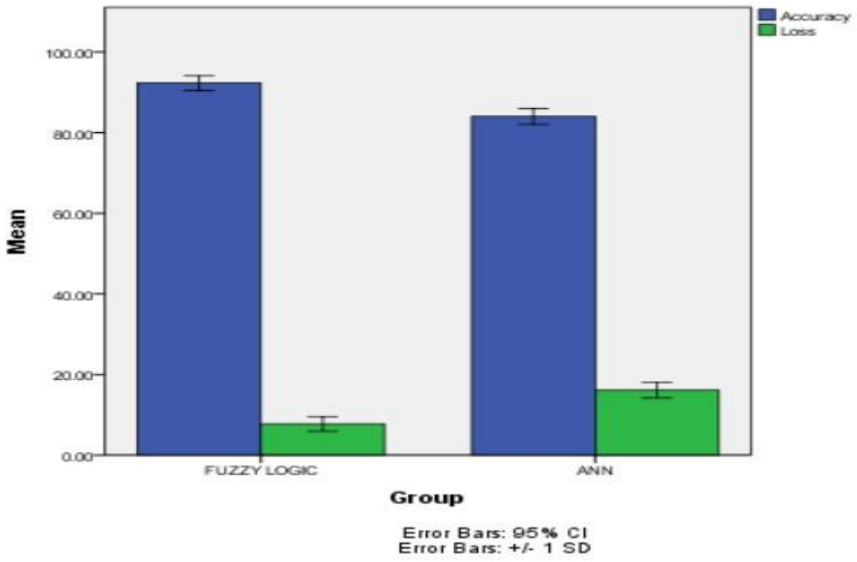

Fig. 1. Comparison of Novel Fuzzy Logic System and Artificial Neural Network Algorithm in terms of mean accuracy. The mean accuracy of the Novel Fuzzy logic system is better than ANN Algorithm. The standard deviation of the Novel Fuzzy Logic System is slightly better than ANN Algorithm. X Axis: Novel Fuzzy logic system vs ANN Algorithm. Y Axis: Mean accuracy of detection ± 1 SD.