



Finger Print Recognition using Minutiae

Biometrics
CSE 190
Lecture 16

CSE190, Winter 2011

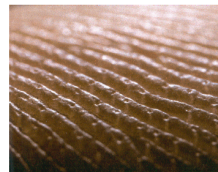
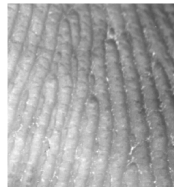
Announcement

- HW4 has been assigned

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Fingerprints

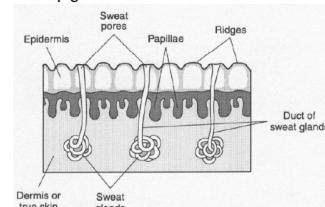
- The inside surfaces of hands and feet of humans (and, in fact, all primates) contain minute ridges of skin with furrows between each ridge
- The purpose of this skin structure is to:
 - Facilitate exudation of perspiration
 - Enhance sense of touch
 - Providing a gripping surface



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Friction skin

- **Friction skin** differs significantly in structure and function from the skin covering the rest of the body:
 - It is hairless
 - It contains no sebaceous (oil) glands
 - It has a much higher concentration of nerve endings
 - It has a much higher concentration of sweat glands
 - There is a lack of pigmentation



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Fingerprints

- Fingerprints are "permanent" in that they are formed in the fetal stage, prior to birth, and remain the same throughout lifetime
- The changes can be made by: flexibility from the skin, growing, a dirty finger, scarring, a wound, or a disease of the skin
- They are only weakly determined by genetics, e.g. identical (monozygotic, one egg) twins (the same DNA) have fingerprints that are quite different
- Fingerprints of an individual are "unique"; they indeed are distinctive to a person
- The right definition of a fingerprint is strictly speaking the **print (stamp)** that a finger left on an object

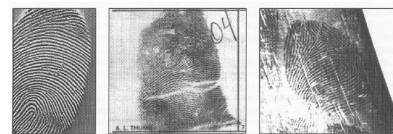


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Fingerprint images



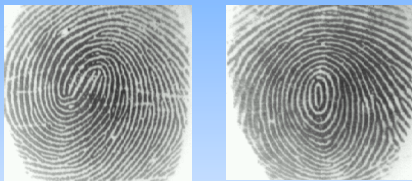
Optical scanner Capacitive scanner Piezoelectric scanner



Thermal scanner Inked impression Latent fingerprint

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Fingerprints



- **Description:** graphical flow like ridges present in human fingers
- **Formation:** during embryonic development
- **Permanence:** minute details do not change over time
- **Uniqueness:** believed to be unique to each finger
- **History:** used in forensics and has been extensively studied

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Biological Principles of Fingerprints

- Individual epidermal ridges and valleys have different characteristics for different fingerprints
- Configurations and minute details of individual ridges and valleys are permanent and unchanging (except for enlargement in the course of bodily growth)
- Configuration types are individually variable, but they vary within limits which allow for systematic classification

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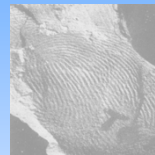
FACES CAN LIE.



FINGERPRINTS, NEVER.

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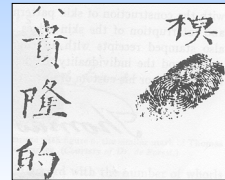
History of Fingerprints



Fingerprint on Palestinian lamp (400 A.D.)



Bewick's trademark (1809)



A Chinese deed of sale (1839) signed with a fingerprint

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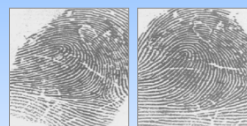
History of Fingerprints

- Many impressions of fingers have been found on ancient pottery
- Grew (1684): first scientific paper on ridges, valleys & pore structures
- Mayer (1788): detailed description of anatomical formation of fingerprints
- Bewick (1809): used his fingerprint as his trademark
- Purkinje (1823): classified fingerprints into 9 categories based on ridges
- Herschel (1858): used fingerprints on legal contracts in Bengal
- Fauld (1880): suggested "scientific identification of criminals" using fingerprints
- Vucetich (1888): first known user of dactylograms (inked fingerprints)
- Scotland Yard (1900): adopted Henry/Galton system of classification
- FBI (1924) set up a fingerprint identification division with a database of 810,000 fingerprints
- FBI (1965): installed AFIS with a database of 810,000 fingerprints
- FBI (2000): installed IAFIS with a database of **47 million 10 prints**; conducts an average of 50,000 searches/ day; ~15% of searches are in **lights out** mode. Response time: 2 hours for criminal search and 24 hours for civilian search

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Fingerprint Matching

- Find the **similarity** between two fingerprints



Fingerprints from the same finger



Fingerprints from two different fingers

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Fingerprint Sensors

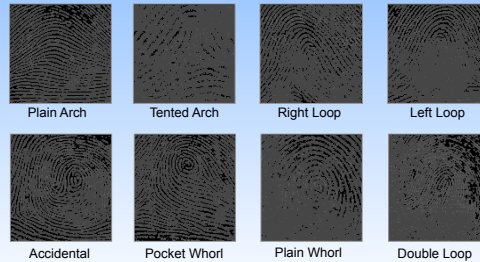
- Optical, capacitive, ultrasound, pressure, thermal, electric field



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Fingerprint Classification

- Assign fingerprints into one of pre-specified types



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THE HEURY SYSTEM

- Divides all fingerprint forms into 524 bundles.

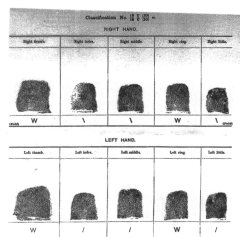


Figure 1: A Fingerprint Slip with Binary Code

- WHEEL PATTERNS ONLY HAVE VALUES.
- EVEN NUMBERS ON THE FORM CONSTITUTE THE NUMERATOR, AND '1' IS BOTH NUM. & DENOM.

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Terminology

- Fingerprint** – Impression of a finger
- Minutiae** – Ridge bifurcations, endings and many other features (52 types listed, 7 are usually used by human experts and two by automated systems)
- Core** – uppermost point on the innermost ridge
- Delta** – separating point between pattern area and non-pattern area
- Feature Levels**

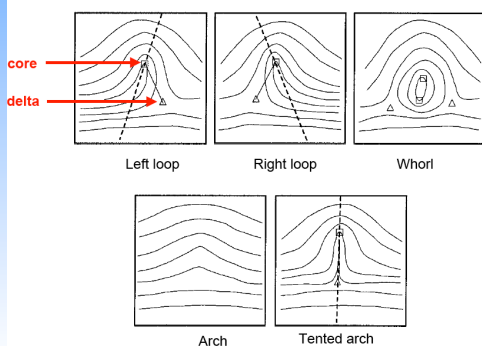
Level 1: pattern

Level 2: minutiae points

Level 3: pores and ridge shape

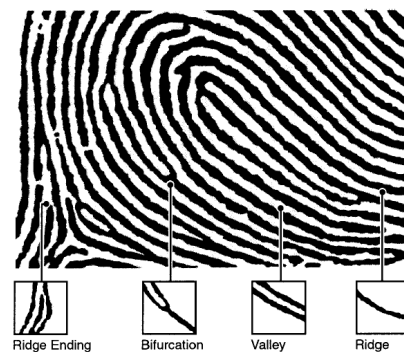
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Level 1 features – singularities (core points)



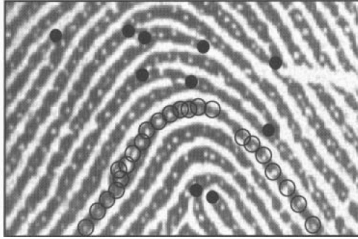
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Minutiae – Level 2 features



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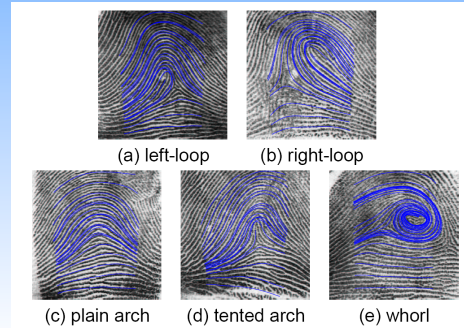
Level 3 features



Sweat pores

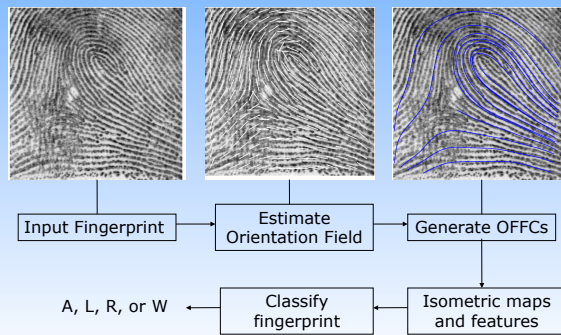
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Orientation Field Flow Curves



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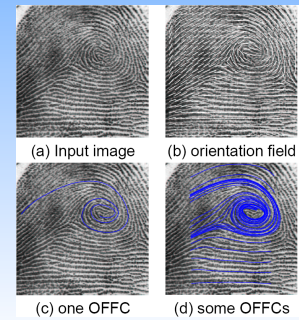
Classification Using Orientation Field Flow Curves



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Orientation Field Flow Curves

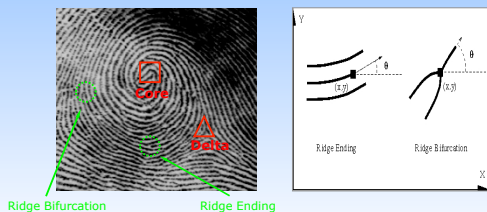
- Study the topology of the curves formed by ridges
- OFFC is a curve inside a fingerprint image whose tangent direction is parallel to the direction of the orientation field
- Starting points of OFFCs are chosen along the vertical and horizontal lines passing through the midsection of the image



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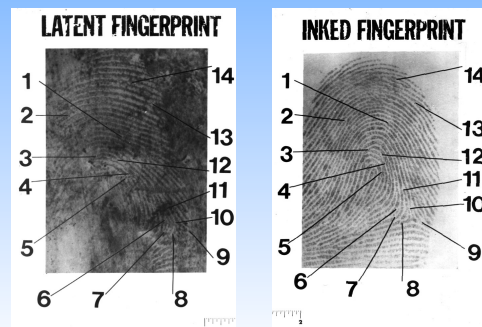
Fingerprint Representation

- Local ridge characteristics (**minutiae**): ridge ending and ridge bifurcation
- Singular points: Discontinuity in ridge orientation



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Minutiae-based Representation



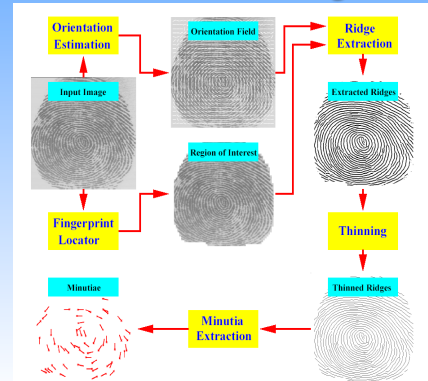
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Steps in Minutiae Extraction

- Orientation field estimation
- Fingerprint area location
- Ridge extraction
- Thinning
- Minutia extraction

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Minutiae Extraction Algorithm



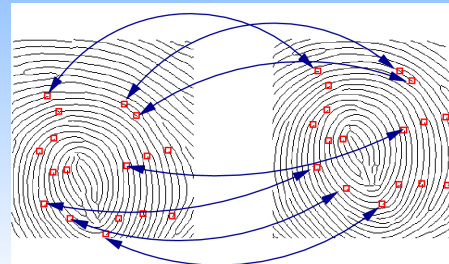
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Minutiae Type Detection

- A ridge pixel is a ridge ending, if the number of ridge pixels in the 8-neighborhood is 1
- A ridge pixel is a ridge bifurcation, if the number of ridge pixels in the 8-neighborhood is greater than or equal to 3
- A ridge pixel is a intermediate ridge pixel, if the number of ridge pixels in the 8-neighborhood is 2
- $[x, y, \theta, \text{associated ridge}]$ are stored for each minutia

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Minutiae Correspondences



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