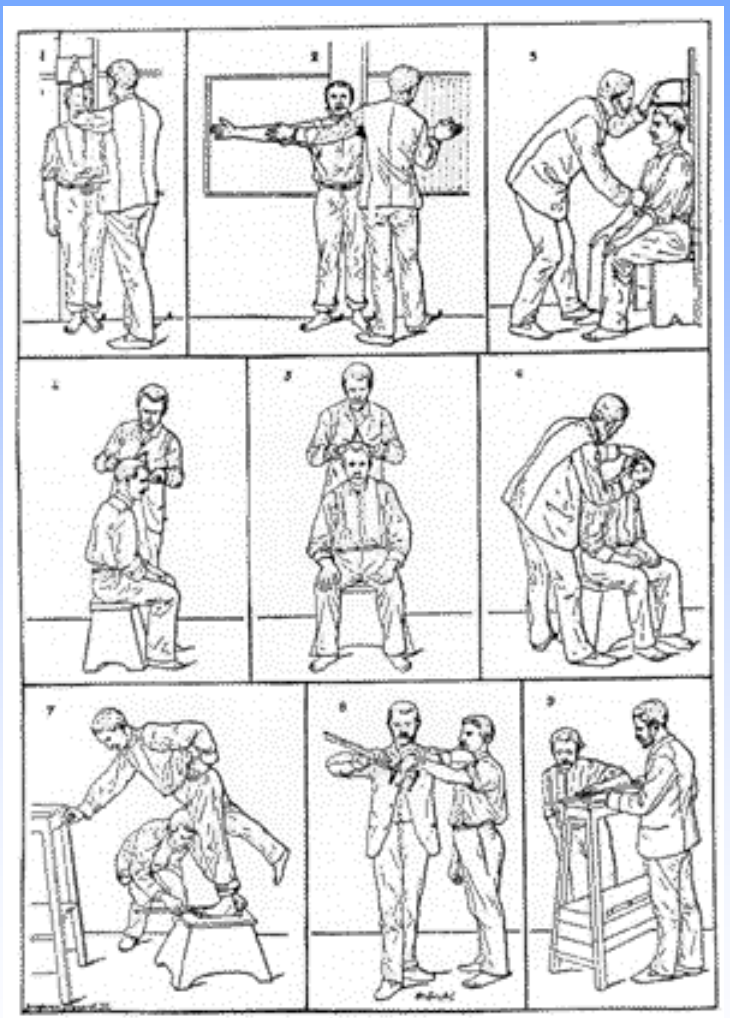
Anthropometry

M. Bertillon conjectured that the measurements of certain bony portions of the human frame do not vary during the period between adolescence and extreme old age. He selected head length, head breadth, middle finger length, foot length and cubit. He quantized these measurements into three classes: small, medium, and large resulting in 243 bins.

Each primary heading is successively subdivided according to height, span, length and breadth of the ear, height of the bust, and eye color, this latter providing 7 divisions. So the total number of bins is $3^{10} \times 7$

Bertillon System



http://www.tld.jcu.edu.au/hist/stats/bert/

The Bertillon system (1882) entailed photographing the subject looking directly at the camera, then in profile, with the camera centered upon the right ear. Besides the two photographs, the subject's height was recorded, together with the length of one foot, an arm and index finger.

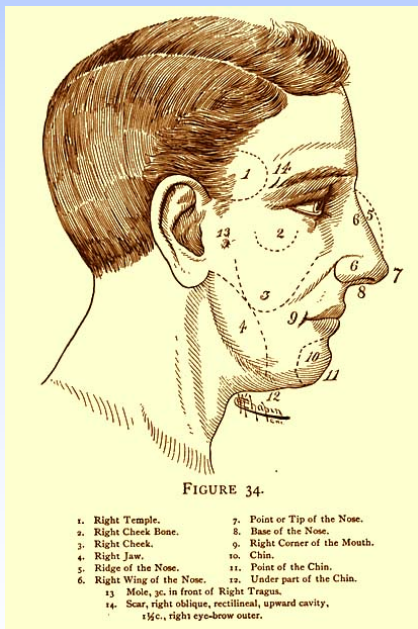
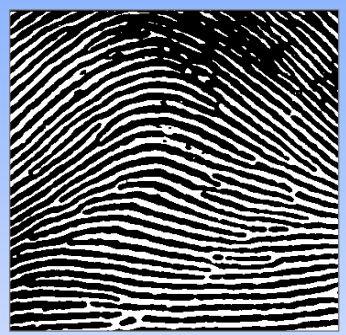


FIGURE 34.

1. Right Temple.
2. Right Cheek Bone.
3. Right Cheek.
4. Right Jaw.
5. Ridge of the Nose.
6. Right Wing of the Nose.
7. Point or Tip of the Nose.
8. Base of the Nose.
9. Right Corner of the Mouth.
10. Chin.
11. Point of the Chin.
12. Under part of the Chin.
13. Mole, 3c. in front of Right Tragus.
14. Scar, right oblique, rectilineal, upward cavity, 1½c., right eye-brow outer.

Fingerprint Classification

- Assign fingerprints into one of pre-specified types


Plain Arch


Tented Arch


Right Loop


Left Loop


Accidental


Pocket Whorl


Plain Whorl


Double Loop

Fingerprint Classification

- Classify fingerprints for binning/indexing
- Goal: 99% classification accuracy with 20% reject rate
- Even experts cannot always do correct classification
- Natural frequencies of W, L, R and A (A + T) are 27.9%, 33.8%, 31.7% and 6.6%

THE HENRY SYSTEM

- DIVIDES ALL FINGERPRINT FORMS INTO 1,024 BUNDLES.

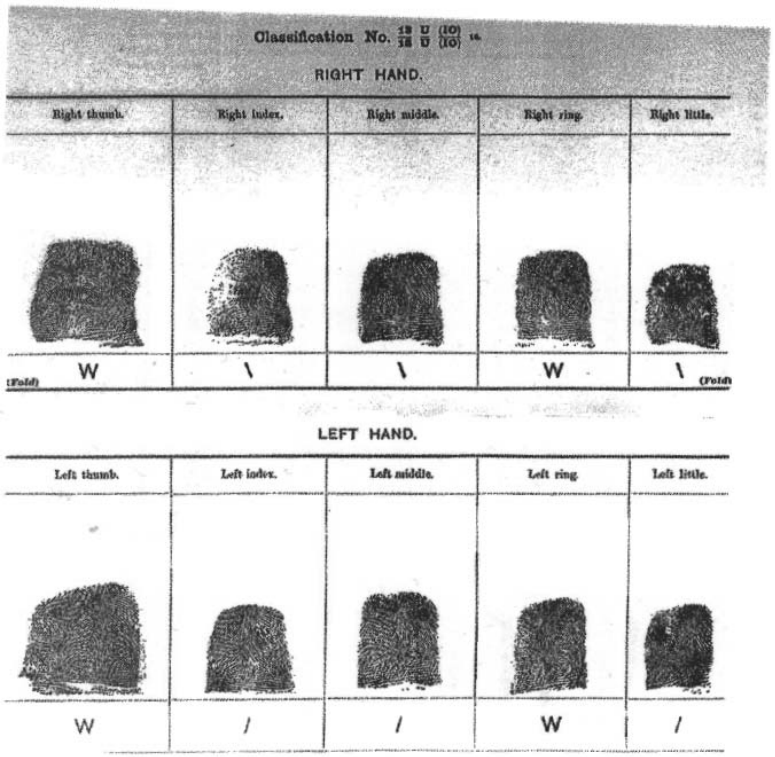


Figure 1: A Fingerprint Slip with Henry Code

1	2	3	4	5
RT 16	RF 16	RM 8	RR 8	RL 4
LT 4	LF 2	LM 2	LR 1	LL 1
6	7	8	9	10

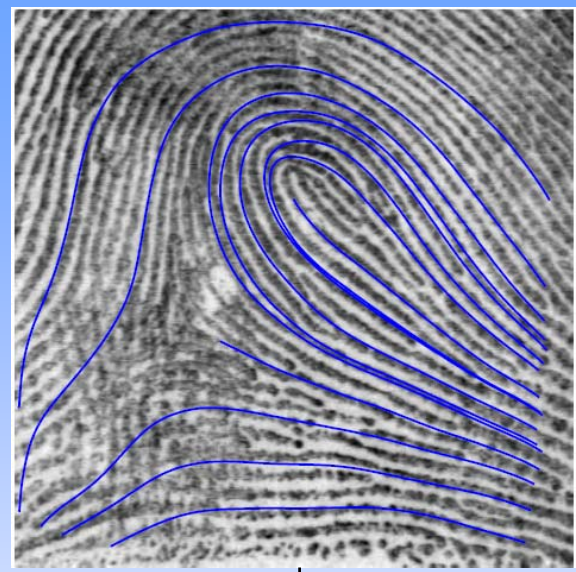
1

W	W			W
	W	W	W	

$= \frac{19}{24}$

- WHORL PATTERNS ONLY HAVE VALUES.
- EVEN NUMBERS ON THE FORM CONSTITUTE THE NUMERATOR, ODD NUMBERS PROVIDE THE DENOMINATOR. ADD '1' TO BOTH NUM. & DENOM.

Classification Using Orientation Field Flow Curves



Input Fingerprint

Estimate Orientation Field

Generate OFFCs

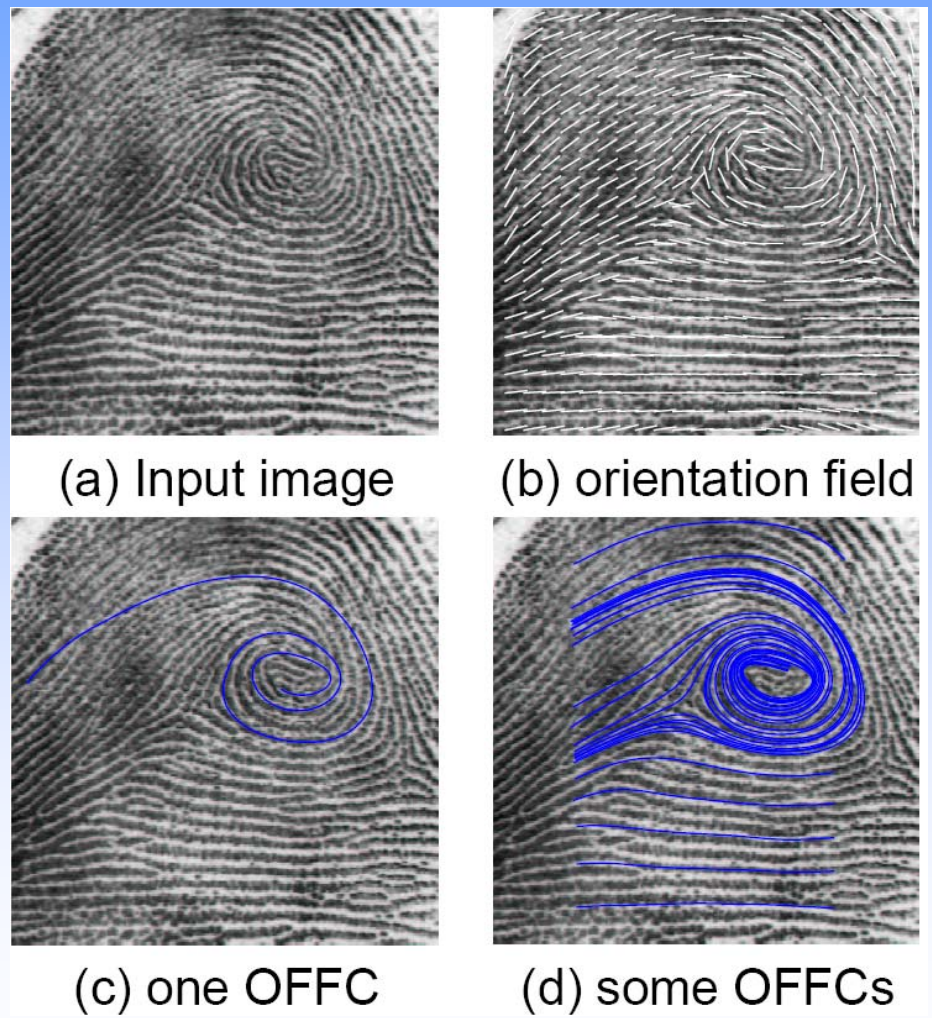
Isometric maps and features

Classify fingerprint

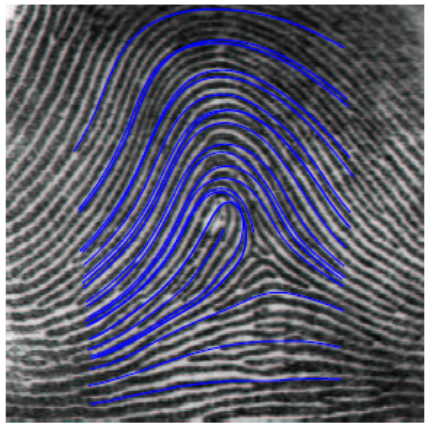
A, L, R, or W

Orientation Field Flow Curves

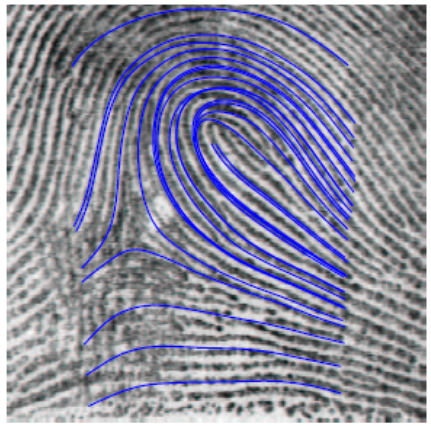
- Study the topology of the curves formed by ridges
- OFFC is a curve inside a fingerprint image whose tangent direction is parallel to the direction of the orientation field
- Starting points of OFFCs are chosen along the vertical and horizontal lines passing through the midsection of the image



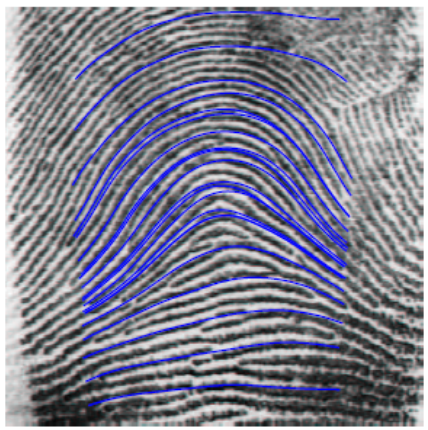
Orientation Field Flow Curves



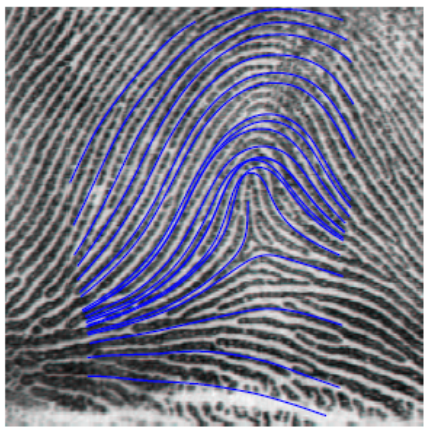
(a) left-loop



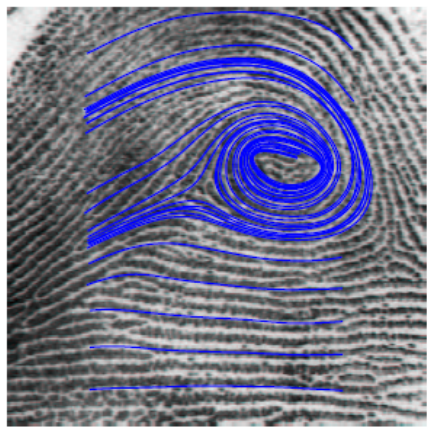
(b) right-loop



(c) plain arch



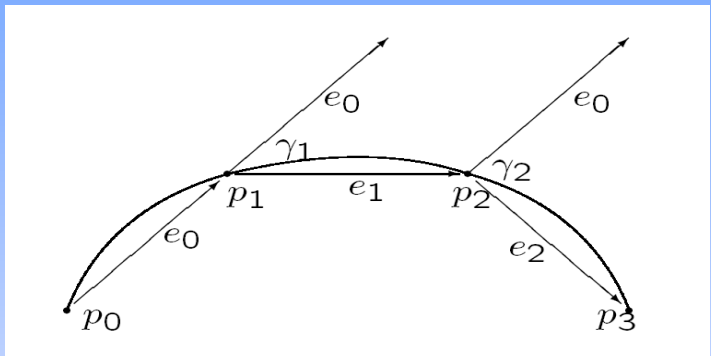
(d) tented arch



(e) whorl

Isometric Maps

• Geometric characteristics of OFFCs are captured by the changes occurring in the tangent space as we traverse along OFFC

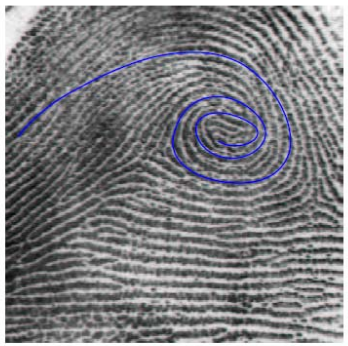


1. Let $p_j = (x_j; y_j)$, $j = 0, 1, 2, \ldots, N$ be equidistant points (at a distance δ) on the OFFC
2. Approximate the tangent vector at p_j by the chord vector:

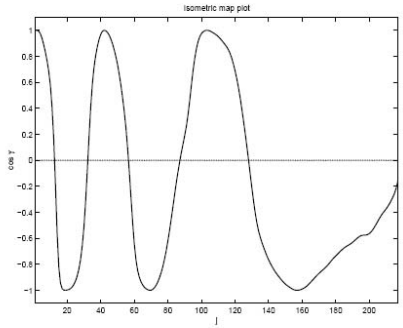
$$V_{p_j} \equiv \frac{1}{\delta}(x_{j+1} - x_j\,,\, y_{j+1} - y_j)^T$$

The unit vector is $e_j = V_{pj}/||V_{pj}||$. Obtain the isometric maps in terms of rotation angles γ_j with $\cos \gamma_j = e_0 \bullet e_j$, where $\bullet$ is the Euclidean inner product on R^2

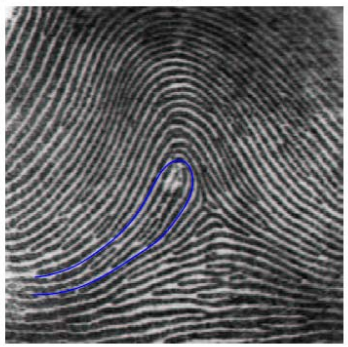
Isometric Maps



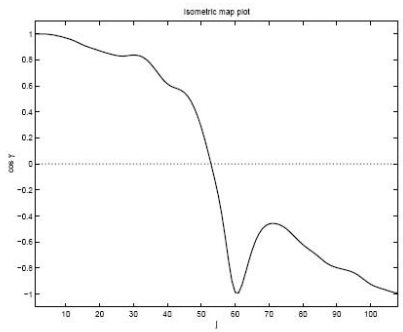
(a) curve type: whorl



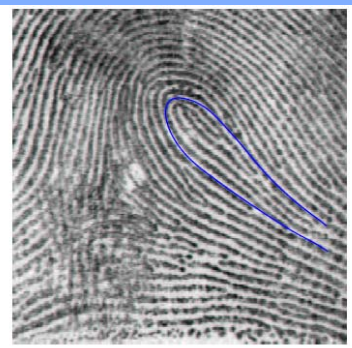
(b) isometric map



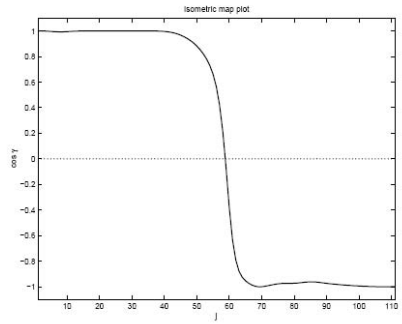
(c) curve type: left-loop



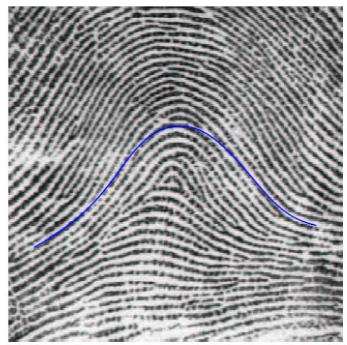
(d) isometric map



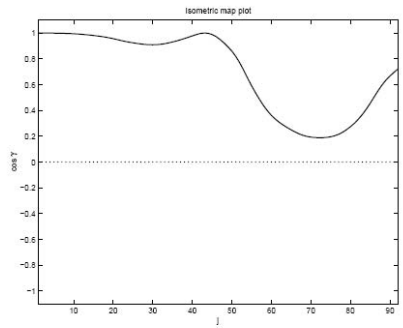
(a) curve type: right-loop



(b) isometric map



(c) curve type: arch



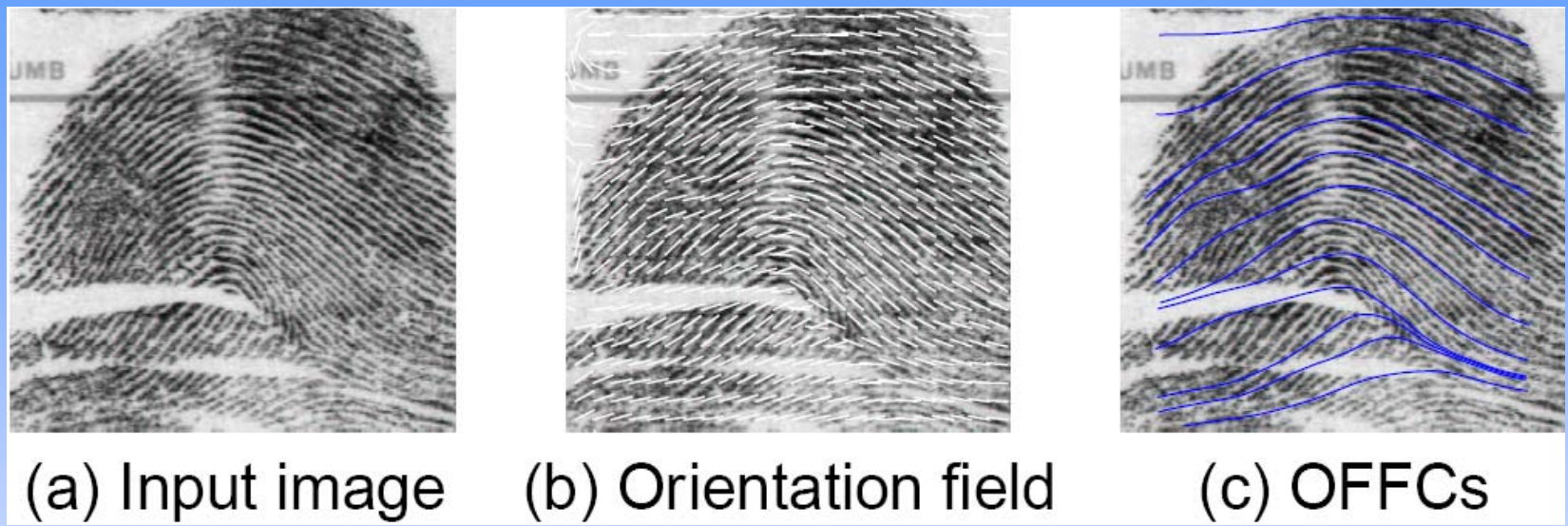
(b) isometric map

Classification Results

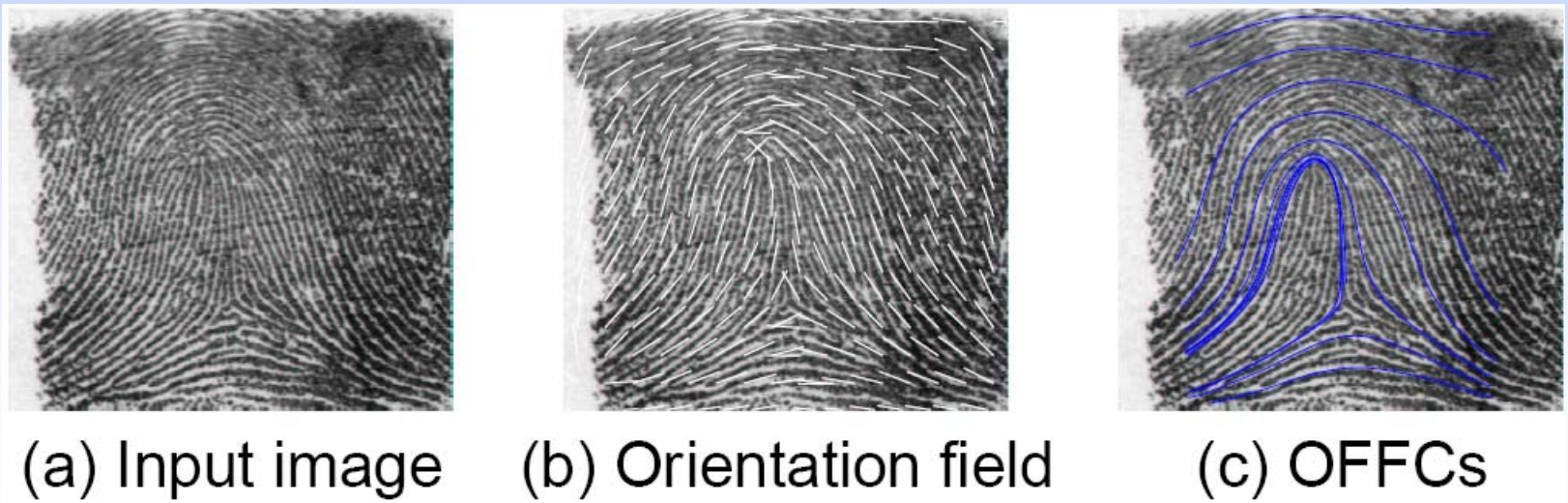
- No. of sign-change points, values of the local max/min between sign-change points are potential features
- NIST 4 database containing 2,000 fingerprint image pairs
- 800 fingerprints from each of the 5 classes: W, L, R, A and T
- Classification accuracy into 4 classes: 94.4%.

True/Assigned	A	L	R	W	Accuracy (%)
A	797	2	1	0	99.62
T	781	19	0	0	97.62
L	63	730	1	6	91.25
R	75	4	720	1	90.00
W	12	23	18	747	93.34

Classification Errors



Oversmoothing of orientation field: True class: L; Assigned class: A



Detection of spurious loops: True class: A; Assigned class: L