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Fingerprint Matching - An Experimental Approach

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Abstract: The significance and usage of biometrics for the authentication purpose, has been increasing consistently, because of, numerous security threats, and the fact that fraudsters are discovering methods to slip each and every safety wall previously developed by cyber defenders. They crack PINs (Personal Identification Number), passwords, and tokens with various types of attacks. To curb this problem, Fingerprint Recognition System has been made available in the market, because of its security and feasibility, it became popular in recent years and has been integrated even with the mobile phones. However, the processing speed depends on the algorithm used, image quality, etc. To improve the image quality several image pre-processing techniques have been used. Many Minutiae-based algorithms have been proposed but there must be a region of interest (ROI) on which matching or verification algorithm has to focus on improving the computing speed. In this paper, an approach has been proposed to find the region of interest (ROI) which is based on dividing the image into blocks. Blocks of 8 images (images of the same fingerprint) are compared in terms of 'Histogram of Oriented Gradients (HOG) Descriptor' and the error is calculated. The group of error points in each block is considered to be a cluster. The cluster which is less scattered would be the region of interest (ROI). Usually, two to three ROIs will be taken for better results.
Keywords: Fingerprint Recognition, Region of Interest, Histogram Equalization, Histogram of Oriented Gradients Descriptor, ORB Descriptor, Harris Corner Point Detection, Skeletonization, CLAHE, Normalization, Minutiae. Segmentation, Morphological Filtering

I. INTRODUCTION

Biometrics is used for identifying an individual based on two characteristics, Physiological and Behavioral. Physiological characteristics consist of fingerprints, face, retina, iris and Behavioral consists of gait, signature, and voice. Physiological characteristics never change whereas Behavioral characteristics alter with age. From past to present the biometric that became prominent due to its availability and the little cost is 'Fingerprints'. Even after considerable research, the existing fingerprint recognition schemes have some issues. As they are unique and permanent they have been utilized in forensic studies and personal identification since earlier times. Ridges and Valleys in a fingerprint are distinguishable clearly. The dark pattern in the fingerprint is noted as ridges and the bright part between ridges is noted as valleys. Every fingerprint is unique due to the fact of unique points present on it. These unique points are described as Minutiae points. Minutiae points exist at ridge termination and ridge bifurcation parts which are illustrated in Fig.1.

Fig.1. Typical Fingerprint Features (Termination and Bifurcation points)

For a typical image, we get the corner and edge points by Harris Corner detector, Shi-Tomasi Corner Detector, etc. Features in the fingerprints are taken out from Harris
Corner Detector for matching purpose initially. HOG descriptor is applied later on for finding the Region of Interest (ROI).
These methods return a set of points in an array which are later picked up by different descriptors such as, Scale-invariant feature transform (SIFT), Speeded up robust features (SURF), ORB descriptors (Oriented FAST and Rotated BRIEF) for generating descriptors of each key points produced by Corner detection algorithms. These descriptor algorithms perform differently, for e.g., ORB Detector is rotation invariant i.e., even if the image is rotated two similar images matches with 100% similarity, SIFT Detector is scale-invariant, orientation invariant, illumination invariant. BF Matcher (Brute-Force Matcher) or FLANN Matcher (Fast Approximate Nearest Neighbor Search Library) are techniques to measure the similarity between two arrays or lists using various distance metrics such as NORM_L1, NORM_L2, Hamming distance, etc.

Processing the entire image for matching purpose would cost a lot of time. Rather, we would accelerate this process by using a region on which algorithm focuses to get the similarity. We will examine various methods to find the Region of Interest. A proposal was carried out to find a method which rotates an image automatically using Principal Component Analysis which at last failed. Finding Region of Interest went well.

Region of Interest for each fingerprint image is determined and is saved in the database. When a query fingerprint image is given to a recognition system, the respective regions in databases are compared across the query image and the matching percentage is taken. A threshold value is fixed, above which is regarded as a true fingerprint and below is regarded to be a false fingerprint. In this paper, we have applied a threshold value of 67% FAR (False Acceptance Ratio).

II. LITERATURE REVIEW

Many ideas have been generated to find Region of Interest in a fingerprint out of which some are listed here in [4] **Error! Reference source not found. Error! Reference source not found. Error! Reference source not found.**. Chan et al. [4] proposed an approach which is based on Reference point extraction and orientation field. The reference point here refers to core and delta points. In an orientation field, a point at which maximum direction change is detected is the core point [2]. Several techniques have been proposed for core point detection **Error! Reference source not found. Error! Reference source not found.** [16]. Based on three classes of fingerprints the method will determine the orientation field, later detect core point, few minutiae points are taken by considering the core point as center taking radius to be

$$r_i = \sqrt{(x_i - core_x)^2 + (y_i - core_y)^2}$$

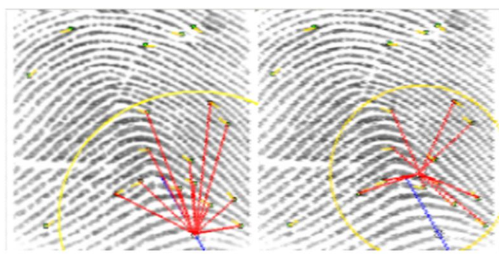

Fig. 2. Finding ROI with core point and radius

The issue arises in the method if the core point is detected near the boundary then circle will be large when correlated to the condition in which the core point is in the middle of the image.

Sandeep Sahu et al. **Error! Reference source not found.** proposed a method in which finding minutiae points is done based on their own algorithms and to find ROI three process was used from which only certain minutiae points are picked up and area bounded around all these minutiae points is considered to be ROI. For filtering minutiae points three processes are used: If the distance between a termination point and bifurcation point is smaller than D then discard that minutiae point. If the distance between two bifurcation points is smaller than D then discard that minutiae point If the distance between two termination points is smaller than D then discard that minutiae point. By applying Closing on the image and erosion techniques ROI can be detached from the original image. Once minutiae points are extracted termination and bifurcation points orientations are found through different methods for each of them. Minutiae Match Algorithm consists of two stages Alignment Stage and Match Stage by which fingerprints can be recognized.

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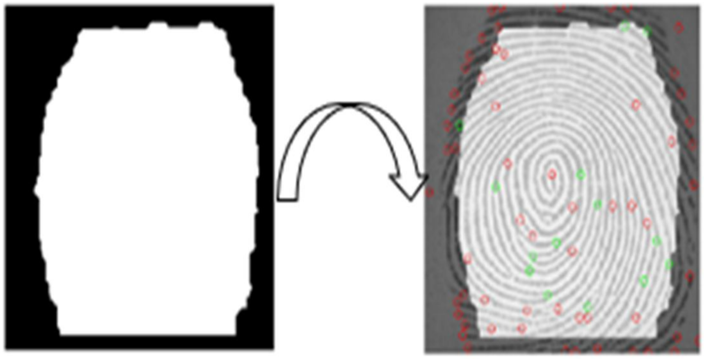

Fig. 3. Region of Interest Extracted by Segmentation

III. FLOW CHART OF THE PROPOSED METHOD

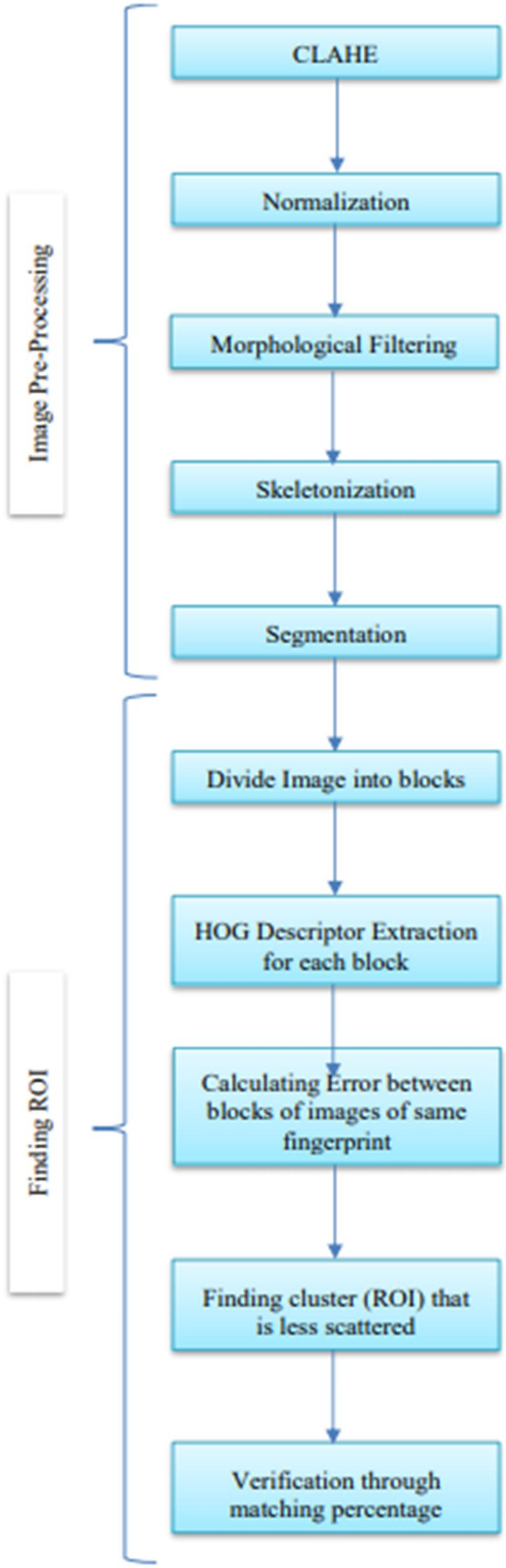

Fig. 4. Flow Chart of our approach

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IV. PROPOSED METHOD

Extensive research had been conducted in the field of Biometrics. Nevertheless, there is a need for new techniques that enhance current methods. One technique that can enhance the current methods can be finding the Region of Interest. Fingerprint images are collected from FVC 2002, FVC 2004 databases. Fingerprint images vary in quality because of many reasons like pressure applied on the scanner when registering affects the contrast of ridges, image quality depends on the scanner and if the finger is wet, then we get a bad quality image. Clearer the ridges in the image are more accurate the minutiae extraction will be. Unfortunately, in real-time fingerprints images were not that precise enough to give whole information. Better the image better the matching percentage so the initial challenge is improving the quality of the image obtained from sensors. This stage is Image Pre-processing.

V. IMAGE PRE-PROCESSING

A. Convert to Gray-scale image:

A colored image is represented by RGB values i.e., 3 channels. And the typical size of image considered in this paper is 400 x 275 px, so computing in all 3 channels is time taking process. So, we convert the colored image into a gray-scale image.

B. CLAHE (Contrast-Limited Adaptive Histogram Equalization):

CLAHE is a method in which enhancement of contrast of the image is done, as a result of which valleys and ridges can be differentiated. An image is divided into 8 x 8 px default by OpenCV library's CLAHE module and histogram equalization is applied to each part. If noise is present in the image then it will also get amplified, to avoid this contrast limiting is exercised. If any histogram bin is more than contrast limit (default value in OpenCV is 40) those pixels are clipped and distributed among other histogram bins. Fingerprint image enhanced by CLAHE is illustrated in Fig. 5

Fig. 5. Applied CLAHE technique to enhance contrast

C. Morphological Filtering

In morphological filtering, Otsu and Inverse Binary threshold techniques were used. The Otsu threshold will automatically select the best generic threshold for the image to get a good contrast between foreground and background information. This happens due to a bimodal distribution of pixel values in an image. For this image, approximately we can take a value in the middle of the peaks of the histogram as a threshold. (for images that are not bimodal, the binary will not be accurate.) Otsu allows us to avoid using a fixed empty value, thereby making the system more general for any recording device. The threshold result can be seen in Fig. 6.

Fig. 6. Morphological Filtering

D. Normalizatio

Image, after morphological filtering, undergoes normalization process in which all pixels are binarized to either 1 or 0 i.e., if the pixel value is 255 then it is binarized to 1 or else 0.

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E. Skeletonization

As the minutiae extraction algorithm focuses on each ridge it is better to represent a ridge as thin as possible. For this, we use Skeletonization module in Scikit-Image package. Image after skeletonization is depicted in Fig. 7.

Fig. 7. Before and After Skeletonization

VI. EXPERIMENT 1

A. Using Block Method and Harris Corner Detection

The first method introduced to find ROI is a fingerprint image was split into 4 blocks (in Fig. 8), descriptors and key points were generated from Harris Corner Detector and ORB descriptor for each block of the image individually i.e., 4 blocks – 4 descriptors (NumPy arrays) demonstrated in Fig. 9.

All the 7 images remaining out of total 8 images (1st image is taken as reference for comparison) of a fingerprint in the database were processed through the above procedure. For the better management of time, all descriptors are stored in a pickle file in python. Later, these descriptors were subjected to BF Matcher to determine the similarity between the reference image and one out of seven images (in Fig. 10).

Consider two images one reference and test. 1st block descriptor of the Reference image is matched with 1st block descriptor of test image and similarity is measured. Similarly done for all blocks in an image.

If there is a similarity above 67% then it is said to be a match. Hence, we took matching percentages of 7 comparisons for 4 blocks which are depicted in Fig. 11.

Fig. 8 Fingerprint Divided into 4 blocks

Fig. 9 Harris Corner Pointsin 4 regions

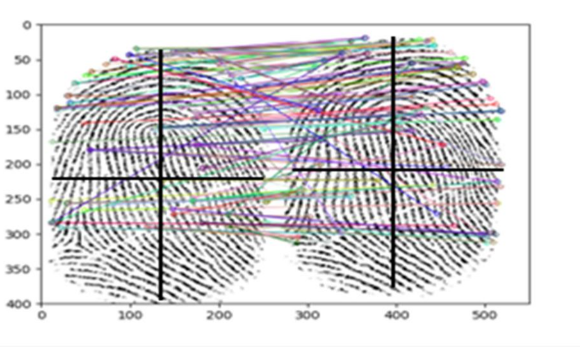

Fig. 10. Matching Harris Corner Points with BF Matcher

The average matching percentage is taken among rows for choosing a block as Region of Interest. The block with a high percentage is considered to be ROI. To depict this in a graphical form, a bar graph is made between Blocks vs Matching Percentages which is depicted in Fig. 12.

	1_2	1_3	1_4	1_5	1_6	1_7	1_8
Block 1	56.52	55.46	73.31	81.91	76.04	77.5	77.38
Block 2	71.22	77.58	80.75	84.77	75.85	79.7	57
Block 3	59.46	58	68.35	47	67.5	46.55	52.73
Block 4	44.33	42.75	56.83	51.28	58.18	52	49.28

Fig. 11. Each row represents a block and each column represents image comparisons. 1_2 represents the 1st image is compared with 2nd image

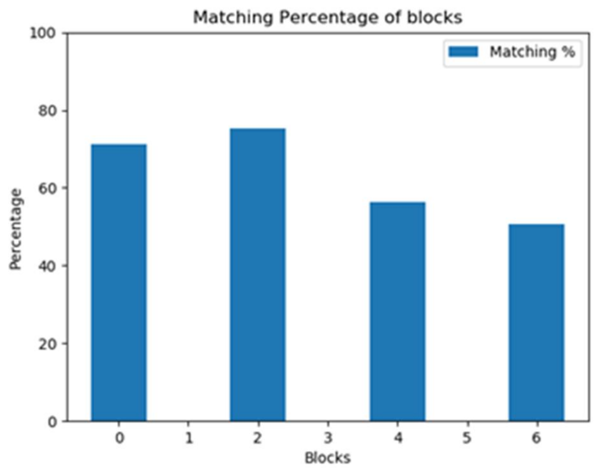

Fig. 12. Matching Percentages of different blocks

Hence for this fingerprint Block-2 is considered as 1st ROI and 2nd ROI is Block-1. But the result was not satisfactory.

VII. EXPERIMENT 2

A. Using Principal Component Analysis (PCA)

PCA is a well-known technique for dimensionality reduction i.e., to find only those dimensions which act as essential features that make sense of data. Here to find essential features of image PCA is applied on fingerprint image. Usually, this can be done using many libraries such as Tensor Flow, Scikit-Learn. But in order to make it simpler and faster computationally MATLAB is used instead of Python. Essentially, PCA is done by Singular Value Decomposition method (abridged as SVD).

$$I = U\Sigma V^T$$

Out of which only a few dimensions (k) will be selected to get appropriate variance hence an image can be compressed in which only important features are depicted.

$$I_{m \times n} = U_{m \times k}\, \Sigma_{k \times k} (V_{k \times n})^T$$

For this to test, PCA is applied on only one image in which 275 columns are considered as 275 dimensions. Now to the approximate value of k-dimensions which are peculiar, the variance is calculated and noticed that

1) To obtain 99% variance all 275 principal components have to be used.
2) To obtain a 50% variance or above at least 20 principal components have to be used.

Fig. 13 illustrates the usage of 20 principal components through which nothing important is carried out.
Hence, the result obtained is unsatisfactory to find essential features in an image by applying PCA.

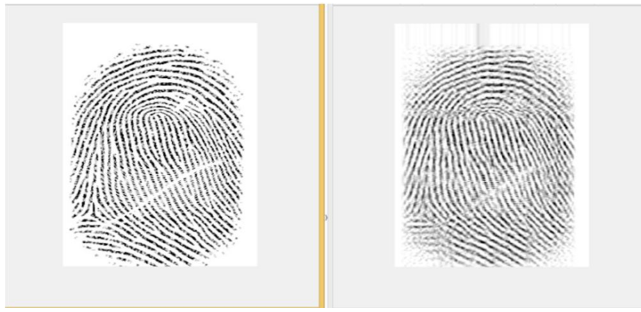

Fig. 13. Left Side – Original image; Right Side – PCA applied the image.

VIII. EXPERIMENT 3

A. Finding Region of Interest Using HOG Descriptor

Histogram of Oriented Gradients Descriptor (HOG) is used to count occurrences of gradient orientation in localized portions of an image. It is generally used for object detection. I have used it to find an ROI in the image. Using HOG descriptor, we get a binned array of numbers which displays features of an image.

There are 8 images of fingerprints which becomes a set that belongs to the same finger. Every image in a set is divided into 9 blocks. HOG descriptors of each block in the image is generated. The output of HOG descriptor will be a binned array.

The first image is taken as a reference compared with the rest of them. HOG Descriptors of 1st block of the reference image is compared with 1st block of every other image with which absolute error between both blocks will be calculated. Next, the average error is being calculated. This process is done with an entire set of images. These average error points are marked against blocks in a graph shown in Fig. 15.

Fig. 14. Comparison between fingerprint blocks

In Fig. 15 there are 9 blocks present each cluster representing each block. Each point in a cluster refers to an average error calculated in comparison. Hence, for every block in the graph, there will be 7 error points.

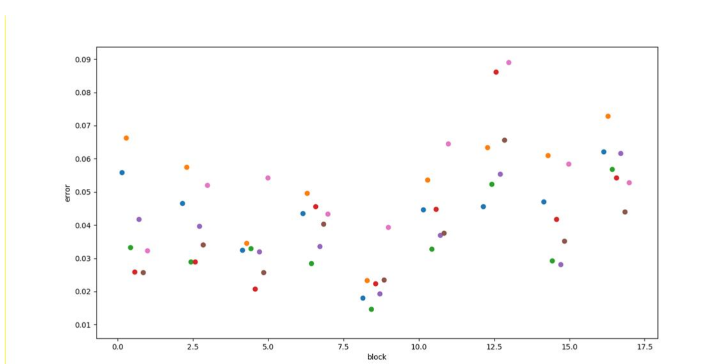

Fig. 15. Nine Clusters of error points (7 points in each) of 9 blocks

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IX. RESULTS

Matching percentages of individual blocks are calculated by following the same procedure mentioned in Experiment 1. But a slight change here is that nine blocks are present instead of four. The bar graph depicted in Fig. 16 represents matching percentages.

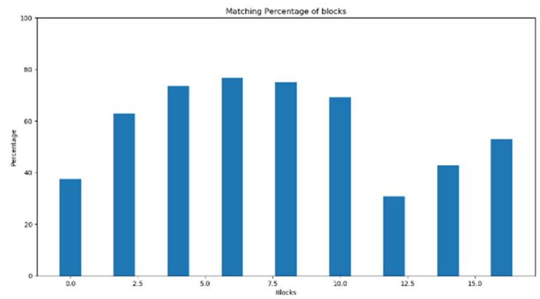

Fig. 16. Matching Percentages of Nine Blocks

An important observation here is that the cluster which is more closely packed in Fig. 15 has the highest matching percentage in Fig. 16 graph. As the scattering in a cluster increases, the matching percentage decreases. Hence, the block which is more closely packed is recommended as Region of Interest.

X. CONCLUSION

This paper introduced a different approach in calculating minutiae points i.e., Harris Corner Detector which is generally used in matching two images and different kinds of minutiae matching algorithms such as Brute Force Matcher and FLANN matcher instead of using traditional approaches like Crossing Number method and Bozorth3 Algorithm. However, Principal Component Analysis (PCA) didn't give satisfying results HOG descriptors did it to calculate Region of Interest (ROI).

XI. ACKNOWLEDGMENT

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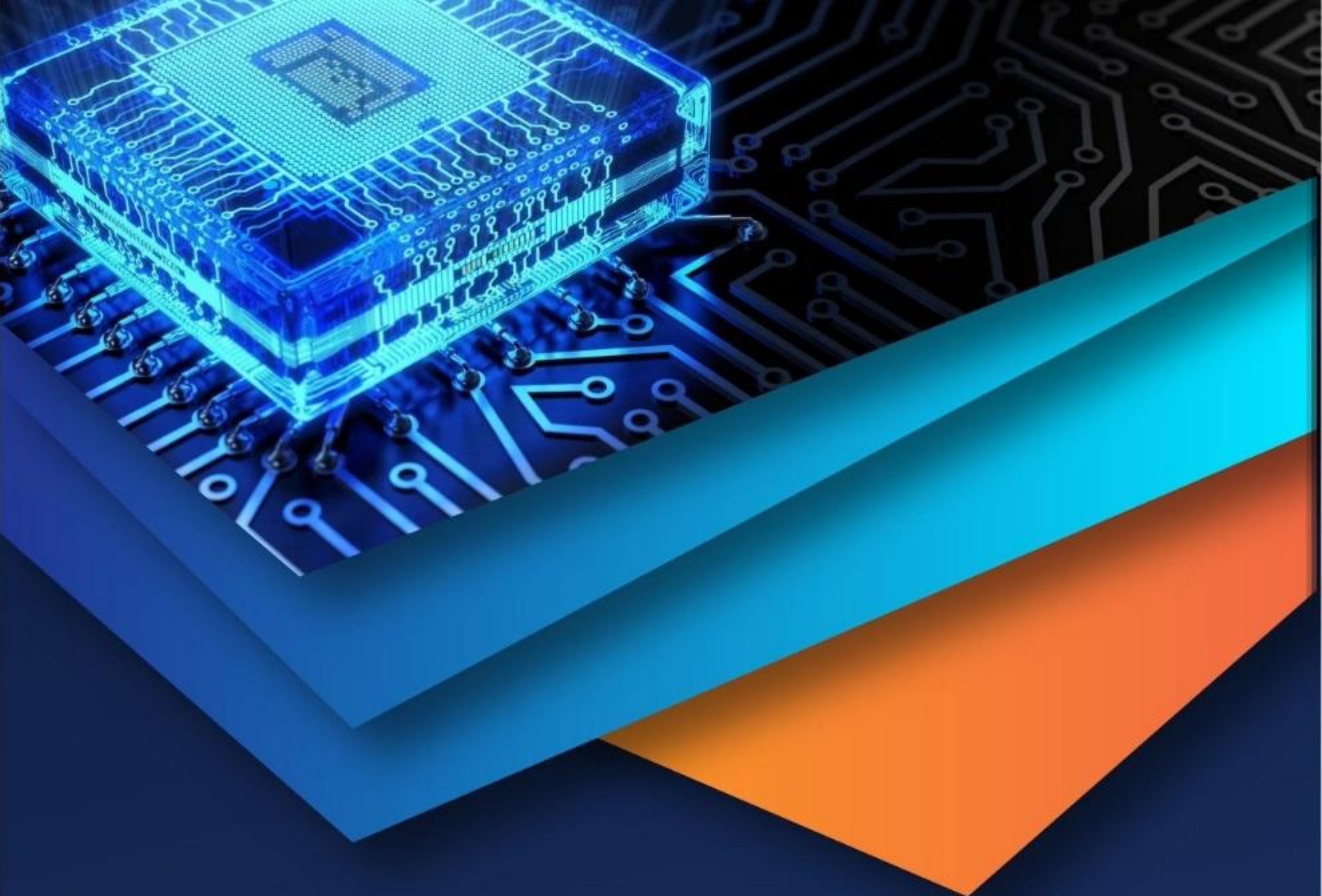
REFERENCES

[1] Shenglin Yang and Ingrid Verbauwhede: A Real-time, Memory-Efficient Fingerprint Verification System, IEEE International Conference on Acoustics, Speech, and Signal Processing, Montreal, Que., Canada, Vol. 5, pp. V – 189, 2004
[2] B. M.Mehtre, Fingerprint Image Analysis for Automatic Identification, Machine Vision and Application, Volume 6, Issue 2–3, pp 124–139, 1993
[3] P. Gnanasivam, S. Muttan: An Efficient Algorithm for fingerprint preprocessing and feature extraction, Procedia Computer Science Volume 2, Pages 133-142, 2010
[4] K.C. Chan, Y. S. Moon, P. S. Cheng: Fast fingerprint verification using sub-regions of fingerprint images, IEEE Transactions on Circuits and Systems for Video Technology, Volume: 14, Issue: 1 , 2004
[5] C. S. Hu and C. S. Hu, "Fingerprint Identification Based on Mopso in SVM", Applied Mechanics and Materials, Vols. 479-480, pp. 810-817, 2014
[6] Dr. Neeraj Bhargava, Dr. Ritu Bhargava, Manish Mathuria, Pooja Dixit: Fingerprint Minutiae Matching using Region of Interest, International Journal of Computer Trends and Technology (IJCTT), Volume 4, Issue 4, 2013
[7] Maltoni D. A Tutorial on Fingerprint Recognition. In: Tistarelli M., Bigun J., Grosso E. (eds) Advanced Studies in Biometrics. Lecture Notes in Computer Science, Springer, vol 3161, 2005
[8] CHING-TANG HSIEH, SHYS-RONG SHYU. "Principal Component Analysis for Minutiae Verification on Fingerprint Image," Proceedings of the 7th WSEAS International Conference on Multimedia Systems & Signal Processing, Hangzhou, China, April 15-17, 2007
[9] Dubey, M. K.. "Fingerprint Minutiae Extraction and Orientation Detection using ROI (Region of interest) for fingerprint matching." 2014.
[10] John M. Trenkle, "Region-of-interest detection for fingerprint classification", Proceedings of SPIE - The International Society for Optical Engineering, 2001
[11] Rajin.R, Rahul Ajithkumar: Efficient Region Of Interest Extraction Method With Two Stage Enhancement Scheme For Low-Quality Fingerprint Images, International Journal of Advanced Computer Technology (IJACT), vol. 4, issue 3, pp. 63-68, 2015
[12] M. A. Khan, A. Khan, T. Mahmood, M. Abbas and N. Muhammad, "Fingerprint image enhancement using Principal Component Analysis (PCA) filters," 2010 International Conference on Information and Emerging Technologies, Karachi, pp. 1-6, 2010
[13] Wang Yongxu Ao Xinyu Du Yuanfeng Li Yongping: A Fingerprint Recognition Algorithm Based on Principal Component Analysis TENCON 2006 - IEEE Region 10 Conference, pp. 1-4, 2006

[14] Ching-Tang Hsieh, Zhuang Yuan Lu, Tan Chi Li and Kung Chen Mei, "An effective method to extract fingerprint singular point," Proceedings Fourth International Conference/Exhibition on High Performance Computing in the Asia-Pacific Region, Beijing, China, vol.2, pp. 696-699, 2000
[15] Bazen, A. M., & Gerez, S. H. (2001). Extraction of Singular Points from Directional Fields of Fingerprints. In 7th Annual CTIT Workshop Mobile Communications in Perspective:, University of Twente, Enschede, the Netherlands (pp. 41-44), 2001.
[16] Mun Koo, Wai & ChiChung Kot, Alex. Curvature-Based Singular Points Detection. 10.1007/3-540-45344-X_33, pp. 229-234, 2001
[17] A. K. Jain, Lin Hong, S. Pankanti and R. Bolle, "An identity-authentication system using fingerprints," in Proceedings of the IEEE, vol. 85, no. 9, pp. 1365-1388, 1997.
[18] Khalil, Mohammed & Muhammad, Dzulkifli & Khan, Khurram & al-nuzaili, Qais. Fingerprint Verification using Statistical Descriptors. Digital Signal Processing. 20. 10.1016/j.dsp.2009.12.002., 2009



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