Biometric Systems
Lesson 11: Fingerprints

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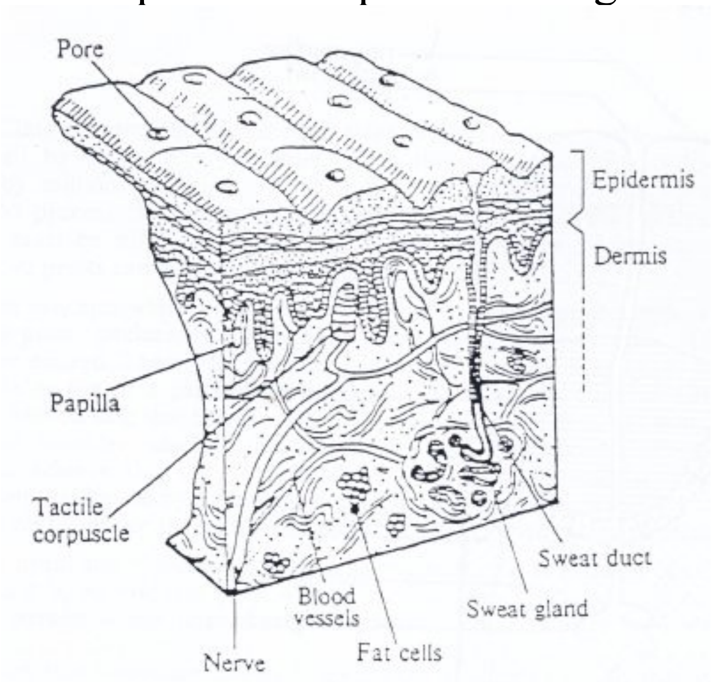
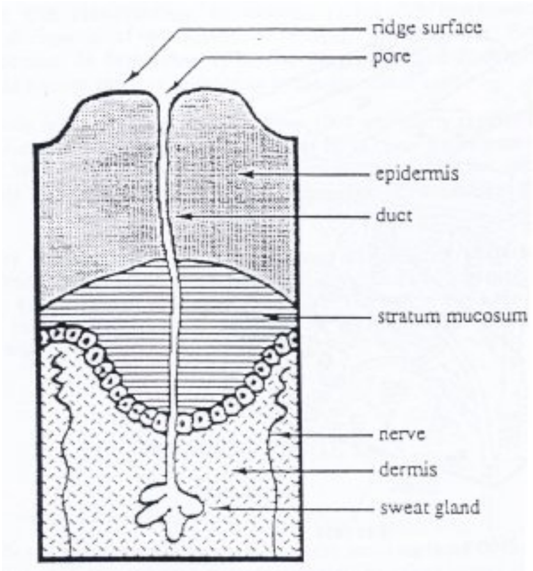
Credits

- This lesson contains some material from a lesson by Dr. Stefano Ricciardi of University of Salerno – BIPLAB and from course of Sistemi Biometrici by Franco – Maio (Univerisity of Bologna)

Fingerprints

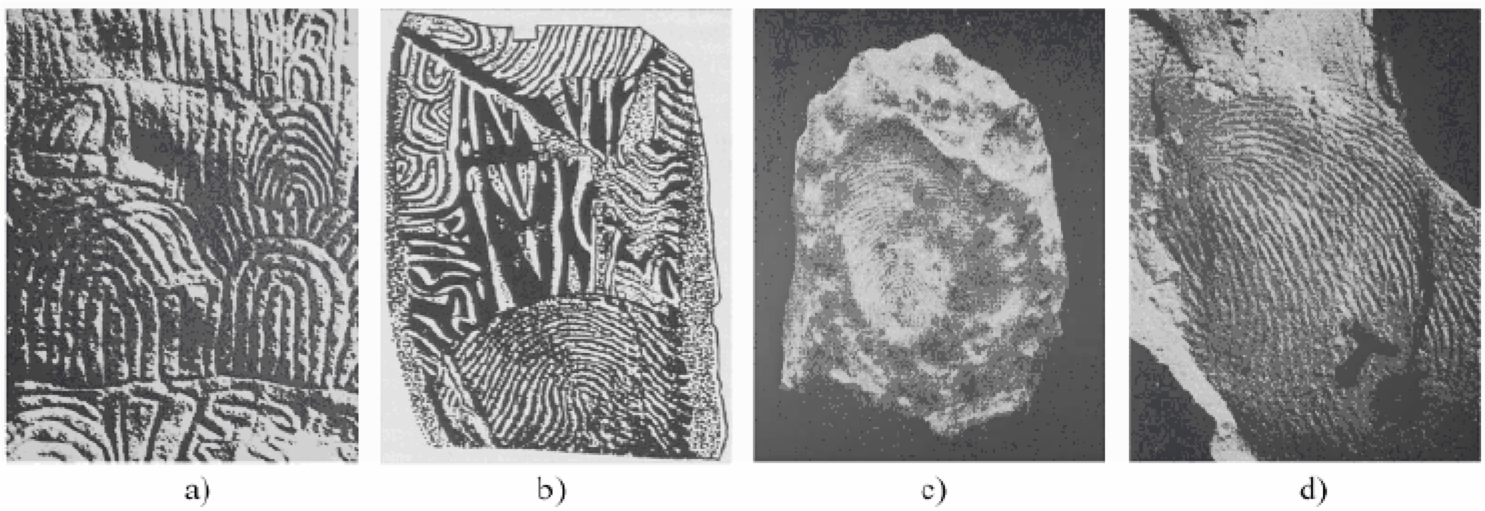
- A fingerprint usually appears as a series of dark lines that represent the high, peaking portion of the friction ridge skin, while the valleys between these ridges appears as white space and are the low, shallow portion of the friction ridge skin.
- Fingerprints are the traces of an impression from the friction ridges of any part of a human or other primate hand or foot.
- Fingerprints are easily deposited on suitable surfaces (such as glass or metal or polished stone) by the natural secretions of sweat from the eccrine glands that are present in epidermal ridges.





Fingerprint history at a glance

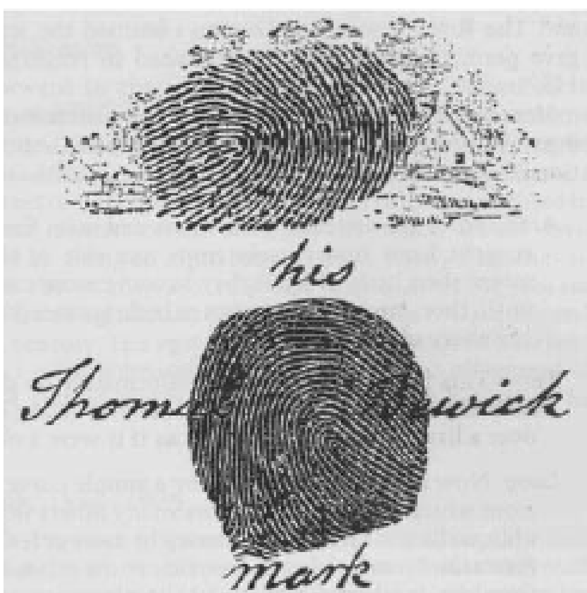
- Many traces of artifacts and historical objects clearly show that many ancient civilizations were aware of the peculiar character of fingerprints even if not of their individuality, for which no scientific argument was available.

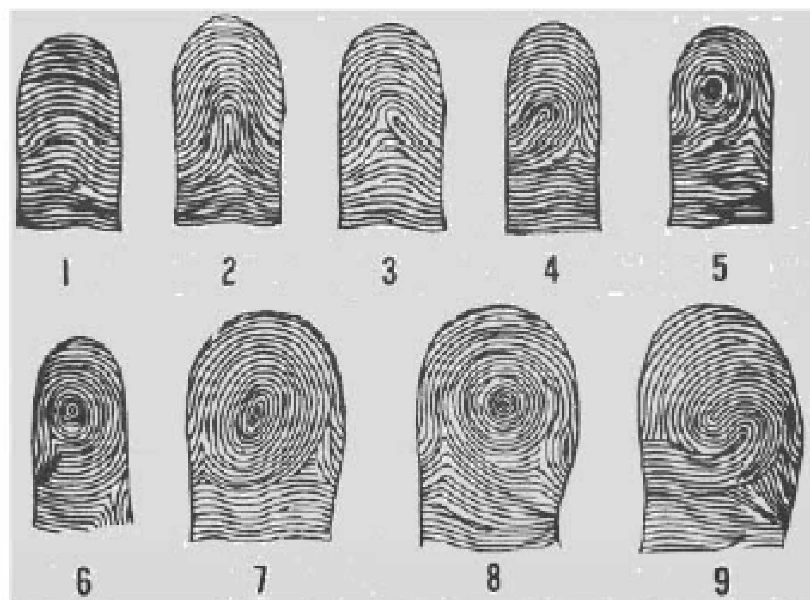


a) Neolithic sculpture with fingerprints; b) engraved monolith (menhir) dated 2000 B.C. .; c) Chinese wax seal 300 B.C..; d) impression of Palestinian lamp dating back to 400 A.D.

Fingerprint history at a glance

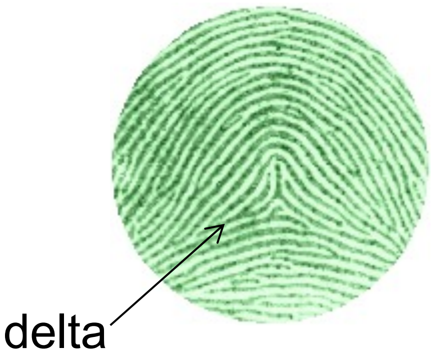
- In 1809 Thomas Bewick began using his fingerprint as hallmark.
- In 1823 Purkinje proposed the first classification of fingerprints based on nine categories, corresponding to several configurations of the ridges.





Fingerprint history at a glance

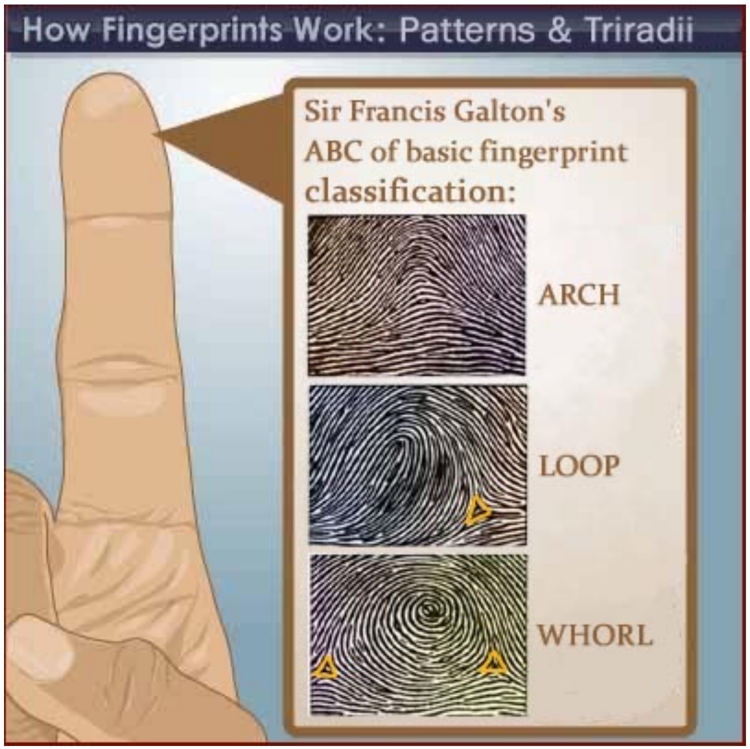
- Sir Francis Galton (1822-1911), an English polymath and anthropologist, published a detailed statistical model of fingerprint analysis and identification and encouraged its use in forensic science in his book 'Finger Prints'.
- Galton was the first who defined the three basic fingerprint types in terms of the number of 'deltas' - discriminating whorls (2 deltas) from: loops (1 delta), and arches (no deltas).



PLAIN ARCH

LOOP

PLAIN WHORL



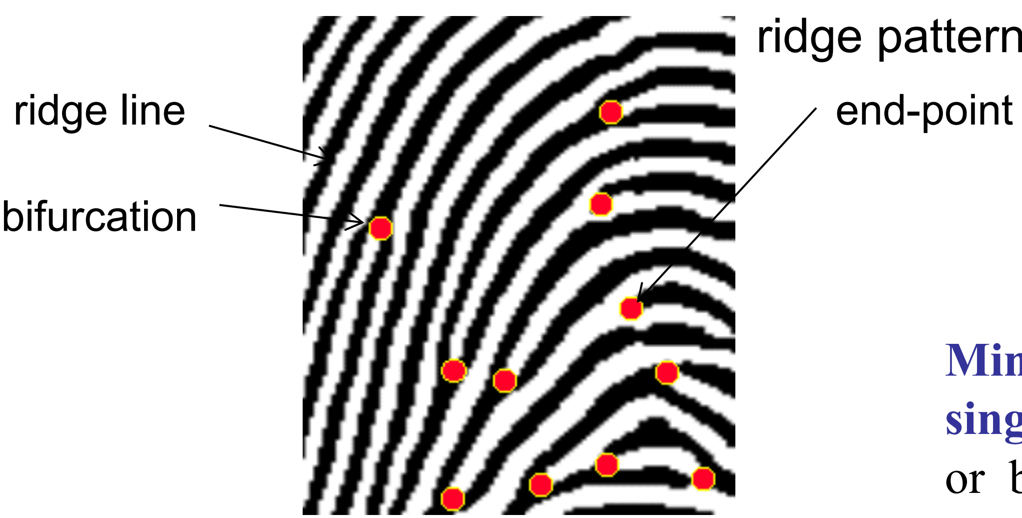
MACRO-SINGULARITIES

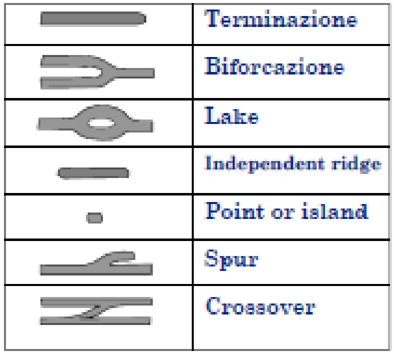
Fingerprint history at a glance

- Actually, Galton was primarily interested in using fingerprints as a support to the study of racial heritage.

- In the book published in 1892 “Finger prints” he introduced the concept of minutia and suggested the first simple classification system, based on grouping patterns in arches, loops e whorls.

- Galton soon discovered that fingerprints had no usefulness in determining the genetic history of a subject, but proved their uniqueness and persistence.





Minutiae, or Galton features, are **micro-singularities** determined by the end-points or bifurcations of ridge lines

Minutiae


crossover
core
bifurcation
ridge ending
island
delta
pore

Fingerprint history at a glance

- Dr. Harold Cummins (1894-1976) achieved world recognition as the "Father of Dermatoglyphics" or the scientific study of skin ridge patterns found on the palms of human hands.
- The findings of his lifetime studies and the techniques he developed, known as the Cummins Methodology, are accepted as important tools in tracing genetic and evolutionary relationships. The methodology has gained common usage in diagnosis of some types of mental retardation, schizophrenia, cleft palate and even heart disease.
- In the book *'Finger Prints, Palms and Soles'* (1943) he e.g. presented a 'family tree' of 39 fingerprint types

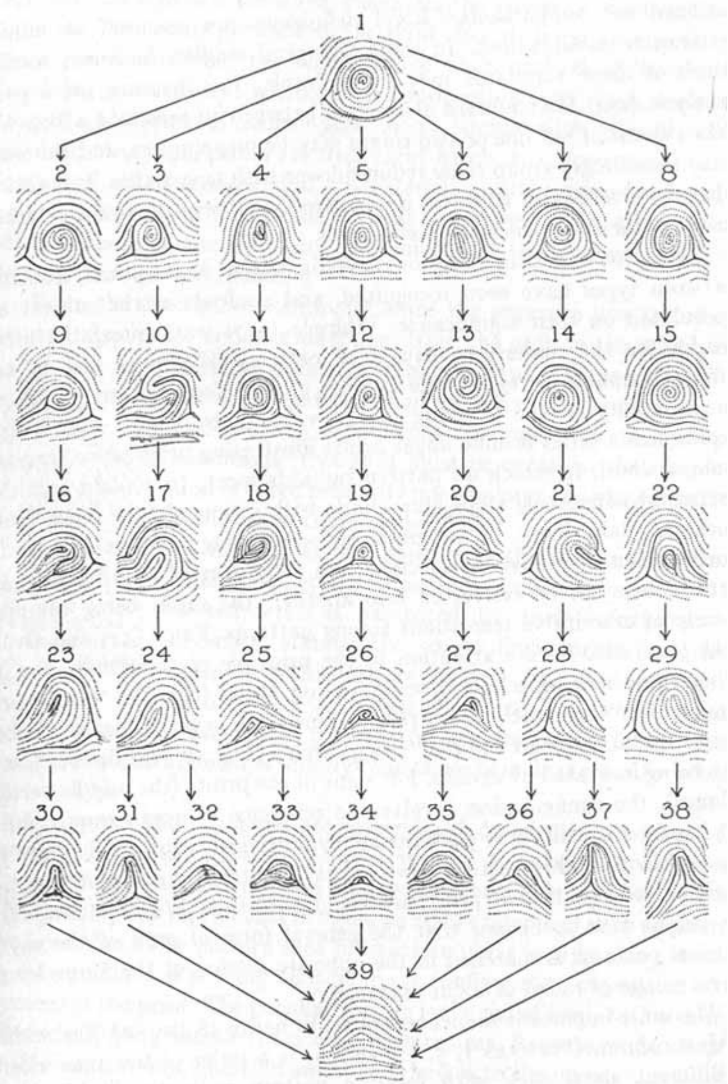
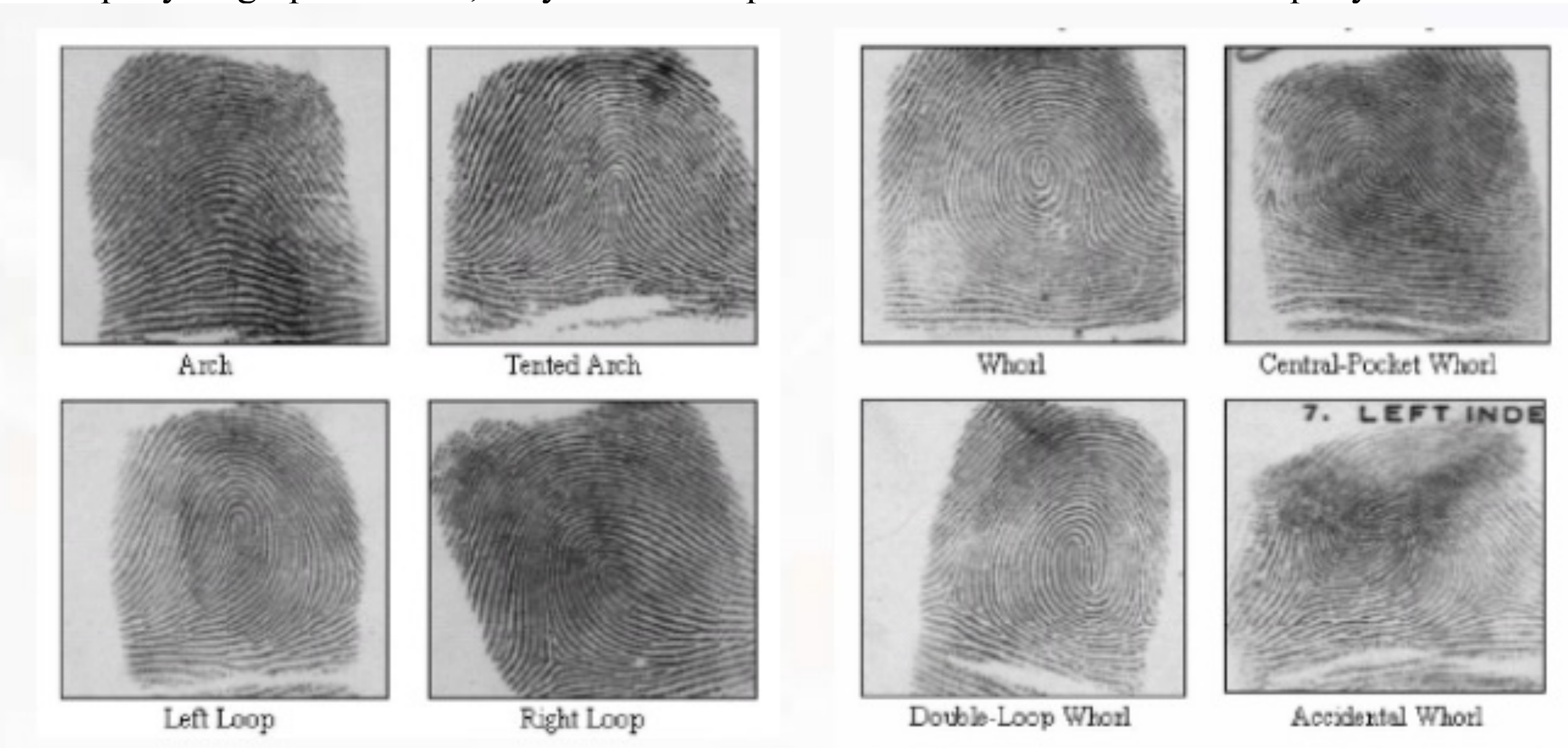


FIG. 48.—A "family tree" of finger-print types. (*Modified from Mairs.*)

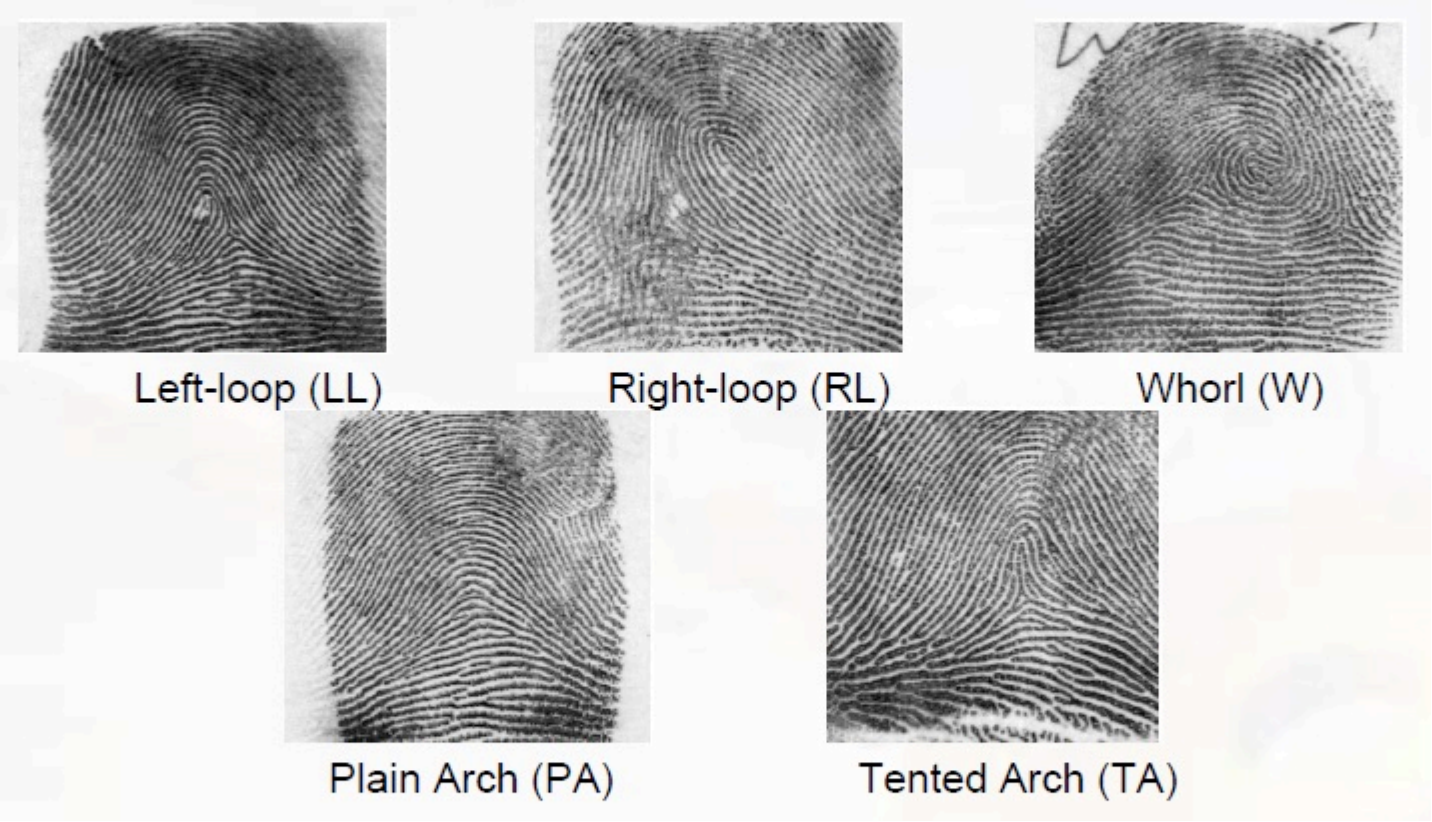
Fingerprint history at a glance

- In 1899, Edward Henry proposed a classification system that takes the name of Henry System.
- Fingerprint classification is a coarse level partitioning of a fingerprint database into smaller subsets. It reduces the search space of a large database: Determine the class of the query fingerprint. Then, only search templates with the same class as the query.



Fingerprint history at a glance

- The four different whorl classes can be combined into one class: Whorl (W).



- The five classes can be reduced to four by combining the PA and TA classes to form the Arch (A) class. The natural frequencies of W, L, R and A (A + T) are 27.9%, 33.8%, 31.7% and 6.6%.

Fingerprint history at a glance

- With the advent of the twentieth century also the formation of fingerprints was understood in its biological principles:
  - ridges and furrows in the individual have different characteristics for various fingertips;
  - the types of configurations vary from individual to individual, but still always within limits that allow a systematic classification;
  - configurations and minute details of the ridges and furrows on the fingertips of a individual are permanent and not subject to change over time.

Fingerprint history at a glance

- In 1924 the FBI already had a database including approximately 810,000 complete fingerprints (10 fingers) transferred on paper by ink.

- Since then the pace of upgrade grew rapidly and brought the total to exceed abundantly 200 million registered profiles, making it virtually impossible to identify a set of fingerprints with manual methods.

- Since the 60s some of the most important world police began to invest financial and human resources in developing systems for the recognition of fingerprints (Automated Fingerprint Identification System - AFIS).

AFIS

- The designers of the first AFIS exploited the observation of the work done by the experts of fingerprints recognition.
- Remind that fingerprint acquisition was made by ink prints.
- It was necessary to identify and address issues such as:
  - the fingerprint capture with digital techniques
  - extraction of local characteristics of the ridges and of the furrows
  - devise a robust comparison between new acquisitions and the registered profiles .

  Today the AFIS are used by the police all over the world, resulting in advantages regarding both the high efficiency in the identification of criminals and the saving of highly specialized personnel.

Fingerprint formation

- The formation of fingerprints is already complete in the seventh month of the fetal development, and the configuration of the ridges on each finger is constant during the entire life cycle.
- Fingerprint ridges are formed according to a growth mode common to that of the capillary or blood vessels during angiogenesis.
- Relevant factors that influence the microenvironment surrounding the fetus are the flow of the amniotic fluid and the position during the process of differentiation.
- The microdiversity of the environmental conditions in the immediate vicinity of each fingertip characterizes the formation of the most minute details of their surface.

Uniqueness of fingerprints

- Each small microenvironmental difference is amplified by the process of cell differentiation, and there are so many changes during the formation of fingerprints to make each of them practically unique (this property is the result of empirical observations).
- As the starting point of the differentiation process is the same for each footprint as determined by the same genes, the resulting patterns are not totally random.
- In the case of identical twins, the minute details of the fingerprints are different, but most of the studies showed significant similarities in the classification of configurations relative to other general attributes (number, width, separation and depth of the ridges).

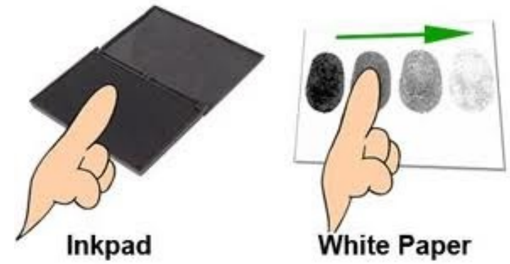
Uniqueness of fingerprints

- The maximum difference between the fingerprints is to be found among individuals belonging to different races.

- They are followed in order of decreasing footprints diversity by:
  - persons of the same race but without any kinship,
  - father and son (who share half their genes),
  - brothers and / or sisters,
  - twins.

Fingerprint acquisition

- There are two basic modes of fingerprint capturing notes as off-line and live-scan.
- The off-line acquisition takes place in two stages,
  - the fingertips are first passed on an ink pad and then transfer the image of the fingerprint through pressure on paper
  - a subsequent digitalization of the impression on paper through optical scanning or high resolution camera concludes the process of acquisition.



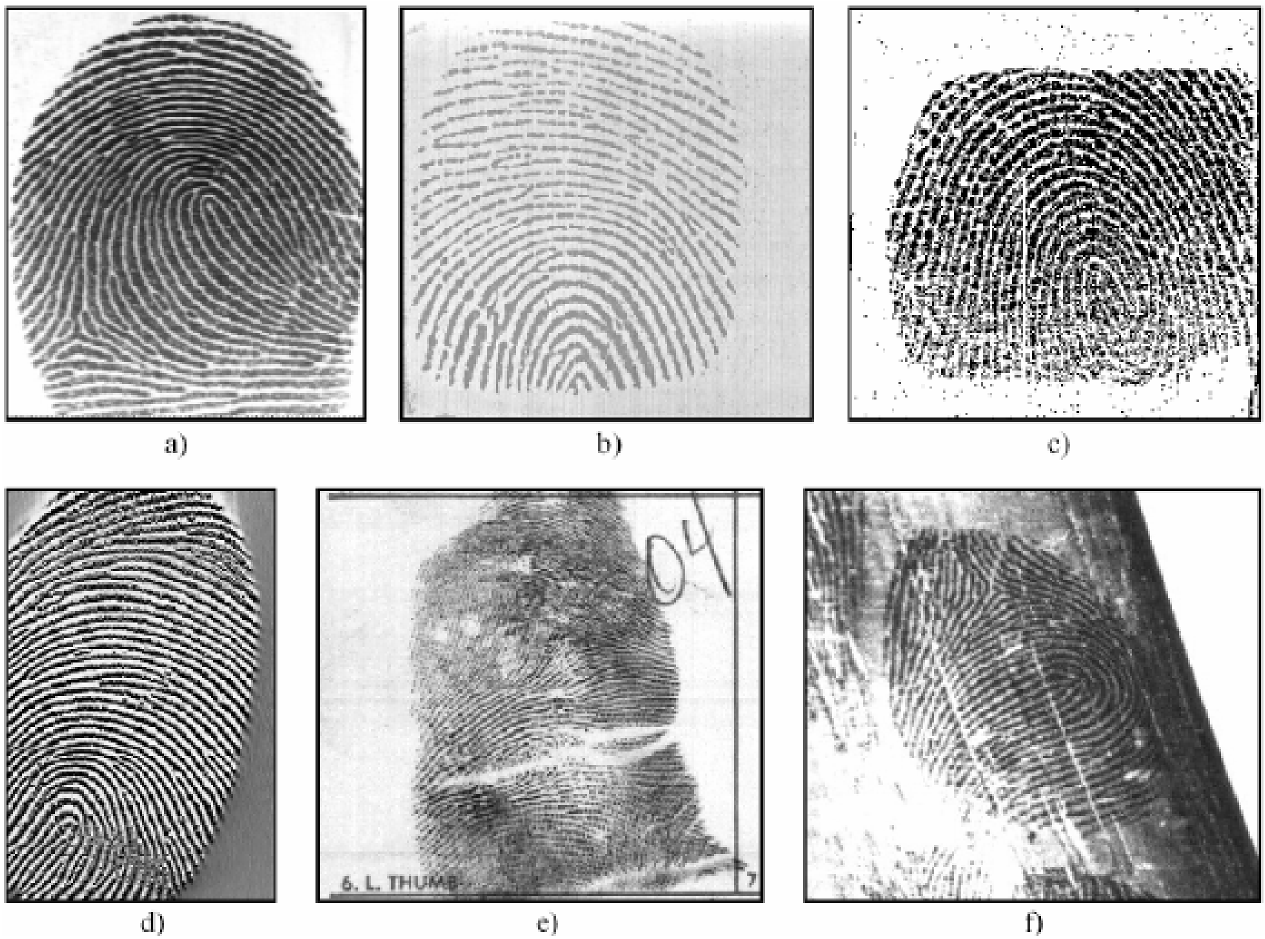
- In the live-scan, the digital image of the fingerprint is acquired directly through contact of the fingertip with a special sensor.

- The so-called latent fingerprints, usually found at the scene of crime, belong to the off-line category and are produced due to the oily nature of the skin that leaves on the surface touched by the fingers a track detectable successively with special chemical reagents.

Fingerprint digitalization

- The main parameters that characterize the digital image of the fingerprints are:
- the resolution
  - the number of dots per inch (dpi). 500 dpi is the minimum resolution of FBI-compliant scanners; the minimum resolution for the extraction of minutiae is about 200-300 dpi.
- the area of acquisition
  - an area greater than or equal to a square of 1×1 inch (according to the FBI specifications) allows the acquisition of an entire clear fingerprint
- the depth
  - number of bits used to encode the value intensity of each pixel
- contrast
  - a sharp image contains better details
- geometric distortion
  - the maximum distortion introduced by the device

Fingerprint digitalization



Fingerprint images produced by: a) optical scanner live-scan; b) capacitive scanner live-scan; c) piezoelectric scanner live-scan; d) thermal scanner live-scan; e) impression through ink off-line; f) latent fingerprint.

Types of scanners

Optical scanner

An optical sensor.

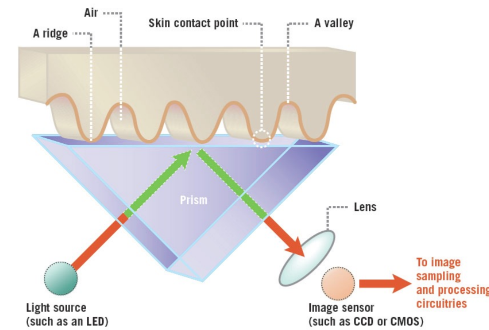
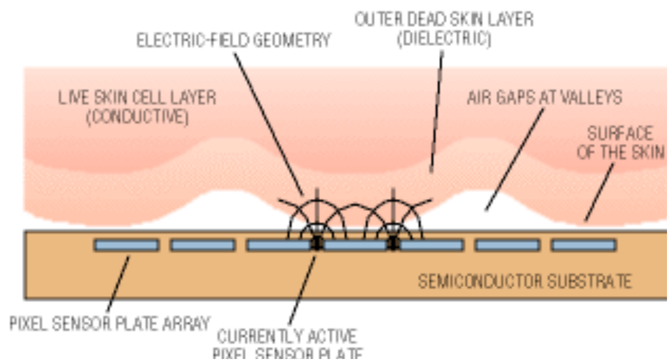
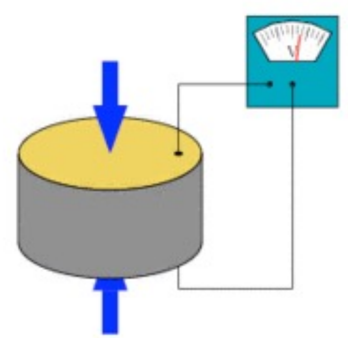


Figure 2

Capacitive scanner (array of *capacitive* proximity sensors) with silicon sensors



A piezoelectric sensor uses the piezoelectric effect, to measure changes in pressure, acceleration, strain or force by converting them to an electrical charge. The prefix piezo- is Greek for 'press' or 'squeeze'.



A piezoelectric disk generates a voltage when deformed

Types of scanners

Optical scanners

Advantages

- They can withstand, to some degree temperature fluctuations.
- They are fairly inexpensive.
- They can provide resolutions up to 500 dpi.

Disadvantages

- Size, the sensing plate must be of sufficient size to achieve a quality image
- Residual prints from previous users can cause image degradation, as severe latent prints can cause two sets of prints to be superimposed.
- The coating and CCD arrays can wear with age, reducing accuracy.
- A large number of vendors of fingerprint sensing equipment are gradually shifting towards silicon-based technology.

From: http://www.slideshare.net/VishwasJangra/zzzzzz-23140965

Types of scanners

Capacitive scanners

Advantages

- The Silicon chip comprises of about 200*200 lines on a wafer the size of 1cm*1.5cm, thus providing a pretty good resolution for the image.
- Hence, Silicon generally produces better image quality, with less surface area, than optical.
- Also, the reduced size of the chip means lower costs.
- Miniaturization of Silicon chips also makes it possible for the chips to be integrated into numerous devices.

Disadvantages

- In spite of claims by manufacturers that Silicon is much more durable than optical, Silicon's durability, especially in sub-optimal conditions, has yet to be proven.
- Also, with the reduction in sensor size, it is even more important to ensure that enrolment and verification are done carefully.

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Types of scanners

Thermal scanners

Advantages

- A strong immunity to electrostatic discharge
- Thermal imaging functions as well in extreme temperature conditions as at room temperature.
- It is almost impossible to **deceive** with artificial fingertips.

Disadvantages

- A disadvantage of the thermal technique is that the image disappears quickly.
- When a finger is placed on the sensor, initially there is a big difference in temperature, and therefore a signal, but after a short period (less than a tenth of a second), the image vanishes because the finger and the pixel array have reached thermal equilibrium.
- However, this can be avoided by using a scanning method where the finger is scanned across the sensor which is the same width as the image to be obtained , but only a few pixels high.

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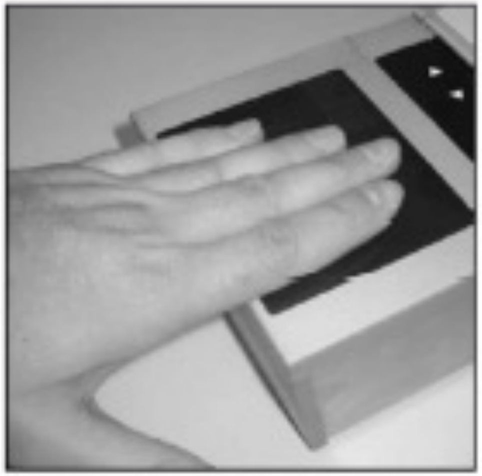
Types of scanners

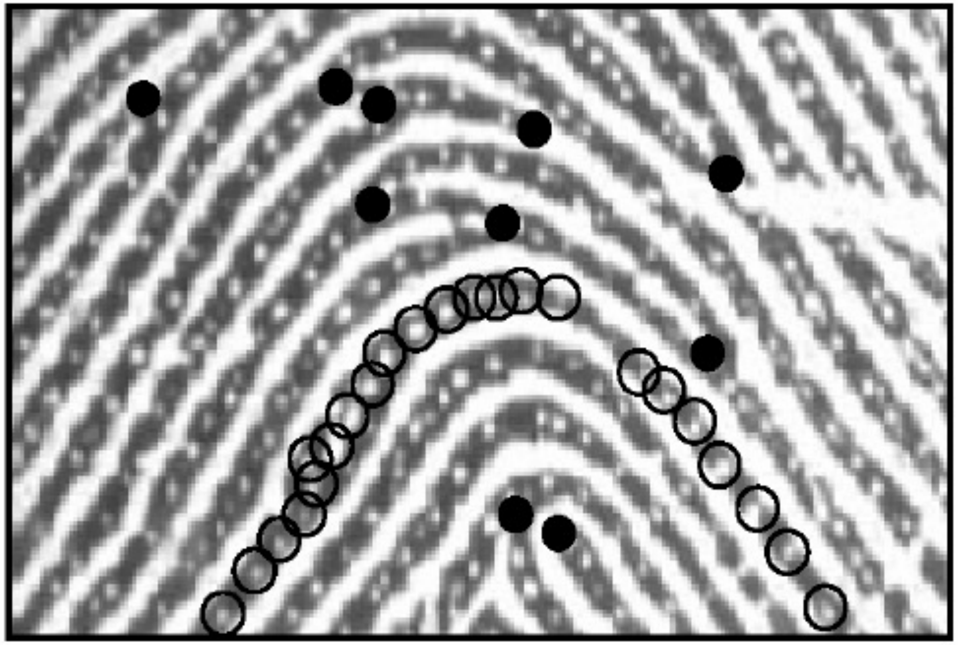
Multi-finger scanners



	Technology	Company	Model	Dpi	Area (h×w)	IAFIS IQS compliant
Optical	FTIR	Crossmatch www.crossmatch.net	L SCAN 1000	1000	3.0"×3.2"	√
	FTIR	L-1 Identity www.l1id.com	TouchPrint 4100	500	3.0"×3.2"	√
	FTIR	Papillon www.papillon.ru	DS-30	500	3.07"×3.38"	√

Beyond minutiae

- At the ultra-fine observation level we can also find details intracreste, which are essentially the skin pores for sweating, whose position and shape are considered extremely distinctive.
- Unfortunately, the extraction of the pores is only possible starting from the fingerprint images acquired at very high resolution, of the order of 1000 dpi, and in ideal conditions, therefore this particular representation is not practical for the majority of application contexts.



Minutiae (blacks filled circles) shown on a portion of the image of a fingerprint.
Position of pores for sweating (unfilled circles blacks) along a single ridge line.

Matching basics

- The experts in the analysis of fingerprints take into account several factors to state that two fingerprints belong to the same individual:
- accord in the configuration of the global pattern, which implies a common typology of the two compared fingerprints;
- qualitative accord, implying that the corresponding minute details are identical;
- quantitative factor that specifies the minimum number of minute details that must match between the two prints (at least 12 according to the US forensic directives);
- correspondence of minute details that must be identically interrelated.

Methodological approaches

- A categorization of classical approaches to fingerprints matching identifies three main classes :
- matching based on **correlation**: the two fingerprint images are superimposed and the computation of correlation between corresponding pixels is iterated for different alignments, which are obtained via roto-translations up to determine the extent of similarity between samples; sensitive to rigid and not linear transformations; high computational complexity
- matching based on **ridge features**: the extraction of minutiae in fingerprint images of low quality is problematic, therefore these methods use other features such as ridges orientation and local frequency, shape of ridges and texture, which are more reliable and easier to extract, but also less distinctive; low discriminating power
- matching based on **minutiae**: the minutiae are first extracted from the two fingerprints and stored as two sets of points in a two dimensional space (possibly annotated with the angle between the tangent and the horizontal plane), and then the methods search for the alignment between the two sets that maximizes the number of corresponding pairs of minutiae, and based on this measure the similarity between the fingerprints (point pattern matching)

Problems with fingerprint matching

Scarce overlap

Different skin conditions

Non-linear distortion

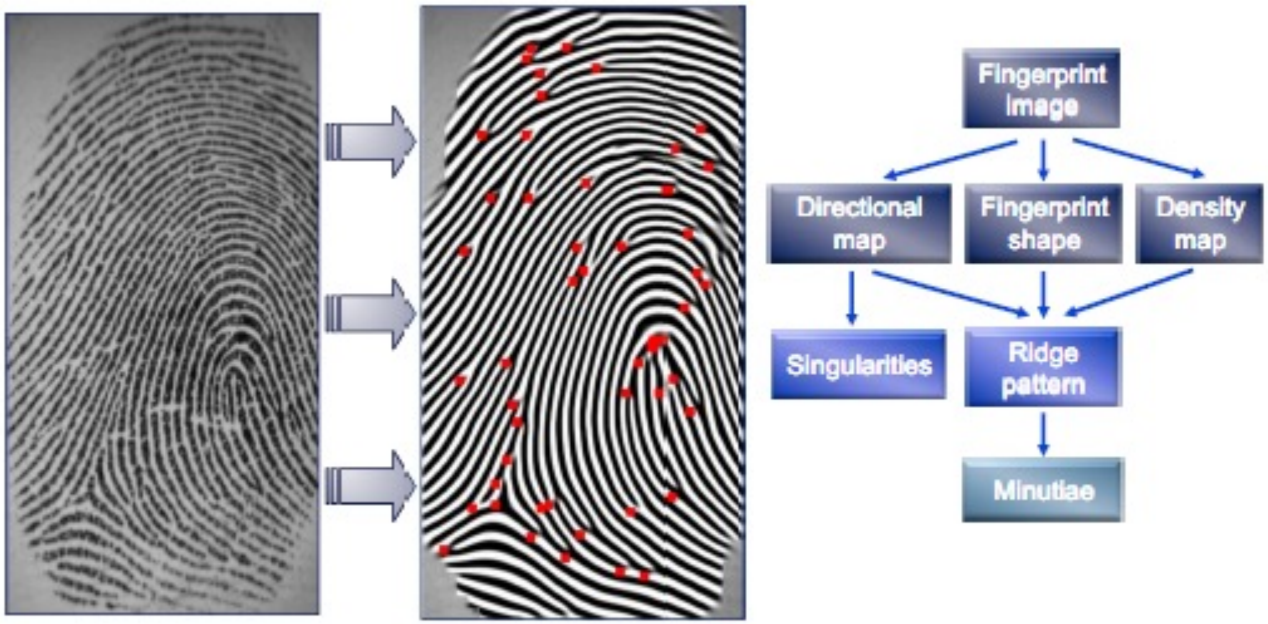
From course content by Franco – Maio
(Univerisity of Bologna)

Problems with fingerprint matching

- Too much movement and / or distortion
  - Little overlap between the template and the imprint in input. This problem is particularly relevant for sensors with small area of acquisition. A displacement of only 2 mm (difficult to detect by the user) determines a shift of about 40 pixels in an imprint acquired at 500 dpi.
- Non-linear distortion of the skin
  - The acquisition of a fingerprint entails mapping a three-dimensional shape onto the two-dimensional surface of the sensor. In this way a non-linear distortions is produced, due to the elasticity of the skin, which may vary among subsequent acquisitions of the same footprint.
- Variable Pressure and skin conditions
  - Uneven pressure of the finger on the sensor, fingerprint too dry or wet, skin diseases, dirt on the sensor, moisture in the air
- Errors in the extraction of the features
  - Feature extraction algorithms are imperfect and often introduce measure errors, particularly with footprints of low quality.

From course content by Franco – Maio (Univerisity of Bologna)

Steps for feature extraction



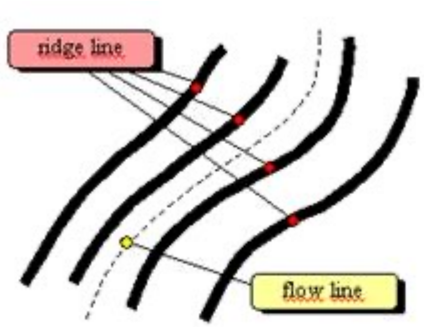
Segmentation

- The term in this case indicated the separation between the foreground fingerprtint (striped and oriented pattern - anisotropic) from the backgound which is isotropic.
- Anisotropy = the property of being directionally dependent, as opposed to isotropy, which implies identical properties in all directions. It can be defined as a difference, when measured along different axes, in a material's physical or mechanical properties (absorbance, refractive index, conductivity, tensile strength, etc.)

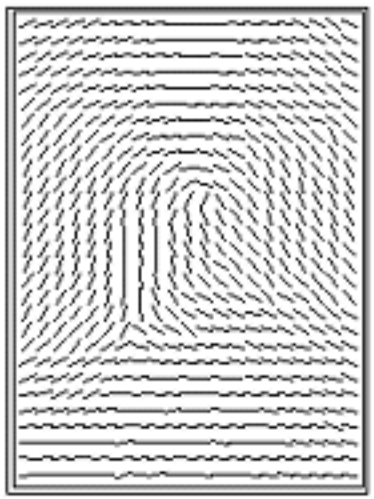
Measures of anisotropy

- Presence of a peak in a histogram of the local orientations (Mehtre et al., 1987)
  - The orientation of the ridge line is estimated at each pixel and a histogram is calculated for each block 16×16. The presence of a significant peak denotes an oriented pattern, while a "flat" histogram is characteristic of isotropic signal.
- Variance of the gray levels in the direction perpendicular to the gradient (Ratha, Chen, Jain, 1995)
  - In noisy regions the pattern does not depend on the direction, while the fingerprint area is characterized by a very high variance in the direction orthogonal to the ridge orientation and very low along the ridge.
- Magnitude of the gradient (Maio, Maltoni, 1997)
  - Because the area of the fingerprint is rich in edge due to the alternation of ridge and valley, the gradient is high in the foreground and lower elsewhere.
- Combination of several characteristics (Bazen, Gerez, 2001)
  - For each pixel we calculate some characteristics (consistency of the gradient, and average and variance of the intensity), and the allocation to foreground / background is operated by a classifier.

Macro-features from ridges



Fingerprint



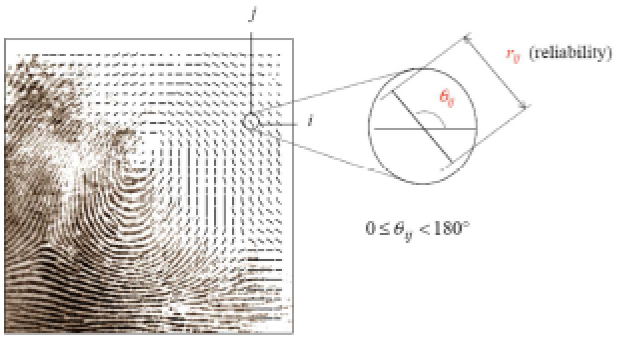
Directional Image

Density image

- The ridge-line flow can be effectively described by a structure called **directional map** (or directional image) which is a discrete matrix whose elements denote the orientation of the tangent to the ridge lines. In detail, each element [i, j], in a grid superimposed to the fingerprint image indicates the average orientation of the tangent to ridge points in a neighborhood of the point.
- Analogously, the ridge line density can be synthesized by using a density map.

Directional map

- The local orientation of the ridge line in the position [i, j] is defined as the angle θ(i, j) that the ridge line, crossing a small at will neighborhood of point [i, j], or the tangent to the ridge lie in that point, forms with the horizontal axis.



- Instead of measuring orientation at each point, most approaches use a grid measure
- The directional image D is a matrix in which each element corresponding to the node [i, j] of a square grid denotes the average orientation of the ridge (of the tangent to the ridge) in a neighborhood of [x_i, y_j].

Directional map

- The simplest approach for extraction and natural orientation location is based on the computation of the gradient of the image.
- The gradient $\nabla (x_i, y_j)$ at the point $[x_i, y_j]$ of image *I* is a two-dimensional vector $[\nabla_X (x_i, y_j), \nabla_Y (x_i, y_j)]$, where ∇_X and ∇_Y are respectively the derivatives of *I* in $[x_i, y_j]$ in the x and y directions.

- Problems:
  - The estimation of a single orientation represents a low level analysis which is too sensitive to noise. On the other hand it is not possible do a simple average of more gradients due to the circularity of corners.
  - The concept of average orientation is not always well defined; for example what is the average of two orthogonal orientations 0 ° and 90 °?
  - Some solutions imply doubling the angles and considering separately the averages along the two axes.

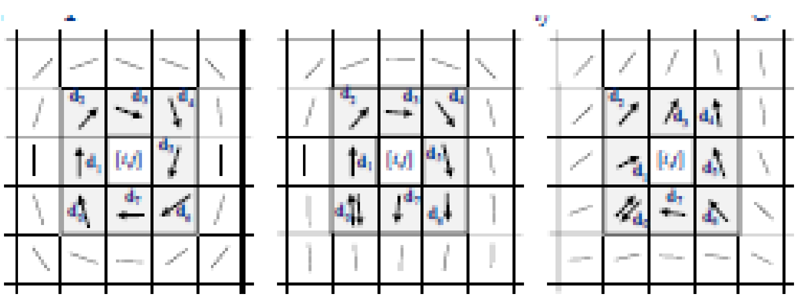
Frequency map

- The frequency of the local ridge line f_{xy} at the point [x, y] is defined as the number of ridges per unit length along a hypothetical segment centered at [x, y] and orthogonal to the orientation of the local ridge.
- It is possible to compute an image frequency F, similar to the directional image D, by estimating the frequency in discrete locations arranged in a grid

- A possible approach is to count the average number of pixels between consecutive peaks of gray levels along the direction orthogonal to the local orientation the ridge line.

Singularities

- Most approaches are based on the directional map.
- A practical and elegant method is based on the calculation of the Poincaré index.
- If G is a vector field and a curve C is immersed in G, the Poincaré index $P_{G,C}$ is defined as the total rotation of the vectors of G along C.
- G is the field associated with the image of the orientations of the fingerprint image D and [i, j] is the position of the element θ_{ij} in the image.



$P_{G,C}(i,j) = 360°$ $P_{G,C}(i,j) = 180°$ $P_{G,C}(i,j) = -180°$

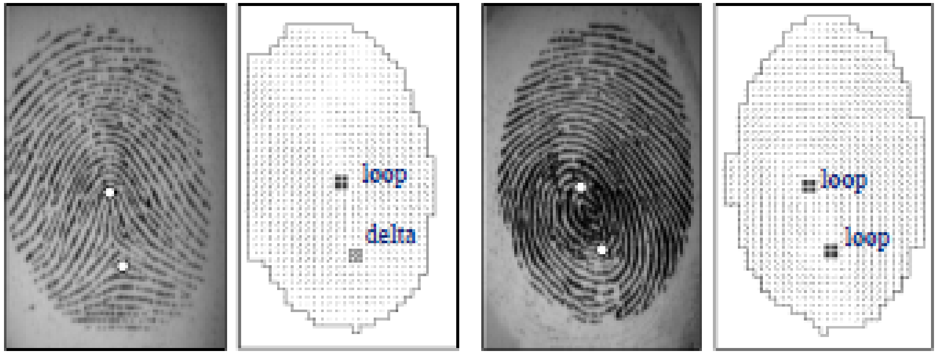
$$P_{G,C}(i,j) = \sum_{k=0..7} angle\left(\mathbf{d}_k, \mathbf{d}_{(k+1)\bmod 8}\right)$$

Singularities

The index of Poincarè can be calculated as follows:

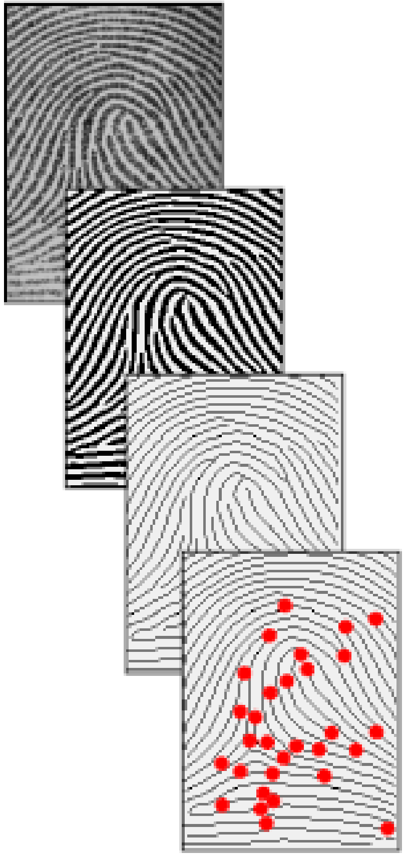
- The curve C is a closed path defined as the ordered sequence of elements of D, such that [i, j] are internal points;
- The index $P_{G,C}(i, j)$ is calculated by algebraically adding the differences in orientation between adjacent elements of C.
- The sum of the differences of orientations requires to associate a direction to each orientation. One can randomly select the direction of the first element and assign the direction closest to that of the previous element to all subsequent elements.
- It is shown that, for closed curves, the Poincare index assumes only one of the discrete values 0 °, ± 180 °, ± 360 °. In particular, regarding the singularities of fingerprints:

$$P_{G,C} = \begin{cases} 0^\circ & \textbf{no singularity} \\ 360^\circ & \text{whorl} \\ 180^\circ & \text{loop} \\ -180^\circ & \text{delta} \end{cases}$$



Minutiae

- Many approaches extract minutiae and perform matching based on them or in combination with them
- In general, minutiae extraction entails :
  - binarization: converting a graylevel image into a binary image (histogram analysis is used but it is less trivial than supposed);
  - thinning: the binary image undergoes a thinning step that reduces the thickness of the ridge lines to 1 pixels (even this step deserved many investigations);
  - location: a scan of the image locates pixels corresponding to the minutiae

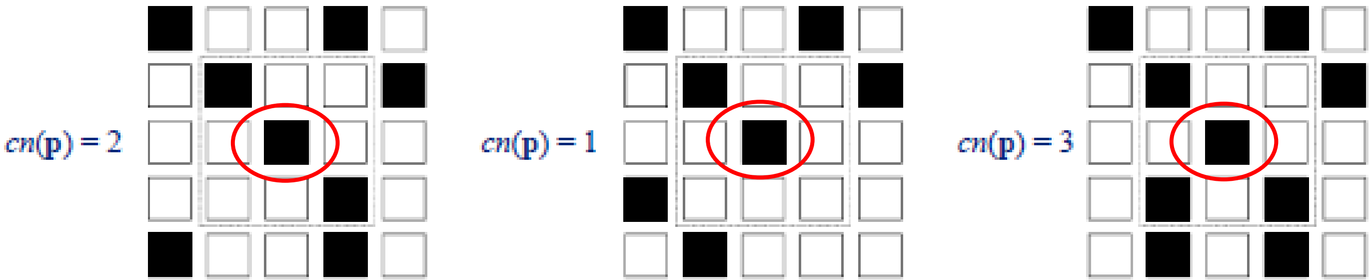


Minutiae location

- Minutiae location is based on the analysis of the crossing number:

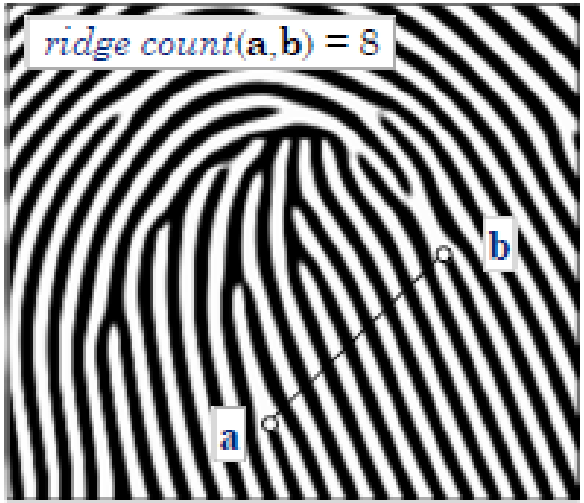
$$cn(\mathbf{p}) = \frac{1}{2} \sum_{i=1..8} \left| val(\mathbf{p}_{i \bmod 8}) - val(\mathbf{p}_{i-1}) \right|$$

- $p_0, p_1, \ldots, p_7$ are the pixels in the neighborhood of p and val (p) $\in \{0,1\}$ is the value of pixel p.
- A pixel p with val (p) = 1:
  - is an internal point of a ridge line if cn (p) = 2;
  - corresponds to a termination if cn (p) = 1;
  - corresponds to a bifurcation if cn (p) = 3;
  - belongs to a more complex minutia if cn (p)> 3.



Estimate of the number of ridge lines

- Among the characteristics of the fingerprints used by experts there is also the detection of the number of ridges (ridge count).
- The ridge count is an abstract measure of the distance between any two any points of a fingerprint.
- Given two points a and b of a fingerprint, the ridge count is the number of ridge lines intersected by the segment ab.
- Points a and b are often chosen as relevant one (e.g., core and delta)



Fingerprint recognition: an hybrid method based on comparison of minutiae and texture

- A possible hybrid approach to fingerprint matching combines the representation of fingerprints based on minutiae with a representation based on Gabor filter that uses local texture information (see Ross, Jain e Reisman, 2003).

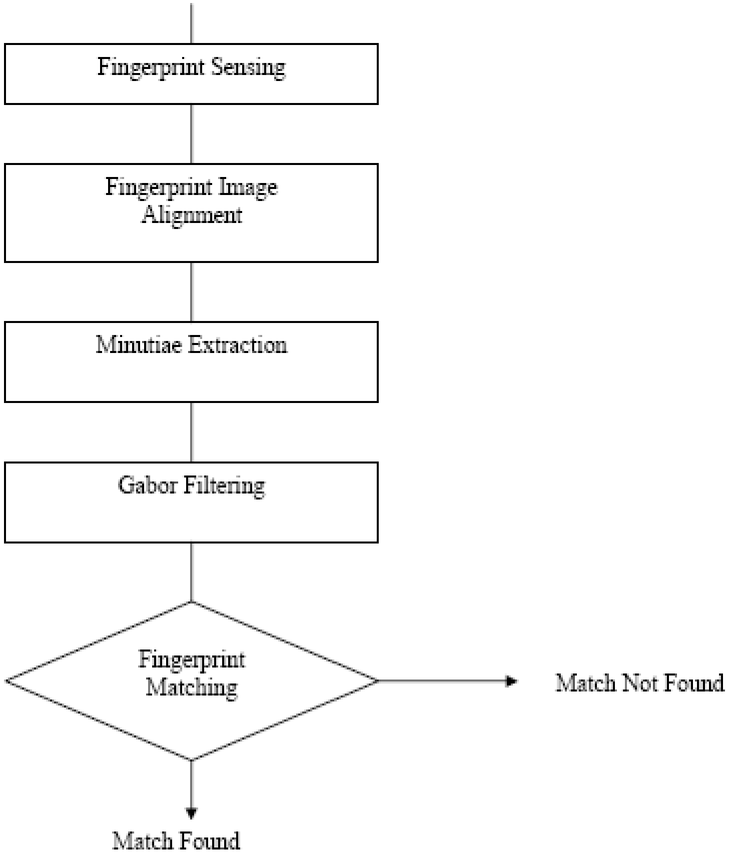
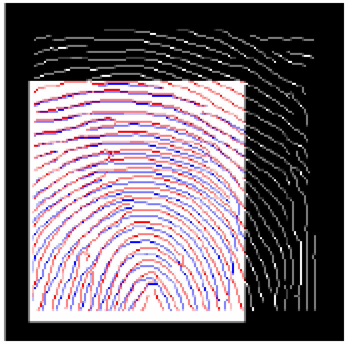


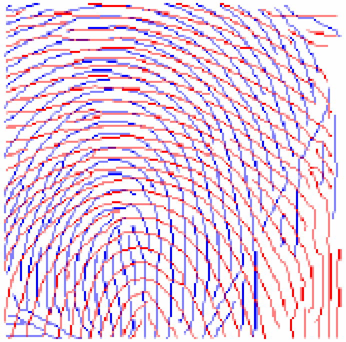
Image alignment

- The alignment phase starts with the extraction of minutiae from both the input and from the template to match.
- The two sets of minutiae are compared through an algorithm of point matching that preliminarily selects a pair of reference minutiae (one from each image), and then determines the number of matching of minutiae pairs using the remaining set of points.
- The reference pair that produces the maximum number of matching pairs, determines the best alignment.

Red and blu lines respectively represent two fingerprints



Same finger



Different fingers

Image alignment

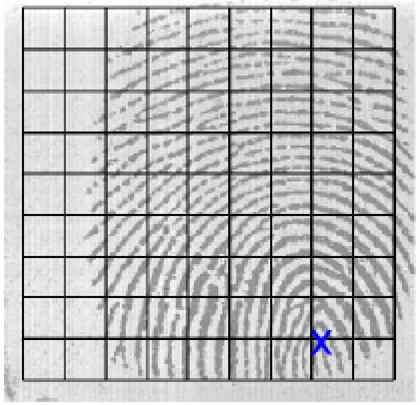
- Thanks to the availability of information relating to the furrows for each local minutia it is not necessary to make a comprehensive assessment of all correspondences between points.

- Once the minutiae have been aligned with this method also the parameters of rotation and translation are known.

- The rotation parameter is the average of the estimated values of rotation of all the individual pairs of corresponding minutiae, while the translation parameters are calculable using the spatial coordinates of the pair of reference minutiae which produced the best alignment.

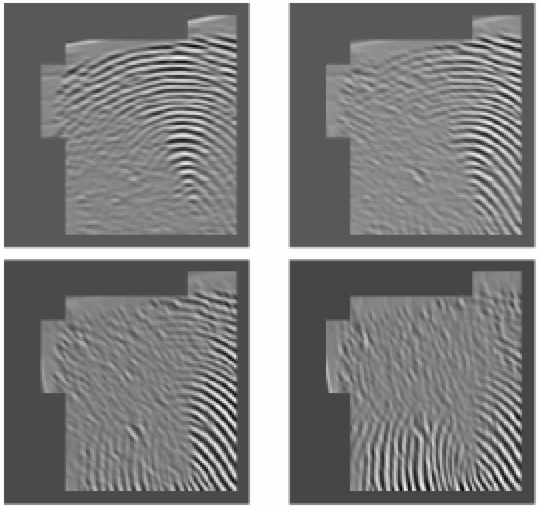
Masking and tesselation

- The regions of the background image of the fingertip input are masked out as unnecessary.
- At this point, the input images and the templates are normalized by building on them a grid that divides them into a series of non-overlapping windows of the same size and also normalizing the light intensity of the pixels within each window with reference to a constant mean and variance.
- The average distance inter-solco for a resolution of acquisition of 300x300 dpi is about 30 pixels, therefore the optimal size for each cell is 30x30 pixels



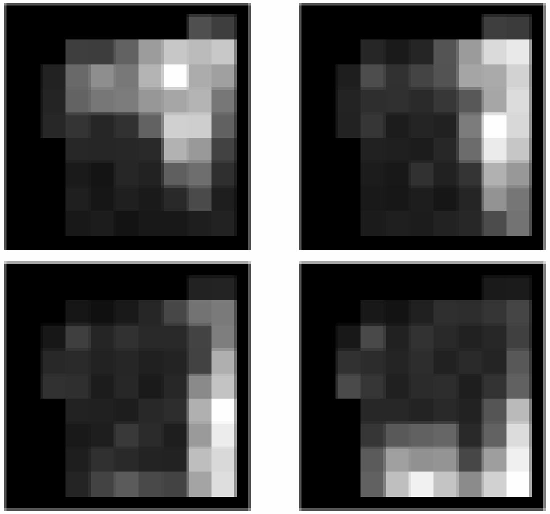
Feature extraction

- In order to perform the feature extraction from the cells resulting from the tessellation a group of 8 Gabor filters is used, all with the same frequency, but with variable orientation. Such filtering produces 8 sorted images for each cell.



Feature extraction

- The mean absolute deviation of the intensity in each filtered cell represents its characteristic value, so one gets 8 characteristic values for each cell in the tessellation.
- The characteristic values of all the cells are then concatenated into a characteristic vector.
- The characteristic values relating to the masked regions in the input image are not used for the subsequent comparison phase, and are marked as missing values in the characteristic vector .



Matching

- The comparison of the input image with the stored template is made by calculating the sum of the squared differences between corresponding characteristic vectors, after discarding the missing values.

- The similarity score is combined with that obtained with the comparison of minutiae, using the rule of the sum of the combinations.

- If the score of similarity is below a threshold, you can state that the input image has a corresponding template in memory and recognition is successful.

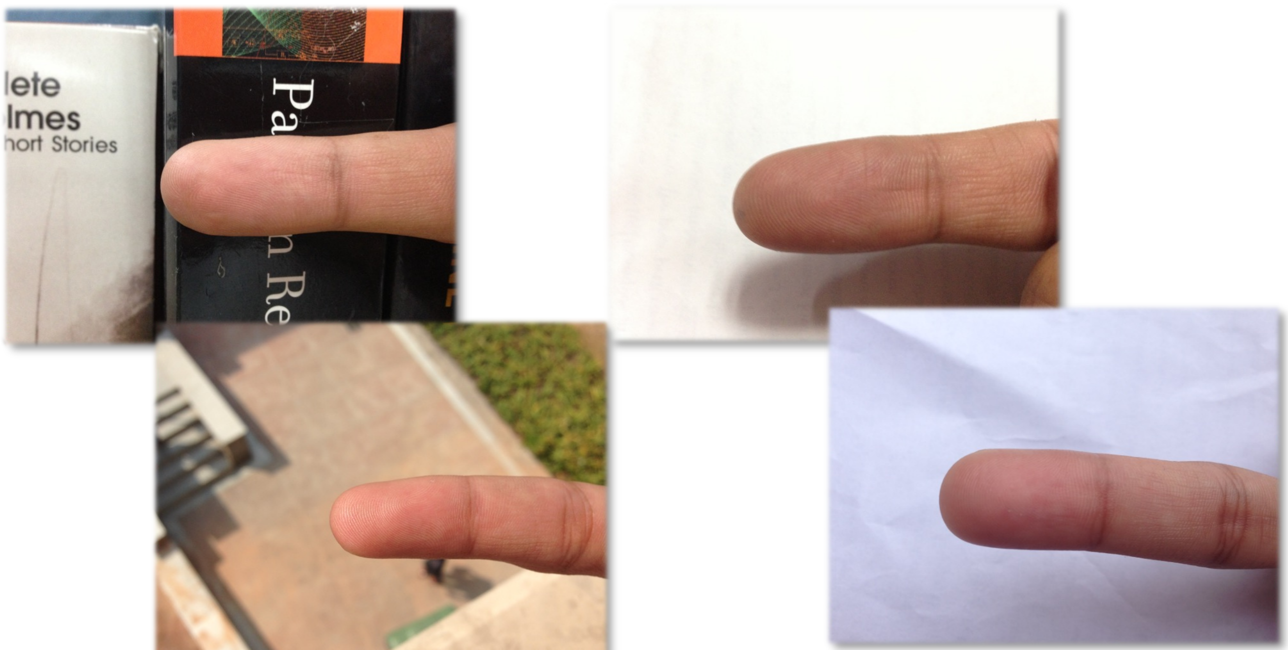
Fingerphotos

- PROS
  - no special sensor required
  - Contactless (more hygienic)

- CONS
  - subject to common problems in image processing: illumination, position with respect to the camera, blurriness, etc.
  - some preprocessing steps require more sophisticated approaches.

An available dataset: IITD v1.0

- 4 folders with fingerphotos of 64 different subjects
  - Indoor white
  - Indoor natural
  - Outdoor white
  - Outdoor natural
- 1 folder with live scans from the same subjects



An example of pre-processing

Image rotation

Background removal | Finger extraction and cropping

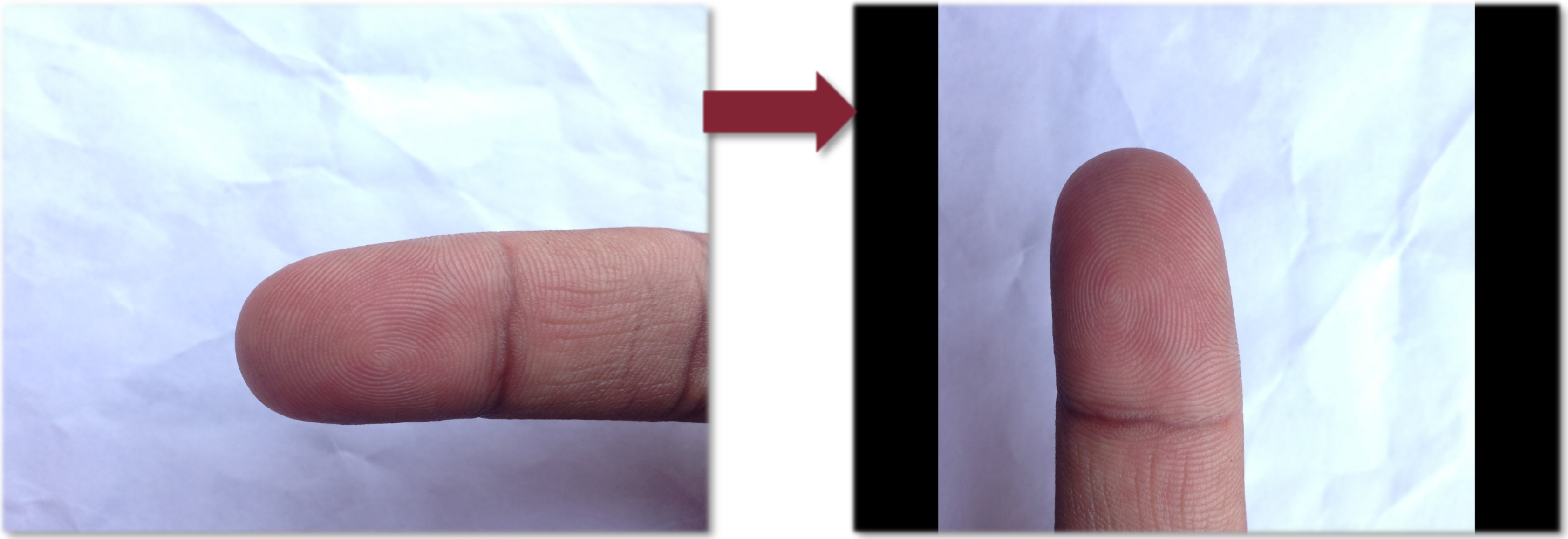
ROI extraction

ROI enhancement

Ridge and minutiae extraction

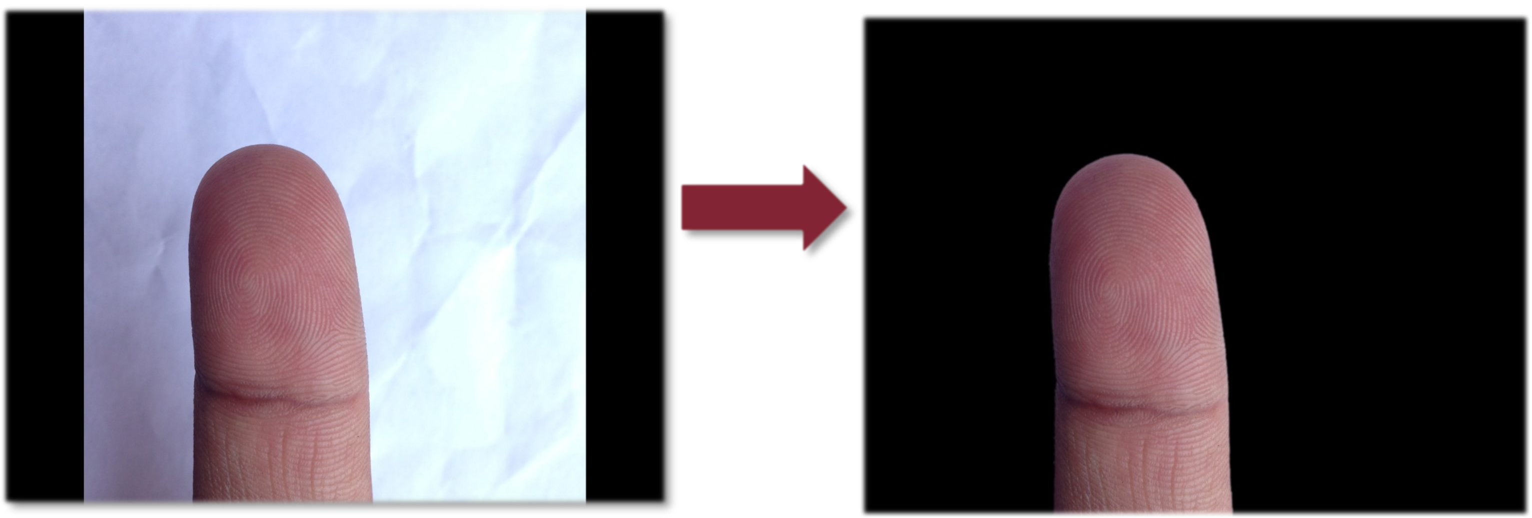
Image rotation

- Detection of the largest connected component and computation of its orientation (PCA)



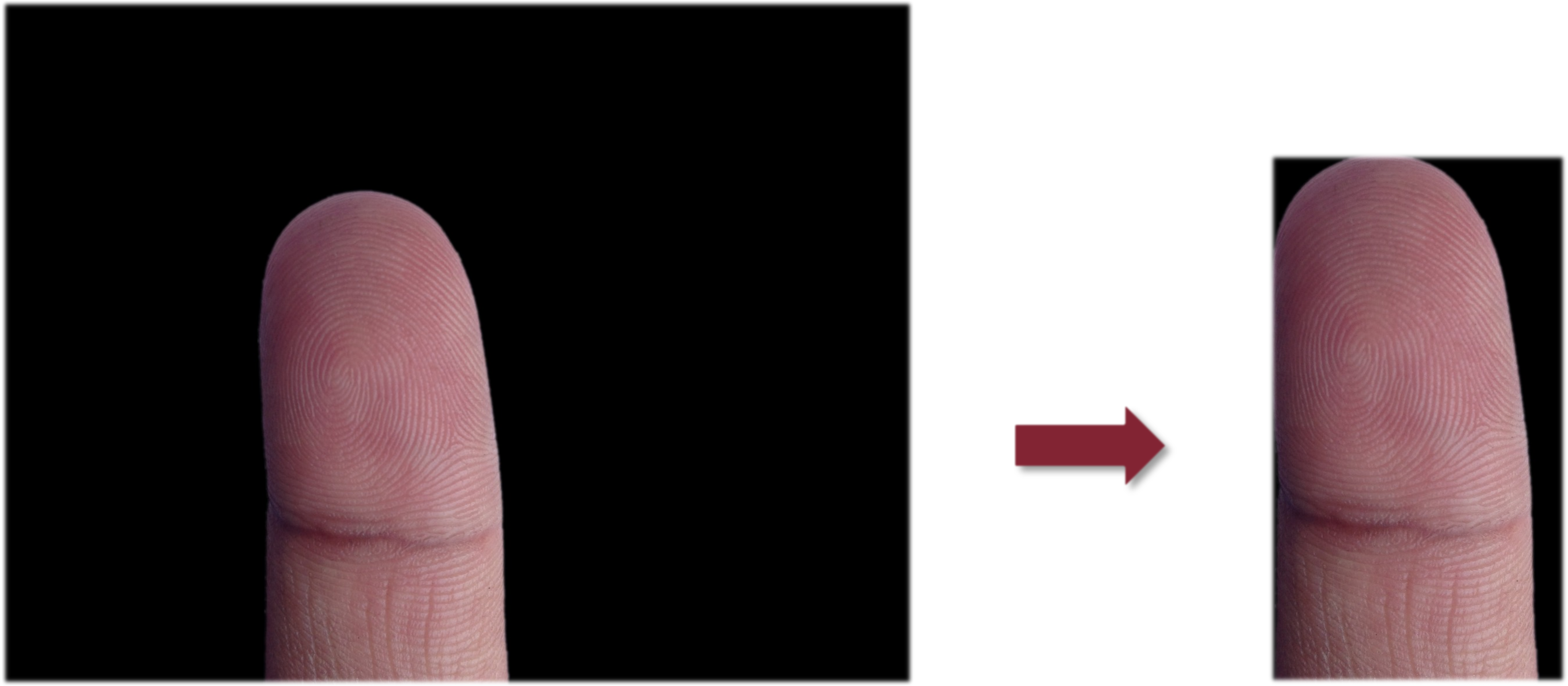
Background removal

- The image is transformed in gray levels
- Contour detection using Canny algorithm
- Identification of the larger area component using opencvfunction .findContours()
- Black empty mask with a white poligon corresponding to the larger contour
- Guassian blurring of the mask
- Fusion with the original image



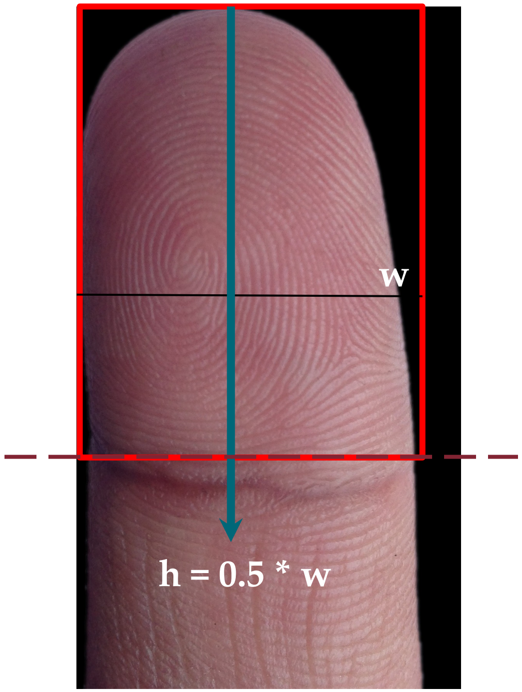
Finger cropping

OpenCv extract_finger() + .rectangle()



ROI cropping

Based on height and width of the finger



ROI enhancement

.normalize()

.createCLAHE()

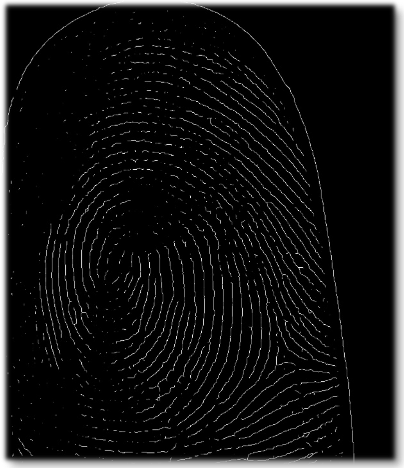
.GaussianBlur()

Ridge extraction and enhancement

Adaprive thresholding

Morpholgical operators

Thinning



Fake fingerprints

- It is not that difficult to reproduce fake fingerprints, most of all from a cooperative user
- The most popular materials are gelatin, silicone, latex.
- Each material produces fingerprints of different quality and with different characteristics.

Gelatin

Silicone

Latex

Liveliness detection

- A safety measure which is particularly interesting in order to counter any attempts of cheating based on systems fingerprints, is to determine if the source of the input signal (the finger) is a living genuine biometric trait rather than a simulacrum from a fraudulent activity (a glove fitting bearing the fingerprint of an authorized user).

- The logical premise of a liveliness detection test is that if the finger is alive, its print impression is actually of the person to whom it belongs.

Liveliness detection

- One of the most common approaches to the vitality test consists of using one or more vital signs common to the entire population of reference, such as for example pulse and temperature.
- The optical scanners of type live-scan with FTIR (Frustrated Total Internal Reflection) technology use a mechanism of differentialacquisition for the ridges and furrows of fingerprints, resulting in this way inherently more resistant to attacks by a simulacrum with two-dimensional impression of the finger.
- The high resolution scan of fingerprint reveals details characteristic of the structure of the pores that are very difficult to imitate in an artificial finger.
- The characteristic color of the skin of the finger changes due to the pressure when it is pressed on the scanning surface, and this effect can be detected to identify the authenticity of the finger.

Liveliness detection

- Even the bloodstream and its pulsation can be detected with a careful measurement of the light reflected or transmitted through the finger.
- The potential difference between two specific points of the musculature of the finger can be used to distinguish it from a dead finger.
- The measurement of the complex impedance of the finger can be useful to check the vitality of the finger.
- Finally, a finger sweats and this can determine the vitality of the finger.

AFIS or human?

- There is a mistaken belief that the problem of digital fingerprint recognition has already been fully resolved, since it was one of the first application areas of research on pattern-recognition.
- In fact many scientific and technological challenges are still to be faced to arrive to the design and implementation of a reliable system for the automatic recognition, especially in the case of fingerprints of low quality.
- Though valid, automatic matching and recognition systems still can not compete with the capabilities of an expert in manual techniques.
- However, automated systems offer an average reliable, fast, consistent and low-cost solution to a growing number of real applications.

Some readings

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