Tutorial 6

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COMP435p
Biometrics Authentication

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Outline

Problem 1.1 Two Stages

Understand two stages (Enrollment and Authentication) in a fingerprint system. (P6:11)

Problem 1.1 Two Stages

Biometrics Research Centre (BRC)

Enrollment stages

- Image acquisition : Inked based scanning & Live based scanning
- Fingerprint extraction : identifying and specifying small details found in finger images
- Storing : recording the result of extraction on the database

Authentication stages

- Capture
- Extraction
  - Preprocessing
  - Detect minutia
- System search for similarities (matching process)

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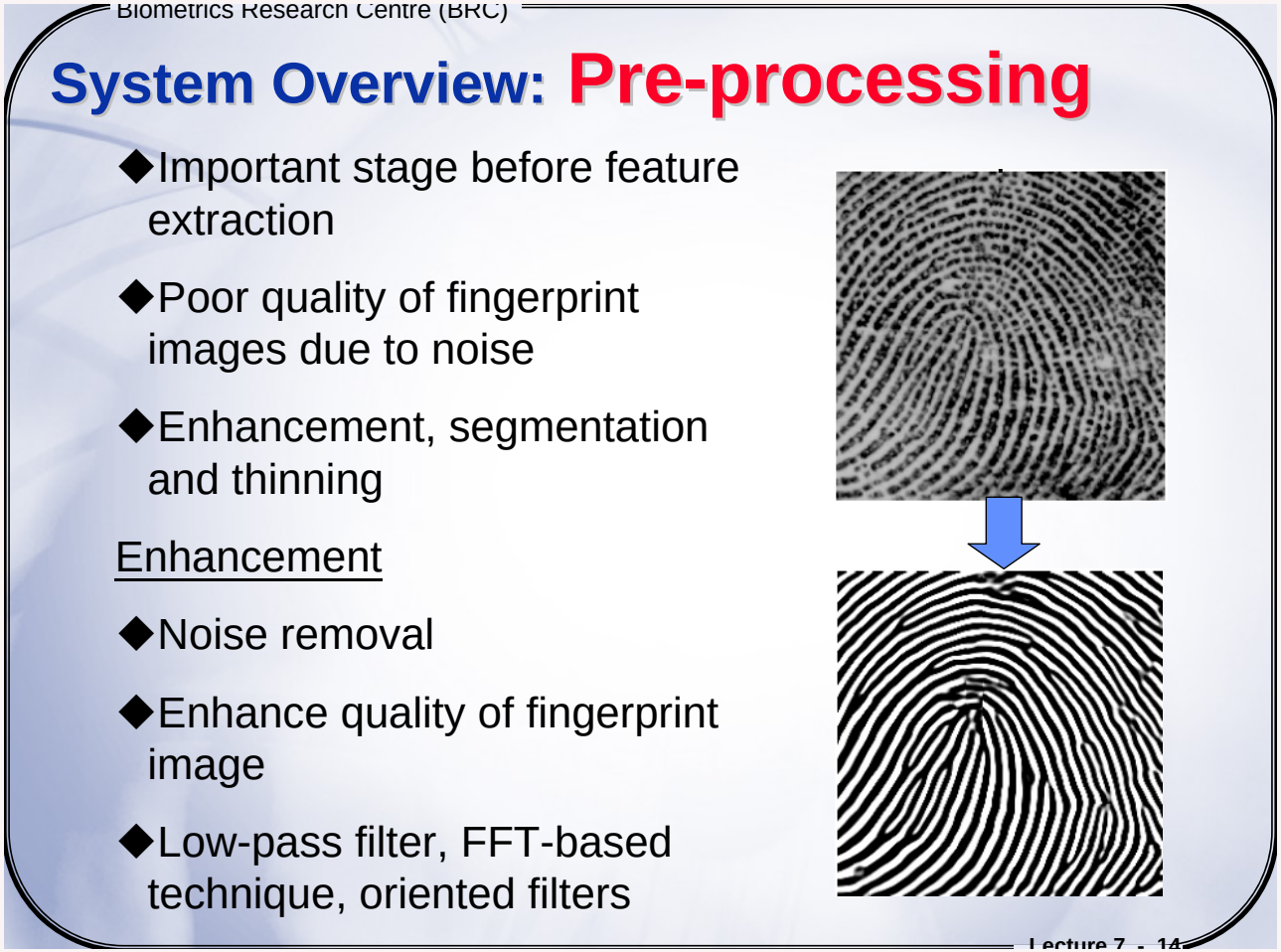
Problem 1.1 Two Stages

- Enrollment stage
  - Image acquisition
  - Fingerprint extraction
  - Storing
- Authentication stage
  - Capture
  - Extraction
  - Matching

Problem 1.2 Pre-processing

In the pre-processing stage, what should be done? (P7:14-16)

Problem 1.2 Pre-processing



Problem 1.2 Pre-processing

Biometrics Research Centre (BRC)

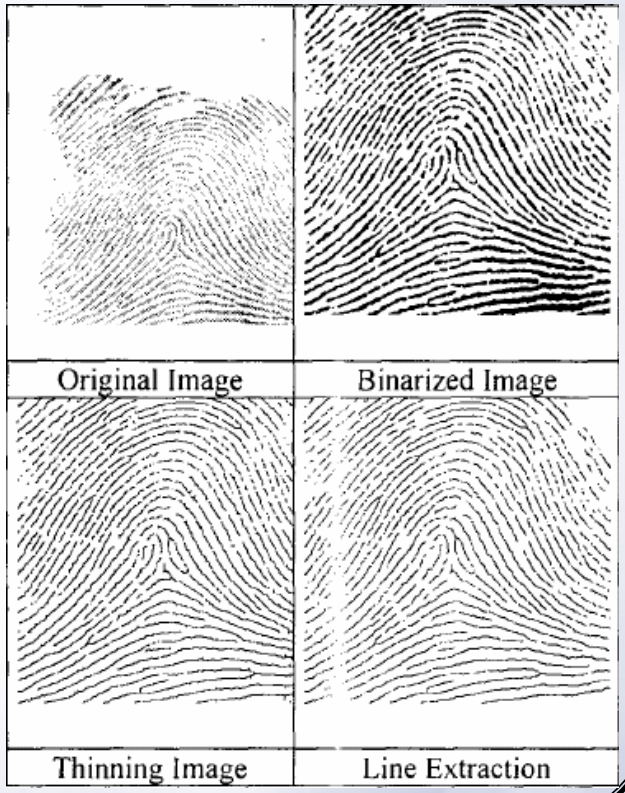
System Overview: Pre-processing

Segmentation

- Decomposition to foreground & background
- Foreground – fingertip image
- Background – Noisy area outside fingertip

Binarization & Thinning

- Binarization by a thresholding operation
- Thinning to reduce the width of ride to a single pixel



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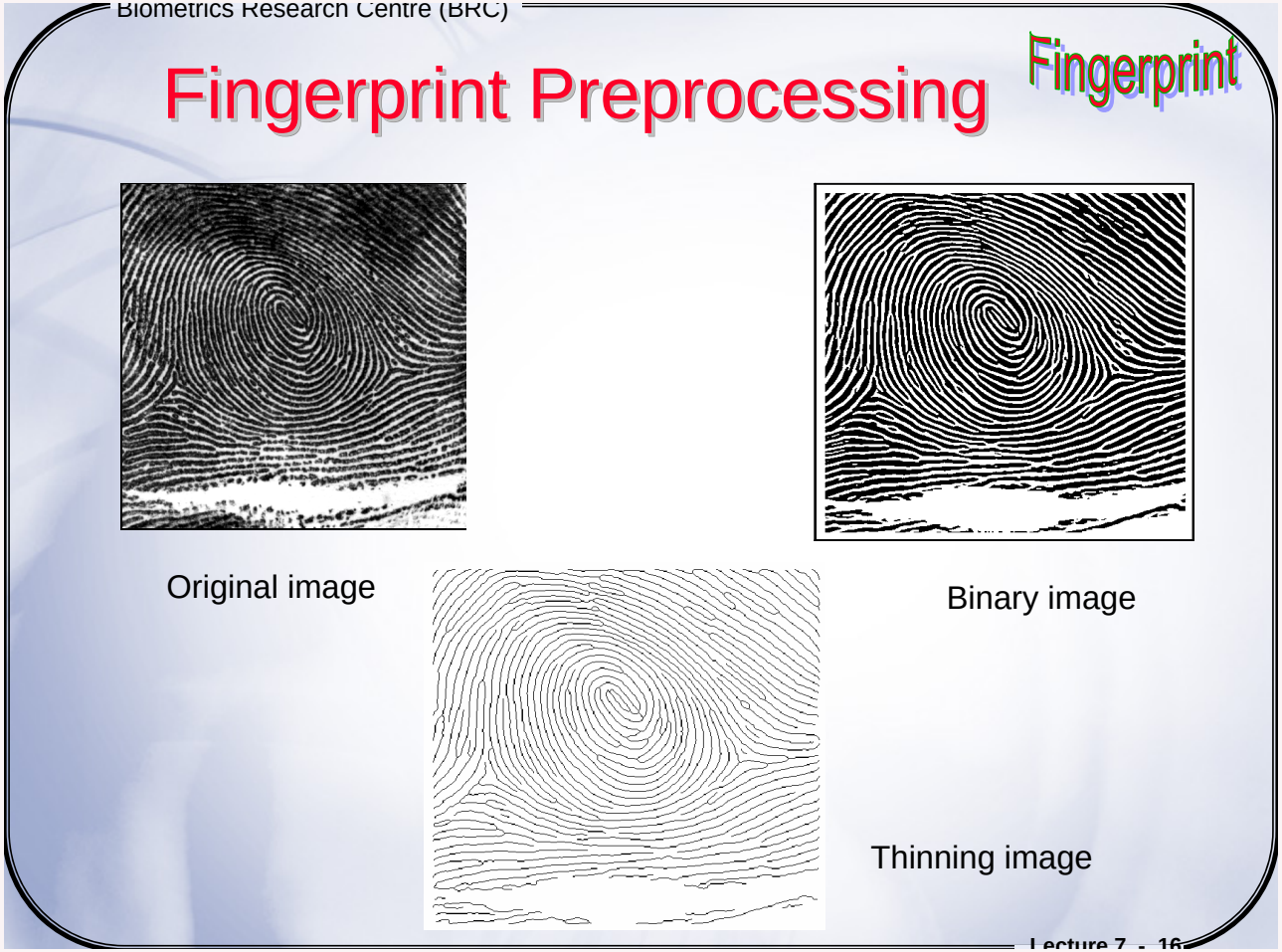
Problem 1.2 Pre-processing



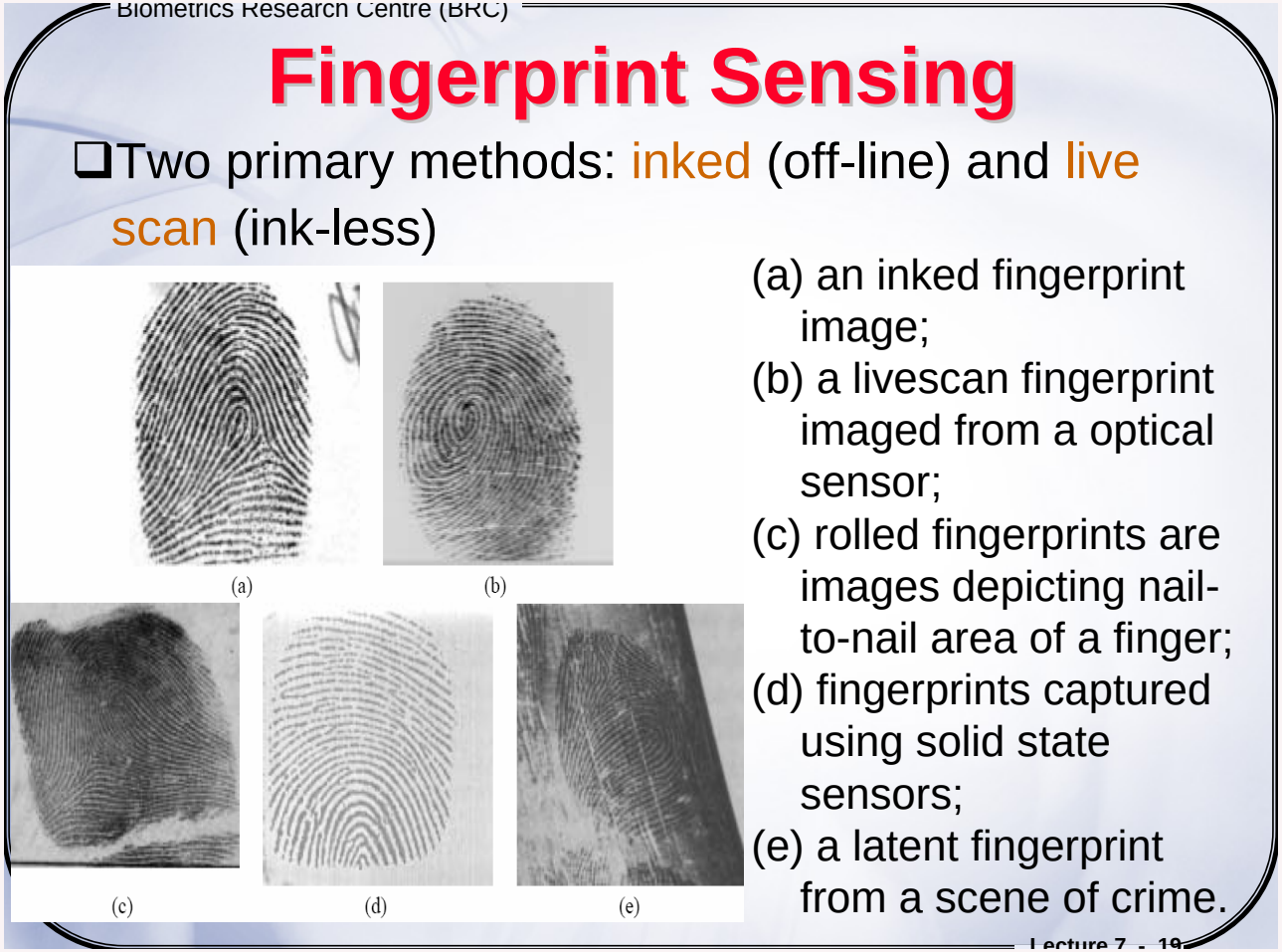
Problem 1.2 Pre-processing

- Enhancement
  - Noise removal
  - Enhance quality of images
  - Low-pass filter, FFT-based technique, oriented filters
- Segmentation
  - Foreground
  - Background
- Binarization & Thinning
  - Binarization by a thresholding operation
  - Thinning to reduce the width of ridge to a single pixel

Problem 1.3 Fingerprint sensing

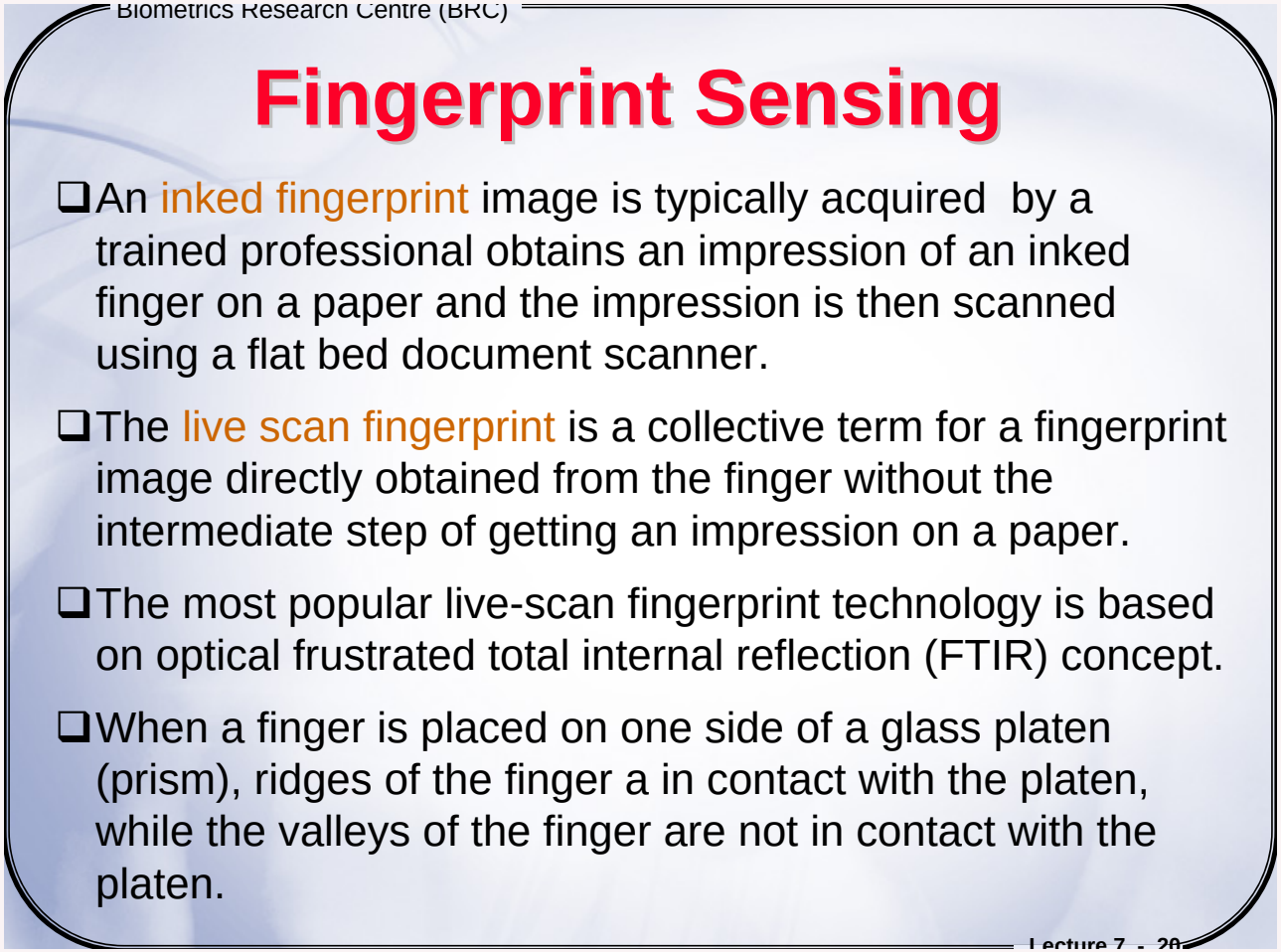
Understand the two primary methods for fingerprint sensing: inked and live scan and compare the different live-scan fingerprint technologies. (P7:19-25)

Problem 1.3 Fingerprint sensing



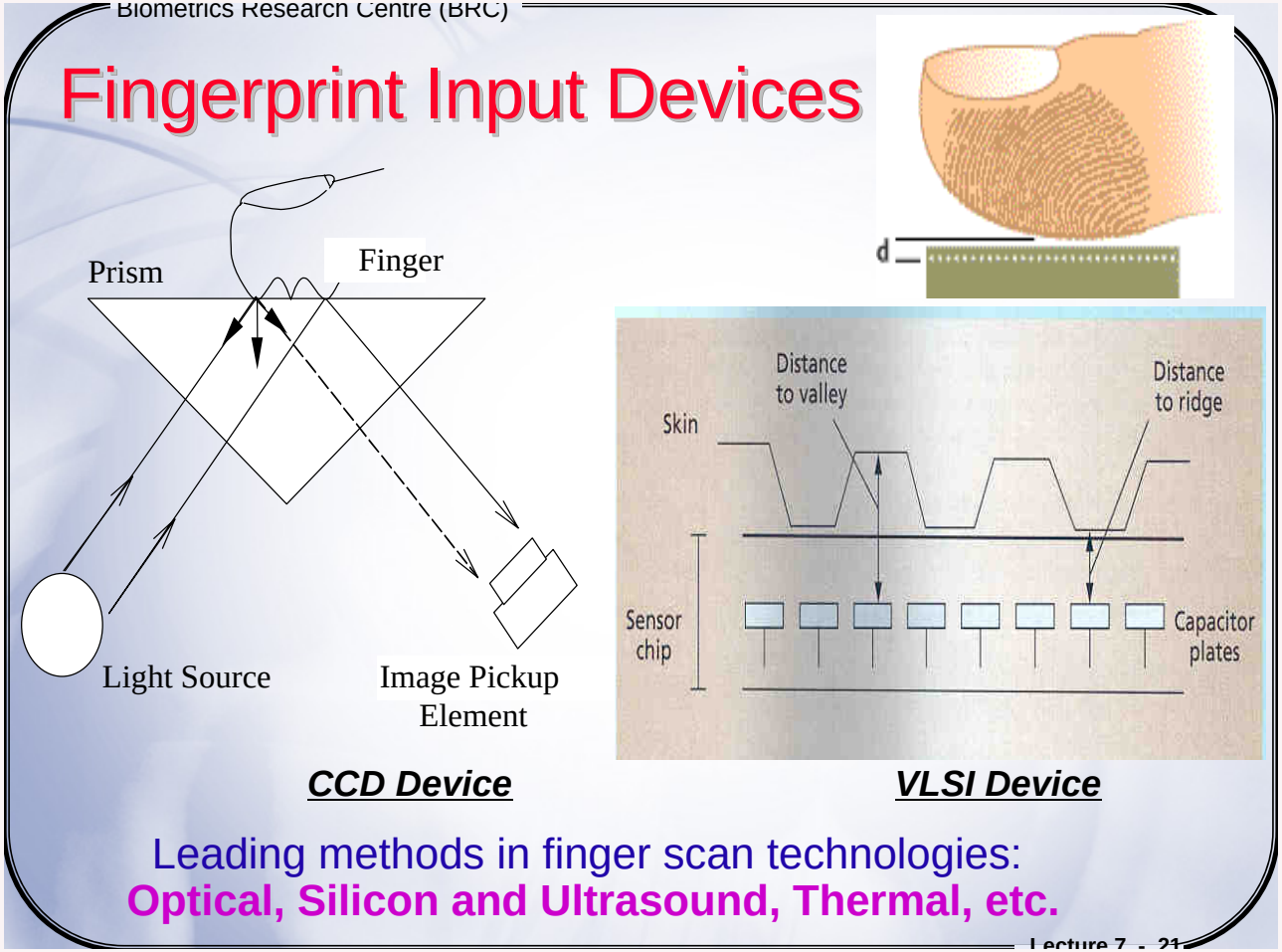
(a) belongs to inked, others belong to live-scan

Problem 1.3 Fingerprint sensing

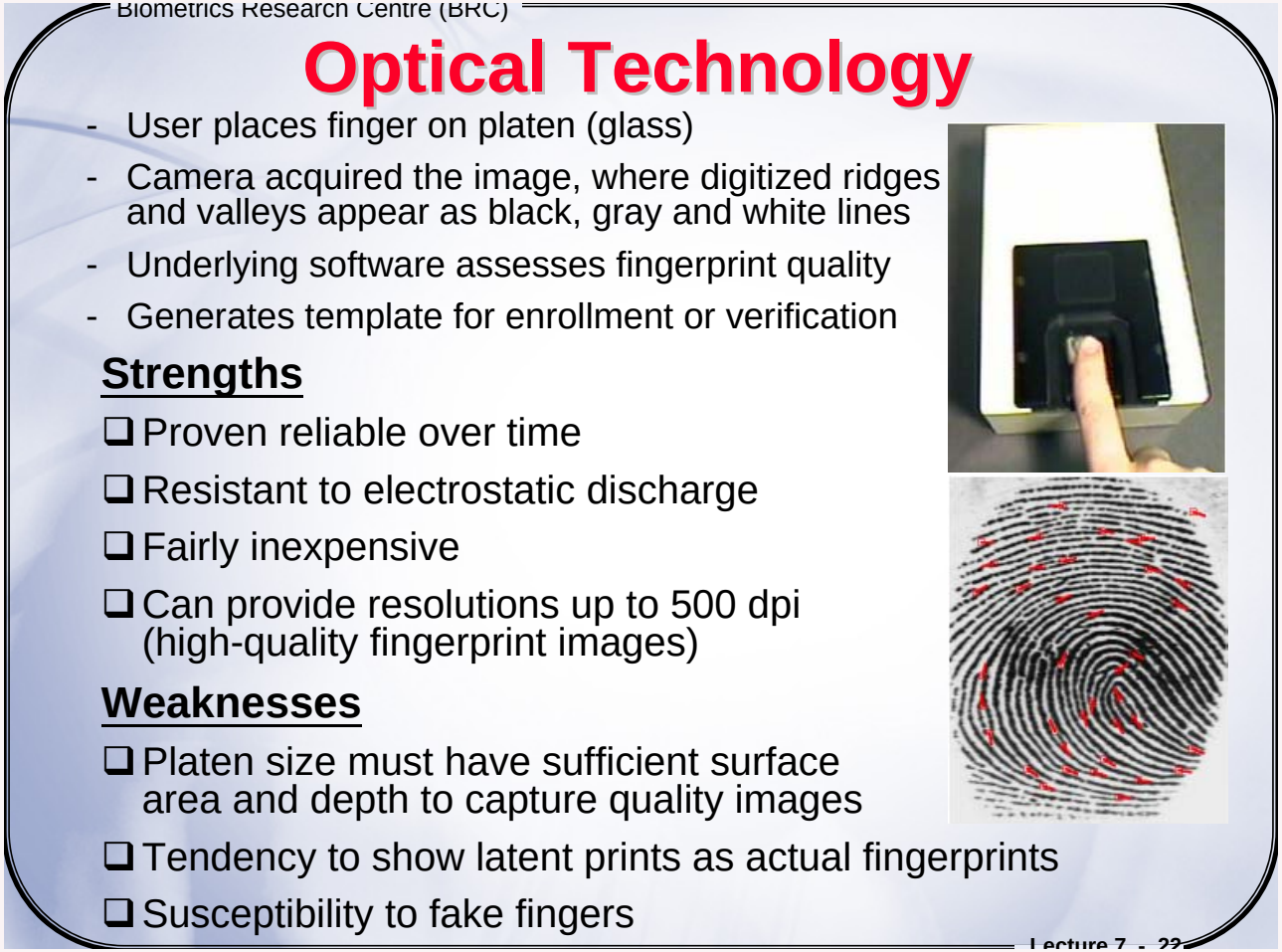


Three main kinds.

Problem 1.3 Fingerprint sensing



Problem 1.3 Fingerprint sensing

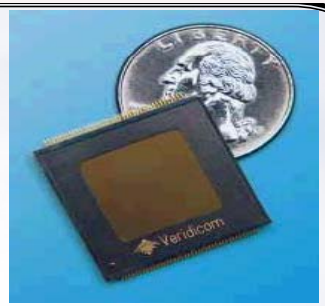


Problem 1.3 Fingerprint sensing

Biometrics Research Centre (BRC)

Silicon Technology

- Silicon chip is used as the platen
- Produces better image quality with less surface area than optical devices



Strengths

- ❑ High image quality (approaching that of the “better” optical devices
- ❑ Modest size requirements (allowing technology to be integrated into small, lower power devices
- ❑ Potentially lower cost (large number of platens can be manufactured from a single wafer)

Weaknesses

- ❑ Durability is subject to question
- ❑ Some silicon technology have been susceptible to electrostatic damage
- ❑ Performance in challenging conditions is unproven

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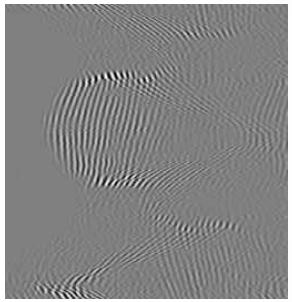
Problem 1.3 Fingerprint sensing

Biometrics Research Centre (BRC)

Ultrasound Technology

- Least frequently used of the three
- Considered the most accurate
- Ultrasonic beam is scanned across the fingerprint surface
- Echo signal is captured at the receiver
- Measures range, thus ridge depth



Impulse Response Reconstruction

Strengths

- ❑ High quality fingerprint images
- ❑ Capable of penetrating dirt and residue

Weaknesses

- ❑ Larger acquisition device due to the machinery involved in ultrasound imaging

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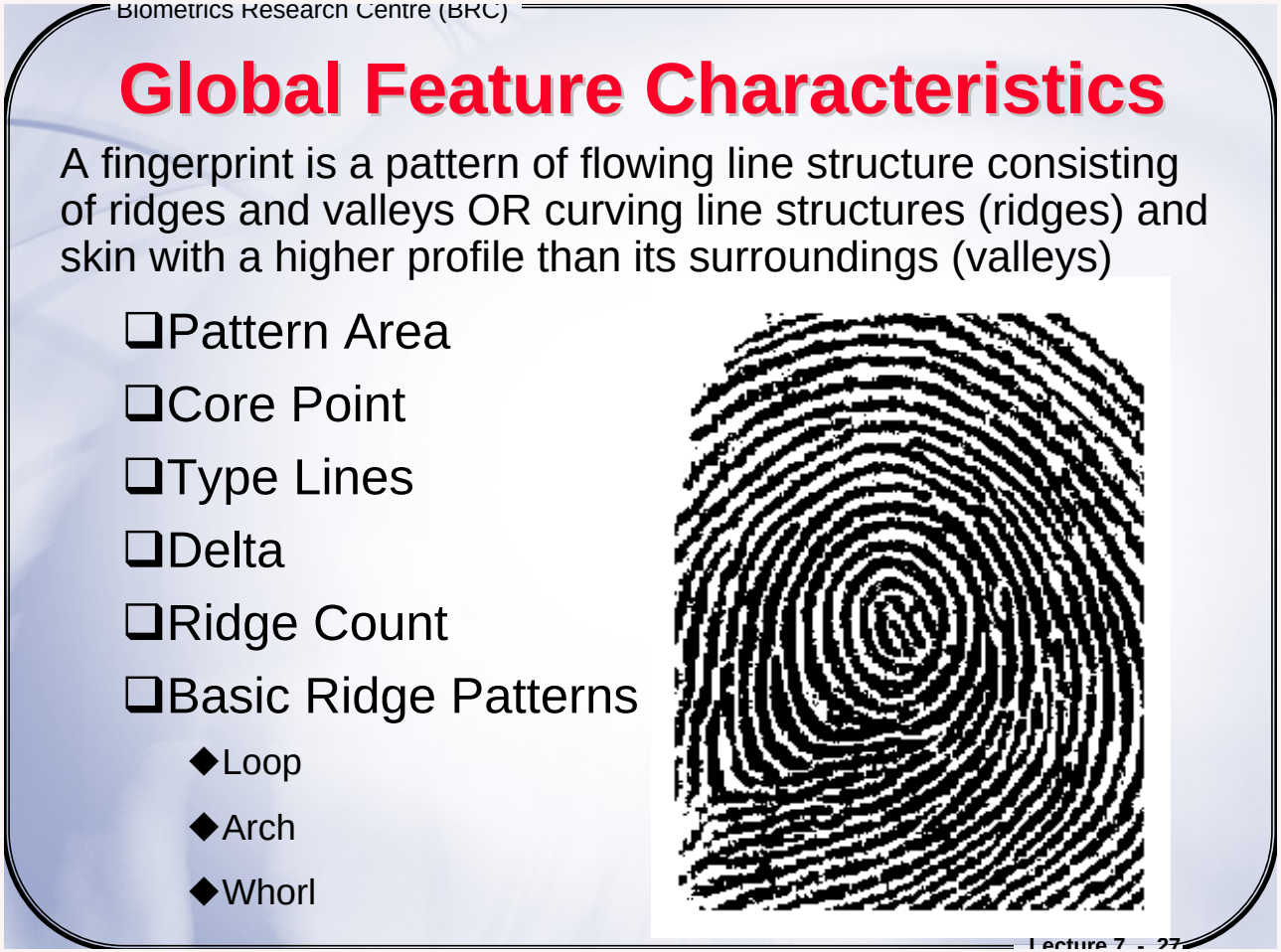
Problem 1.3 Fingerprint sensing

Problem 1.4 Global and Local Features

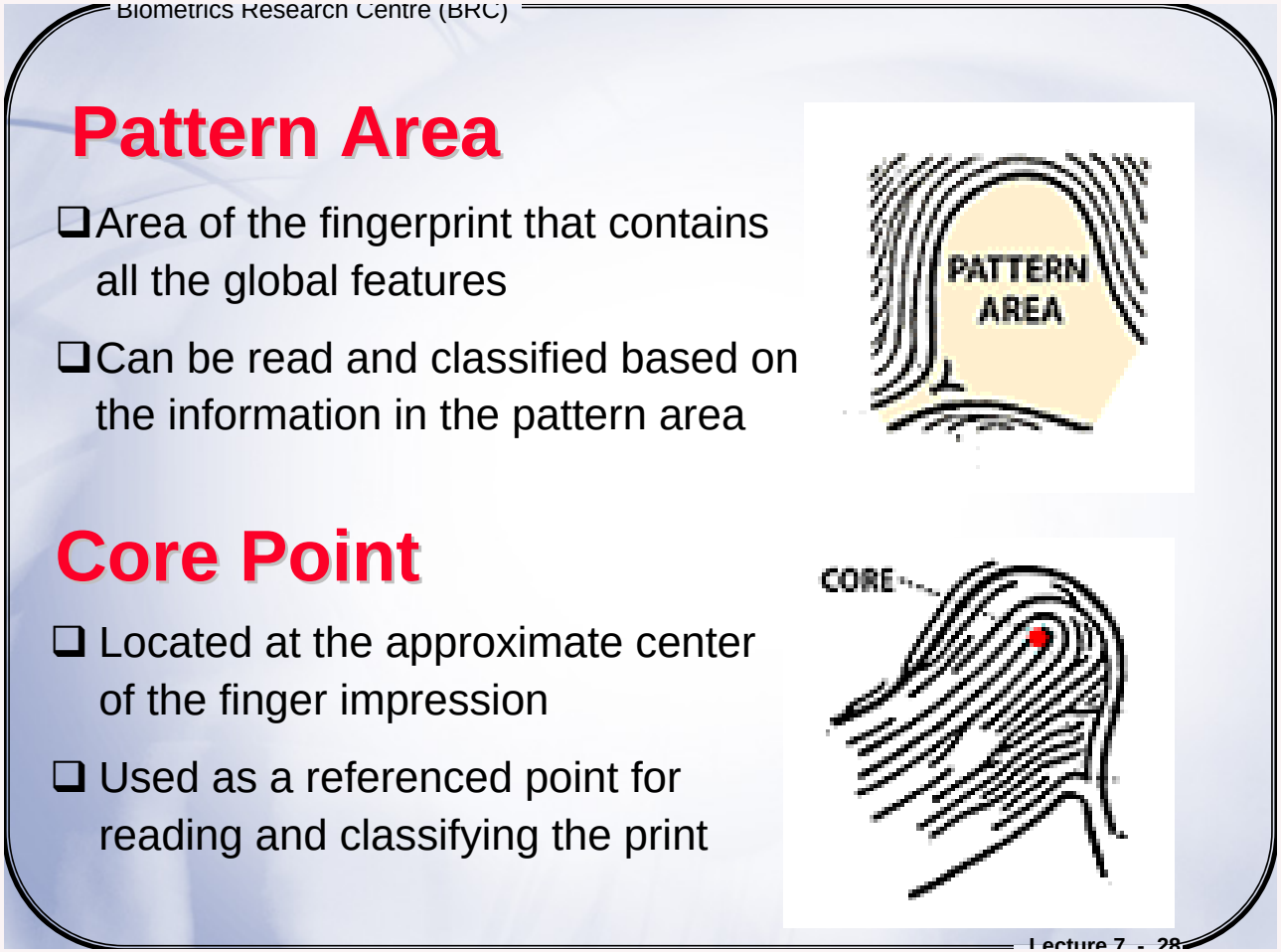
Please understand the feature definitions in both P7:27-29 (Global feature) and P7: 34-35 (Local feature).

Problem 1.4 Global and Local Features

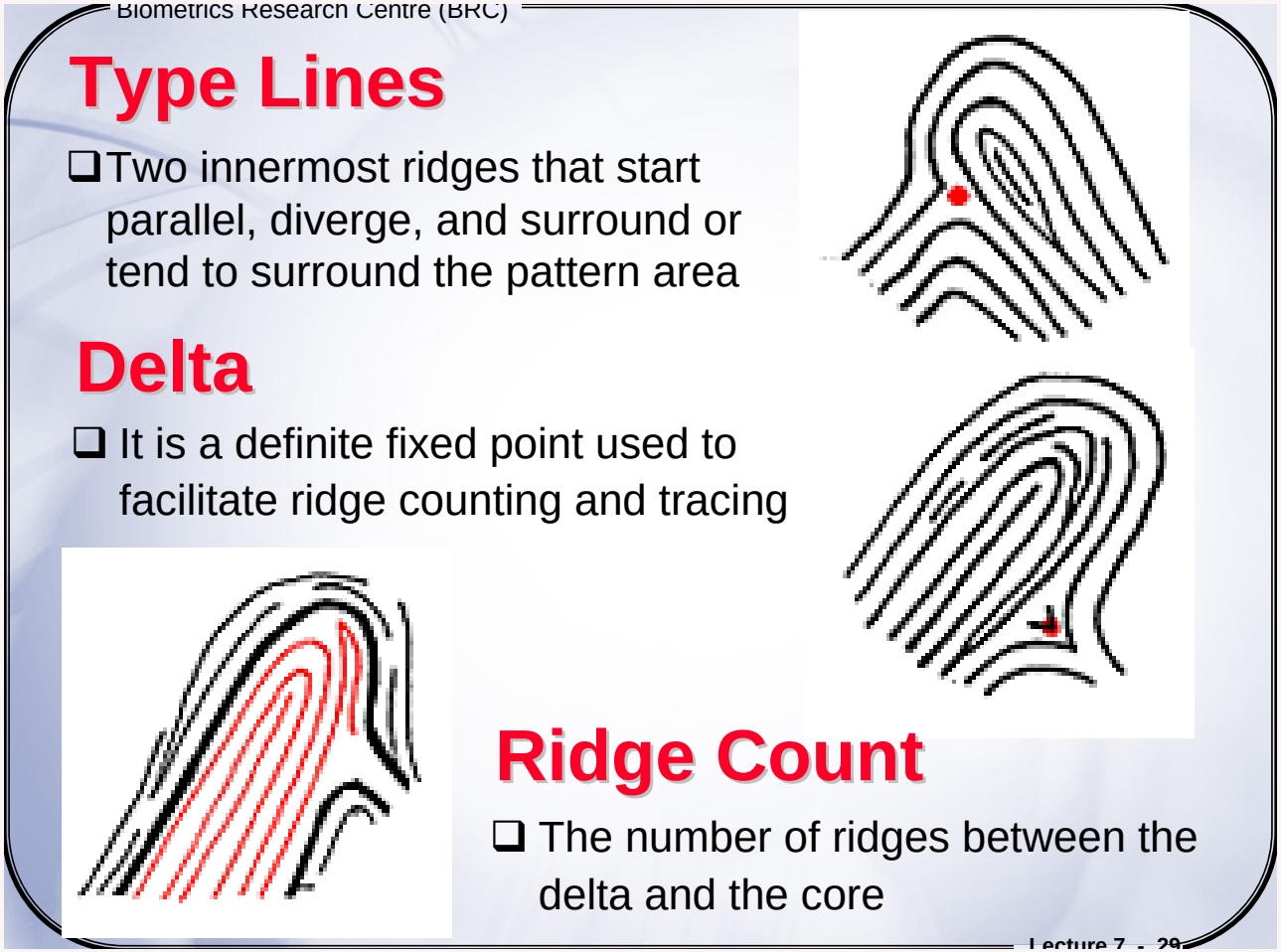


Global features.

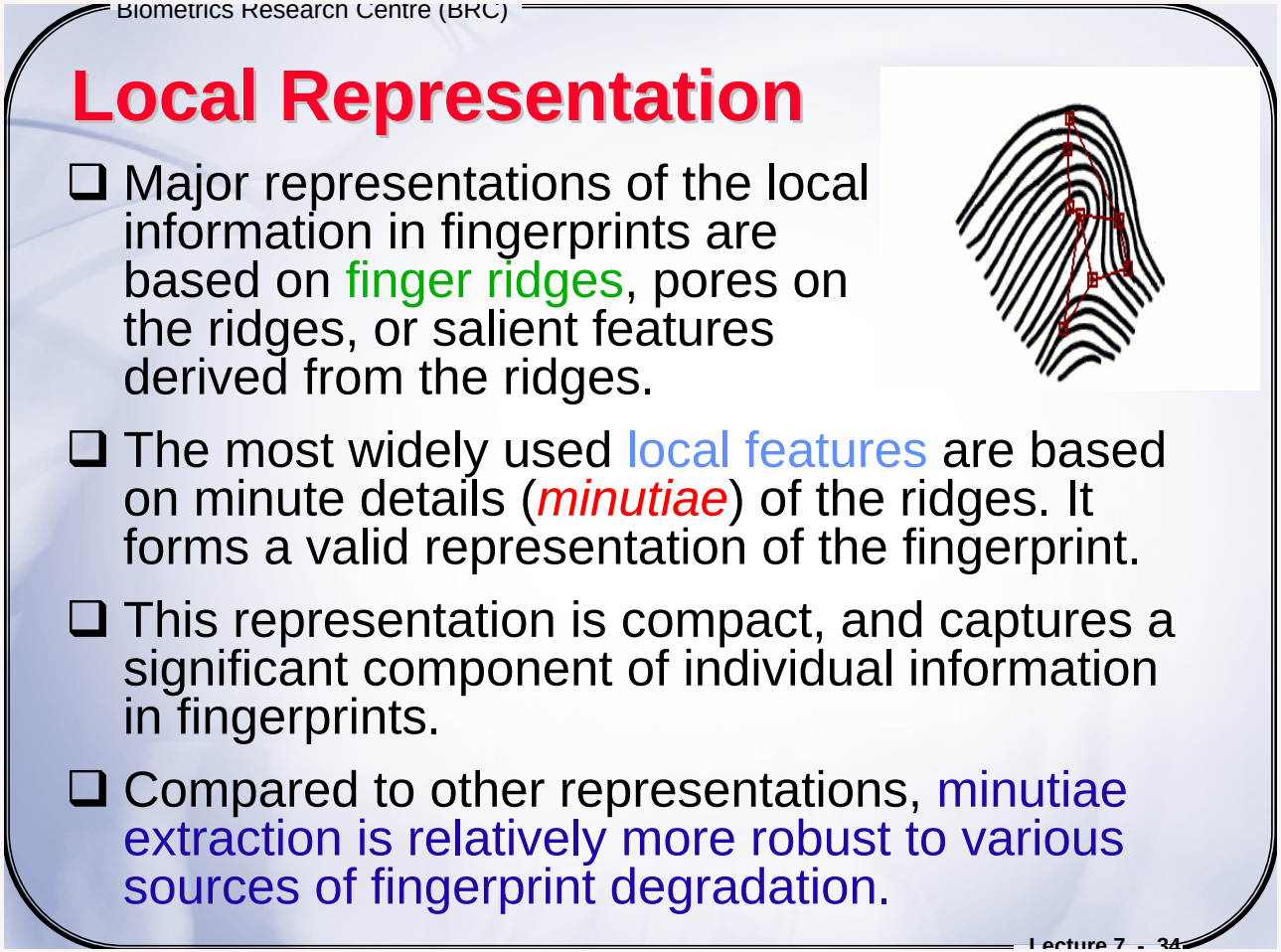
Problem 1.4 Global and Local Features



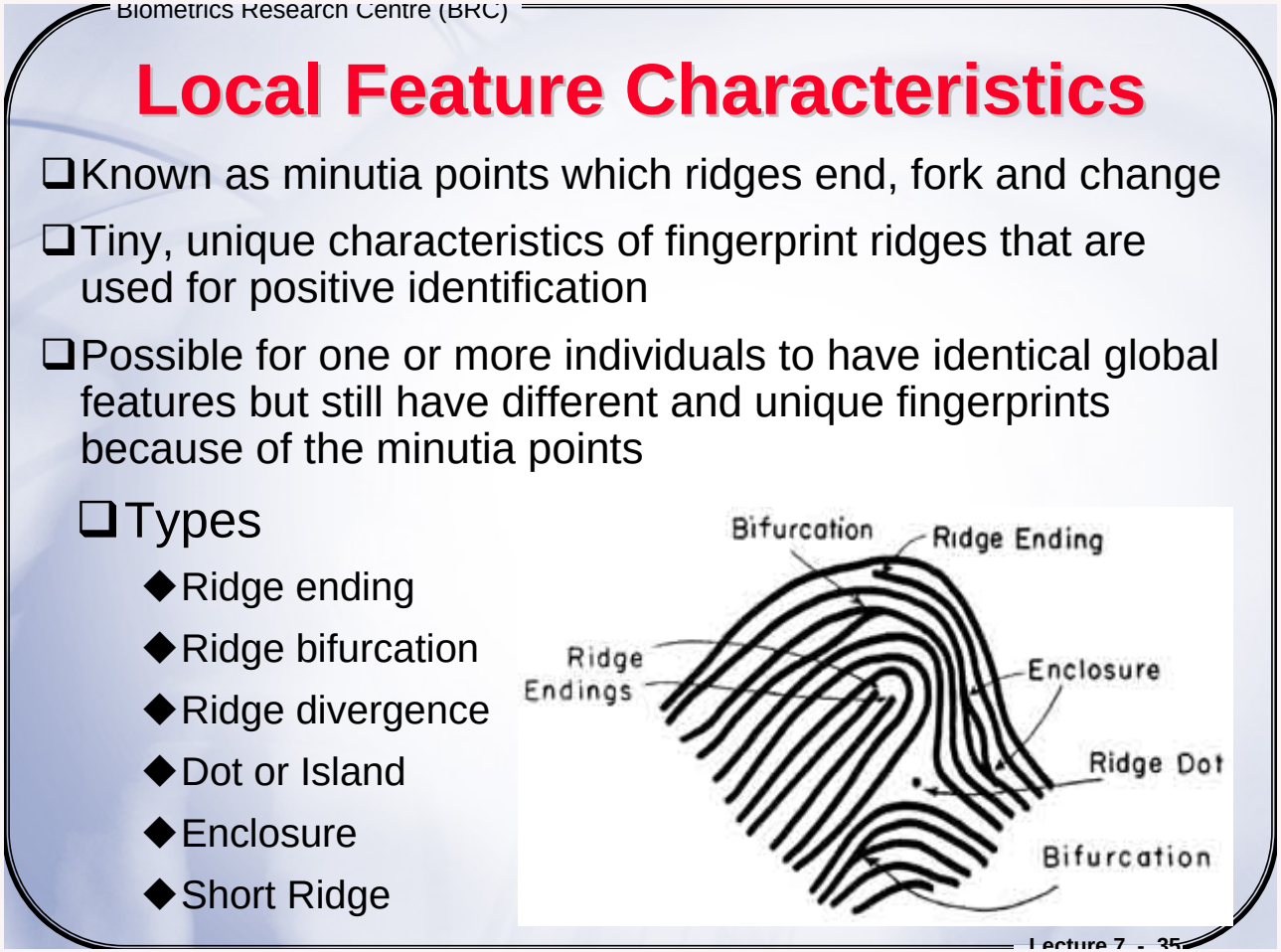
Problem 1.4 Global and Local Features



Problem 1.4 Global and Local Features



Problem 1.4 Global and Local Features



Local features.

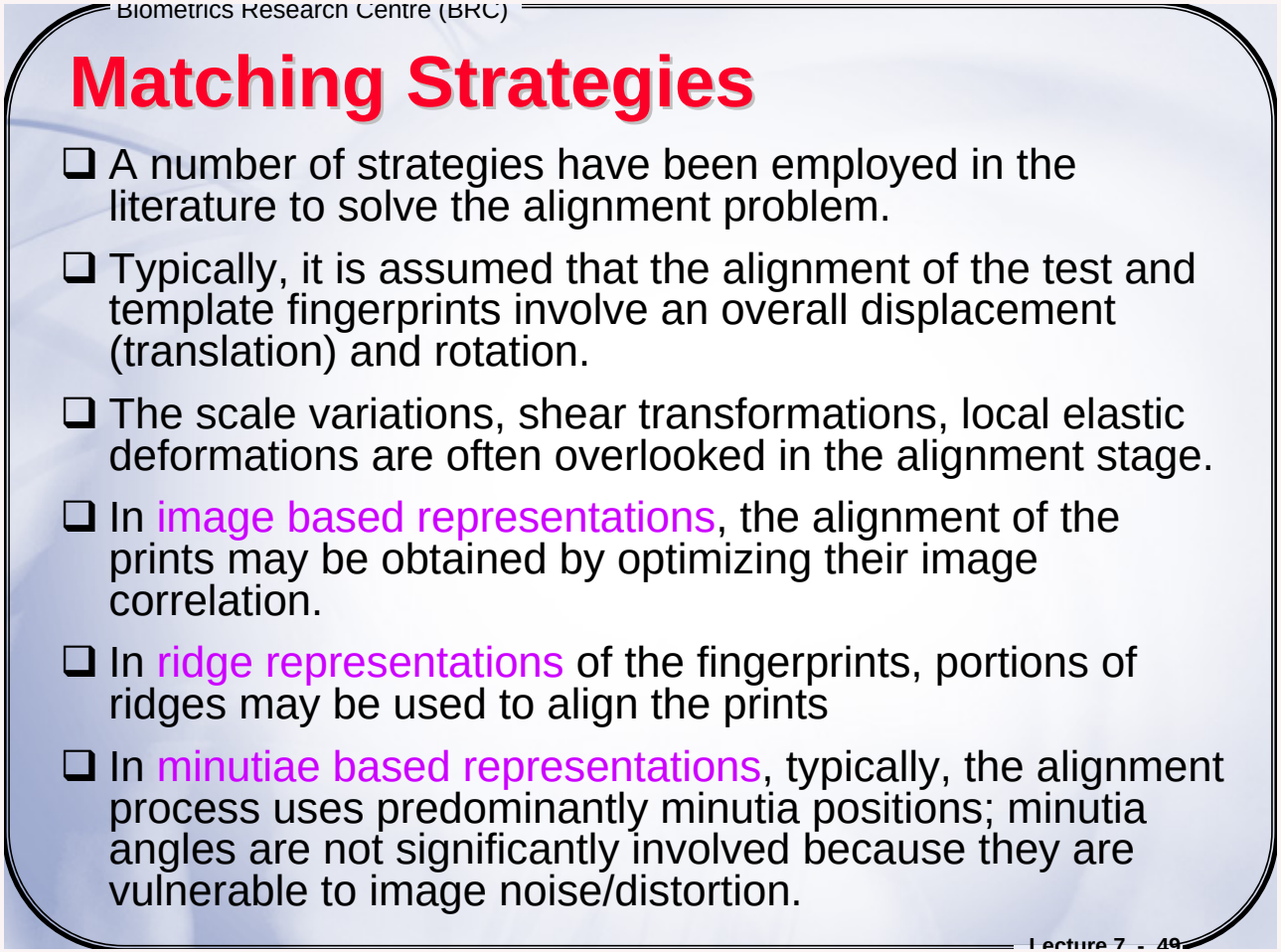
Problem 1.4 Global and Local Features

- Global features
  - Pattern Area
  - Core Point
  - Type Lines
  - Delta
  - Ridge Count
  - Basic Ridge Patterns: Loop, Arch, Whorl
- Local features
  - Ridge ending
  - Ridge bifurcation
  - Ridge divergence
  - Dot or island
  - Enclosure
  - Short ridge

Problem 1.5 Matching Strategies

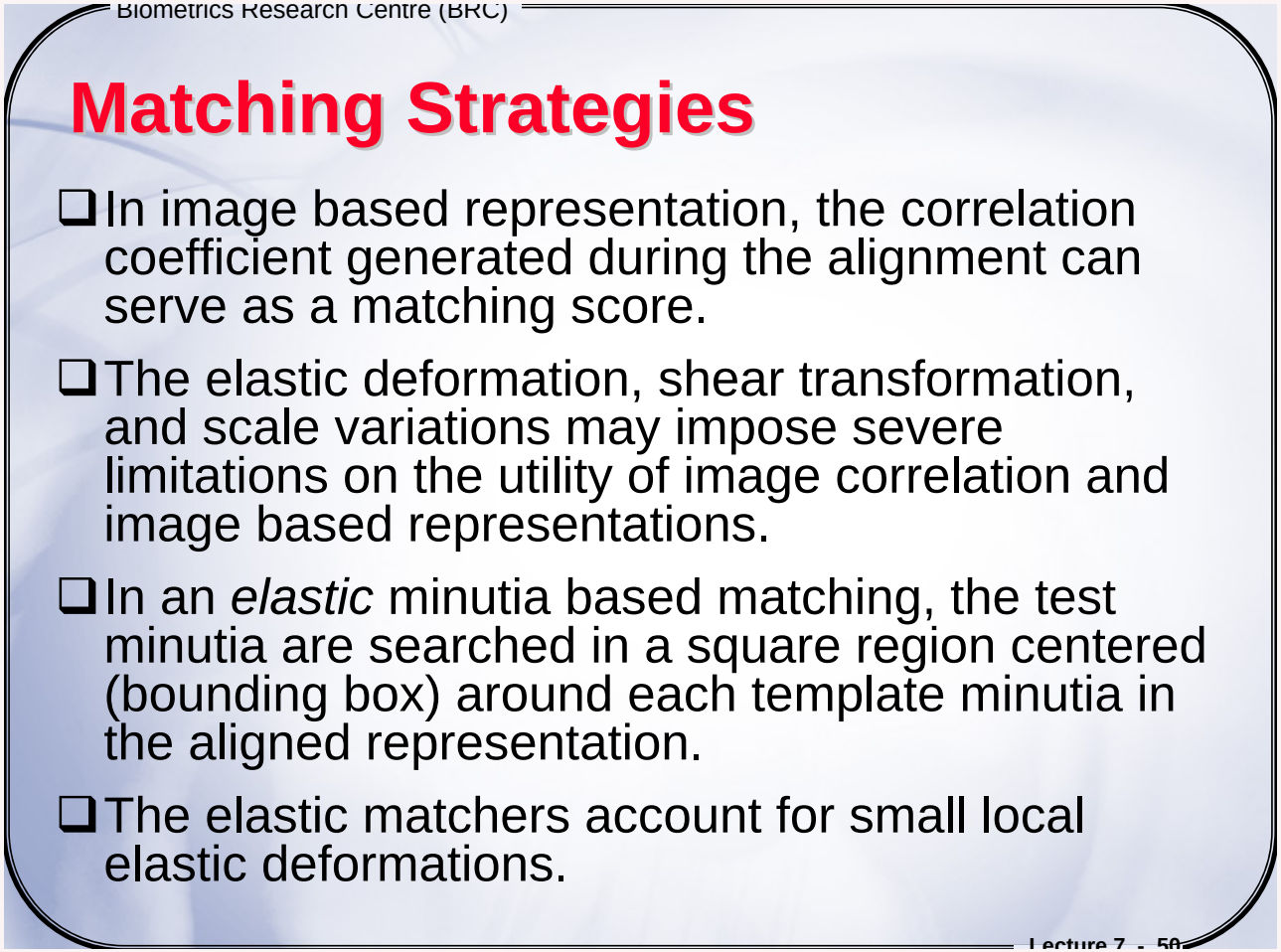
How many strategies can be used for fingerprint matching? Please compare their difference. (P7:49-52)

Problem 1.5 Matching Strategies

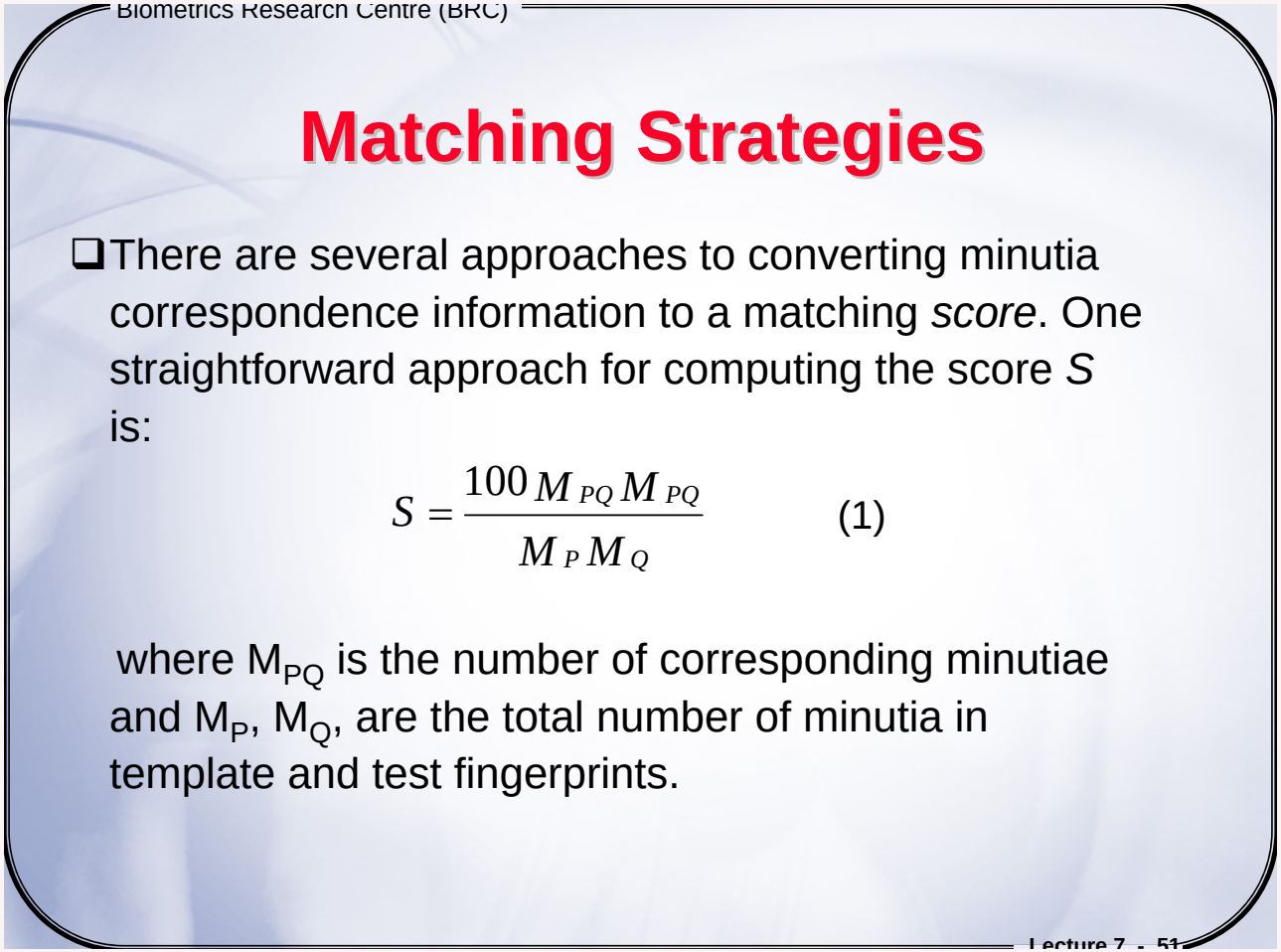


Three kinds of matching strategies based on three different represenation of the fingerprint.

Problem 1.5 Matching Strategies

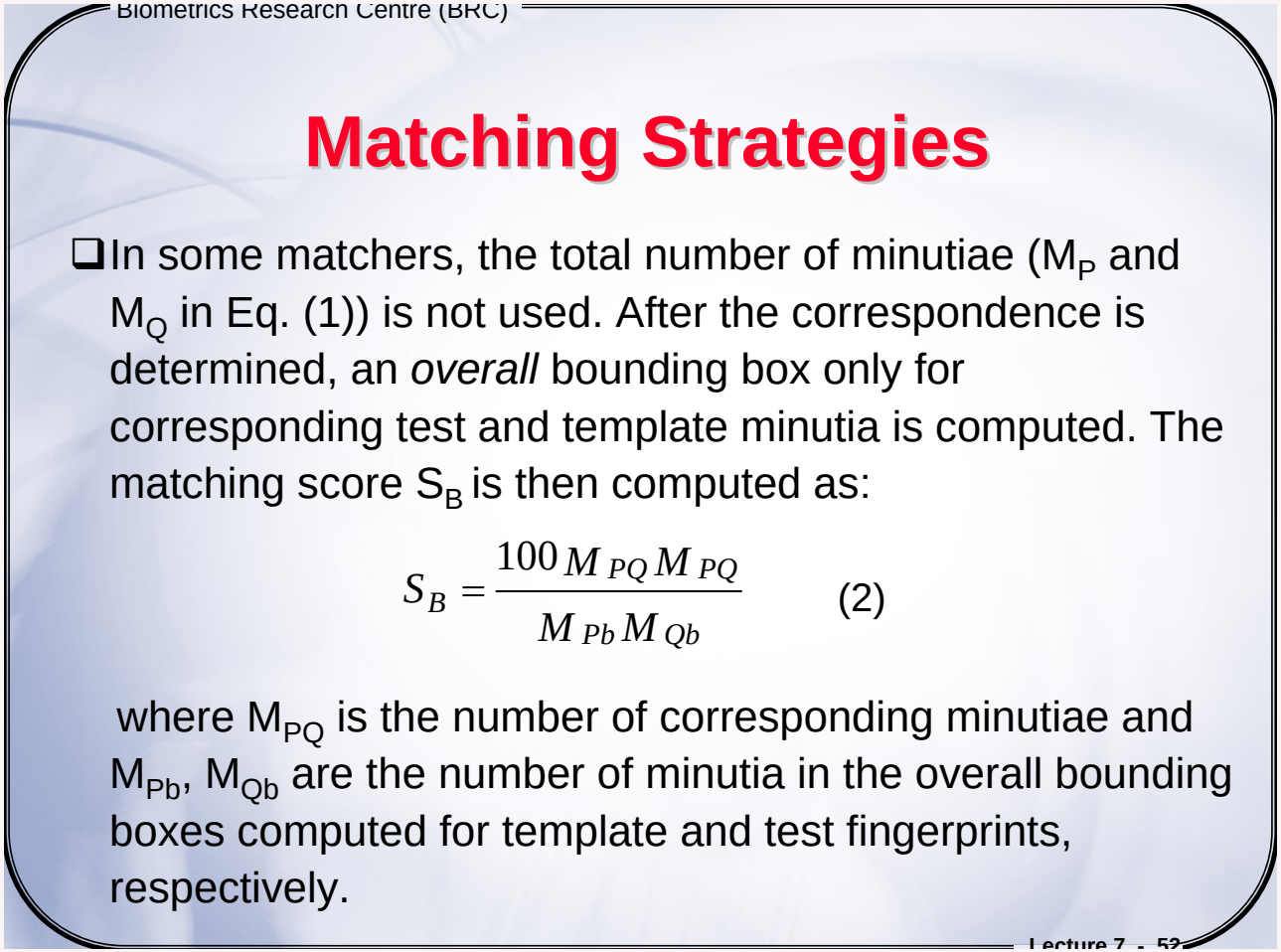


Problem 1.5 Matching Strategies



a Simple way to compute the matching score

Problem 1.5 Matching Strategies



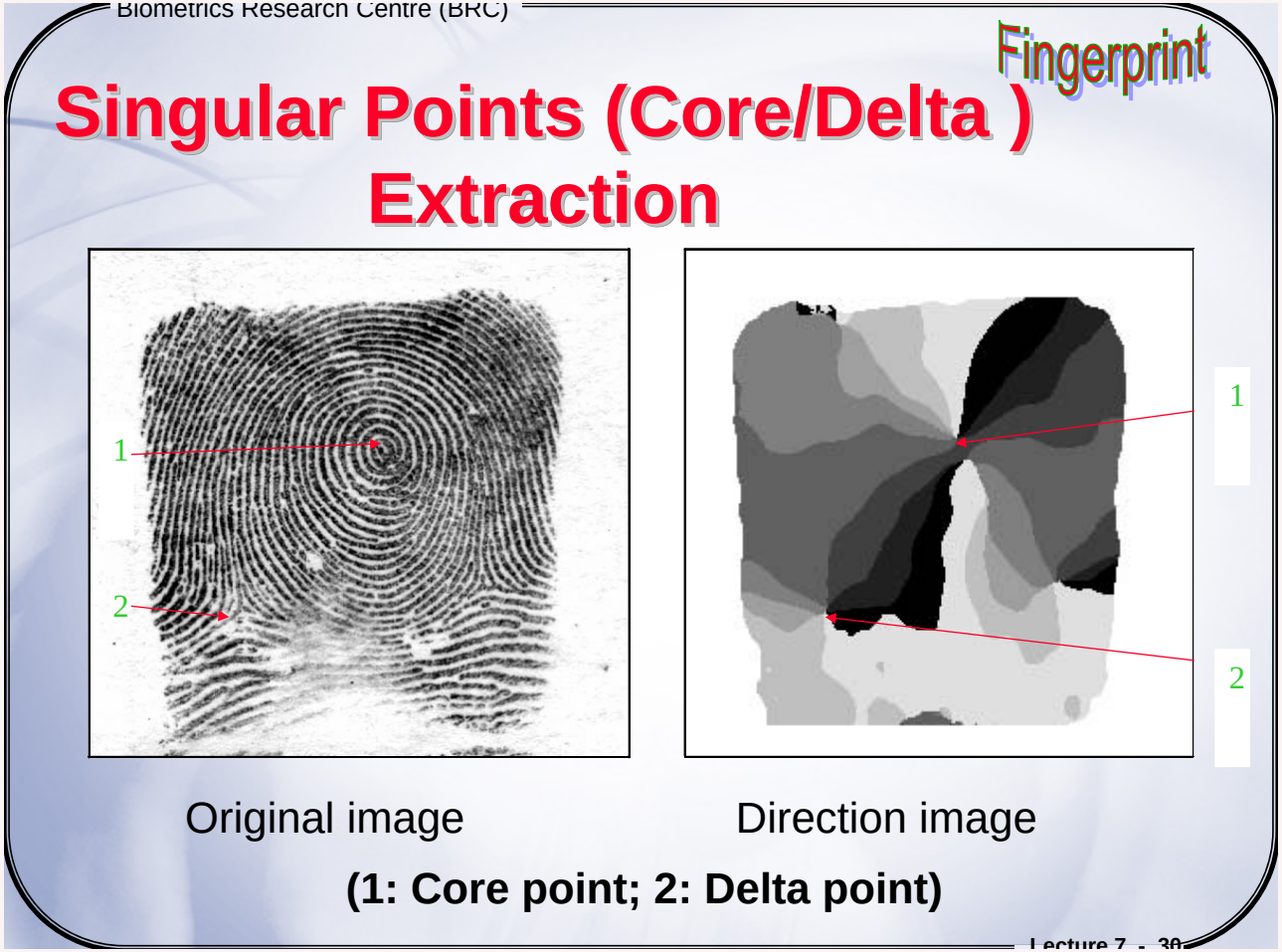
a General way to compute the matching score □

Outline

Problem 2: Singular Points

Singular points consist of Core point and Delta point. In P7:30 we can use the directional map to find them (one Core point and two Delta points). Please think about how to make an algorithm to do so.

Problem 2: Singular Points



Problem 2: Singular Points

1. Find the most compact circle of the point
2. Turn the direction value around the circle into direction vetors
3. sum up all the direciton vectors[a] [b]
4. The sum of core points and delta points should be almost zero.

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[a] Kalle Karu, Anil K. Jain, Fingerprint classification, Pattern Recognition, Volume 29, Issue 3, March 1996, Pages 389-404, ISSN 0031-3203, 10.1016/0031-3203(95)00106-9.

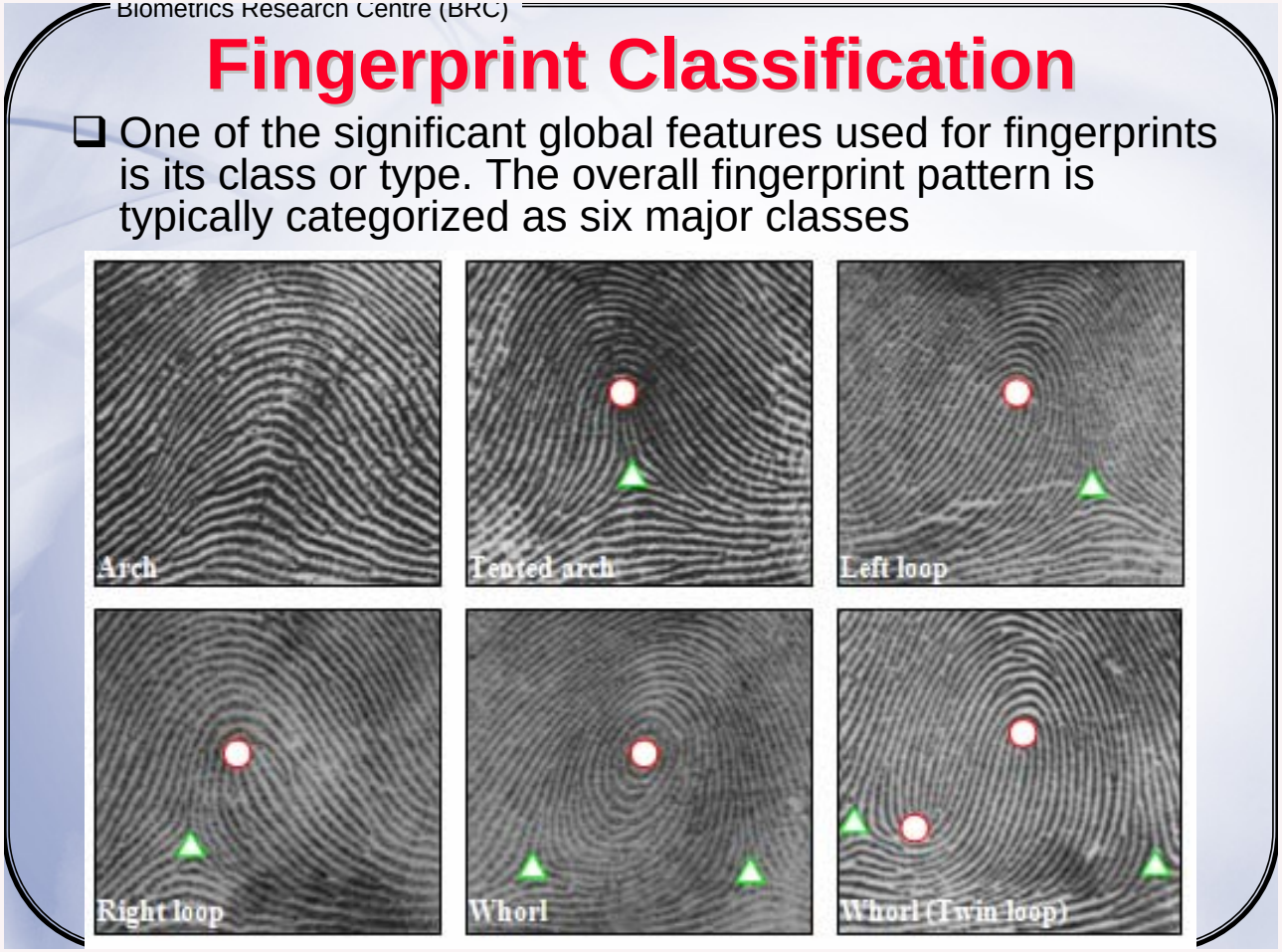
[b] Thien Hoang Van; Hoang Thai Le; , "An Efficient Algorithm for Fingerprint Reference-Point Detection," Computing and Communication Technologies, 2009. RIVF '09. International Conference on , vol., no., pp.1-7, 13-17 July 2009

Outline

Problem 3: Fingerprint Patterns

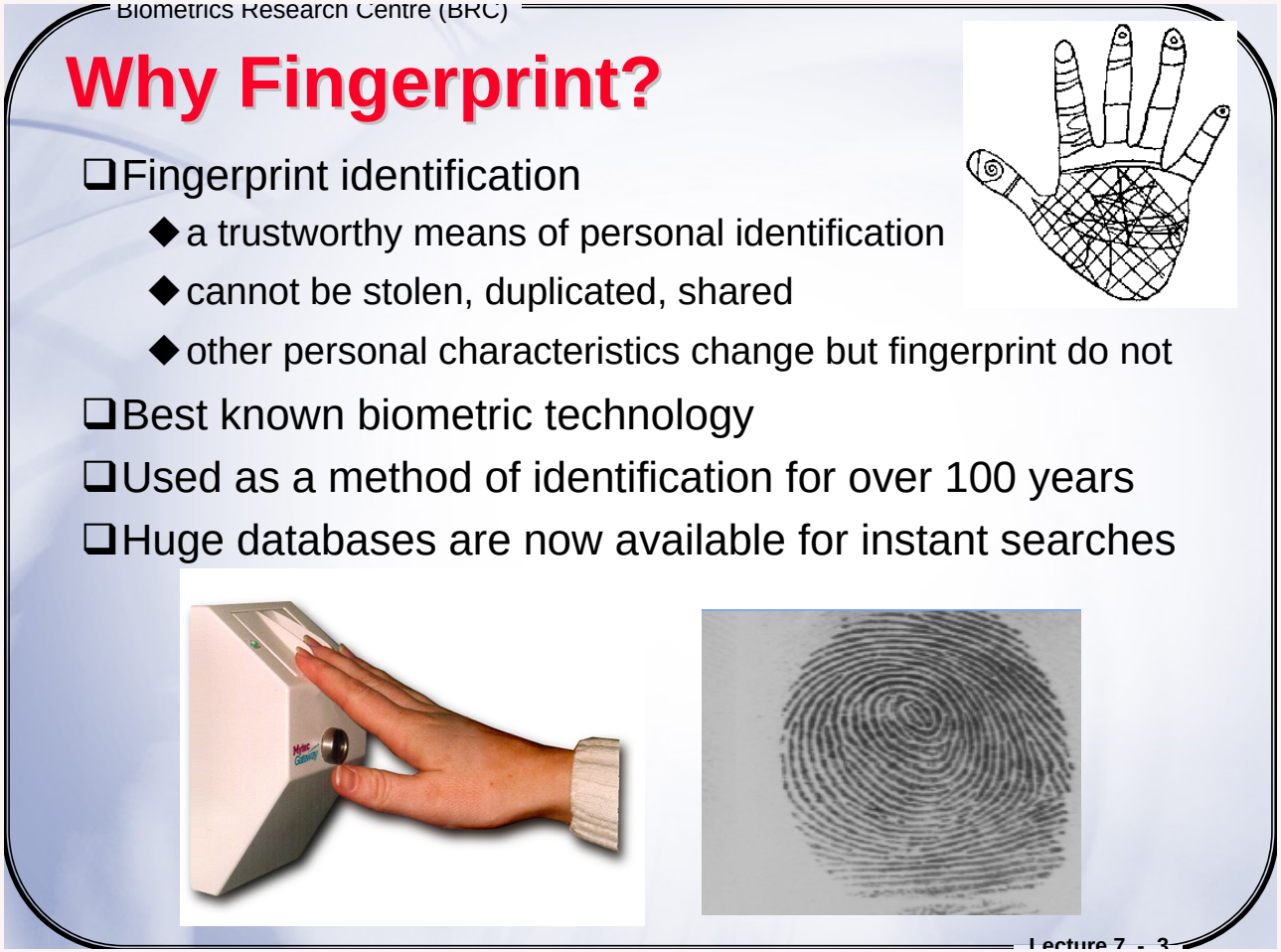
In P7:33 six major classes of the overall fingerprint patterns are given. Please compare them and try to classify the other all fingerprint samples in P7:3, 8-9, 12, 14-19, 24, 27, 31.

Problem 3: Fingerprint Patterns



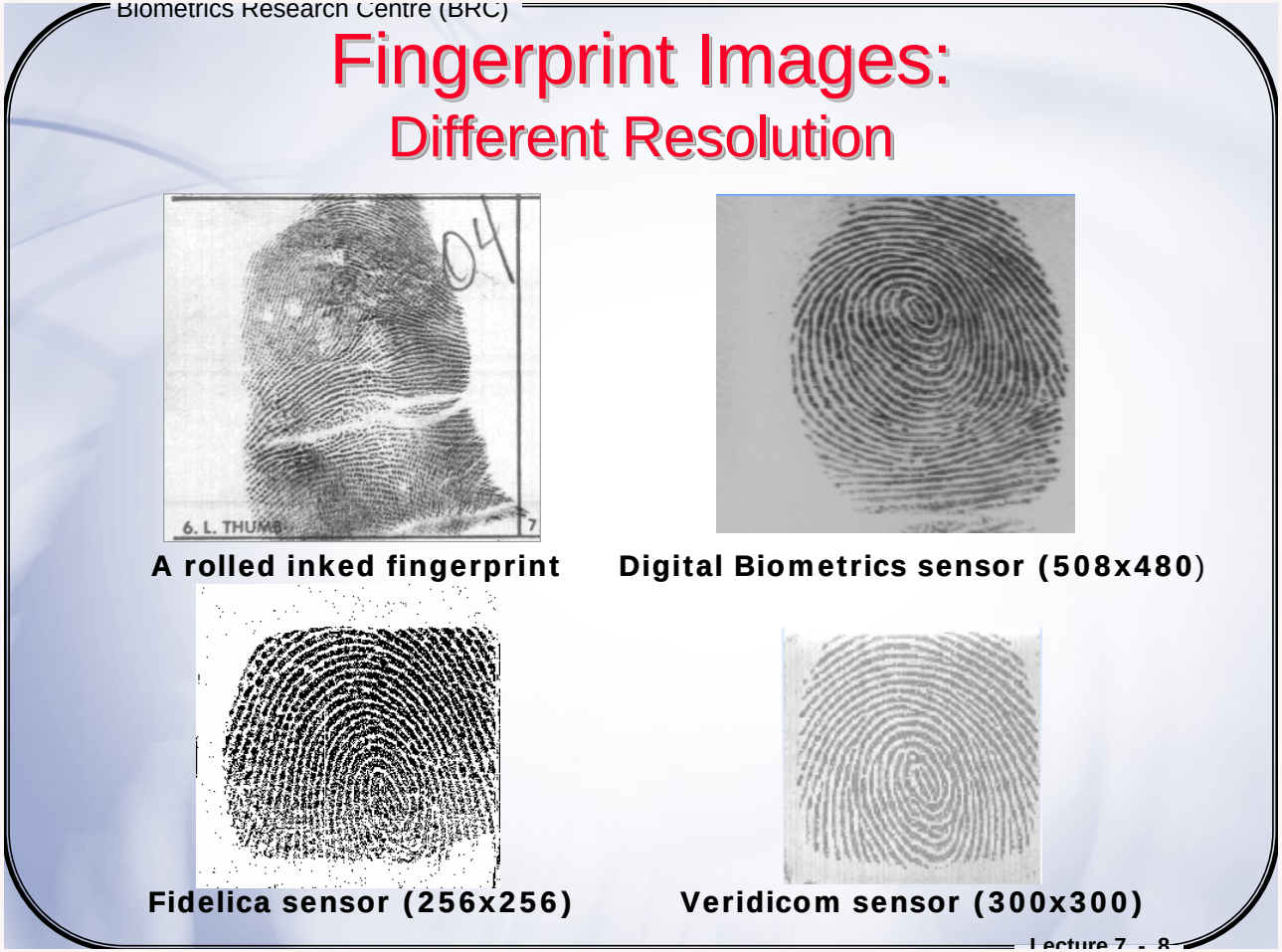
Arch, Tented arch, Left loop, Right loop, Whorl, Whorl(Twin loop)

Problem 3: Fingerprint Patterns



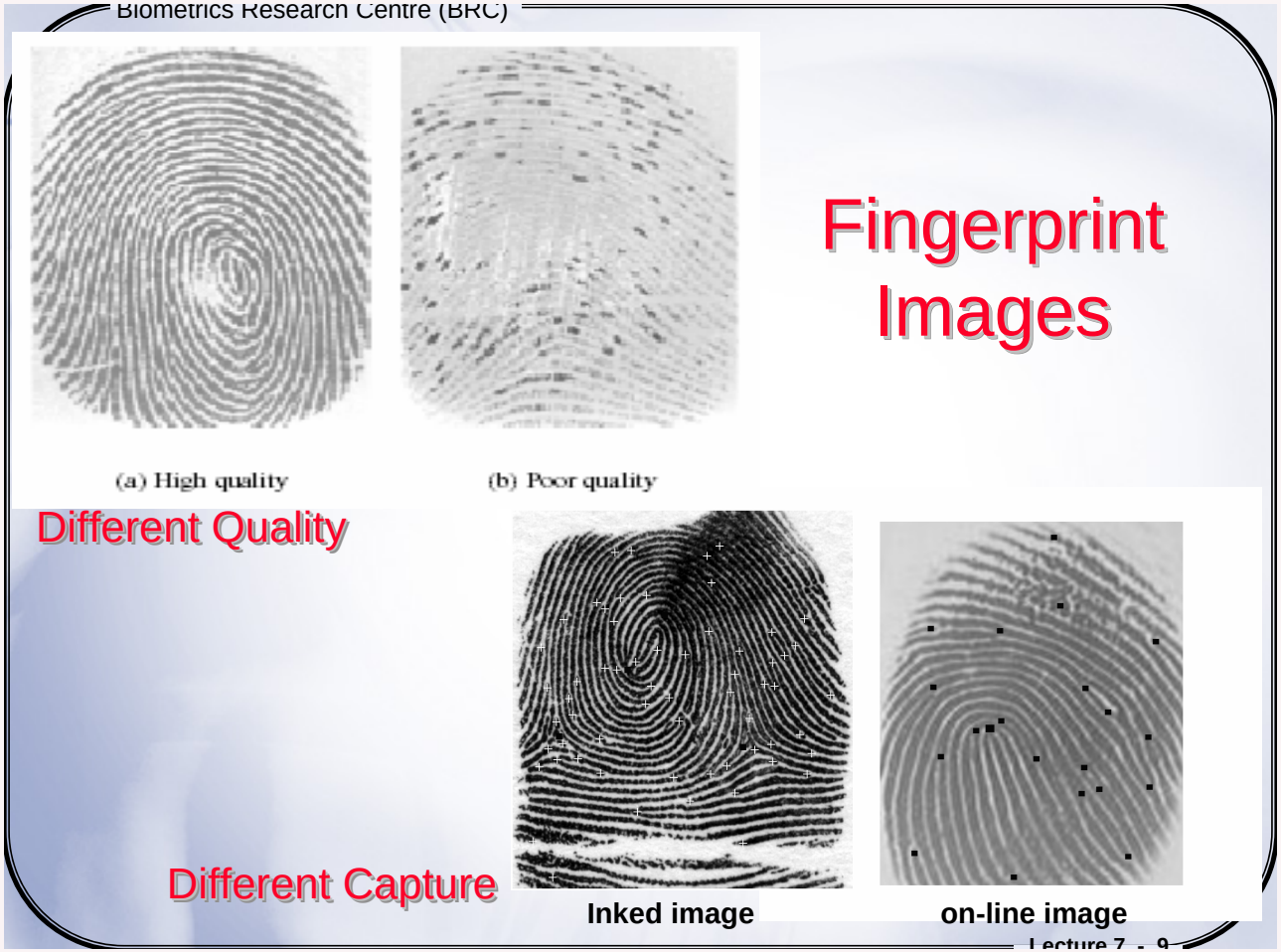
Whorl

Problem 3: Fingerprint Patterns



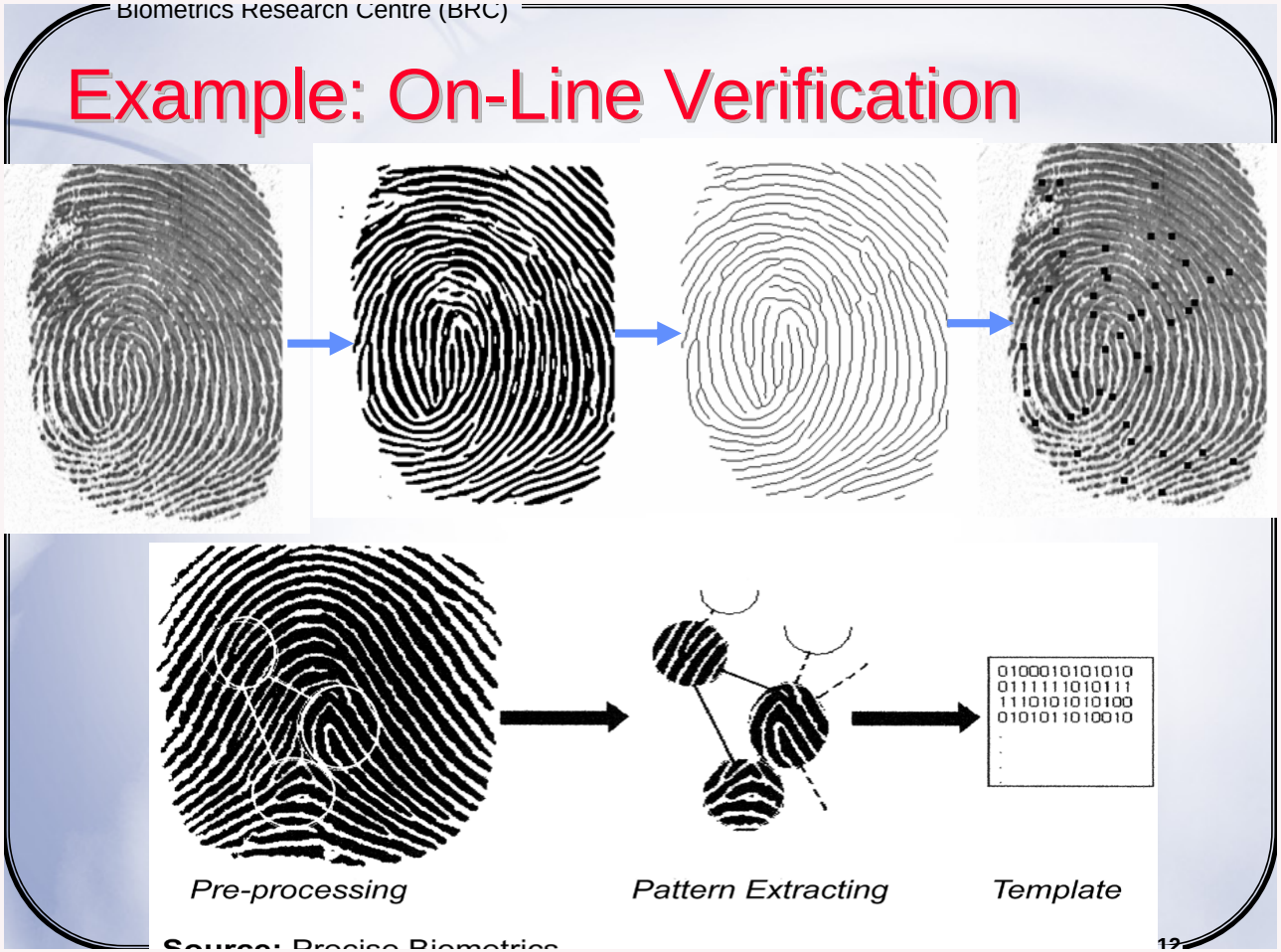
Left loop, Whorl, Whorl, Whorl

Problem 3: Fingerprint Patterns



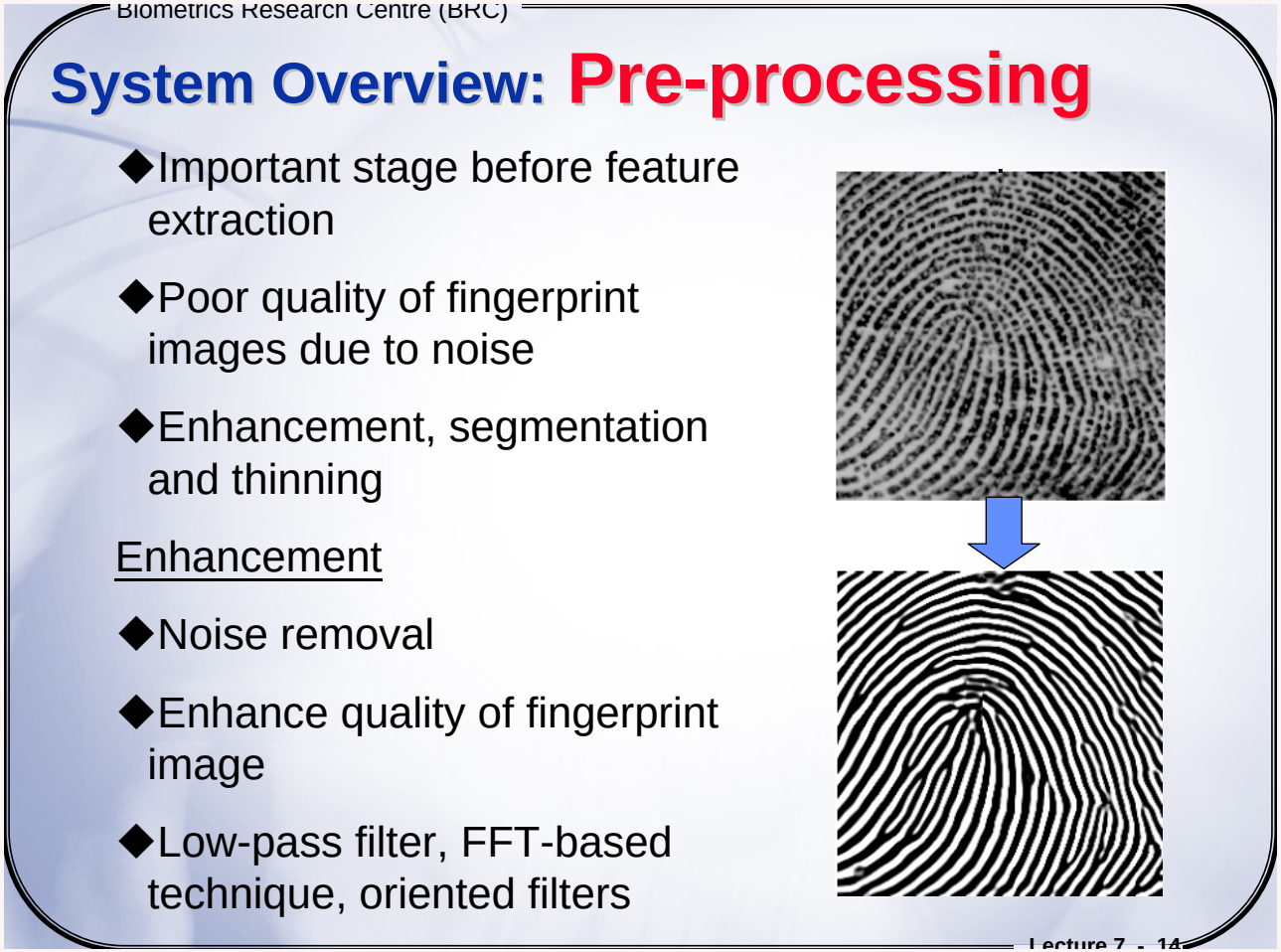
Whorl, Arch, Whorl, Right loop

Problem 3: Fingerprint Patterns



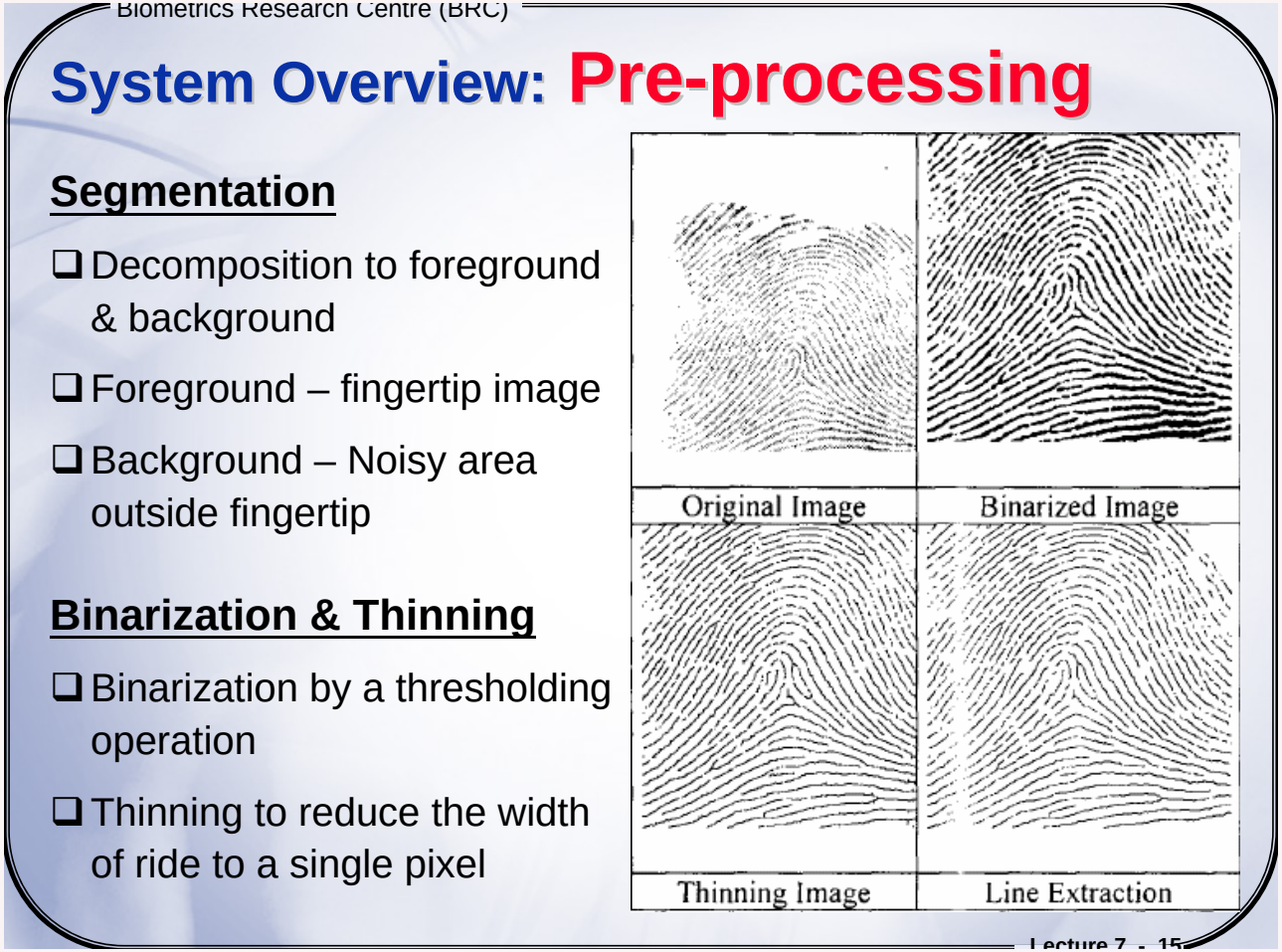
Whorl, Tented arch

Problem 3: Fingerprint Patterns



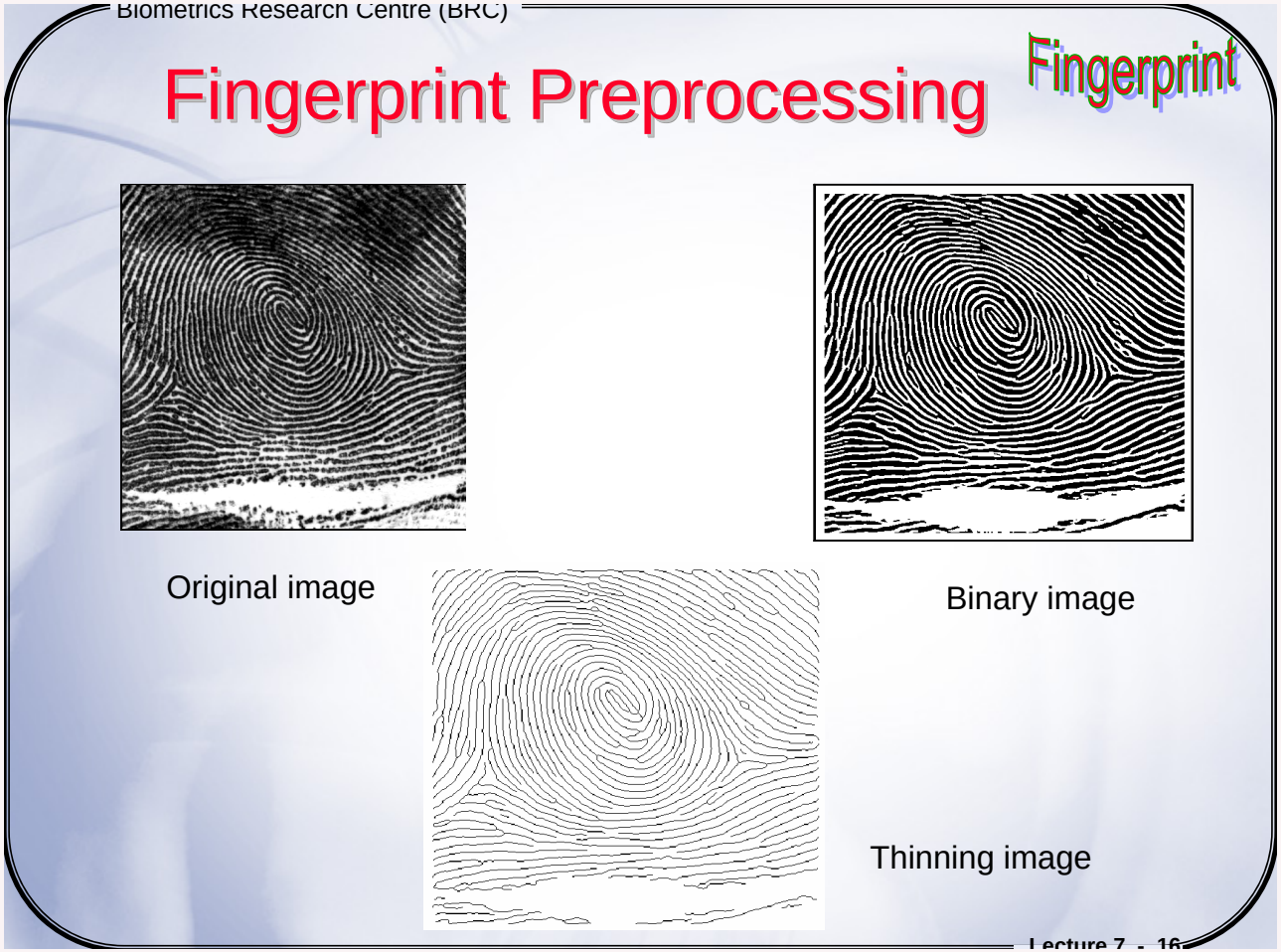
Left loop

Problem 3: Fingerprint Patterns



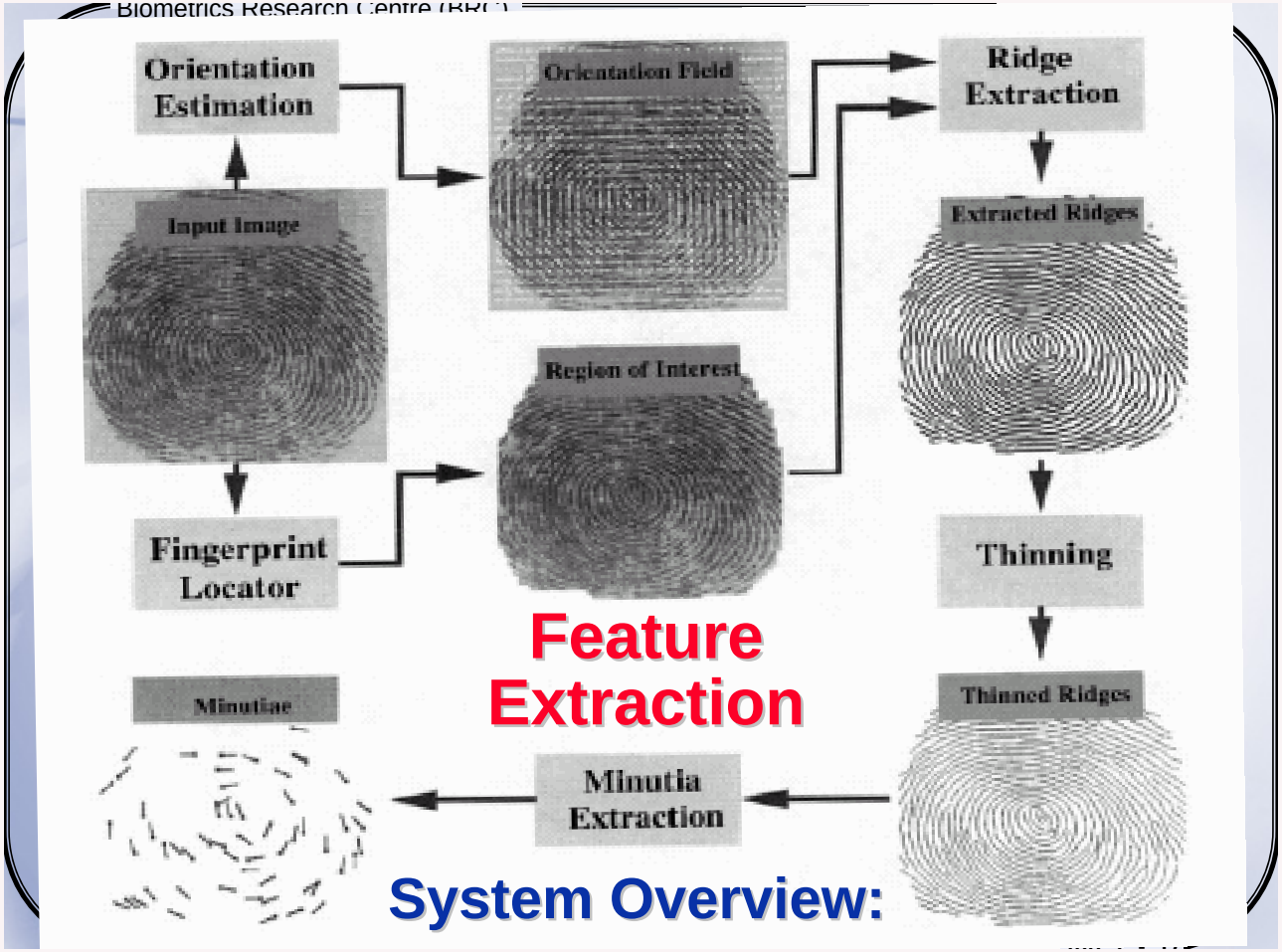
Arch

Problem 3: Fingerprint Patterns



Whorl

Problem 3: Fingerprint Patterns



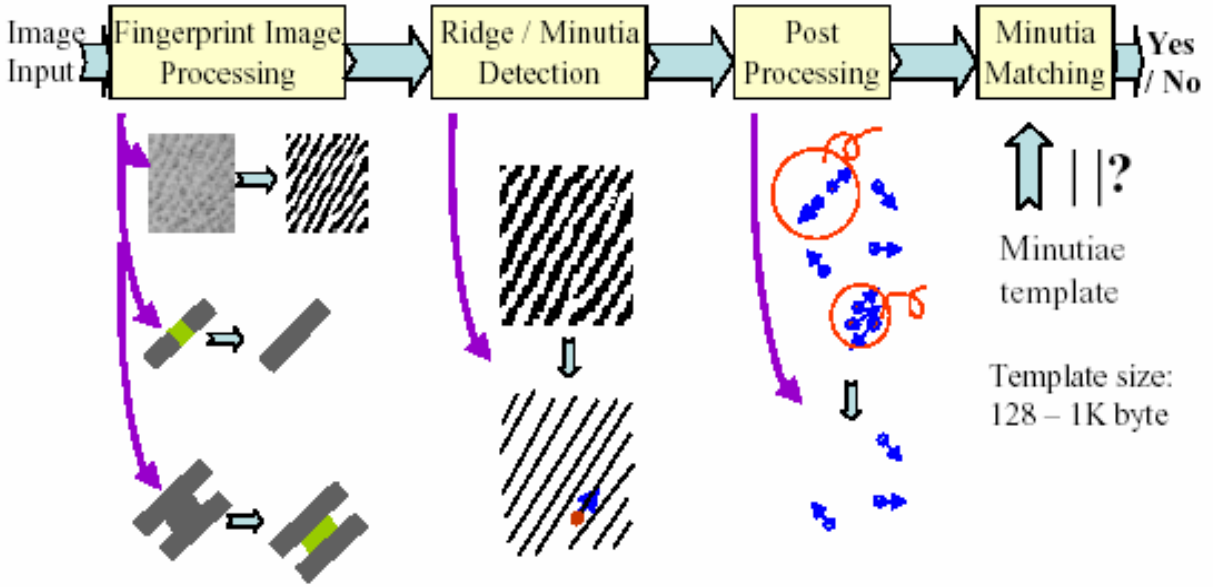
Whorl

Problem 3: Fingerprint Patterns

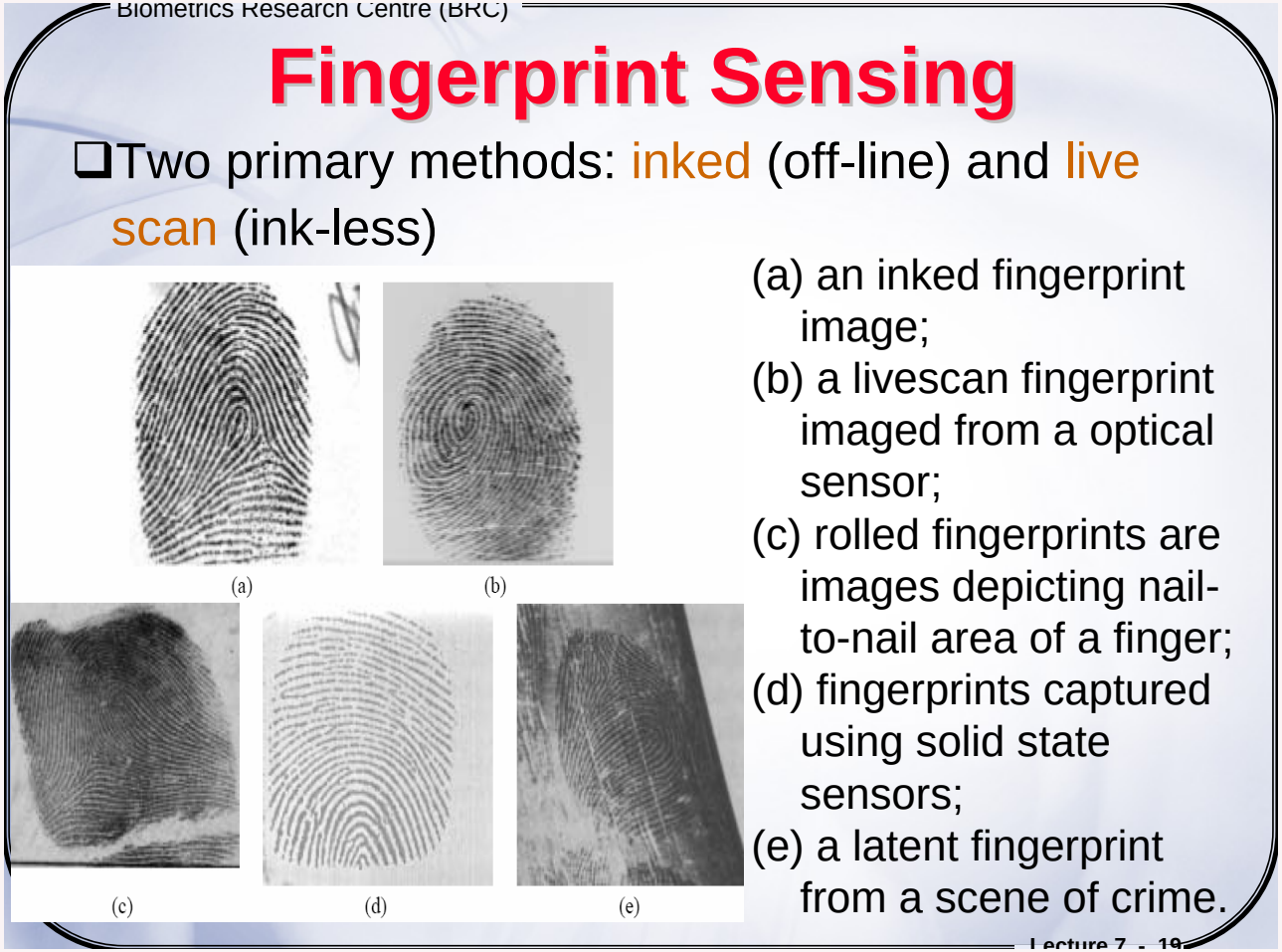
Biometrics Research Centre (BRC)

System Overview: Feature Matching

- Align the test and reference pattern
- Count the number of minutia pairs
- Determine the matching score
- Based on certain threshold to determine 'match' or not

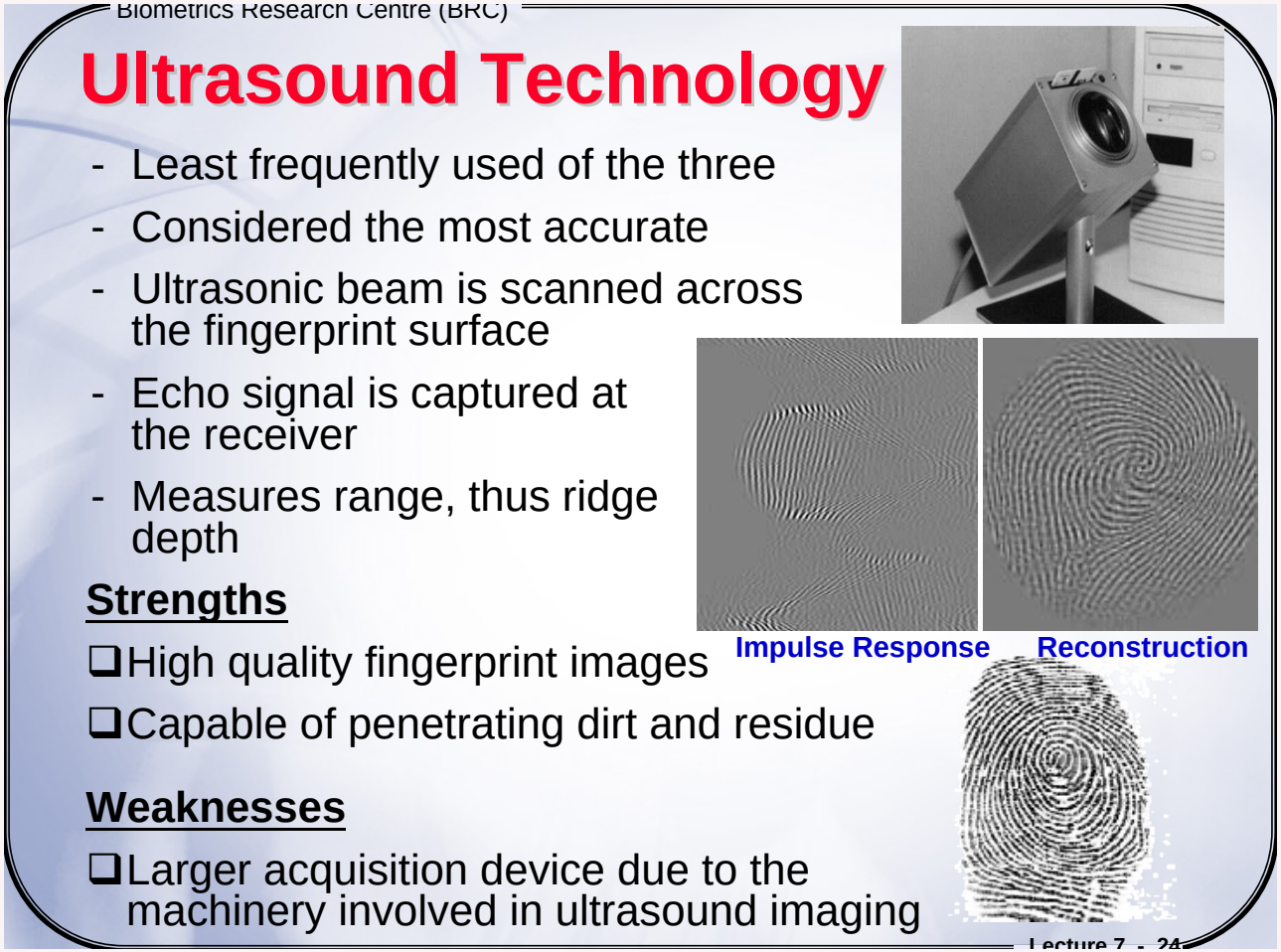


Problem 3: Fingerprint Patterns



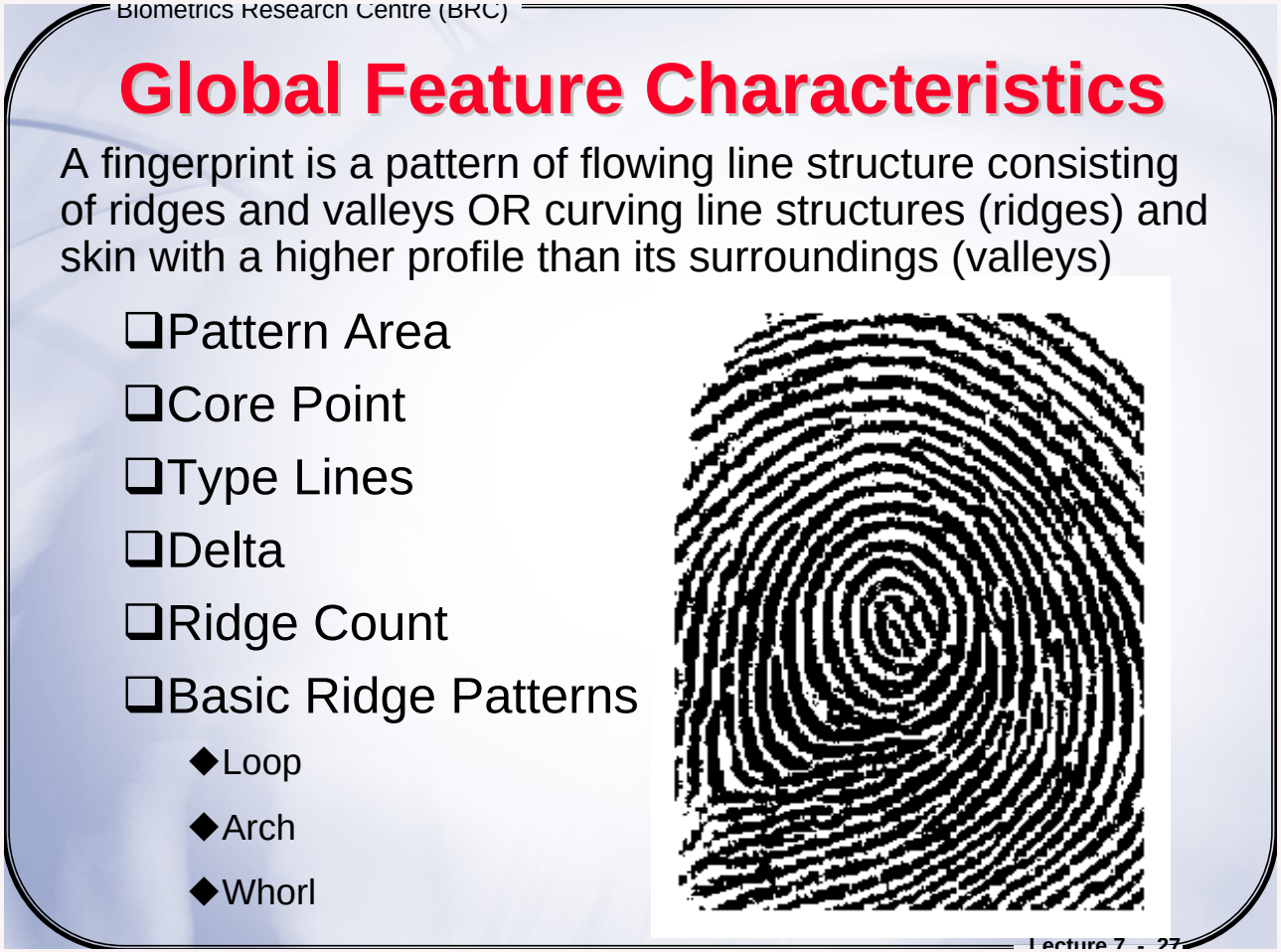
Left loop, Whorl, Right loop, Whorl, Whorl(Twin loop)

Problem 3: Fingerprint Patterns



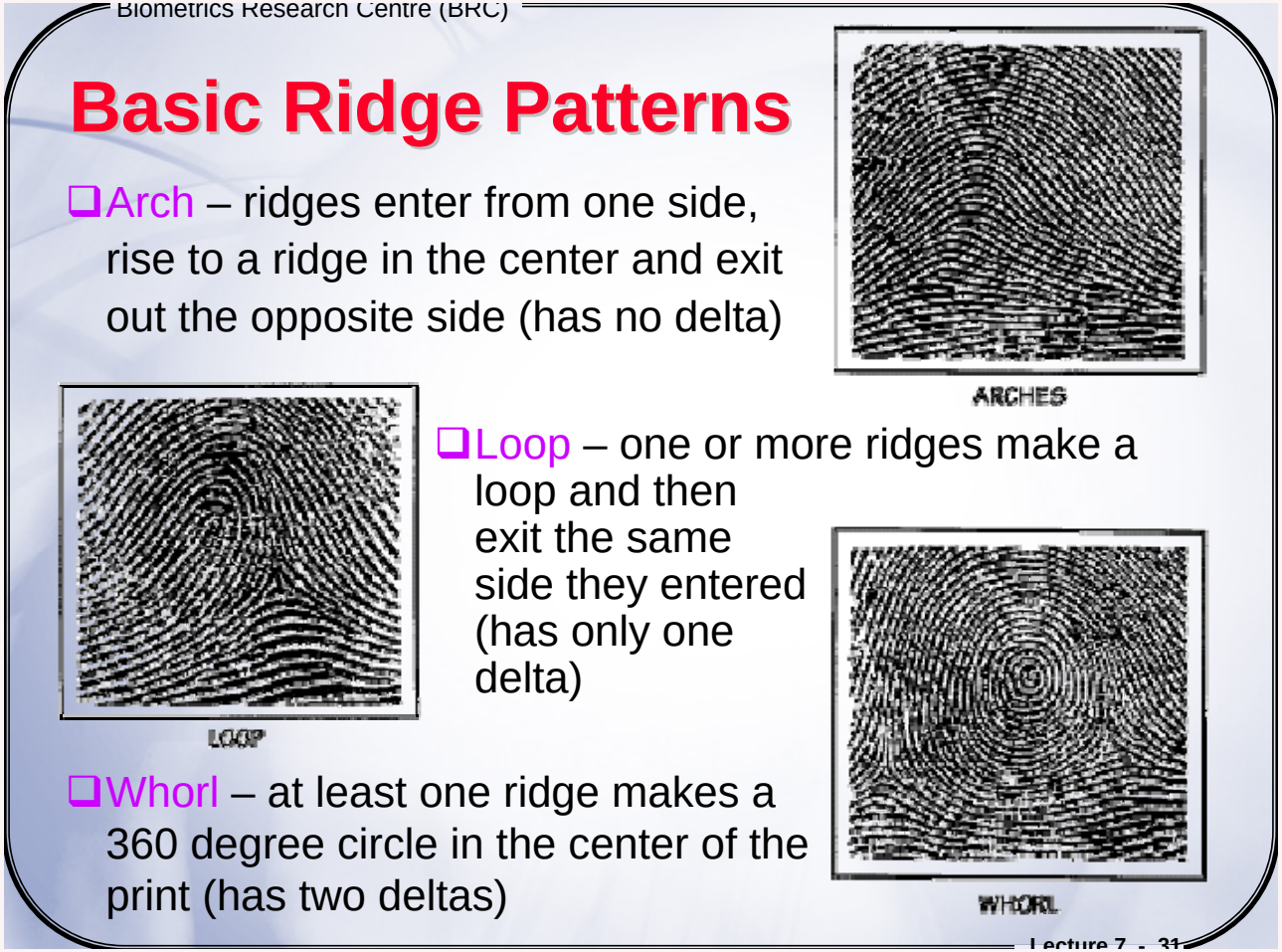
Whorl, Whorl

Problem 3: Fingerprint Patterns



Whorl

Problem 3: Fingerprint Patterns



Arch, Left loop, Whorl

Outline

Problem 4: Global and Local Fingerprint Features

Which features are used as global and local features, respectively? Could you find them in the given fingerprint image (P7:35)?

Problem 4: Global and Local Fingerprint Features

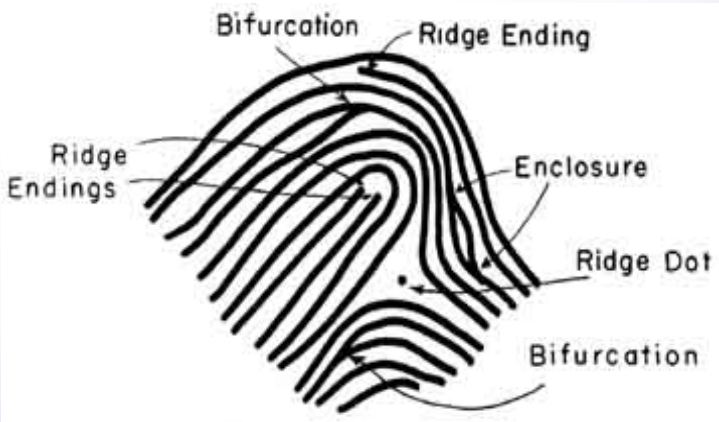
- Global features
  - Pattern Area
  - Core Point
  - Type Lines
  - Delta
  - Ridge Count
  - Basic Ridge Patterns: Loop, Arch, Whorl
- Local features
  - Ridge ending
  - Ridge bifurcation
  - Ridge divergence
  - Dot or island
  - Enclosure
  - Short ridge

Problem 4: Global and Local Fingerprint Features

Biometrics Research Centre (BRC)

Local Feature Characteristics

- Known as minutia points which ridges end, fork and change
- Tiny, unique characteristics of fingerprint ridges that are used for positive identification
- Possible for one or more individuals to have identical global features but still have different and unique fingerprints because of the minutia points
- Types
  - Ridge ending
  - Ridge bifurcation
  - Ridge divergence
  - Dot or Island
  - Enclosure
  - Short Ridge



Lecture 7 - 35

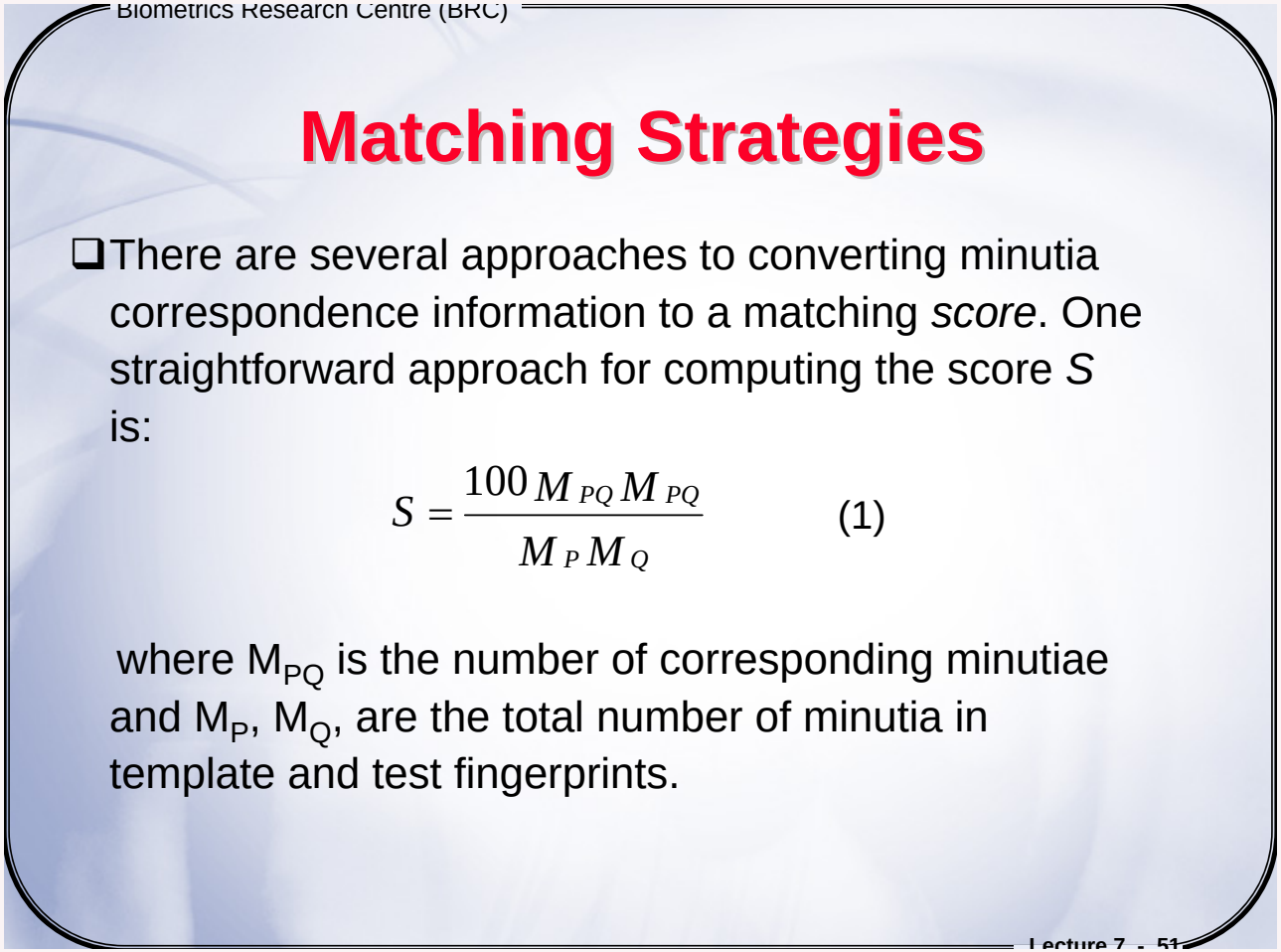
(Left Loop, Delta point: 1 Bifurcation: 4 and Ending: 3) □

Outline

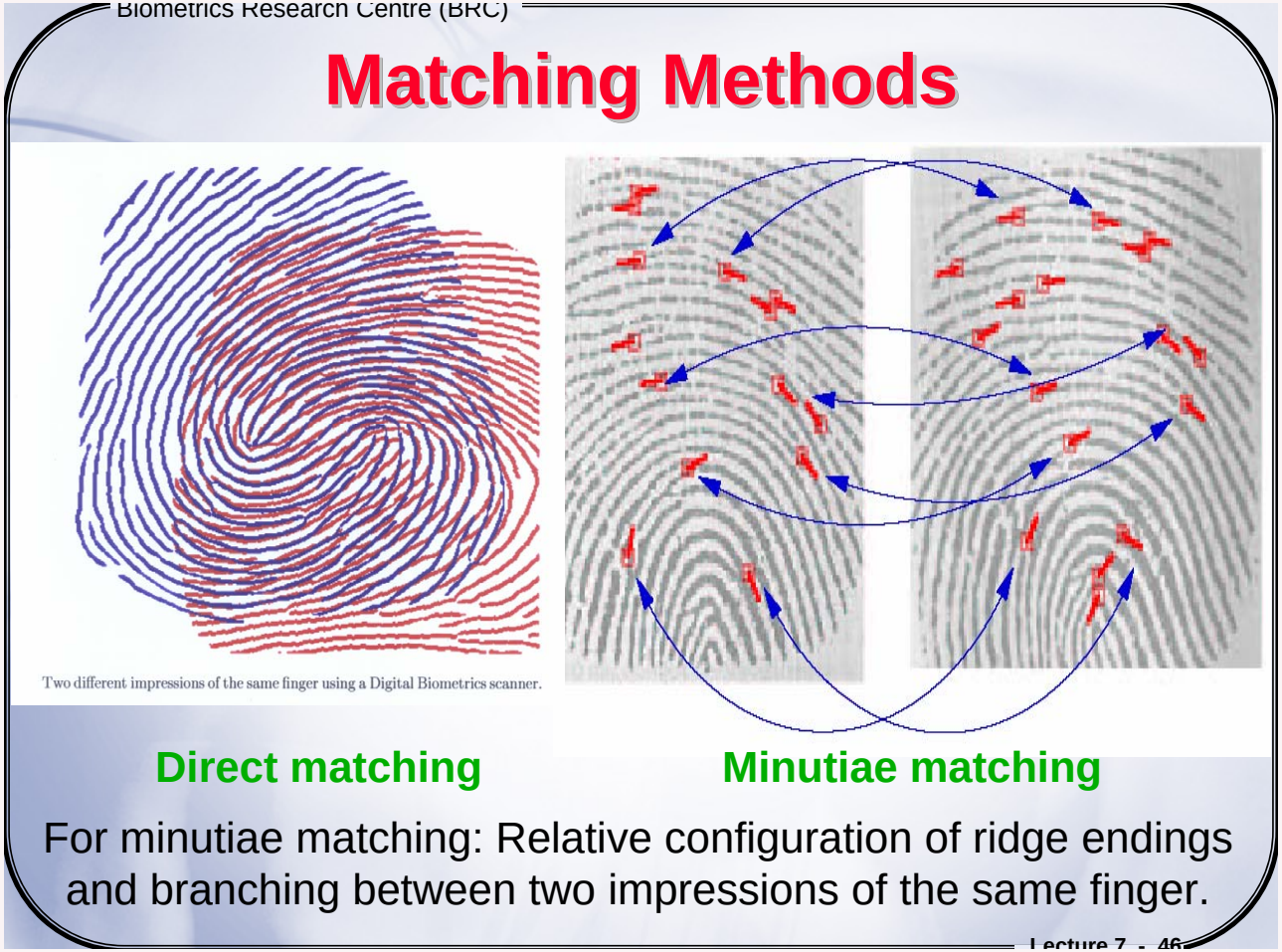
Problem 5: Minutiae Matching

Please check the Minutiae matching in P7:46 and compute the matching score according to the Eq.(1) in P7:51.

Problem 5: Minutiae Matching



Problem 5: Minutiae Matching



$$S = \frac{100 M_{PQ} M_{PQ}}{M_P M_Q} = \frac{100 \times 8 \times 8}{14 \times 17} = 26.9$$

Q & A

Any questions?