Review on Latent Fingerprint Recognition Technique

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Abstract— Fingerprints are the oldest and most extensively used form of biometric recognition. A fingerprint is that the pattern of ridges and valleys on the surface of the tip. The uniqueness of a fingerprint is solely determined by the native ridge characteristics and their relationships. The most vital ridge characteristics, known as trivia, are ridge ending and ridge bifurcation. The performance of a fingerprint recognition system is possessed with the collection of fingerprint pictures. This poses a tangle for the fingerprint image as the image quality is usually low. As a result, fingerprint structures like trivialities and ridges might not be clearly visible to the human eye of a fingerprint examiner, nor to the machine eye of automatic matching systems. This paper deals with the problem of choice of associate optimum rule for fingerprint matching so as to style a system that matches needed specifications in performance and accuracy. This paper provides varieties of fingerprint recognition techniques like Spectral Image Validation and Verification (SIVV), Fuzzy Neuro-genetic approach, cascaded scheme, alignment-based elastic matching algorithm which increases the recognition rate and reduce the processing time.

Key words: SIVV, Finger Print, CN

I. Introduction

Fingerprints are in use for biometric recognition since long owing to their high adequacy, immutability and individuality. fingerprint recognition technique employing a grey level watershed methodology to seek out the ridges gift on a fingerprint image by directly scanned fingerprints or inked impression(1) A method proposed for enhancing the ridge pattern by employing a method of familiarized diffusion by adaptation of aeolotropic diffusion to sleek the image within the direction parallel to the ridge flow(2). The image intensity varies swimmingly joined traverse on the ridges or valleys by removing most of the small irregularities and breaks however with the identity of the individual ridges and valleys preserved. Fingerprint verification which has each trivia and model primarily based orientation field is employed. It provides strong discriminatory data aside from trivia points. Fingerprint matching is completed by combining the selections of the matchers supported the orientation field and trivia[3]. A method for performance live of native operators in fingerprint by police investigation the sides of fingerprint pictures victimization five native operators (4).A method to analyze the result of five totally different force levels on fingerprint matching performance, image quality scores, and trivia count between optical and capacitance fingerprint sensors(5). Descriptive statistics, analysis of variance, and Kruskal-Wallis statistic tests were conducted to assess important variations in trivia counts and image quality scores supported the force level. . The results reveal a big distinction in image quality score supported the force level and every sensing element technology, nevertheless there's no important distinction in trivia count supported the force levels of the capacitance sensing element. The image quality score, shown to be accomplished by force and sensing element kind, is one amongst several factors that influence the system matching performance; nevertheless the removal of quality pictures doesn't improve the system performance at every force level.

Fingerprints are in use for biometric recognition since long due to their high acceptableness , unchanged ability and individuality. Unchanged ability refers to the persistence of the fingerprints over time whereas individuality is expounded to the individuality of ridge details across people. The probability that two fingerprints are alike is 1 in 1.9 x 1015 (6). The uniqueness of a fingerprint is solely determined by the native ridge characteristics and their relationships. Two most vital ridge characteristics, known as trivialities, area unit ridge ending and ridge bifurcation.

Ridge ending is outlined as a degree wherever a ridge ends suddenly. an honest quality fingerprint generally contains 40-100 trivialities. There are variety of fingerprint classification and recognition algorithms that works well in unnatural environments. For fingerprint image enhancement Fronthaler et.al algorithm is used[7].An algorithmic program supported Crossing Number (CN) technique is employed to extract trivia. This technique extracts the ridge endings and bifurcations from the skeleton image (8). The extracted trivia square measure given to the Fuzzy logical thinking System (FIS) to eliminate the false point points. Neural network is employed to offer the coaching to the situation of thosepoint points and to boost the performance of the system. Back propagation is preferred supervisor learning algorithmic program used for coaching in varied systems(9)(10)(11)(12).Genetic algorithmic program is incorporated to with efficiency assign the foremost optimum initial price for weights and learning rate of the neuralnetwork(13)(14)(15).

The use of neural network parameters obtained from genetic formula makes theoverall formula of fingerprint recognition additional economical and reconciling. Latent fingerprints from relativecareless unintended individuality on objects area unit sometimes of poor quality thanks to noise and non-linear distortion. In Automatic Fingerprint Identification System (AFIS), matching two fingerprint pictures is one in every of the most tasks. It decides the performance of the system.Many identification techniques have been proposed which usually takes large amount of search time. One of the potential solutions to scale back the identification time is to use cascading technique thatintegrates several algorithms from easy to complicated into associate degree AFIS (16)(17).This technique proposes a 4-layers cascaded design for latent fingerprint identification system. within the 1st layer, latent fingerprint is recognized by its potential fingers supported basic pattern options so reordered(18). In the second layer, trivialities and their native ridge-valley structure are going to be extracted and assessed for affine matching within the third layer.If the matching result's uncertain, matchingalgorithmic program supported P-TPS model improved from are going to be applied to determine before verification(19).P-TPS matching helps eliminate the distortion effectively. so as to decrease identification time, fingerprints in info square measure organized and indexed by finger codes, basic fingerprint pattern.

In this method, we introduce an algorithm to come up with a score from the matched templates derived by the symbolic examiner at the ACE-V stage.The friction ridge examination presently followed in symbolic domain is understood as ACE-V (analysis, comparison, analysis and verification).The perception and therefore the higher cognitive process ability among symbolic examiners vary, e.g. the choice created by a novice examiner isn't continuously according to the choice created by skilled examiner for constant welfare work (20).The latent fingerprints that square measure the accidentally left impressions of the friction ridge skins obtained from the crime scene followed by chemical process of the latent print and photographing it square measure of poor quality in nature (22)(23)(24).The ultimate objective of the examiner here is that the identification of the offender from a population of suspects supported these poor quality pictures. the primary step typically followed is to manually extract thetrivialities options from the latent fingerprint pictures so search against an oversized info of notable suspects mistreatment an automatic Fingerprint Identification System (AFIS). The AFIS generates a collection of doable suspects on a rank basis employing a similarity score.Once there's a range of suspects, a rhetorical examiner can manually compare the latent fingerprint with every of the shortlisted impression fingerprints following the ACE-V methodology to yielda call as towhether the given latent and impression print match, don't match or the comparison is inconclusive.The latent examiner following the ACE-V methodology not solely uses trivialities configuration, however conjointly extended info like general ridge flow, variety of ridges between two trivialities, presence of creases and different Level threeoptions (21) (24).several studies are created towards as well as extended options like ridge quality map, ridge flow map, skeletanized pictures, dots and inchoate ridges (24) further as use of trivialities based mostly descriptors to boost the performance of automatic latent fingerprint matchers. Importance of rarity within the configuration of fingerprint options were emphasized by latent print examiners whereas creating selections at the ACE-V stage (21).

II. METHODOLOGY

A. *Spectral Image Validation and Verification*

This method relies on associate degree extension of the Spectral Image Validation and Verification (SIVV).SIVV was originally developed to differentiate ten-print or rolled fingerprint pictures. The objective of most digital preprocessing technology applied to latent fingerprint pictures is to point out additional distinction between ridges and furrows, letting clearer identification of item points. The ridges and furrows seem as periodic structures within the fingerprint image. This regularity manifests as spikes within the frequency spectrum of the image. Such a spike within the frequency domain may be a sensible metric to live the image quality of the ridges and furrows. Fingerprints are habitually used as a way for person identification for quite a century. one among all the irreplaceable practicality of fingerprint recognition is its capability to link partial prints found at crime scenes to suspects whose fingerprints are antecedentlylisted in a giant info of rolled fingerprints. These partial prints, known as latent fingerprints or just latent's, are upraised from surfaces of objects that are unwittingly touched or handled by an individual. Before the introduction of Automatic Fingerprint Identification systems (AFIS), latent's were manually matched against full prints (rolled or plain) by latent examiners through a procedure currently named as ACE-V, namely, analysis,comparison, analysis and verification. Due to the poor quality of latent fingerprint pictures,digital image preprocessing is mostly a necessary step within the rhetorical analysis progress. Image preprocessing is performed to extend latent fingerprint image quality. A number of the common transformations utilized in commission of this goal include: color management, distinction adjustment, edge improvement, background suppression, and noise filtration.

The analysis community has developed many approaches and algorithms for fingerprint image quality and latent fingerprint enhancement (6). Yoon, et al.proposed a latent fingerprint enhancement algorithmic program requiring a manually marked region of interest (ROI) and singular points.The new method proposed was an extension of the Spectral Image Verification and Validation analysis (SIVV) (1) to the rhetorical latent fingerprint preprocessing domain. The initial SIVV algorithmic rule was designed for image validation and verification of ten-print.

fingerprint pictures from live-scan devices, and for maintaining the fidelity of fingerprint image databases. As the periodic structure of the fingerprint ridges and furrows could be a level one feature, SIVV is probably applicable to the latent fingerprint preprocessing domain. The objective of most digital preprocessing technology applied to latent fingerprint pictures is to indicate additional distinction between ridges and furrows, giving clearer identification of point. The ridges and furrows seem as periodic structures within the fingerprint image. Thisregularity manifests as spikes within of the image. Such a sign (spike)within the frequency domain could be a smart metric to live the image quality of the ridges and furrows The objective of most digital preprocessing technology applied to latent fingerprint pictures is to indicate additional distinction between ridges and furrows, The objective of most digital preprocessing technology applied to latent fingerprint pictures is to indicate additional distinction between ridges and furrows, giving clearer identification of pointpoints. The ridges and furrows seem as periodic structures within the fingerprint image. Thisregularity manifests as spikes within the frequency spectrum of the image. Such a sign (spike)within the frequency domain could be a smart metric to live the image quality of the ridges and furrows.

SIVV analysis derives from the cyclicity of ridges and furrows (1). For completeness, initial we tend to summarize the SIVV algorithmic rule. The algorithmic rule takings as follows:-

1) *Step 1. Image Windowing*

The length of the one dimensional window is N. Given the image with N rows and M columns, the two dimensional

Blackman Window is that the tensor product of windows of length N and M. once the second Blackman Window is applied to the fingerprint image, the window is applied on the middle of the fingerprint texture and therefore the size is customized to the dimensions of the fingerprint image.

$$w(n) = 0.42 - 0.5\cos\left(\frac{2\pi n}{N-1}\right) + 0.08\cos\left(\frac{4\pi n}{N-1}\right)$$

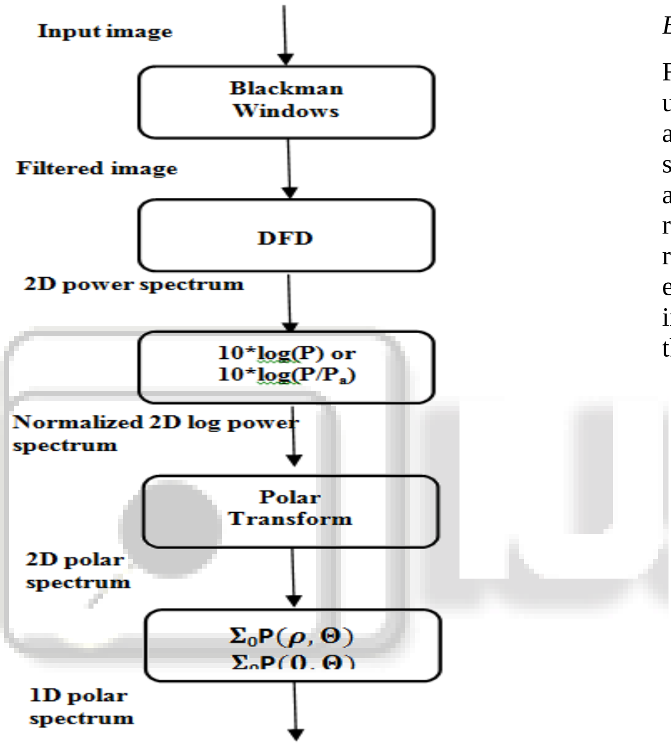
Where $0 \le n \le N - 1$

2) Step 2. Discrete Fourier Transform (DFT)

$$H(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} \exp\left[2\pi iy\frac{v}{N}\right] exp\left[2\pi ix\frac{u}{M}\right] h(x,y)$$

Here u and v denotes frequency components in x & y directions ranging from –M/2 to M/2 and –N/2 to N/2

3) Step 3. 2D (normalized) Log Power Spectrum



The 2D power spectrum is computed as:

$$p(u,v) = |H(u,v)|^2$$

Depending on the implementation, the output of this step can be normalized or not-normalized; that is

$$10 * \log P(u,v)$$
$$10 * \log \frac{P(u,v)}{P(0,0)}$$

4) Step 4. 2D Polar Transform of Power Spectrum

The 2D power spectrum is represented in polar coordinates using the transformation:

$$\rho = \frac{\sqrt{u^2+v^2}}{\sqrt{M^2+N^2}}$$
$$\theta = \tan^{-1}\left(\frac{v}{u}\right)$$

We use P(ρ,Θ)to represent the 2D results of the polar transformation, where ρ is divided by the maximum dimension of the input image N, normalized to 0 and 0.5 cycles/pixels.

5) Step 5. 1D Normalized Polar Transform

Finally, the 1D polar transform is computed as the sum over angles of:

$$P(\rho) = \sum_{\theta=0}^{180} P(\rho,\theta)$$

$\rho = 0, \dots, 0.5$cycles / pixels

The normalized 1D polar curve is:

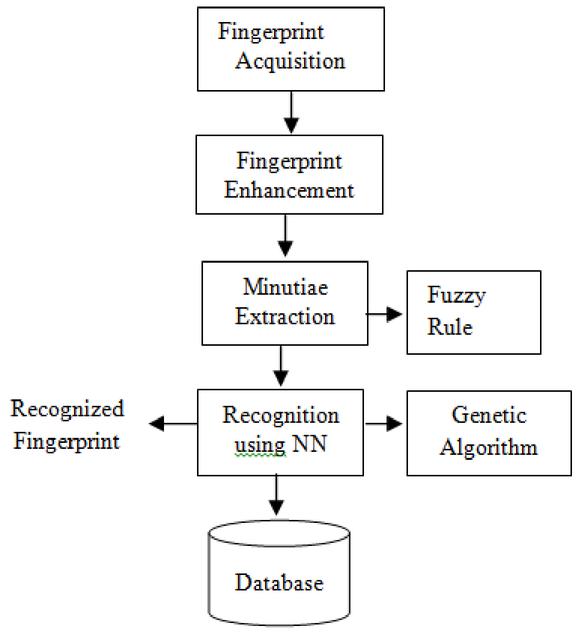
$$P_N(\rho) = \frac{P(\rho)}{P(0)}$$

$\rho = 0, \dots, 0.5$cycles/pixels

This method proposes two approaches to identify,enhance and recover the SIVV spike i) Region of Interest (ROI) to focus only on the local region which contains fingerprint signal in spatial domain ,ii) the peak location constraint to focus on the small window which may contain the ridge and furrow spike in the frequency domain.

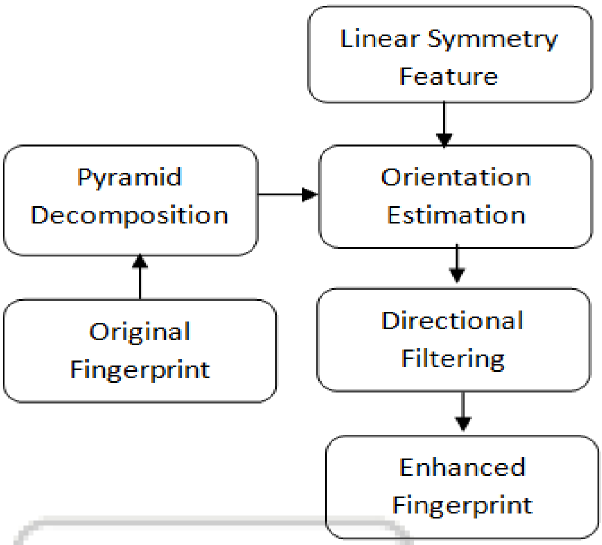
B. Fuzzy rule based Neuro Genetic approach

Fingerprints are used as a way to spot people unambiguously for a awfully durable, having many alternative functions like criminal identification, high security access management, mastercard usage verification and worker identification. the most reason for the recognition of fingerprints as a technique of identification results forms the very fact every fingerprint of someone is exclusive similarly as straightforward to access. The individuality of a fingerprint is completely determined by the native ridge characteristics and their relationships.



Two most vital ridge characteristics, known as trivia, square measure ridge ending and ridge bifurcation.A crucial step in fingerprint matching is to faithfully extract options from the input fingerprint pictures. For a decent quality fingerprint feature extraction is far easier, economical and reliable as compared to a comparatively lower quality fingerprint. the standard of fingerprints is degraded by skin conditions, detector noise, non-uniform contact with detector surface, and inherently caliber fingerprint pictures. There are two major objectives of fingerprint enhancement i)to increase the contrast between ridges and valleys and ii) to connect broken ridges. With use of Fuzzy rule based mostly Neuro- Genetic algorithmic program it overcomes low recognition rate, low accuracy and hyperbolic time of recovery. The projected technique involvesvaried stages like image improvement, feature extraction and Neuro-Genetic based mostly fingerprint recognition. Fronthaler et.al [6] algorithm is used for fingerprint image enhancement. Crossing Number (CN) method extracts the ridge endings and bifurcations from the skeleton image.

$CN = 0.5\sum_{i=1}^{8}|P_i - P_{i+1}|$, $P_9 = P_1$



This technique extracts the ridge endings and bifurcations from the skeleton image by examining thenative neighborhood of every ridge picture element employing a 3x3 window. The CN for a ridgepicture element P is given by (16)

Where Pi is the pixel value in the neighborhood of P. For a pixel P, its eight neighboring pixels are scanned in an anti-clockwise direction and CN is calculated.

If value of CN is one, then the central pixel is termination.

If value of CN is two then the central pixel is usual pixel.

If value of CN is three or greater than three then the central pixel is bifurcation

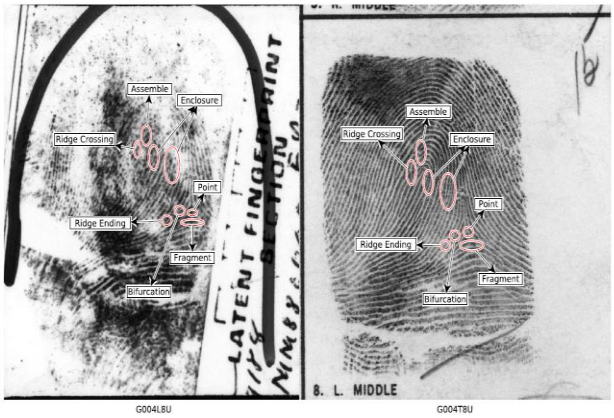
In order to search out the spurious point points a brand new formula is developed supported Fuzzy rules.The first step during this formula is to search out the space between termination and bifurcation. We have used geometer methodology for locating the space. once finding the spacesome fuzzy rules are outlined for removing the false point points. Some of the rules are:

(1) If (Distance is too small) then (Minutia is false)
(2) If (Distance is medium) then (Minutia is true)
(3) If (Distance is large) then (Minutia is true)

In neural network training, the foremost usually used algorithms square measure versions of the rear propagation advanced nonlinear optimization issues have typically resulted in inconsistent and unpredictable performance. They usually begin at a haphazardly chosen purpose (set of weights) so modifyweights to maneuver within the direction which is able to cause the errors to decrease most apace. These styles of algorithms work well once there's a swish transition toward the purpose of minimum error.

C. Elastic Algorithm

This method is used to generate a score for the templates in Guardia Civil database Matched GCDB-M. This rule may be tailored to templates by discarding the weights for sort info once hard typeError explained within the rule.



1) Step 1: Alignment and correspondence

The framework is developed to influence matched databases, we have a tendency to expect that forreal matches, superimposing the centroids of each latent and impression trivialities points withapplicable rotation in an exceedingly vary of (-45° to +45°) alignment would result in associate degreeapproximate fitting of purpose patterns supported mated pairs with minimum overall fitting error, and for impostors it'd result in a high fitting error. After the alignment, all those trivia pairs that area unit at intervals a threshold distance area unit thought of to be mated pairs.

2) Step 2: Fitting and Orientation errors

Minutiae that established correspondences supported best rotation, we discover a fitting error mistreatment associate degree transformation for the mated trivia patterns by least sq. fitting. This score is denoted as fittingError, that is averaged w.r.t total variety of mated trivia pairs.Again for all the mated trivia pairs, we have a tendency to add up all the orientation variations of correspondingtrivia and average this add of degrees w.r.t total variety of mated pairs. once averaging the orientations, the roundness of degrees are taken care of. This score is denoted as orientation Error.

3) Step 3: Type errors

If the mated pairs disagree w.r.t sort data, that otherwise square measure mated supported solely location and orientation attributes, we have a tendency to associate a penalty for such sort of mismatches.This score is denoted as typeError.

4) Step 4: Final Score

Since all the individual scores we've got generated are of various nature, particularly fitting Error in distance, orientation-Error in degrees, typeError in chance primarily based value, these scores are combined exploitation supply regression to come up with the ultimate score [22].

$$\text{finalScore} = (\alpha \times \text{fittingError}) + (\beta \times \text{orientationError}) + (\gamma \times \text{typeError})$$

Where α,β,γ are the logistic regression coefficients for each classifier respectively.

D. Cascaded system for latent finger print Recognition

This method introduces the constituent elements of the cascaded design and therefore the identification.

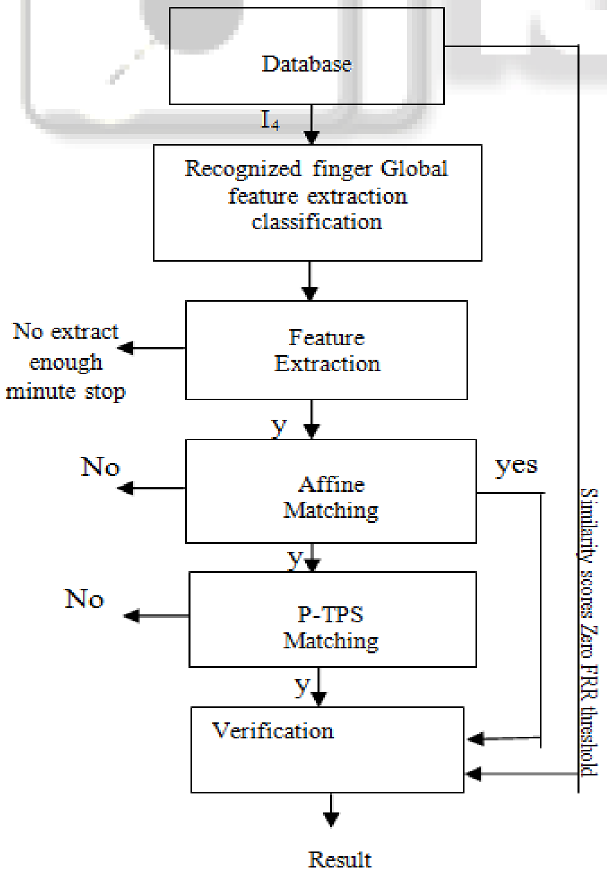
1) Step 1: Finger classification

Forensic fingerprints and registered fingerprints in database are classified into 10 types by combining the two methods. If this procedure produces ambiguous outcomes, Karu's methodology are used. Then, if the outcomes square measure still ambiguous, basic ridge are taken into thought. If ridges at the core region square measure in smart quality, Wang's methodology is applied (26). Otherwise, delta pointsare searched victimization Karu's methodology (25). once the core region and also the delta points square measure unclear, we tend to use basic ridge to validate ambiguous cases. This methodology helps eliminate incomplete and unclear trivia.

2) Step 2:Cascaded Identification:

After the acquisition part, latent fingerprint I.Q. is pre-processed and classified. Ridge counts area unitcalculated and also the finger order is decided.In the classification module, basic pattern of I.Q. is decided either mechanically or manually. If there area unit ambiguous outcomes, they're used forchecking out the match by the priority of the dependability.In the feature extraction module (27), (28), the options of I.Q. as well as trivia points and ridge-valley associated structure with quality map area unit extracted by interactive writing technique. In the affine matching module, the options of fingerprint It within the info area unit consecutive retrieved to match with the options of I.Q. (taken from Step3) for calculative the initial corresponding trivia set and also the similarity.Sorting the search result listper priority: finger code, basic pattern code, ridge count, similarity. The system verifies supported the priority and displays the results.

3) Step 3: Organizing the database



To accelerate the looking out and matching processes, it's necessary to prepare the fingerprint info in an exceedingly smart fashion. within the info, fingerprints square measure indexed and arranged hierarchically per the subsequent fields: fingerprint code, basic pattern, ridge counts and ridge density. Data concerning trivia points and associated ridge-valley try is keep with the corresponding fingerprint image for quicker parallel looking out.The extraction of basic attributes from fingerprint with higher responsibleness for assortment remains AN open analysis drawback (29). to cut back the false rejection rate (FRR), fuzzy search technique combining major code and minor codes for committal to writing ambiguous attributes has been planned.

4) Step 4: Parallel Matching

The server receives matching requests and performs looking out per the essential attributes. It then splits the list into tiny items and distributes them to data processing nodes for trivialities matching. Data processing nodes receive task and perform matching. They deliver ends up in terms of a look result list to the server. Workstations receive the search results from server. They show the results to human specialists who then perform the ultimate verification.

III. Conclusion

This paper presents the work done by different researchers associated with fingerprint verification system. Specifically the area under review in fingerprint recognition is pores extraction and matching system. During this chapter description concerning all reference papers area unit summarized. This paper presents a quick survey of fingerprint level three options extraction and matching approach that could be a novel approach, its characteristics, style problems and applications.

Experimental result of different approaches reviewed in this paper demonstrated that a Nuero-fuzzy system can overcome disadvantages present in the current technologies. A new method can be presented which will incorporate neural network as well as state of art method for classification, which will definitely give better result.

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