

Training on Fingerprint Sensor and Applications

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Introduction to Biometrics

- Biometrics deals with identification of individuals based on their biological or behavioral characteristics.
- Biometric recognition (or simply biometrics) refers to the use of distinctive anatomical (e.g., ***fingerprints, face, iris***) and behavioral (e.g., ***speech***) characteristics, called biometric identifiers or traits or characteristics for automatically recognizing individuals.
- Biometrics is becoming an essential component of effective person identification solutions because biometric identifiers cannot be shared or misplaced, and they intrinsically represent ***the individual's bodily identity***.

Biometrics Applications

- Biometrics deals with identification of individuals based on their biological or behavioral characteristics.
- Biometrics has lately been receiving attention in popular media. it is widely believed that biometrics will become a significant component of the identification technology as:
 - The prices of biometrics sensors continue to fall.
 - The underlying technology becomes more mature.
 - The public becomes aware of the strengths and limitations of biometrics.

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Fingerprint Identification Systems

- Automatic fingerprint recognition based on the digital representation of fingerprints calls Automatic Fingerprint Identification Systems (AFIS).
- The use of fingerprints for identification has been employed in law enforcement for about a century.
- A much broader application of fingerprints is for personal authentication, for instance to access a computer, network, bank-machine, car or home.

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Fingerprint Characteristic

- According to criminal investigators, fingerprints follow 3 fundamental principles, those are:
- A fingerprint is an individual characteristic; no two people have been found with the exact same fingerprint pattern.
- A fingerprint pattern will remain unchanged for the life of an individual; however, the print itself may change due to permanent scars and skin diseases.
- Fingerprints have general characteristic ridge patterns that allow them to be systematically identified.

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Fingerprint Classes

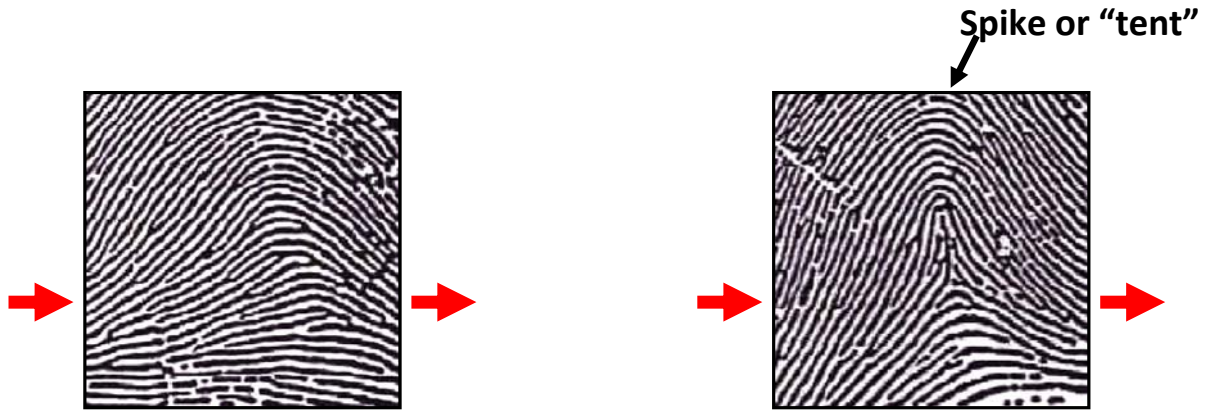
- There are 3 specific classes for all fingerprints based upon their visual pattern: arches, loops, and whorls.
- Each group is divided into smaller groups as seen in the lists below:
- **Arch**: Plain arch, Tented arch
- **Loop**: Radial Loop, Ulnar loop
- **Whorl**: Plain whorl, Central pocket whorl, Double loop whorl, Accidental
- Fingerprint Facts: 60% of people have loops, 35% have whorls, and 5% have arches

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Arches

Arches are the simplest type of fingerprints that are formed by ridges that enter on one side of the print and exit on the other. No deltas are present.



Plain Arch

Ridges enter on one side and exit on the other side.

Tented Arches

Similar to the plain arch, but has a spike in the center.

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Loops

Loops must have one delta and one or more ridges that enter and leave on the same side. These patterns are named for their positions related to the radius and ulna bones.



Ulnar Loop (Right Thumb)

Loop opens toward right or the ulna bone.

Radial Loop (Right Thumb)

Loop opens toward the left or the radial bone.

NOTE: On the left hand, a loop that opens to the left would be an ulnar loop, while one that opens to the right would be a radial loop.

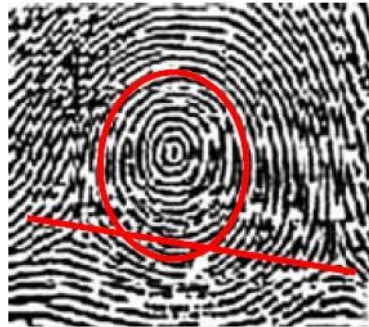
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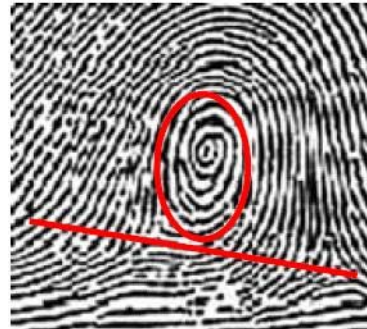
Whorls (1/2)

Whorls have at least one ridge that makes (or tends to make) a complete circuit. They also have at least two deltas. If a print has more than two deltas, it is most likely an accidental.

Plain Whorl



Central Pocket Whorl



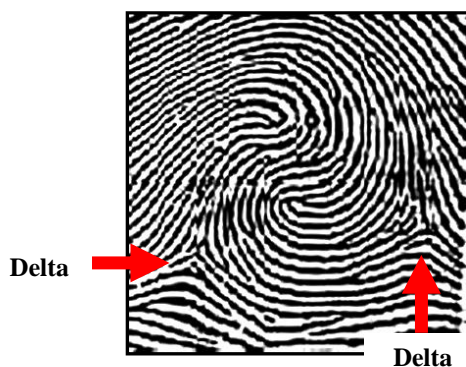
Draw a line between the two deltas in the plain and central pocket whorls. If some of the curved ridges touch the line, it is a plain whorl. If none of the center core touches the line, it is a central pocket whorl.

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Whorls (2/2)

Double Loop Whorl



Double loop whorls are made up of any two loops combined into one print.

Accidental Whorl



Accidental whorls contain two or more patterns (not including the plain arch), or does not clearly fall under any of the other categories.

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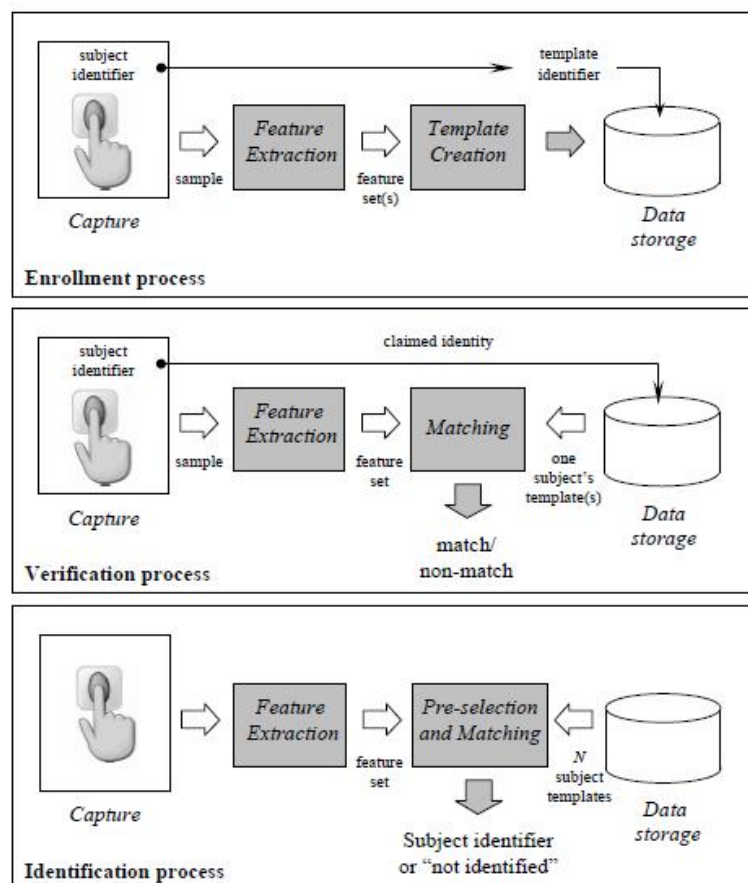
Fingerprint System

- Depending on the application context, a biometric system may be called either a verification system or an identification system:
- An identification system recognizes an individual by searching the entire enrollment template database for a match. It conducts one-to-many comparisons to establish if the individual is present in the database and if so, returns the identifier of the enrollment reference that matched.
- A verification system authenticates a person's identity by comparing the captured fingerprint characteristics with her previously captured (enrolled) biometric reference template pre-stored in the system. It conducts one-to-one comparison to confirm whether the claim of identity by the individual is true. A verification system either rejects or accepts the submitted claim of identity.

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Verification and Identification systems (1/4)



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Verification and Identification systems (2/4)

- These processes use the following modules: capture, feature extraction, template creation, matching, pre-selection, and data storage. In the identification process pre-selection and matching are often combined.

Verification and Identification systems (3/4)

- **Capture:** a digital representation of biometric characteristic needs to be sensed and captured. A biometric sensor, such as a fingerprint scanner, is one of the central pieces of a biometric capture module.
- **Feature extraction:** in order to facilitate matching or comparison, the raw digital representation (sample) is usually further processed by a feature extractor to generate a compact but expressive representation, called a feature set.

Verification and Identification systems (4/4)

- **Template creation:** the template creation module organizes one or more feature sets into an enrollment template that will be saved in some persistent storage.
- **Pre-selection and matching:** the pre-selection (or filtering) stage is primarily used in an identification system when the number of enrolled templates is large. Its role is to reduce the effective size of the template database, The matching (or comparison) stage takes a feature set and an enrollment template as inputs and computes the similarity between them in terms of a matching score, also known as similarity score. The matching score to make the final decision; if the match score is higher than the threshold, the person is recognized, otherwise not.
- **Data storage:** is devoted to storing templates and other demographic information about the user. Depending on the application, the template may be stored in internal or external storage devices or be recorded on a smart card issued to the individual.

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3. Frank Y. Shih, *Image processing and pattern recognition : fundamentals and techniques*, IEEE & John Wiley & Sons, 2010.

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