# Finger vein Recognition

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2022 International Telecommunications Conference (ITC-Egypt) | 978-1-6654-8808-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/ITC-Egypt55520.2022.9855699

***Abstract*—Biometric systems are quickly replacing traditional password authentication solutions. Security and recognition accuracy are the two most important factors to consider when designing a biometric system. Biometric identification is the study of an individual's physiological and behavioral features to solve security and identification challenges. Fingerprint biometrics have been used for a long time, but finger-vein image identification has lately gained traction as a potential biometric technique. Fingerprints have long been a widely accepted biometric for identification, but their flaws and vulnerability to spoofing prompted the development of finger vein biometrics, which were thought to be safer and more dependable. Finger vein recognition (FVR) is a technology in biometric that analyses the patterns of a person's finger veins to authenticate their identity. This article evaluates all aspects of fingerprint and finger vein recognition (FVR), including image acquisition, pre-processing, feature extraction, and matching. An overview of fingerprint and finger vein biometric systems has been presented, along with some benefits and drawbacks. For the development of an auto fingerprint and finger vein identification system, it is critical to extract fingerprint minutiae. Deep learning and algorithms can both be utilized to determine the best ways for feature extraction for fingerprints and finger veins, which will improve the fusion to create a multimodal system.**

***Keywords—Finger vein, Biometrics, Minutiae, Recognition, Image, Extraction***

## 1. Introduction

Currently, an accurate, cost-effective, and reliable biometrics solution is required. Finger vein biometric authentication is a method that identifies a person based on the vein pattern in their fingers. The blood vessels that convey blood towards the heart are known as veins. Everyone has their own veins physical and behavioural characteristics. A high level of security and better information protection can be provided by the finger vein biometric system for control to access. A comparison survey of the main biometrics methods based on factors such as anti-forgery, speed, accuracy, enrolment rate, resistance, and cost in terms of anti-forgery, accuracy, and speed, the finger vein is optimum; but, in terms of cost, resistance, and enrolment rate, it is average [1].

There is a wider range of advantages using finger vein biometrics and they include:

(a) Every person's finger vein pattern is distinctive and individual.
(b) It is extremely difficult to fake finger vein because it is located in the body.
(c) Only a live person's finger vein patterns can be taken.
(d) Because finger veins leave no trace throughout the authentication procedure, and as a result, it cannot be reproduced.
(e) Due to the fact that the finger pattern is permanent and does not change over time, the finger vein recognition system can capture low quality images and re-enrolment of vein pattern is not necessary once enrolled. [2].

## 2. OVERVIEW OF FINGER VEIN RECOGNITION SYSTEM

Near-infrared (NIR) light which is usually between (690–980 nm) is deployed in finger-vein identification systems to visualise the veins in a finger because visible light cannot penetrate the finger as NIR does. Within the last two decades, finger vein recognition has captivated the interest of many researchers. This technology has advanced significantly as a result of the countless efforts of researchers [3],[2]. This imaging technique's physiological foundation is as follows:

Haemoglobin in the bloodstream is absorbed by the NIR light.

The pigment haemoglobin, which is mostly made of iron and carries oxygen, is found in the blood.

NIR light is known to be absorbed by haemoglobin.

Therefore, under NIR illumination, vessels appear as dark structures, whereas surrounding tissue has a significantly lower light absorption coefficient in that wavelength and appears bright. When comparing blood in veins to blood in arteries, the amount of deoxygenated haemoglobin in veins is obviously higher. At 800 nm, both oxygenated and deoxygenated haemoglobin both equal amount of NIR light, whereas deoxygenated haemoglobin absorbs more at 760 nm, and oxygenated haemoglobin absorbs more above 800 nm [4],[5].

Near infrared (NIR) image sensor with a Near infrared (NIR) light source are needed to visualize the vascular patter (vein) of the finger. Based on the illumination wavelength, either both vessels (artery or vein) or one type of blood vessel can be observed which happens in most instances. The notion /rationale for vascular (hand-based) sensory system including finger and palm vein detection is the ability of deoxygenated haemoglobin to absorb oxygen. Research is still yet to prove if the acquired images are entirely vein with no presence of arteries. Finger vein recognition is based on vascular pattern in the enrolled human fingers, as hand/palm/wrist vein recognition visualises the pattern of the arteries in the middle/wrist area of the hand. [6].

The angle at which the light source is positioned in relation to the camera and the subject's finger, or hand is crucial. Here's how reflected light imaging differs from transillumination imaging.

## 3. FINGER VEIN CAPTURING METHODS

### *a. Light reflection method*

In the light reflection approach, the finger is placed on the same sides as the image sensor and the light source. The light reflected from the surface of the figure is captured by the image sensor. The image's vein pattern is created by small changes in the intensity of reflected light. Blood vessels absorb light and as a result, the area surrounding the vein would be clear as the veins would appear as dark lines as indicated in fig 2a. The light reflection method provides a limited advantages for device development, including

(1) The light source and the sensor and can be combined, allowing the device to be compact.

(2) The user and the device have no obstacle between them, and the device appears to be open.

The pattern of the vein in the palm or back of the hand (fingers) is now used in several biometric systems, all of which use the light reflection approach. This strategy necessitates the use of advanced image processing techniques because there is usually a low contrast between the vein pattern and the additional parts [7].

### *b. Light transmission method*

The light source and the camera are on different sides of the hand in this method which means that the light enters the hand's (finger) skin and tissue before being caught by the camera as indicated in fig 2b. Aappropriate thickness, and free penetration of light are requirement for authentication in this method. Near infrared (NIR) light can pass through the finger as it is placed between the image sensor and the light source. This approach produces a high-contrast vein pattern image. In this method, there is no reflected light from the other side of the finger. [7] .

In transmission light imaging, a further differentiation is established if the palmar or ventral side of the finger is acquired, or the dorsal side is acquired. Further distinction is also made based on the position of the camera. The camera can be positioned to capture the palmar side of the hand while the light is positioned on the dorsal side as indicated in fig 1. [8]

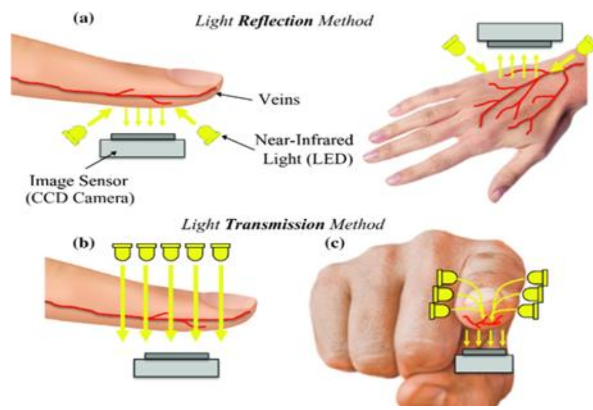


Fig. 1 Mode of operation for finger vein detection [9].

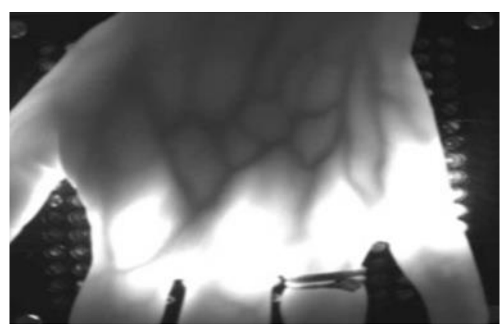

Fig 2a. Reflected light 2b. transillumination [8].

## 4. ADVANTAGES AND DISADVANTAGES OF VASCULAR BIOMETRICS

When compared to other biometric modalities, vascular biometrics do have several advantages. However, compared to fingerprint, these modalities have had a very minimal amount of commercial adoption so far. This could be because these modalities have certain drawbacks as well, which will be discussed. The next sections go over some of the benefits and drawbacks:

*a. Advantages*

1. In vascular biometrics, contactless sensing is possible since there is no need to touch the acquiring camera, unlike in transillumination, where the light source could directly illuminate the sensing camera. However, in the case of finger vein recognition, all commercial systems and nearly all other sensors now under development need the user to place the finger directly on a sensor plate. This is done to ensure some position normalisation and to keep the camera from getting dazzled if a finger is misplaced.

2. Due to detectable blood flow, liveness detection is simple. However, this necessitates the capture of NIR video and successive video analysis, and research is still on going to in this aspect.

3. Vascular biometrics should be unaffected by skin surface factors such dryness, filth, lotions, and abrasion from cuts and scars. This trait is strongly suggested by the imaging principle, but no actual evidence has been provided to back this up.

4. Because veins can be visible only in infrared light, vascular biometrics are more resilient to fakes such as spoofing and presentation attacks. On the one hand, capturing these biometric features without user agreement and from a distance is nearly impossible. Artefacts for presentation attacks are more difficult to create since they must be visible in NIR [10],[11].

*b. Disadvantages*

1. These modalities cannot be obtained at a distance, which is a privacy benefit, but they are difficult to obtain when on the move. a combination of fingerprint and vascular biometrics will be required.
2. Commercial sensors currently do not provide access to, output, or storage of imagery for additional analysis and processing. As a result, all available evaluations of these devices must adopt a black-box approach, with only commercial recognition software. Leading to various prototype devices been built for research objectives.
3. The dispersion of NIR rays in human tissue causes images to have low contrast and overall quality. In comparison to other vascular imaging, the vessel pattern in the hand (finger) is less sharp. Medical imaging methods such as Magnetic Resonance Angiography (MRA) create high-quality images of vessels within the body. These techniques are too expensive for biometric applications.

## 5. FINGER VEIN RECOGNITION

Finger vein system composes of the following steps as indicated in fig 3:

6. Image acquisition (Registration of finger)
7. Pre-processing
8. Feature Extraction
9. Matching

*a. Image acquisition (Registration of finger).*

The finger vein image is acquired using NIR (near infrared) light in the illumination method, which is the first basic stage in FVR. The acquisition equipment consists of putting together NIR component for positioning the finger, followed by a charge-coupled device (CCD) pre-processor camera for obtaining a finger vein image [12],[1],[13]. Although NIR light goes through a finger, haemoglobin in the blood absorbs more than other tissues including bones and muscles. The image of a finger vein can be captured as a dark line when the vein absorbs infrared light [14]. NIR imaging captures images through the finger and renders the images secure [15]. For the capture of finger vein images, three methods are commonly used: light reflection, light transmission, and radiating (operating in two ways). Because the transmission approach captures a high contrast image, the light transmission method is used by most finger vein imaging devices [16]. Several issues, including low contrast, noise in images translational and rotational variation, cannot be rectified during the image capture process, necessitating the following step of image pre-processing, which solves these issues [17].

*b. Pre-processing*

Data the image sensor device acquires should be pre-processed before the feature extraction procedure. For the finger vein patterns to be viewable, image enhancing is done in the pre-processing stage using a specific image scaling rule. The goal of image pre-processing is to create a stable Region of Interest (ROI) image that may be used for feature extraction. The quality of a finger vein image determines the image's performance. Noise, shades, and low contrast are common in finger vein images. As a result of light fluctuation, the finger's rotational and translational variation, and the capturing device's performance [18]. To alleviate these issues, the pre-processing phase is used.

The three most common stages of pre-processing are as follows:

(I). *image quality assessment*: The primary sub-step of pre-processing is image assessment. The quality of the obtained image samples is assessed at this stage to determine their potential for further processing. There are two options if the raw data from the sample isn't satisfactory. One solution is to obtain the data from the user again, while another is to create an exception that triggers the need to conduct other appropriate actions. Various quality assessment systems have recently been presented to improve the performance of the finger vein recognition system [15]. The HSNR (the human visual system contributes to the signal to noise ratio.) evaluation index is designed to imitate the qualities of the human visual system to evaluate image quality [19].

(II). *Region of Interest extraction (ROI):* The ROI extraction stage is the next most essential step. There are unwanted regions and valuable areas which are the finger area in an acquired finger vein image. The useful region is referred to as ROI, and its extraction is the process of detecting and extracting the finger area from a captured image while removing the image background [15]. Region-based method, template method, thresholding, and edge-based method can be deployed to segment the finger region from an enrolled image [20].

(III). *normalization and enhancement:* The term "normalisation" refers to the process of bringing to a consistent level the range of pixel intensity values in an image. After obtaining the ROI, the finger vein image is normalised to compensate for geometric changes and maintain image size consistency [21]. Furthermore, image normalisation in the pre-processing step eliminates the image's variation issues [22]. Another important stage in the pre-processing phase is the Image enhancement. The primary purpose of image enhancement is to improve the interpretability or understanding the information in the images, or to obtain a standard improved image from an unsteady acquired image [18]. To improve matching performance in finger vein recognition, image augmentation is required. The major goals of image improvement for a finger vein are contrast enhancement and noise removal. To improve the image quality, a variety of enhancing techniques are applied.

*c.Finger Region Extraction.*

The most important and significant processes in FVR is feature extraction. This stage helps in identifying the individual by creating the template, a measurable feature of the basic biometric attribute. In a fingerprint biometric system [23], the location and orientation of minutiae points in a fingerprint picture is a vital property that must be distinct from that of another person. A step that improves the accuracy of finger vein recognition is an efficient feature extraction technique. Several feature extraction strategies have been proposed, and this study focuses on four of them: minutiae-based, local binary-based, vein-based and dimensionality-based method [15].

*i. Minutiae-based method*

Minutiae points of the finger and the points where the ridge structure end and branch. Minutiae points are a type of key characteristic of a finger vein image that refers to the terminal and bifurcation sites of blood vessels. In finger vein recognition, minutiae points are used, and similar methods are already used in fingerprint recognition [24],[25].

*ii. Local binary-based method*

The finger vein local feature information is represented by a local binary pattern, which is a local feature descriptor. The LBP code is an ordered set of binary values determined by comparing the grey value of a central pixel to the grey values of its neighbours [26].

*iii. Vein-based method*

Gabor filtering is a powerful feature extraction approach for extracting textural features from images, and it's used in a variety of pattern recognition applications like iris recognition, fingerprint recognition and hand vein identification [21]. Gabor filtering is especially useful for extracting finger veins because of its directional acuity, ability to recognise oriented features, and optimised to a single frequency.

*iv. Dimensionality-based method*

The distinguishing information is maintained, and noises are suppressed in the dimensionality reduction-based method, which transforms the image of the finger vein into a low-dimensional space using dimension reduction. Regarding this type of procedure, the most common feature extraction strategy involves a training step to learn the transformation matrix, and the matching process uses a classifier. Residual information, such as variation in position, finger muscle and bone around the vein is received during image acquisition and can impact the accuracy of the identification system.

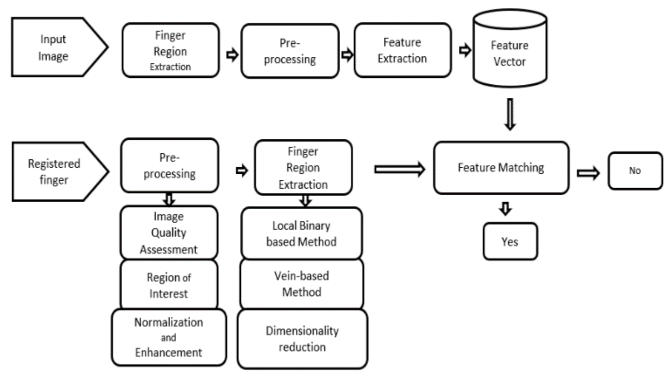


Fig 3. The Flow of finger (Vein) recognition system [1]

*d. Matching*

The final stage of recognition is the technique for matching, in which a matching score is calculated, to determine if an enrolled/input image is real or fake. The relationship between the enrolled template and the input (scanned) image is measured using a matching score. The matching score is same as classification [7]. The distance classifier is used to match the images, which is essentially the difference/similarities between features of distinct or identical images of a finger vein, and the difference is compared to a threshold value. Distance-based matching and classifier-based matching are the two types of matching strategies employed. The distance-based matching technique is used in traditional finger vein identification, but classifier-based matching can be used in machine learning techniques for finger vein recognition. Articles [18],[27],[7],[28] used classifier-based matching algorithms for finger vein recognition systems.

## 10. CONCLUSION

The paper goes over all the FVR recognition process which begins with image acquisition through to pre-processing, extraction of feature, and ending with matching as the procedures (handcrafted and learning base) were evaluated. Incorporating deep learning techniques into FVR can improve cognitive function in a wide sense. Acknowledging the short comings of the finger vein biometrics such as inability of commercial sensors to provide captured image, and impact of temperature and diseases in vascular anatomy, a multimodal recognition system which comprises of the popular fingerprint and finger vein would be a robust recognition system with for identification, recognition, and security.

## ACKNOWLEDGEMENT

My study is sponsored by the government of Ghana. This project has received funding from the European Union's Horizon-MSCA-RISE-2019-2023, Marie Skłodowska-Curie, Research, and Innovation Staff Exchange (RISE), titled: Secure and Wireless Multimodal Biometric Scanning Device for Passenger Verification Targeting Land and Sea Border Control.

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