

A Study on Palm Vein Recognition Technologies

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Abstract: Since the COVID-19 epidemic, biometrics have grown in prominence, and contactless biometrics are now being pushed even more. As far as physiological or behavioural traits go, biometrics encompasses them everything. The recognition step is what makes up a biometric system. During the recognition step, a biometric system may work in two different modes: verifying or denying a claimed identity, while identifying a person. In verification mode, the system verifies or negates a claimed identity. Fingerprint, hand geometry, face and iris, retina, and voice recognition are examples of biometrics. However, there are many more. Using contactless biometric technology, the palm vein recognition system scans your hand without requiring you to put it near the sensor. The vein pattern of a person's hand is used to verify their identification. To prove your identity, just wave your palm over the scanner's sensor without touching it. This is much more sanitary than biometrics like fingerprints, which require you to contact the scanner.

An in-depth look at current advances in palm vein identification research is presented in this paper, which covers everything from background information through data collection, public databases, pre-processing, feature extraction, and matching. The research also looks at the merging of palm veins. Finally, the authors talk on palm vein recognition's challenges and prospects for the future.

Keywords: Authentication, Recognition, Palm vein, Biometrics.

1. INTRODUCTION

1.1 The History of the Palm Vein Recognition Technology.

Palm vein recognition uses the unique vein patterns seen on each person's hand to identify them. Biometric technologies such as palm vein recognition take a picture of a target, collect, and analyse image data, and compare it to a previously recorded record for that person [10,13].

The palm vein recognition gadget utilises infrared light to collect data, making it a potent biometric. Using these data points, a pattern is created, which is then encrypted with a unique code. While other biometrics don't rely on the interior structure, this one does. As a result, it has many distinct benefits, making it the most cutting-edge biometric available today.

Forgery and duplication are still possible with traditional biometric systems, which are linked to security. Sensors that

authenticate biometrics are used by the majority of gadgets. Those biometrics still have room for spoofing, even with rapidly advancing technology.

Biometrics has been around for a long time, even if it isn't ancient. In the past century, biometrics has advanced at the same rate as other fields of science and technology. Biometrics have evolved from crude categorization techniques to identification authenticators with many applications.

Biometric technology research has advanced rapidly even in the last decade alone. They've evolved from being a cutting-edge novelty to an integral part of daily life. Biometrics were extensively utilised as authenticators when Apple included fingerprint as an unlocking option for the iPhone.

Vein Recognition is a form of biometrics that uses vein patterns on the fingers or palms of humans to identify people. Infrared light is used to collect data points from the palm vein Recognition system. From there, a pattern may be deduced and utilised for authentication. Clearly, the palm vein recognition system is the best authentication method since it is the most secure, precise, and reliable [14,19].

1.2 Getting Started with Palm Vein Imaging:

There are four stages in a typical palm vein identification system: capturing an image of the vein, pre-processing, particularly in ROI location, feature extraction, and matching (Fig. 1). The collection of palm vein images is carried out using the method of palm vein image capture. To extract features from the palm vein picture, pre-processing splits a section of the image. The pre-processed palm veins are used for feature extraction, which extracts useful properties from them. Using a matcher, two palm vein characteristics are compared, and a database is used to record the results.

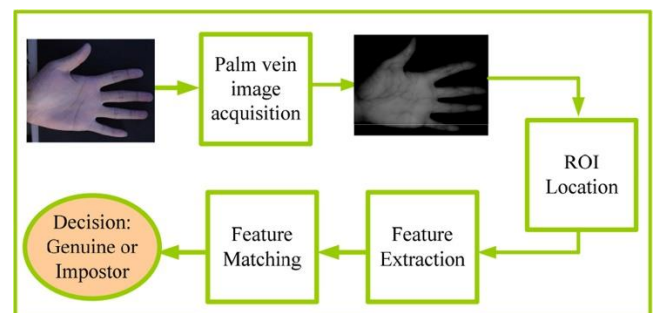


Figure 1: Image Acquisition of the Palm Veins

After summarizing the basic Introductory part in this section 1, Further section 2 elaborates the related research literature survey, section 3 explains about methodology used along with the benefits, challenges and future prospectus contains in section 4. Lastly section 5 summarizes the conclusions.

2. THE LITERATURE SURVEY

For palm vein-based identification systems, researchers Yingbo Zhou and Ajay Kumar [4,7] have proposed two novel methods to enhance performance. One method uses subspace learning to create holistic methods, while the other uses vessel extraction to find line/curve matches. The palm-vein pictures are projected onto subspaces constructed from training data in subspace learning, which has emerged as a strong method. For this reason, extracting curve- or line-like characteristics from palm vein pictures has drawn a lot of attention.

The ROI extraction approach proposed by W. Kang and Q. Wu [1] makes use of the OTSU method and a radial distance function (RDF). The pictures are first smoothed using Gaussian blur. With this initial threshold Th , we can begin segmenting hand shapes using the OTSU method. This new threshold Th^* is obtained by multiplying the original Th by an adjustment coefficient C . Last but not least, in order to further enhance the binary image's performance, the notion of the maximally connected domain is presented. To reduce the amount of noise in the wrist portion of the picture, a new approach has been suggested.

As a technique for convolving with ROI's to enhance the underlying texture, the authors Amioy Kumar; M. Hanmandlu; H. M. Gupta [2] suggested a two-dimensional Gabor filter. Convolved with a ROI, the 2D Gabor filter divides the image into genuine and fictitious portions. Only the actual portion is used for further processing such as feature extraction when employing Gabor wavelets.

There are many writers that summarised Branch point and Box method is used for depicting vein pattern, like Amioy Kumar; M Hanmandlu; Vamsi K. Madasu; Brian C. Lovell [3]. A vein pattern point is considered a branch point in the Branch point method if there are more than two vein pattern pathways that originate from it. The thinned picture of the vein pattern is taken into account to identify all of the branch locations.

Hand geometry elements were suggested by Irfan Ahmad, Zahoor Jan, Inayat Ali Shah, and Jamil Ahmad [16]. The dimensions of a hand include the length, breadth, and length and width of the fingers.

Verification using principal lines was expanded by De-Shuang Huang et al. [18].

As suggested by authors Jain and Duta [5,6] who measures the average alignment error between contours.

Hand geometry was used by Bahareh Aghili et al.[15] to identify individuals. They've been able to wring 15 useful details from a single user hand picture.

A pre-processing method has been developed by Hafiz Imtiaz et al. [17] for the detection of main lines in palms. DCT is used in the detection of palm prints.

DCT coefficient performance of a bimodal system is utilised for palmprint authentication, according to A. Kumar et al. [2,3,11,20]. A database of 100 users has been used to evaluate the system's effectiveness.

Texture-based feature extraction for palm print authentication was suggested by Kong et al. A low-pass filter applies a gradation to the input picture before it is filtered. The technique that has been suggested works well and is not affected by translation.

Structured light imaging for 3D scanning was suggested by Zhang et al. [20]. This technique uses a light source to project patterned light onto an object's surface. Fast feature matching technique, score level, and feature-level fusion methods were utilised to categorise the palm prints.

Extraction of three global characteristics from a 3D palm print picture was presented by B. Zhang, W.Li, P. Qing, and D. Zhang et al. This technique utilises a ROI extraction procedure to eliminate the border area that is both redundant and distracting.

A pre-processing method suggested by Hafiz Imtiaz et al. [17] uses a 2 dimensional Discrete Cosine Transform to perform feature extraction in local zones (2D-DCT).

An online palmprint identification system was suggested by David Zhang et al.

3. METHODOLOGY.

3.1 Basic Working

To match palm veins, you need to know how this works. Near-infrared rays and the way haemoglobin in the veins respond to these rays are used in palm vein scanning devices, including those for finger vein ID. Oxygenation of haemoglobin in the lungs leads to delivery of oxygen-rich blood to tissues all throughout the body via arteries. The veins return the deoxygenated blood to the heart through the lungs and other organs.

The deoxidized haemoglobin travelling through the veins is absorbed by the near-infrared light from a palm scanner. When haemoglobin is deoxygenated, it absorbs more light, limiting the capacity of the veins to reflect it back. This results in a black pattern on the veins, which the camera on

the device may record as a picture. After then, the image's raw data is processed and compared to a previously recorded record on the subject.

3.2 Improved Palm Vein Recognition System Research

Image normalisation and picture enhancement backdrop intensity profiles are estimated in this work by splitting the

image into slightly overlapping blocks and calculating the average value of each block, using a coordinate system built for image normalisation. Figure 2 depicts the fundamental vein system of a palm leaf in more detail.

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

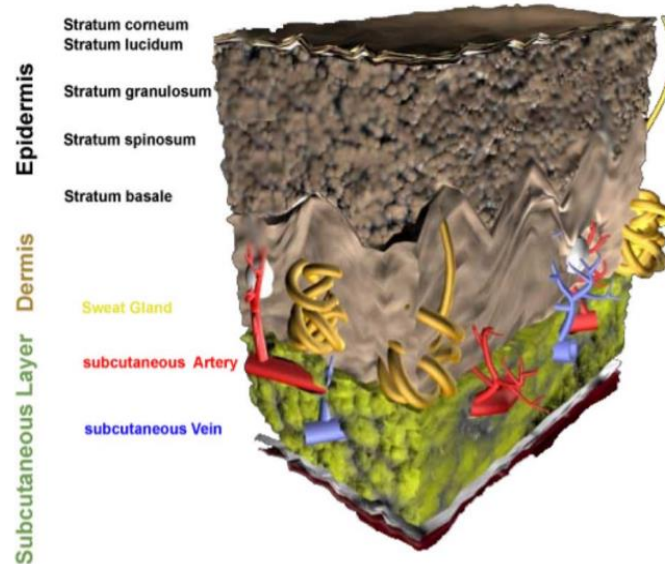


Figure 2 : The Basic Vein Anatomy of The Palm of The Hand

Figure 3 depicts the block design of the Enhanced Palm vein Recognition system, which takes a palm vein picture as input and identifies the person as an output. To construct the coordinate system, two webs are used as reference points, namely the web between the index finger and the middle finger and the web between the little finger and the thumb. To distinguish the palm from the backdrop, the pictures are first binarized. The distance from the centre of the binarized

palm to the palm's edge is then estimated. The webs are found by calculating the distance between two points and then looking for the associated local minima. Based on the distance between two webs, the parameter's location and ROI size are chosen. Images are first enhanced by estimating 32*32 background intensity profiles, which are then used to calculate the average grey levels of the pixels inside each block.

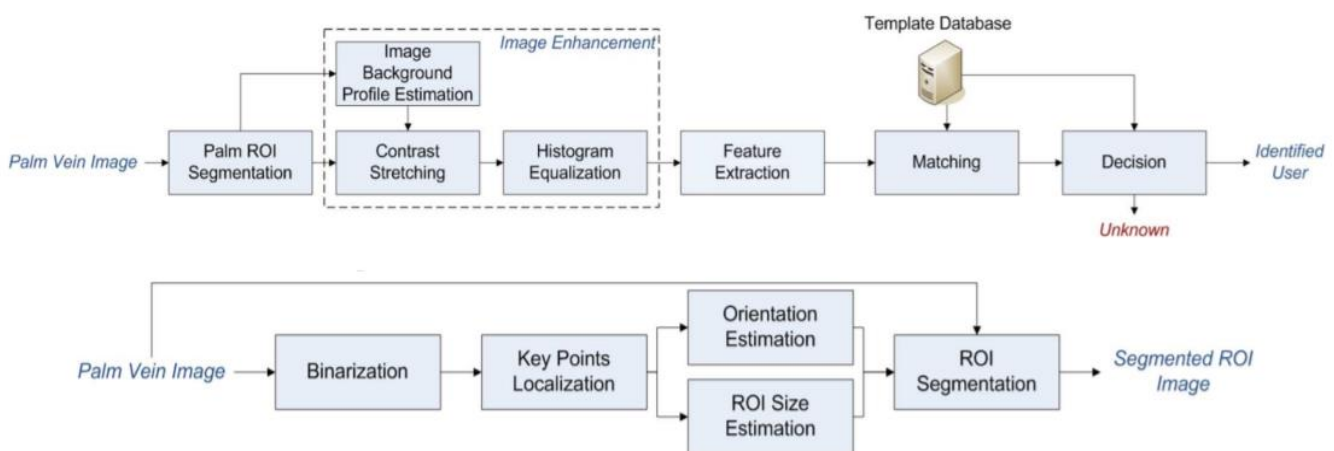


Figure 3: Block diagram of Enhanced Palm vein Recognition system

Once the estimated background intensity profile, as shown in figure 4, has been scaled using bicubic interpolation to the

original picture's size, it is subtracted from that image to arrive at the ROI image. Finally, the palm vein pictures are

normalised and improved using the histogram equalisation technique [1].

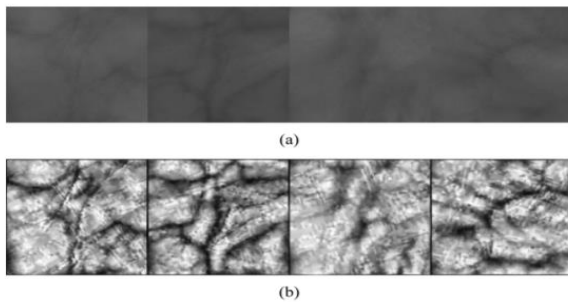


Figure 4 : The system's intensity profile.

Figure 6 shows Gabor wavelets generated at orientations E 1,2,3,4, although the scale is set at $s=4$ in this work. Since the findings are unaffected by changing the scale from 0 to 3, the value of s is set to 2 as a consequence. The Gabor filter convolved ROI is then divided into 8×8 no-overlap windows to create the actual component. This is done via convolution with consecutive windows spanning the ROI, and the mean of each convolution is used as a feature. Each Gabor wavelet is then constructed in this manner [3].

To begin, the authors determine where the binary image's centroid is located and then pad out the right-side area with zeros until the base's horizontal distance from the centroid equals L . The midpoint of the right vertical line is used as a reference point p_{ref} for the extraction of peak and valley points, and the Euclidean distance between p_{ref} and all points on the hand contour is computed to produce RDF. For a more extensive ROI, use the midpoints p_1 and p_2 of the valley points on each index and little-finger side as two points of reference throughout the ROI extraction process [2]. See the Palm vein identification system's flowchart in Figure 5, which illustrates how it works to get the required outcomes.

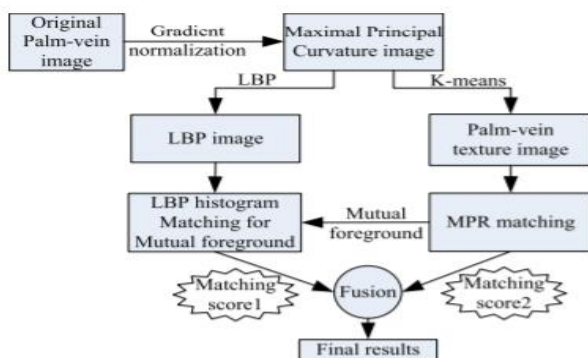


Figure 5: Flow Diagram Of Palm Vein Recognition System

When using the Box method, thinning pictures are split into equal numbers of boxes. The distance from the box's left

corner may be used to compare any two input photos, and the orientation can be utilised as a feature in each box. This is necessary since the size of the vein pattern changes. Each square in the resized vein design is the same size as the next. The average distance between each vein pattern pixel in a square is calculated from the square's left corner. The average distances between squares are then saved as a feature vector. It is possible to compare two feature vectors by calculating their Euclidean distance from each other.

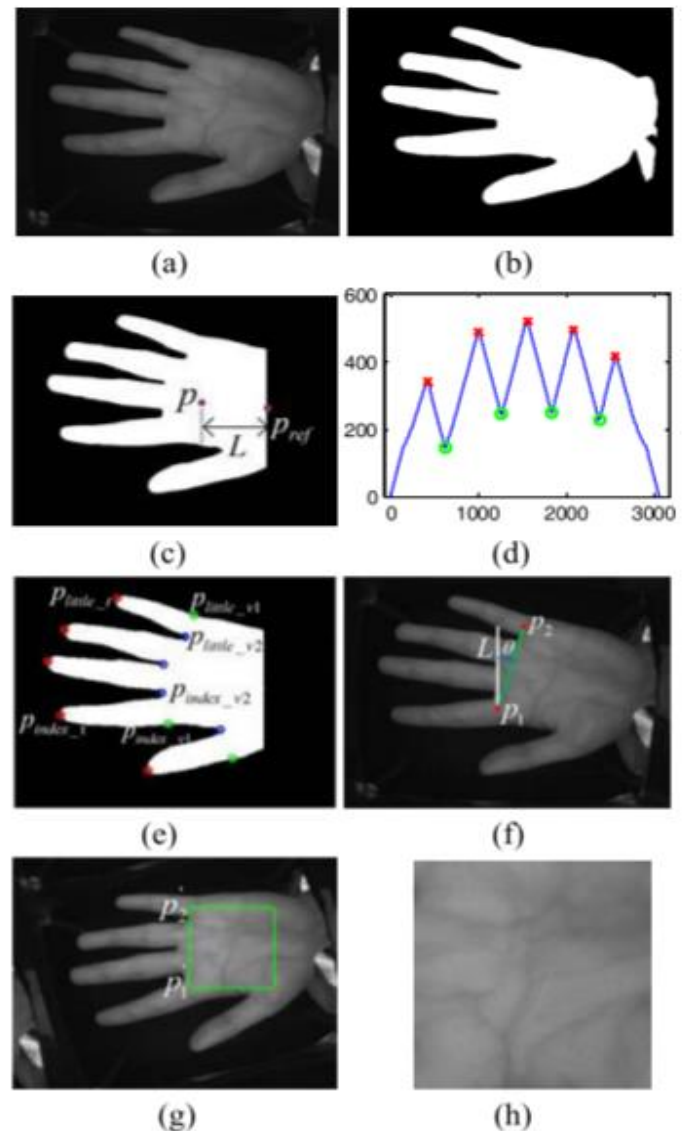


Figure 6: Representation Of Gabor Wavelets

There are two kinds of impersonators: those who are real and those who aren't. As can be seen in Figure 7, the system's histogram and associated graphics illustrate the findings.

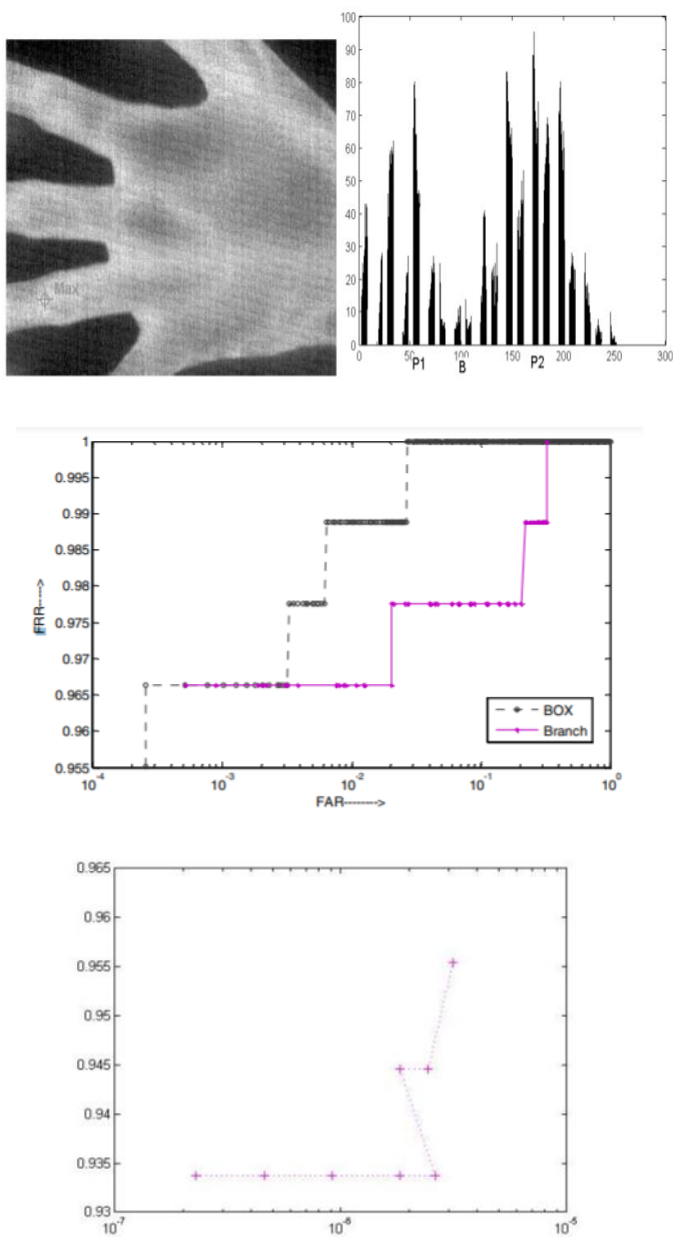


Figure 7: Histogram And Related Graphical Results Of The System

4.0 ADVANTAGES, CHALLENGES, AND FUTURE PROSPECTUS

There are many advantages, but there are also many challenges.

4.1: Benefits of Palm Vein Recognition Technology

Rather of using fingerprints or palm prints to identify people, vascular matching systems depend on the uniqueness of vein patterns seen in each individual. Palm vein scans are almost difficult to forge since the veins are situated under the skin's surface and because the scans depend on blood flowing through live people. As a result of

their contact lessness, these systems are more sanitary than those that rely on human skin for input. This aspect is crucial in high-traffic areas like supermarkets and healthcare facilities. Additionally, palm scanners safeguard individual privacy better than other biometric technologies, such as face recognition, since a sample cannot be taken without the person's knowledge or permission in most cases. However, there is one exception to this rule: in a hospital setting, a palm scan may be used to identify an unconscious person [8,9].

4.2 The Challenges

Reviewing the best examples, we believe palm vein identification is up against four major obstacles right now.

i. Image capture of palm veins at low cost and miniaturisation

The initial challenge in developing palm vein identification technology is how to capture recognisable pictures of palm veins at cheap cost and with downsizing. A light source and an image sensor are the two most expensive components of the palm vein capture system. A complementary metal oxide semiconductor (CMOS) image sensor is utilised to photograph an LED array as a light source, resulting in much lower manufacturing costs.

(ii) Remove veins from pictures with poor contrast, excessive noise, and uneven lighting

Low contrast, excessive noise, and uneven lighting characterise the palm vein picture. This is owing to the skin tissue covering the palm vein not being transparent, being inhomogeneous, and being anisotropic, all of which induce NIR light dispersion. An additional problem that veins recognition may help with is figuring out how to separate veins from photos of palm veins for identification. The research of palm vein augmentation technology is the breakthrough point in this issue since such pictures must be properly improved to extract.

iii) Image analysis in a non-contact acquisition for the detection of deformation pictures that are not rigid:

The non-contact picture collection technique used in non-contact palm vein identification is popular with users since it reduces user restrictions while also preventing disease transmission. Although this technique includes rotation, translation, and scaling, it is possible that the recognition rate will be significantly reduced as a result of using it. A non-rigid deformation is unavoidable, though. The ROI's focal points may be impacted if the picture is wavy. Stable palm vein characteristics in such pictures have to be found, expressed, and an algorithm for recognising palm veins has to be developed.

(iv) Quality assessment of images of the palm vein:

If the palm vein picture supplied by the user does not satisfy the identification criteria, the quality evaluation of the image may be utilised to determine if hardware acquisition performance is adequate. It's still difficult to make an accurate assessment of the quality of a palm vein picture.

4.3 Perspectives for the future

The palm vein recognition development trend may be described as follows, taking current research state and challenging analysis into account:

i. Deep learning-based palm vein identification.

These days, deep learning in biometrics is quite popular. However, this is an uncommon occurrence in a region where palm veins may be seen. Because there isn't a large palm vein picture database like a face or fingerprint database, this is an issue. As a result, a bigger database is required in order to expand the usage of palm image identification technologies. Transfer learning expands the number of options for palm vein identification, but it has certain drawbacks.

(ii) Recognition based on a combination of biometrics.

To improve identification accuracy while maintaining high speed, the fusion method is often used in biometrics. It's possible that combining palm vein and hand form, palm vein and palmprint, as well as combining numerous hand characteristics, will have positive outcomes.

iii) Handling changes in the skin's characteristics:

Skin changes such as age-related pigmentation and thickness of the epidermal layer may affect how well one can see the veins in the palms of their hands. Furthermore, further research is needed to determine how drinking and severe weather conditions affect palm vein identification.

iv) Spoofing attacks are possible because of vulnerability.

Using the network of blood veins beneath the palm skin, which are frequently photographed using near-infrared (NIR) light, palm vein identification offers excellent security. The veins on the palm are hidden when the hand is in its normal form, and most individuals hold their hands in the gesture of a half-fist. Palm vein also has the benefit of preventing identification by corpses or damaged palms, which may effectively prevent living detection. Another security issue is the preservation of the palm vein template.

5. CONCLUSIONS

For palm vein identification, we looked at a variety of approaches and methodologies after reviewing many academic publications. Even with all of the existing methods, there is still room for improvement. Using shorter pre-

processing times, better feature extraction, and clearer infrared pictures may all help enhance this even more. Using modern technology, a system's accuracy and resilience may be improved by obtaining better-quality pictures. Because of these advantages, it's clear that the palm vein-based system is the best option for any company, regardless of any particular industry.

As far as we know, several techniques of palm vein feature extraction and fusion have been studied. Lastly, we talked about palm vein recognition's current challenges and prospects for the future.

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