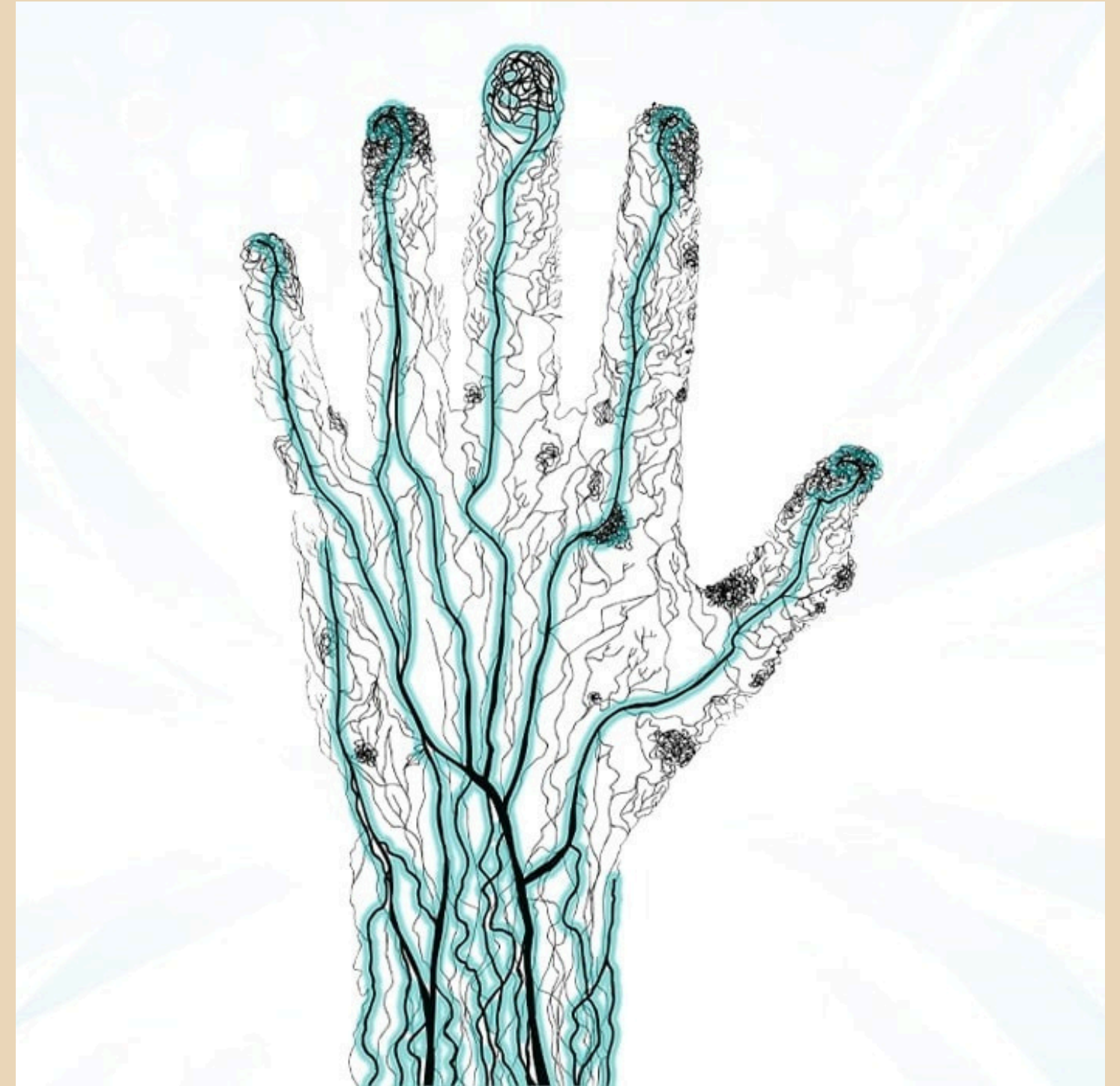# Vein Recognition

TOQA ABDEEN
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Introduction

- The ability of an individual to identify himself is very important in our lives.
- Why do we need to develop identity management systems?
- Choosing Biometric Technologies as an Identity Recognition System.
- What is vein recognition technology?

Types of Vein Biometrics

1. Finger Vein Recognition:

   ○ Most commercially used; compact sensors and high accuracy.

2. Palm Vein Recognition:

   ○ Captures more area for richer features; used in healthcare and banking.

3. Wrist Vein Recognition:

   ○ Emerging method, suitable for wearable devices.

4. Dorsal Hand Vein Recognition:

   ○ Uses the back of the hand; provides more stable images.

How Does Vein Recognition Work?

1. NIR Imaging: Infrared light highlights veins under the skin.

2. Image Preprocessing: Enhances quality and extracts the region of interest.

3. Feature Extraction: Uses traditional or deep learning methods (e.g., CNN).

4. Matching: Compares features with stored templates using similarity measures.

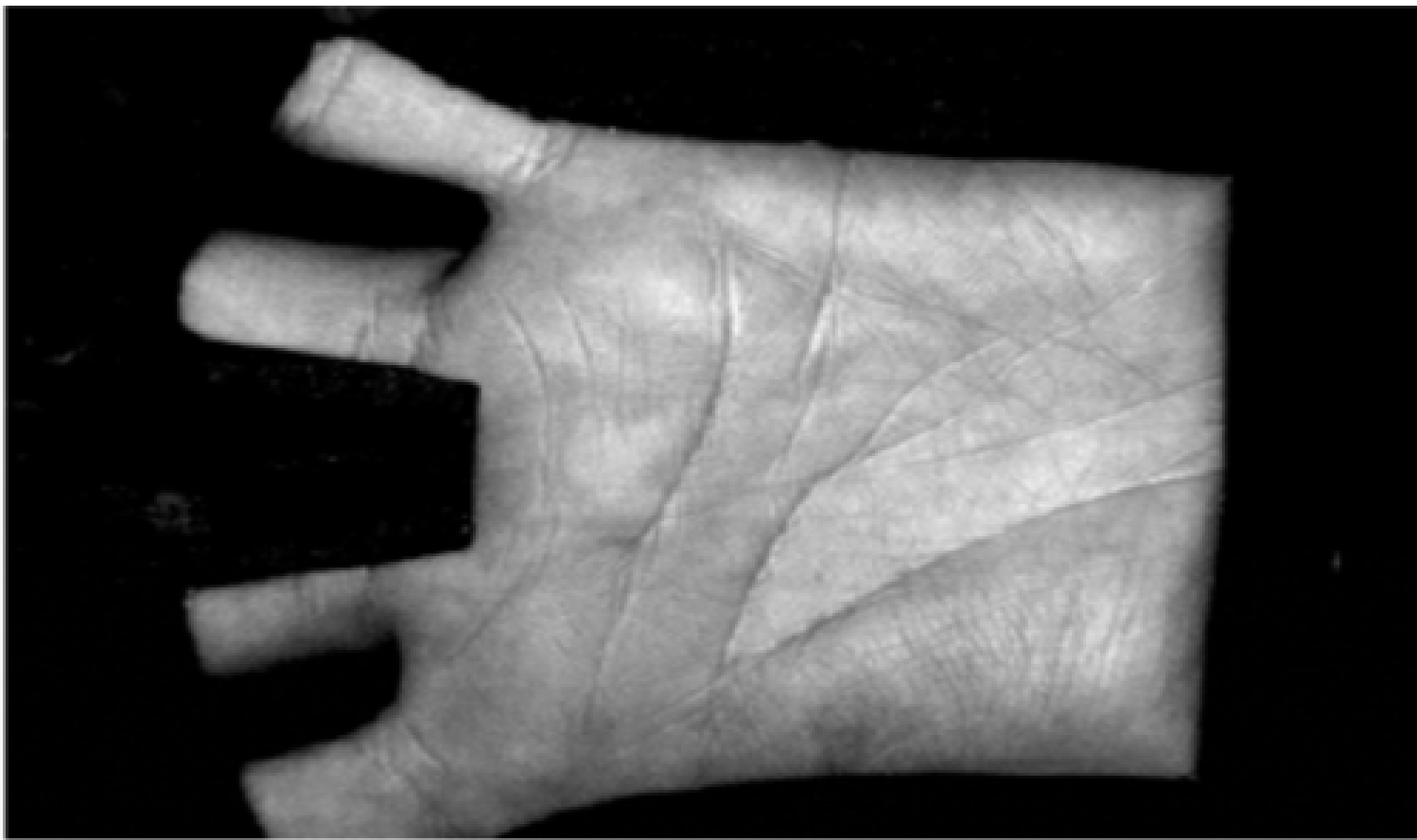# Common databases used in researches

- Why Do We Use Vein Image Databases?
- Common databases used in researches:
  - CASIA, CASIA Multi-Spectral Palmprint Database.
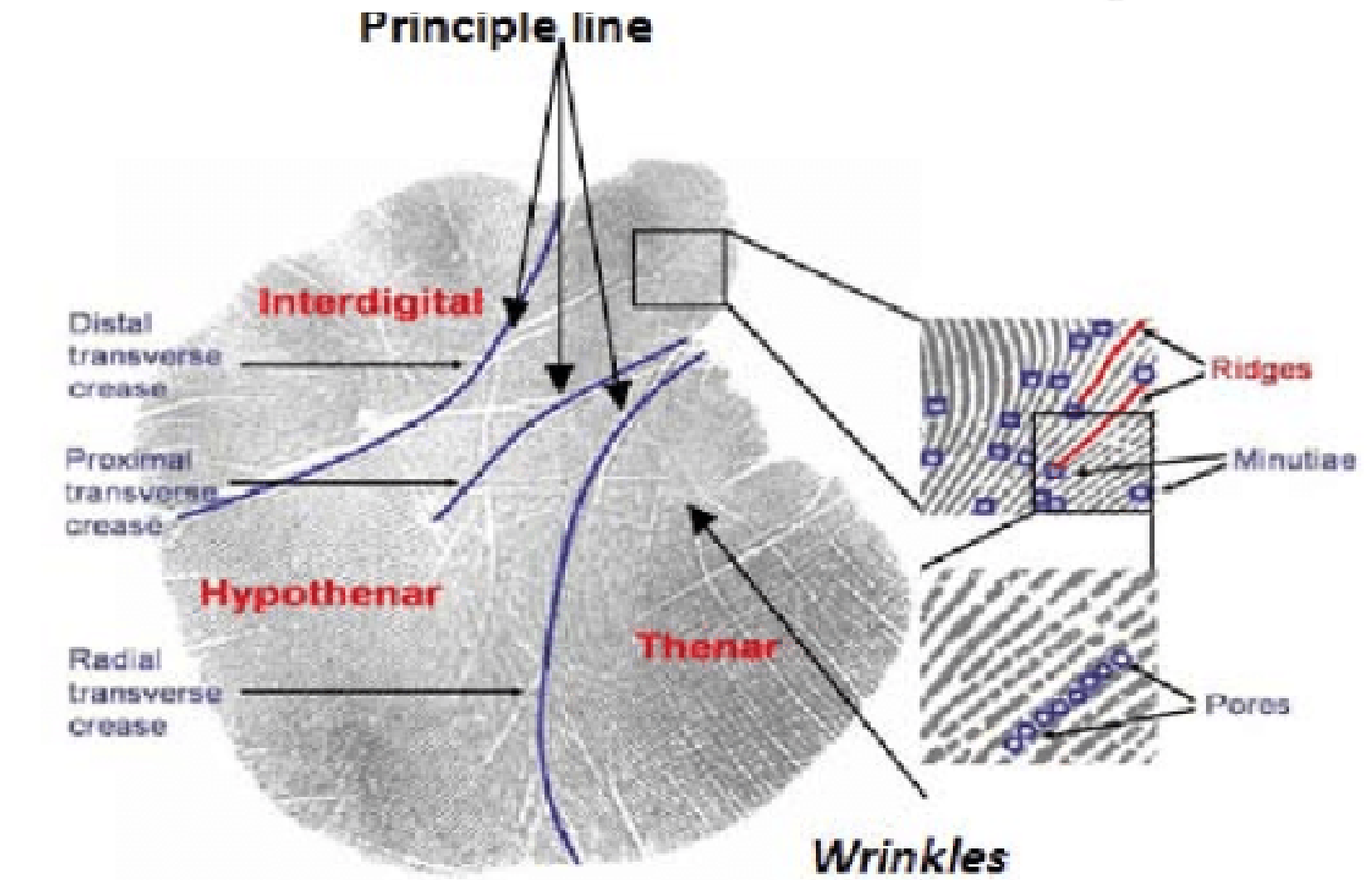 - PUT Vein Database.
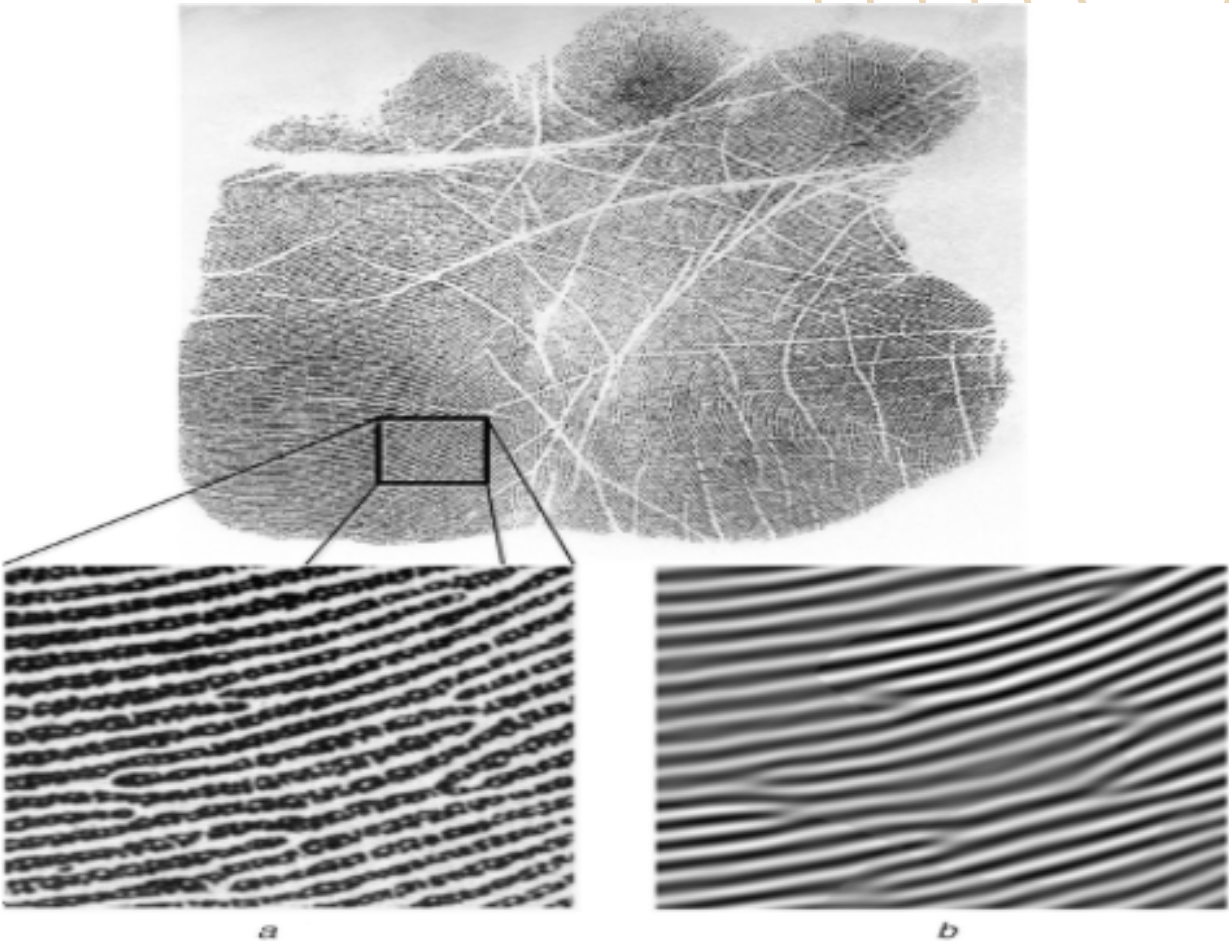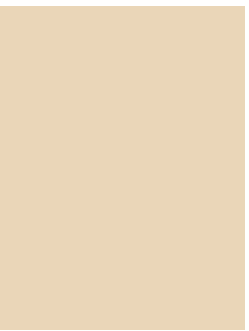 - HKPU Finger Vein Database.

CASIA Palmprint Image Database

- Created by the Institute of Automation, Chinese Academyof Sciences.

- CASIA Palmprint: Image Data and Key Biometric Traits.

- Research Studies Based on the CASIA Palmprint Database.

  - Multispectral Palmprint Encoding and Recognition

  - Low-cost Biometric Recognition System Based on NIR Palm Vein Image:

    https://ietresearch.onlinelibrary.wiley.com/doi/epdf/10.1049/iet-bmt.2018.5027

  - Palm Vein Recognition Using Wavelet Transform and CASIA Database:

    https://ieeexplore.ieee.org/document/7273725

- DataBase link: http://biometrics.idealtest.org/#/datasetDetail/5

Lines

Minutiae

Principle line

Distal transverse crease

Proximal transverse crease

Radial transverse crease

Interdigital

Hypothenar

Thenar

Ridges

Minutiae

Pores

Wrinkles

Texture

PUT Vein Pattern Database

- Developed by researchers from the Institute of Computer Science, University of Wrocław, Poland

- PUT Vein Pattern Database: Data Collection and Description.

- Research Studies Based on the PUT Vein Pattern Database:

   - SIFT Based Vein Recognition Models: Analysis and Improvement

- Access the PutVein Database

Hardware used in vein recognition

- Types of Vein Recognition Devices:
    a. Visible Light Imaging
    b. Mid-Infrared Imaging
    c. X-Ray Imaging
    d. Ultrasound Imaging
    e. Thermal Imaging
    f. Near-Infrared (NIR) Imaging
- Smart NIR-Based Vein Recognition Devices

Vein image processing techniques

One of the main challenges in vein-recognition system is the low quality of captured images due to indistinct vein patterns and unwanted noise in hand images, which may result to false detection. To address this, image enhancement techniques are essential for improving image quality, making vein patterns more visible, and reducing errors during the detection process.

Various methods have been proposed for effective image enhancement, these include some classical techniques such as histogram equalization, and contrast stretching, as well as more advanced and adaptive approaches like Fase Median-Based Filtering (FMBF) and Hybrid Cumulative Histogram Equalization (HCHE).
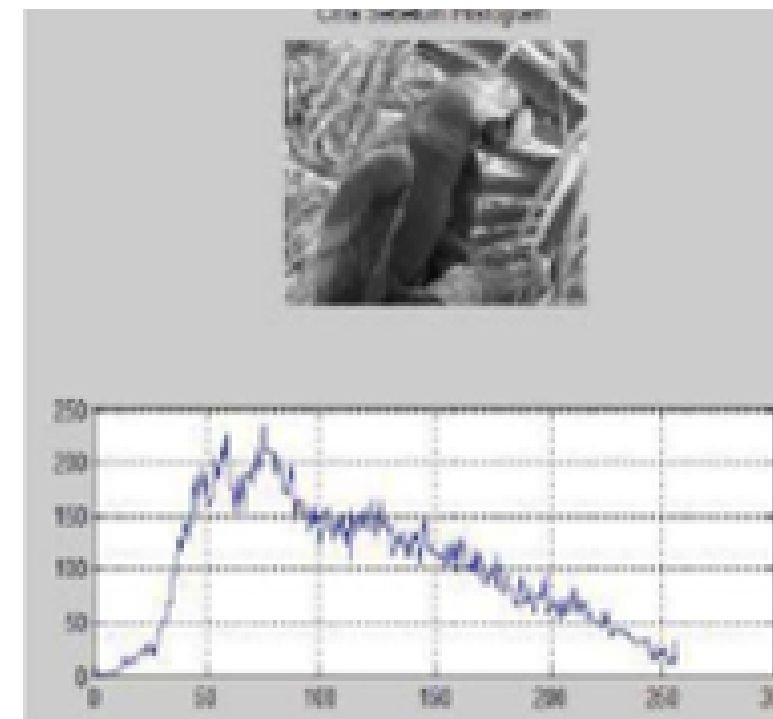
Classical image enhancing techniques:
Histogram Equalization

Histogram equalization is a technique that increases the dynamic range of pixel intensities in an image. It works by redistributing the pixel intensities so that the output image has a more uniform histogram. The goal is to enhance image contrast, making darker regions brighter and enhancing overall visibility. Instead of "flattening" the histogram completely, its "spreads" the intensity distribution more evenly across the available range. This process assigns new intensity values to pixels based on their original levels and can be applied to the entire image or just specific regions.
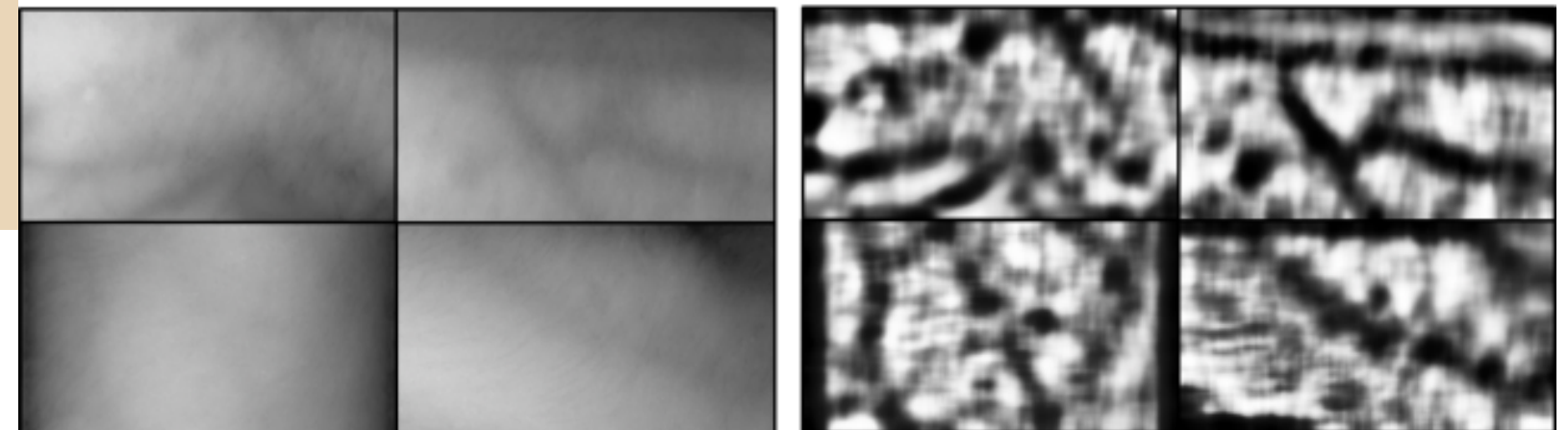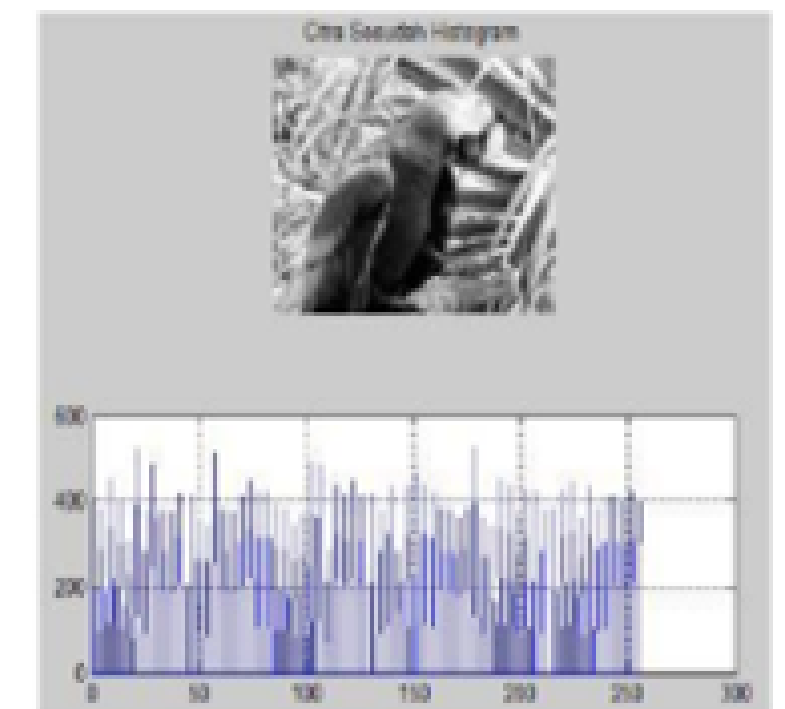

A. Image before

B. After applying HE

A. Image before

B. After applying HE

Advanced image enhancing techniques:
## Fast Median-Based Filtering

FMBF (Fast Median-Based Filter) is a noise reduction technique commonly used in infrared imaging to enhance image quality by detecting and eliminating noisy pixels. Unlike traditional filters that may blur important details, FMBF focuses on preserving critical structures such as edges and fine patterns like vein structures. It works by comparing each pixel to its surrounding neighbors and selectively replacing only those pixels identified as noisy. This targeted approach helps maintain the integrity of the original image while effectively reducing random noise, making it especially useful in sensitive applications such as medical imaging or biometric recognition.
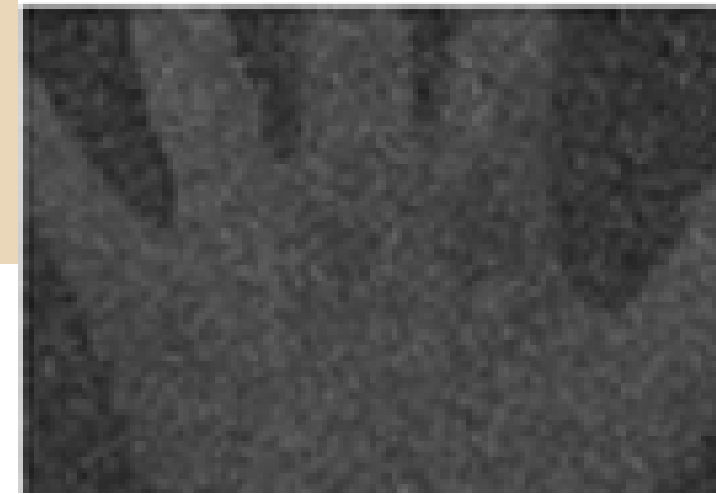
A. Image before with 20% impulse Noise

B. Filtered by FMBF
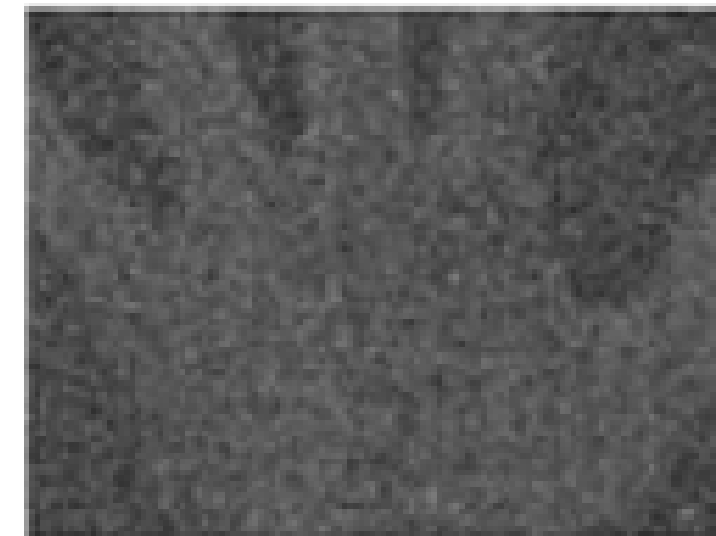
A. Image before with 50% impulse Noise

B. Filtered by FMBF

Pattern recognition methods

After enhancing the images captured. Vein patterns should be extracted precisely, and the process must be executed speedily in order to satisfy requirements for user convenience. Early system relied on traditional image processing techniques such as line tracking and template matching to identify characteristic features of vein patterns, these methods have been widely used due to their simplicity. However, these techniques are sensitive to poor image quality or light variations in hand placement. Recently, machine learning and deep learning techniques have been integrated, such as Convolutional Neural Networks (CNNs), which automatically learn and detect complex features in vein patterns with higher accuracy.

Traditional pattern recognition technique: Line Tracking

Modern pattern recognition technique: Convolutional Neural Networks

Line tracking is a common method for extracting vein patterns from near-infrared (NIR) images by following dark lines that represent veins. It starts from random points and traces the darkest directions, storing tracking frequency in a matrix called locus space. Repeating this process improves accuracy and reduces noise. During matching, patterns are compared using a mismatch ratio — lower values mean a better match. This makes line tracking a simple but effective technique for vein recognition.

Convolutional Neural Networks (CNNs) are deep learning models that automatically extract features from images. They consist of multiple layers, such as convolutional, pooling, and fully connected layers, which work together to detect and learn patterns from vein images. In vein recognition, these layers help identify edges, textures, and complex vein structures without manual feature engineering. CNNs provide high accuracy and robustness, even under challenging conditions like lighting variations or slight finger misplacement, making them more effective than traditional methods.

Biometric traits

In the experiment conducted in "Palm Vein Recognition Based on Convolutional Neural Network," the use of CNNs achieved an accuracy of nearly 99%, with a False Acceptance Rate (FAR) of 0% and a False Rejection Rate (FRR) below 1%.

Vein recognition offers high universality and distinctiveness, as everyone has unique, stable vein patterns. Its performance is strong, delivering real-time results with low error rates, and its resistance to forgery is high due to the internal location of veins. However, collectability and acceptability are moderate, as image quality can be affected by environmental conditions and biological factors like tissue thickness or certain health conditions.

Applications and Advantages

Applications:

- ATMs, Hospitals, Smartphones, Access Control

Advantages:

- Internal and hard to forge

- Contactless and hygienic

- Stable over a lifetime

- Robust under different conditions

Challenges and Future Directions

Challenges:

- Limited large-scale datasets for model training.
- Image quality issues under different conditions.
- High cost of specialized hardware.

Future Directions:

- Develop better deep learning models.
- Enhance spoof detection mechanisms.
- Improve real-world usability and system performance.

Comparison with Other Biometric Methods

Biometric Method	Security Level	Contactless	Light Sensitivity
Fingerprint	Medium	No	Low
Facial	Low	Yes	High
Iris	High	Yes	Medium
Vein	High	Yes	Low

Real world application

- Banking and Finance sector
- Healthcare Sector
- Government and Public Services Sector