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Finger print Analysis and Matching using fuzzy logic design

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***Abstract**: fingerprint authentication is implemented using many algorithms, which are based either on minutiae analysis or non minutiae analysis. Preprocessing of the fingerprints is important for better accuracy. Preprocessing includes segmentation and noise removal, which are considered two major steps in preprocessing. In this paper segmentation is performed by using fuzzy logic system, as the edges of the finger print plays a major role in the authentication fuzzy logic analysis improves sharpness of edges. This preprocessed image is taken as the input, and then fingerprint authentication is performed on two modules analysis on matching percentage is determined.*
***Keywords:** authentication minutiae, segmentation preprocessing, matching percentage*

I. Introduction:

Fingerprint segmentation is an important pre-processing step in automatic fingerprint authentication system. Traditional fingerprint segmentation methods either highly depend on empirical thresholds chosen by experts or a learned model trained by elements generated from manually segmented fingerprints. It is time consuming and requires lot of man power. These methods try to tune their fingerprint segmentation methods to be universal to all unseen fingerprints. However, one fingerprint may have a significantly distinct distribution from another in feature space because fingerprint acquisition is affected by several factors such as pressure, the type of sensors, finger tip condition (dry, wet etc.). As a result, the delicate threshold and the well trained model may not be suitable for a new fingerprint. It further worsens when automatic fingerprint identification systems meet sensor interoperability. To solve the above problems, this paper proposes a personalized fingerprint segmentation method: fingerprint segmentation using neural networks, which has a segmentation model, for each input fingerprint image.

In this paper section 2: gives the literature survey of fuzzy logic theory and finger print segmentation. Section 3: describes the related works of previous implementations section 4: method followed for finger print segmentation with step wise implementation and also gives a brief description of the finger print modules used for testing and the dataset description. The paper further gives the results conclusion and bibliography.

II. Fuzzy theory:

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. The following are the different kinds of image fuzzification:

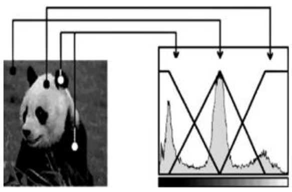

Fig.1:histogram analysis of the gray scale image

Histogram-based gray-level fuzzification (or briefly histogram fuzzification)
Example: brightness in image enhancement
Local fuzzification (example: edge detection)
Feature fuzzification (scene analysis, object recognition as above figure)

In order to be in a form suitable for computer processing an image function $f(x, y)$ must be digitized both spatially and in amplitude (intensity). Digitization of spatial co-ordinate (x, y) is called *image sampling*, while amplitude digitization is referred to as *intensity* or *gray-level quantization*. The latter term is applicable to monochrome images and reflects the fact that these images vary from black to white in shades of gray. The terms intensity and gray-level can be used interchangeably. Suppose that a continuous image is sampled uniformly into an array of *N* rows and *M* columns, where each sample is also quantized in intensity. This array, called a *digital image*, may be represented as,

$$f(m,n) = \begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{n1} & x_{n2} & x_{n3} \end{pmatrix}$$

where n is discrete variable

Each element in the array is called an image element, picture element, or pixel.

Spatial domain technique: this method refers to aggregate of pixels composing an image, and they operate directly on these pixels. Processing functions in spatial domain may be expressed as

g(x, y) = h[f(x, y)]

f(x, y) is the input image

g(x, y) is the resultant image

h is the operator on f defined over some neighborhood of (x, y)

The principal approach used in defining a neighborhood about (x, y) is to use a square/rectangular subimage area centered at (x, y). Although other neighborhood shapes such as circle are sometimes used, square arrays are by far most predominant because of their ease of implementation.

Fuzzy image processing is not a unique theory. It is a collection of different fuzzy approaches to image processing. Nevertheless, the following definition can be regarded as an attempt to determine the boundaries:

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on selected fuzzy technique and on the problem to be solved.

Fuzzy image processing (FIP) has three main stages:

1. Image fuzzification
2. Modification of membership values
3. Image defuzzification

The general structure of an FIP is shown in the figure. The fuzzification and defuzzification steps are due to fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques.

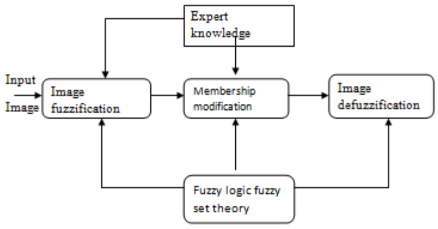

Fig 2: basics of fuzzy logic theory

The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering; a fuzzy rule-based approach, a fuzzy integration approach and so on.

Necessity of FIP*:* there are many reasons for use of fuzzy techniques in image processing. The most important of them are as follows: In many image-processing applications, we have to use expert knowledge to overcome the difficulties (e.g., object recognition, scene analysis). Fuzzy set theory and fuzzy logic offer us powerful tools to represent and process human knowledge in form of fuzzy if–then rules. On the other side, many difficulties in image processing arise because the data/tasks/results are uncertain. This uncertainty, however, is not always due to randomness but to the ambiguity and vagueness. Beside randomness, which can be managed by probability theory, we can distinguish between three kinds of imperfection in image processing.

These problems are fuzzy in nature. The question whether a pixel should become darker than already it is, the question where is the boundary between two image segments, and the question what is a tree in a scene analysis problem, all of these and other similar questions are examples for situations that a fuzzy approach can be the more suitable way to manage the imperfection.

Before one is able to conduct meaningful pattern recognition exercises with images, one may need to preprocess the image to achieve the best image possible for the recognition process. The original image might be polluted with considerable noise, which would make the recognition process difficult.

Processing, reducing, or eliminating this noise will be a useful step in the process. An image can be thought of an ordered array of pixels, each characterized by gray tone. These levels might vary from a state of no brightness, or completely black, to a state of complete brightness, or totally white. Gray tone levels in between these two extremes would get increasingly lighter as we go from black to white.

III. Related works

The rapid growth in the field of Cellular Neural Networks (CNNs) and analogical cellular computing CNN-UM [1] has found a number of potential applications [2], especially in image and video processing problems [3], [4] where real-time signal processing is required. Fingerprint-based identification (and verification) systems using CNNs are very promising for personal identification and in particular, if incorporated in a VLSI chip, for use in portable applications.

An algorithm for fingerprint verification using Scale Invariant Feature Transform (SIFT) [5], in such a way to exploit the high degree of parallelism inherent in a single-layer CNN. SIFT detects and describes local features in images. The SIFT features are local and based on the appearance of the object at particular interest points and are invariant to image scale and rotation.

An approach for fingerprint segmentation using CNN-based thresholding, in which the threshold of CNN is calculated via fuzzy set theory, was done by Jiayin Kang and Wenjuan Zhang [5].

The above works give an analysis only on the enhancement of finger print. This paper shows the enhancement finger print of the proposed method and analysis report of the authentication in two finger print modules

IV. Proposed method

Finger print enhancement: an image X of $N \times M$ dimensions can be considered as an array of fuzzy singletons, each with a value of membership denoting the degree of brightness level p, $p = 0, 1, 2 \ldots P - 1$ (e.g., range of densities from $p = 0$ to $p = 255$), or some relative pixel density. Using the notation of fuzzy sets, we can write,

$$X = \begin{pmatrix} \mu_{11}/x_{11} & \mu_{12}/x_{12} & \cdots & \mu_{1M}/x_{1M} \\ \mu_{21}/x_{21} & \mu_{22}/x_{22} & \cdots & \mu_{2M}/x_{2M} \\ \vdots & \vdots & & \vdots \\ \mu_{N1}/x_{N1} & \mu_{N2}/x_{N2} & \cdots & \mu_{NM}/x_{NM} \end{pmatrix}$$

Where $0 \leq \mu mn \leq 1$, $m = 1, 2 \ldots M$,
$n = 1, 2. \ldots N$.

Contrast within an image is measure of difference between the gray-levels in an image. The greater the contrast, the greater is the distinction between gray-levels in the image.

Images of high contrast have either all black or all white regions; there is very little similar gray levels in the image, and very few black or white regions. High-contrast images can be thought of as crisp, and low contrast ones as completely fuzzy. Images with good gradation of grays between black and white are usually the best images for purposes of recognition by humans.

The object of contrast enhancement is to process a given image so that the result is more suitable than the original for a specific application in pattern recognition. As with all image-processing techniques we have to be especially careful that the processed image is not distinctly different from the original image, making the identification process worthless. The technique used here makes use of modifications to brightness membership value in stretching or contracting the contrast of an image. Many contrast enhancement methods work as shown in the figure below, where the procedure involves primary enhancement of he image, denoted with an E1 in the figure, followed by a smoothing algorithm, denoted by an S, and a subsequent final enhancement, step E2.

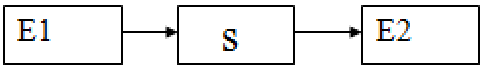

Fig 3: Method of contrast enhancement

The function of the smoothing operation of this method is to blur (make fuzzier) the image and this increased blurriness then requires the use of final enhancement step E2. Generally smoothing algorithms distribute a portion of the intensity of one pixel in the image to adjacent pixels. This
distribution is greatest for pixels nearest to the pixels being smoothed, and it decreases for pixels farther from the pixel being smoothed. The contrast intensification operator, on a fuzzy set A generates another fuzzy set, A_ = INT (A) in which the fuzziness is reduced by increasing the values of $\mu A(x)$ that are greater than 0.5 and decreasing the values that are less than 0.5. If we define this transformation $T1$, we can define $T1$ for the membership values of brightness for an image as,

$$T_1(\mu_{mn}) = T_1^{'}(\mu_{mn}) = 2\mu_{mn}^2 \quad 0 < \mu_{mn} \leq 0.5$$
$$= T_1^{''}(\mu_{mn}) = 1 - 2(1-\mu_{mn})^2 \quad 0.5 \leq \mu_{mn} \leq 1$$

The transformation *Tr* is defined as successive applications of *T*1 by the recursive relation,

$$T_r(\mu_{mn}) = T_1[T_{r-1}(\mu_{mn})] \quad r = 1, 2, 3, \ldots$$

The graphical effect of this recursive transformation for a typical membership function is shown in figure below. The increase in successive applications of the transformation, the curve gets steeper. As *r* approaches infinity, the shape approaches a crisp function. The parameter *r* allows the user to use an appropriate level of enhancement for domain-specific situations.

V. Design Flow of analysis:

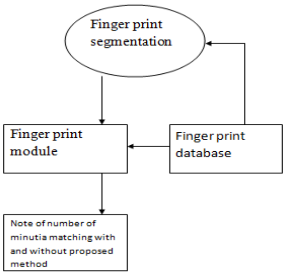

Fig 4: flow chart of steps performed in this paper

VI. Testing Modules:

Minutia-based finger print authentication:

In [6] approach, which is minutia-based, represents the fingerprint by its local features, like terminations and bifurcations. This approach has been intensively studied, also is the backbone of the current available fingerprint recognition products.

Wavelet based finger print authentication:

In [7] Details the work of an efficient fingerprint matching technique via the use of wavelet based features. It is a kind of image based processing technique. So first core point is detected via using the hybrid technique. Then wavelet is applied on a smaller region cropped around the core point. The system uses the distance based classification along with four distances. So due to four distances usage, concept of voting is introduced which is new and saves a lot of computational time

VII. Results:

Fig a b c d e f

Fig g h I j k L

Fig 5: a to f are the finger print database and fig g to L are the corresponding segmented image with proposed method

Minutia count

Fig A B

Fig C D

Fig 6: a and b are the input finger print and preprocessed image .fig c and d are corresponding minutiae extracted finger prints

Observation:

The minutia (parameters) extracted from the input finger print and preprocessed finger print is observed and tabular column is presented below.

Tabular Analysis:

Db1: finger print dataset using ink thumb
Db2: sensor captured finger print dataset
Db3: camera captured finger print dataset

db	Percentage of matching	5 to 10	10 to 15	15 to 20
1	increment	40	6	20
	decrement	5	0	0
2	increment	45	0	4
	decrement	20	0	0
3	Increment	56	10	2
	decrement	2	0	0

The authentication of two finger prints is based on the matching percentage of the minutia parameters.

The difference in the matching percentage for the database with normal fingerprints and the proposed method finger print is tabulated .The percentage matching parameters in divided into intervals to classify.

Tested methods	frr			far		
database	1	2	3	1	2	3
Discrete wavelet transform	26.4	20	24	0.5	0	0.4
Minutiae based authentication	30	25.4	22	0.2	0	0

VIII. Conclusion:

The analysis on the three different databases containing 80 fingerprints each of 10 different persons concludes that segmented finger print increases the matching minutiae upto 20 % .The computation time for preprocessing a finger print image is 0.9 sec.

IX. Future scope:

The proposed method is to be implemented on the non-minutiae module as the number of extracted parameters are more compared to minutiae based module

References:

[1] J. Yin, X. Yang, G. Zhang, C. Hun, "Two steps for fingerprint Segmentation," Image and Vision Computing, Vol. 25, pp. 1391–1403,2007.
[2] L. O. Chua, L. Yang. "Cellular neural networks: theory and Applications," IEEE trans. circuits and system, Vol. 35, pp. 1257-1290, 1988.
[3] L. O. Chua. "CNN: a vision of complex," Int. J. bifurcation and chaos, Vol. 7, No. 10, pp. 2219-2425, 1997.
[4] L. O. Chua, T. Roska. Cellular neural networks and visual computing. Cambridge Press, London, 2002.
[5] M. Yao. Digital image processing (In Chinese). Mechanical Industry Publishing House, Beijing, 2006.
[6] Ursula Gonzales-Barron, Francis Butler. "A comparison of seven threshold techniques with the k-means clustering algorithm for measurement of bread-crumb features by digital image analysis," Journal of Food Engineering, Vol. 74, pp. 268–278, 2006.
[7] N. Otsu. "A threshold selection method for grey level histograms," IEEE Trans. Syst. Man Cybern, SMC-9 (1), pp. 62–66, 1979.