# Biometric Identification using Facial Vein Patterns

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Biometric systems play a crucial role in personal identification, leveraging the reliability and distinctiveness of physiological or behavioral traits. Among these, vein patterns in the face have gained attention for their stability and security, offering a robust method for biometric identification. This paper focuses on advancing the field with a Face Veins Based MCMT Technique. This technique utilizes a Multi-Channel Multi-Threshold approach to enhance accuracy and reliability in identifying individuals based on their unique vein patterns. By exploring the development and application of this innovative technique, the research aims to contribute to the evolution of biometric systems, addressing challenges and improving the efficacy of personal identification technologies.

**Keywords:** Biometric, Vein, DNA Recognition, MCMT

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# 1. Introduction

Identifying a person uniquely is a complex task, often requiring sophisticated biometric techniques. Biometrics involves identifying individuals based on physiological and behavioral traits, a concept defined by the International Organization for Standardization (ISO). Techniques such as fingerprints, iris, DNA recognition, and voice recognition have been employed historically. For example, fingerprint identification dates back to ancient Babylon and was further refined by AzizulHaque in India with the development of Henry's system. Fingerprint recognition, while prevalent, has limitations due to the possibility of ridge alterations, leading to the advancement of more secure methods like finger vein pattern recognition, which is harder to modify.

Modern biometric techniques have evolved to include face veins, heartbeat, and hand geometry, each offering unique advantages. The face vein technique, captured using Mid Wave Infra Red (MWIR) cameras, has proven effective due to the stability and uniqueness of facial vein patterns. Similarly, DNA analysis remains a gold standard, though it falters with identical twins. High and low-resolution palm print images are utilized in forensic and commercial applications respectively. Vein pattern recognition, employing Near Infra Red (NIR) technology, stands out for its security and stability, forming the basis for advanced systems like the Finger Vein Authentication System (FVAS). This method is particularly resistant to falsification, positioning vein-based biometrics as a superior choice in contemporary security systems.

## 1.2 Background of Vein-Based Biometric Systems

Vein-based identification systems belong to the category of physiological feature-based systems, as they extract and utilize vein patterns to uniquely identify individuals. These systems have gained prominence due to their robustness and reliability compared to other biometric techniques such as fingerprint, palm print, hand geometry, facial expression, skin color, voice recognition, gait signature, body language, DNA recognition, and heartbeat. These methods often fail to distinguish between identical twins or can be circumvented through various means, unlike vein-based systems which remain unaltered and provide accurate identification even in complex scenarios.

Vein-based systems require less storage space in memory for database storage. By converting visual images into vein-based representations, the size of the stored data is significantly reduced. Matching an individual's image with the database ensures precise identification based on vein patterns, which remain consistent over time and cannot be easily altered.
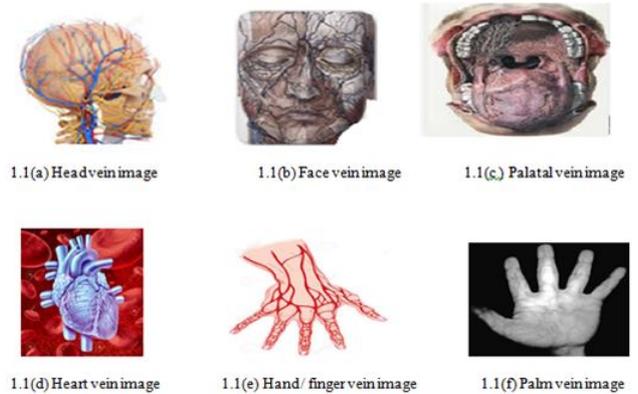


1.1(a) Head vein image    1.1(b) Face vein image    1.1(c) Palatal vein image

1.1(d) Heart vein image    1.1(e) Hand/ finger vein image    1.1(f) Palm vein image

**Figure 1.1:** Vein image based personal identification of the person

In earlier stages of personal identification research, methods such as account numbers, driving licenses, and PAN cards were employed but proved ineffective. Subsequently, biometric systems utilizing physiological and behavioral traits emerged, including iris, hand veins, DNA, face veins, palm veins, heartbeat pulse, fingerprints, voice recognition, and gait signatures (Srivastava, 2013). Various scanning devices like IR, NIR, LWIR, SWIR, and MWIR cameras have been utilized to capture biometric features, with thermal imaging particularly useful for displaying facial vasculature and tissue vessels without physical contact (Chennamma, 2010; Garbey, 2007; Gault, 2010; Hartung, 2011). Thermal images not only aid in personal identification but also find applications in fields such as engineering, medicine, space technology, and biomedical engineering (Arandjelovic, 2010; Chekmenev, 2007). Specifically, face veins based identification leverages IR cameras to capture thermal images highlighting unique facial vein structures, crucial for identifying individuals due to their thermal characteristics and the inherent uniqueness of vein patterns (Buddharaju, 2008; Garbey, 2007). The size and structure of face veins, typically 10 to 15 micrometers in diameter, can be affected by temperature and mental stress, influencing their appearance and providing distinctive identifiers (Trujillo, 2005; Guzman, 2013).
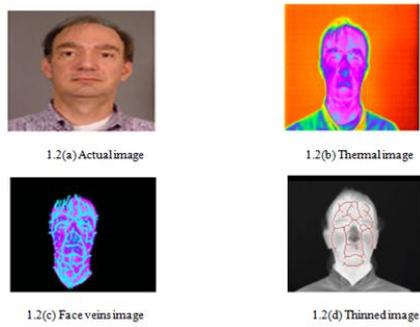
**Figure 1.2:** Sample of actual image, thermal image, face veins image and thinned face veins [Guzman, 2013]

**1.3 Problem Statement**

While vein-based biometric systems show promise, there are challenges that need to be addressed for their widespread adoption. These include the development of robust techniques for vein pattern extraction, enhancement of recognition accuracy, and adaptation to different environmental conditions. Moreover, there is a need for exploring multi-biometric systems that combine vein patterns with other modalities to enhance overall performance and reliability.

# 2. Literature Review

| S. No. | Methods | Description | Advantages | Disadvantages | Performance Percentage |
|---|---|---|---|---|---|
| 1 | Finger and Iris Vein fused system | This system is used to identify the individuality of the person with the help of finger and iris vein fused system. | Finger and iris veins based fusion system produces very accurate result rather than unimodal veins based system. In the multi-modal veins based system each vein's features are separately compared with other person's vein's features and then the result is given. | The multi modal vein based system takes more time in processing the images than unimodal veins based system. | 92.4% |
| 2 | Face and finger vein based fusion system | The face and finger vein based fusion system is used as low resolution fusion based technique for identifying the uniqueness of the person. | The face and finger based fusion multimodal system is very useful when the face or finger, any one is damaged then the multi-vein based fusion system is required and if the person's finger is damaged in any accident then the multimodal system plays an important role. | The face and finger veins based multimodal fusion system is failed when the person is burned, or the finger and face are burned. In this situation this multimodal system cannot identify the identity of the person. | 92% & above |
| 3 | Palm veins and face based multimodal system | The palm veins and face image based multi-modal identification system uses palm vein features and face image features for identifying the uniqueness of a person. | The palm vein and face image based multi-modal systems uses palm vein features and face features for identifying the identity of the person. The main benefit of this system is that if the face or palm of a person is damaged in an accident then this system identifies the identity of the person on the basis of face feature or palm vein feature. | The disadvantage of palm veins and face veins based multimodal system is that when the palm and face based feature are unavailable due to any reason then this system cannot identify the uniqueness of the person. | 90% & above |
| 4 | Hand and palm vein based multimodal system | The hand and palm vein based identification system uses hand and palm vein based features for identifying the individuality of the person. In this system separate methods are used for hand and palm veins for obtaining the results. | Hand and palm vein based multimodal system is very useful in the field of personal identification of the person. The main advantage of this multimodal system is that if a person's finger is damaged then these techniques can be used for identifying the person on the basis of hand and palm veins but if palm is damaged then hand vein is used for identifying the uniqueness of the person. | The main disadvantage of this vein based multimodal system is that if the hand of a person is damaged or gets cut in an accident or any way then this system cannot identify the identity of the person. | 94% |

**2.1 Objectives**

The primary objectives of this research are as follows:

1. To propose an advanced MCMT (Multi-Channel Multi-Threshold) technique for identifying individuals based on face vein patterns.

2. To develop a veins-based multi-biometric system that integrates multiple vein features for enhanced accuracy and reliability in personal identification.

3. To investigate the feasibility of using vein patterns for distinguishing between identical twins, leveraging the uniqueness of vein patterns even in genetically similar individuals.

# 3. Face Veins Based MCMT Technique

The proposed MCMT technique for vein-based biometric identification employs multi-channel data acquisition to capture vein patterns across different spectral bands of the face, particularly focusing on infrared wavelengths where veins are most distinct. This approach enhances robustness against variations in lighting conditions, facial poses, and expressions by utilizing multiple thresholds in the matching process. Key steps include high-resolution vein pattern extraction, followed by feature extraction using advanced image processing algorithms to derive discriminative features. Multi-channel fusion integrates vein patterns from various spectral channels to create a comprehensive and unique representation of each individual's vein pattern. The multi-threshold matching strategy further improves accuracy by reducing false acceptance and rejection rates compared to single-threshold methods. Additionally, to bolster the reliability and security of personal identification systems, a veins-based multi-biometric approach is proposed. This system integrates vein patterns with other biometric modalities like fingerprints or iris scans, employing data fusion techniques at both feature and decision levels to enhance performance. Score level fusion combines matching scores from different biometric systems to enhance overall system reliability, while cryptographic techniques are employed to secure biometric templates during transmission and storage, ensuring privacy protection.

# 4. Identifying Individuals between Twins

A unique aspect of vein-based biometric systems is their ability to distinguish between identical twins. Despite genetic similarities, vein patterns exhibit sufficient variation due to environmental influences and developmental factors. This research investigates:

**Twin Identification Techniques**: Development of specialized algorithms and metrics to quantify the differences in vein patterns between twins.

**Case Studies and Experiments**: Empirical studies involving twins to validate the effectiveness of vein-based biometric systems in distinguishing between genetically similar individuals.

## 4.1 Techniques used for Identifying the Individual

Various techniques are employed for individual identification based on finger veins. One approach is the Multimodal Personal Authentication using Finger Vein and Face Biometric Traits (MPAFFI), integrating finger vein patterns and facial images to establish unique person identification (Yang, 2011c). Additionally, the SVM scheme utilizes the K-means clustering algorithm to automatically cluster finger vein images, optimizing cluster numbers through maximum and minimum distance algorithms for effective classification. Another method involves the Gaussian Point Spread Function (PSF) model, defined mathematically in Eq. (2.8), where convolving operators enhance finger vein images by minimizing noise factors ($hs(x,y)$, $hl(x,y)$, $n(x,y)$), thereby clarifying images for precise individual identification based on finger vein characteristics.
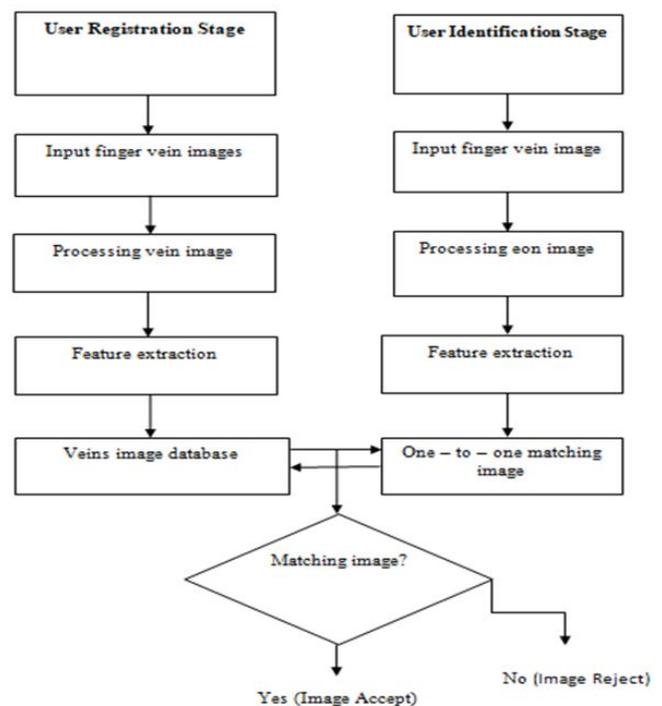


**Figure 4.1:** Steps of matching the finger vein image from the database [Wang, 2010].

# 5. Conclusion

The use of vein patterns for biometric identification, particularly in the face, offers significant advantages in terms of reliability, security, and resistance to spoofing attacks. The proposed Face Veins Based MCMT Technique and veins-based multi-biometric system represent advancements in the field, addressing key challenges and paving the way for enhanced personal identification systems.

Future research directions include further optimization of vein pattern extraction techniques, exploration of fusion strategies with other biometric modalities, and validation in large-scale deployment scenarios.

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