Module 2

Fingerprint Matching Techniques

Fingerprint Processing

- Human fingerprints are unique to each person and can be regarded as some sort of signature, certifying the person's identity.

- Because straightforward matching between the fingerprint pattern to be identified and many already known patterns has problems due to its high sensitivity to errors (e.g. various noises, damaged fingerprint areas, or the finger being placed in different areas of fingerprint scanner window and with different orientation angles, finger deformation during the scanning procedure etc.).

- Modern techniques focus on extracting minutiae points (points where capillary lines have branches or ends) from the fingerprint image, and check matching between the sets of fingerprint features.

Progressive Fingerprint Matching

- **Image Processing**

    - Capture the fingerprint images and process them through a series of image processing algorithms to obtain a clear unambiguous skeletal image of the original gray tone impression, clarifying smudged areas, removing extraneous artifacts and healing most scars, cuts and breaks.
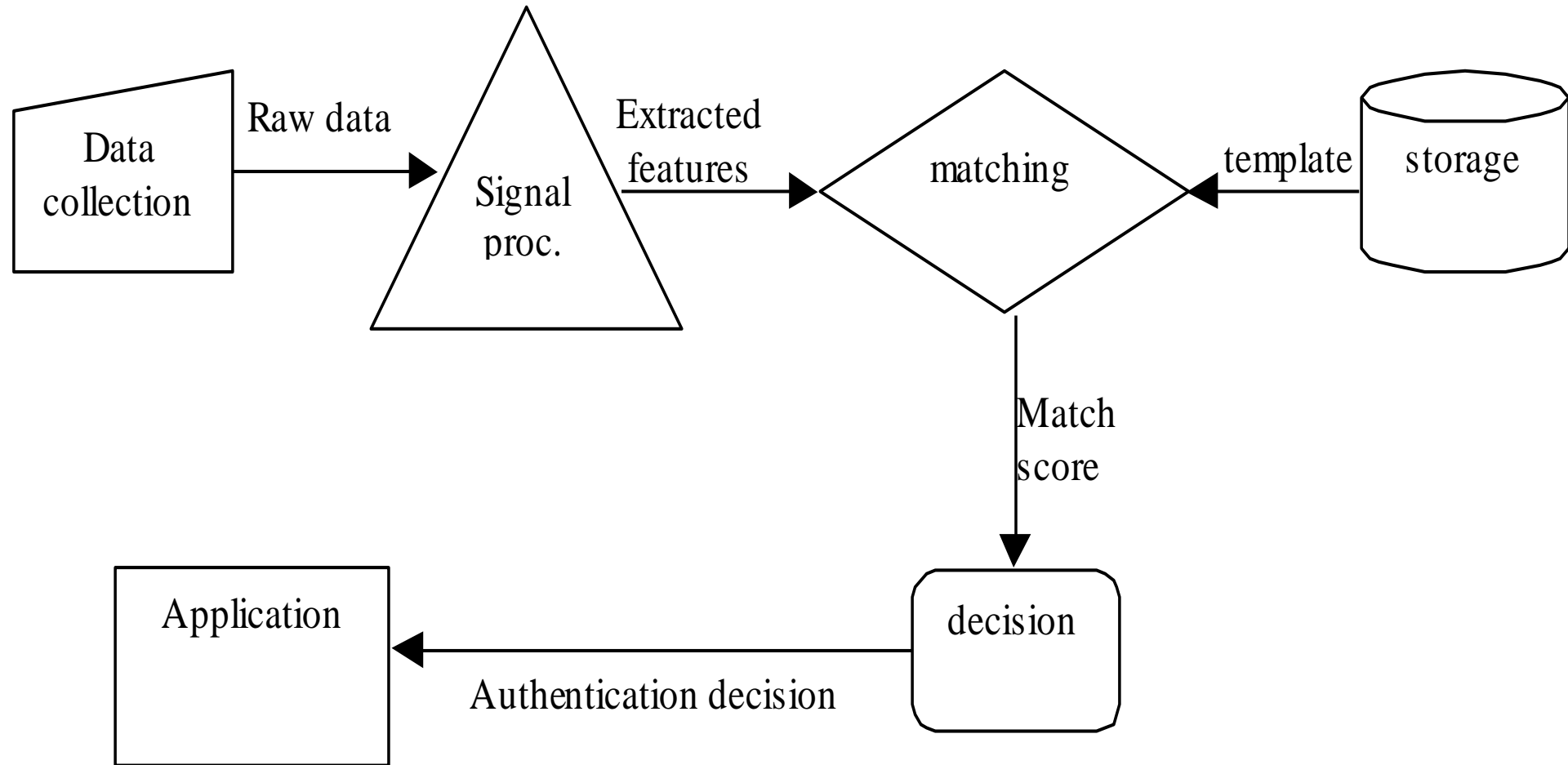

Original image
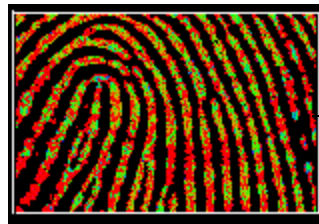
Undesirable features marked

Final image

General Model for Fingerprint Authentication

Fingerprint matching techniques

- There are two categories of fingerprint matching techniques: minutiae-based , correlation based and Ridge based.
  - **Minutiae-based techniques** first find minutiae points and then map their relative placement on the finger.
  - The **correlation-based** method is able to overcome some of the difficulties of the minutiae-based approach.
  - **Ridge based techniques** used even if features are damaged or shortage of features.

Minutiae based Processing

- The following steps are followed in a minutiae based system:
    - directional field estimation
    - adaptive filtering for noise reduction
    - thresholding to obtain a binary fingerprint image
    - morphological operations like thinning to obtain ridges that are only one pixel wide
    - minutiae extraction from the thinned image
    - application of heuristics to reduce the number of false minutiae
    - registration of minutiae templates by Hough transform
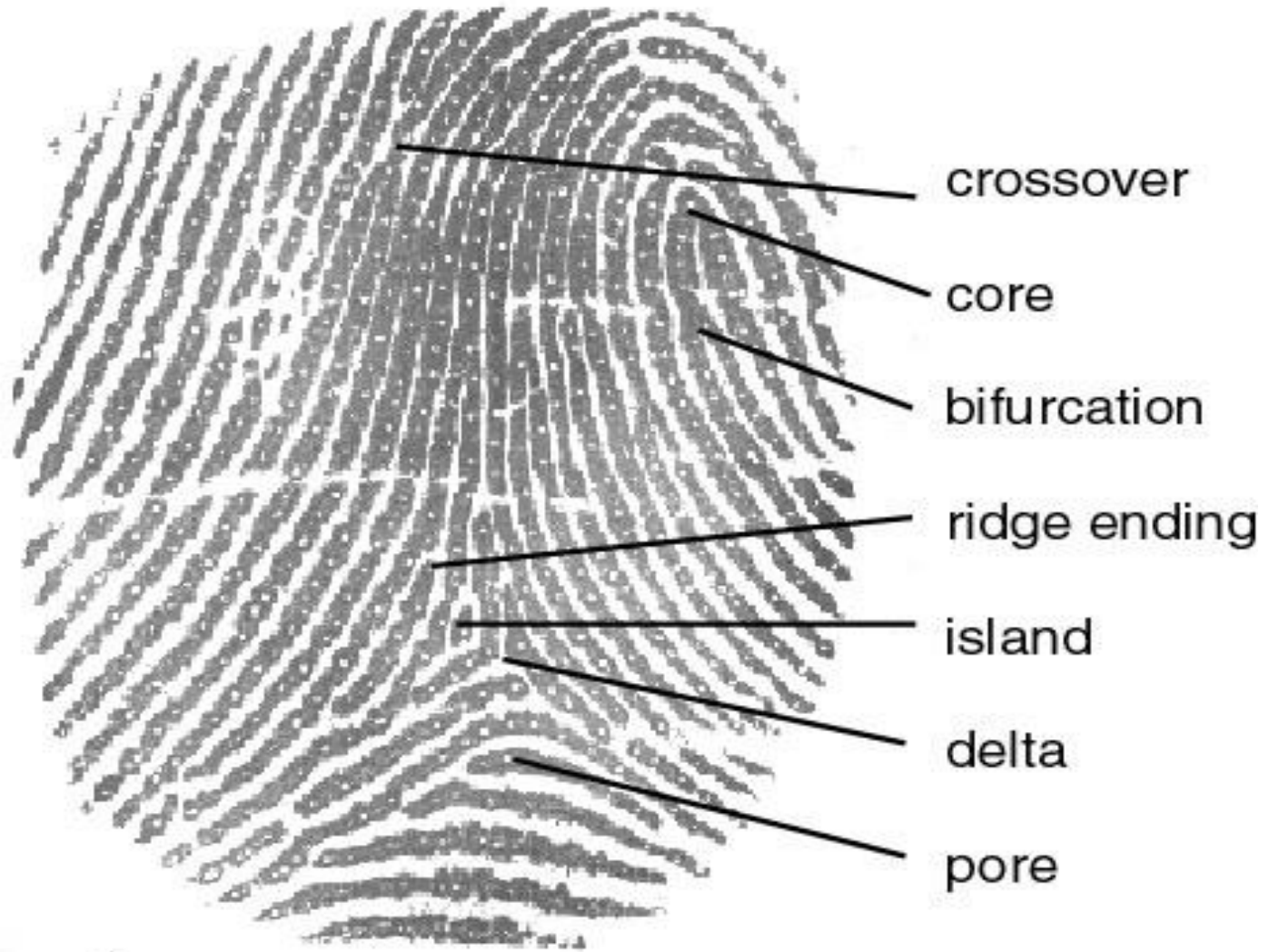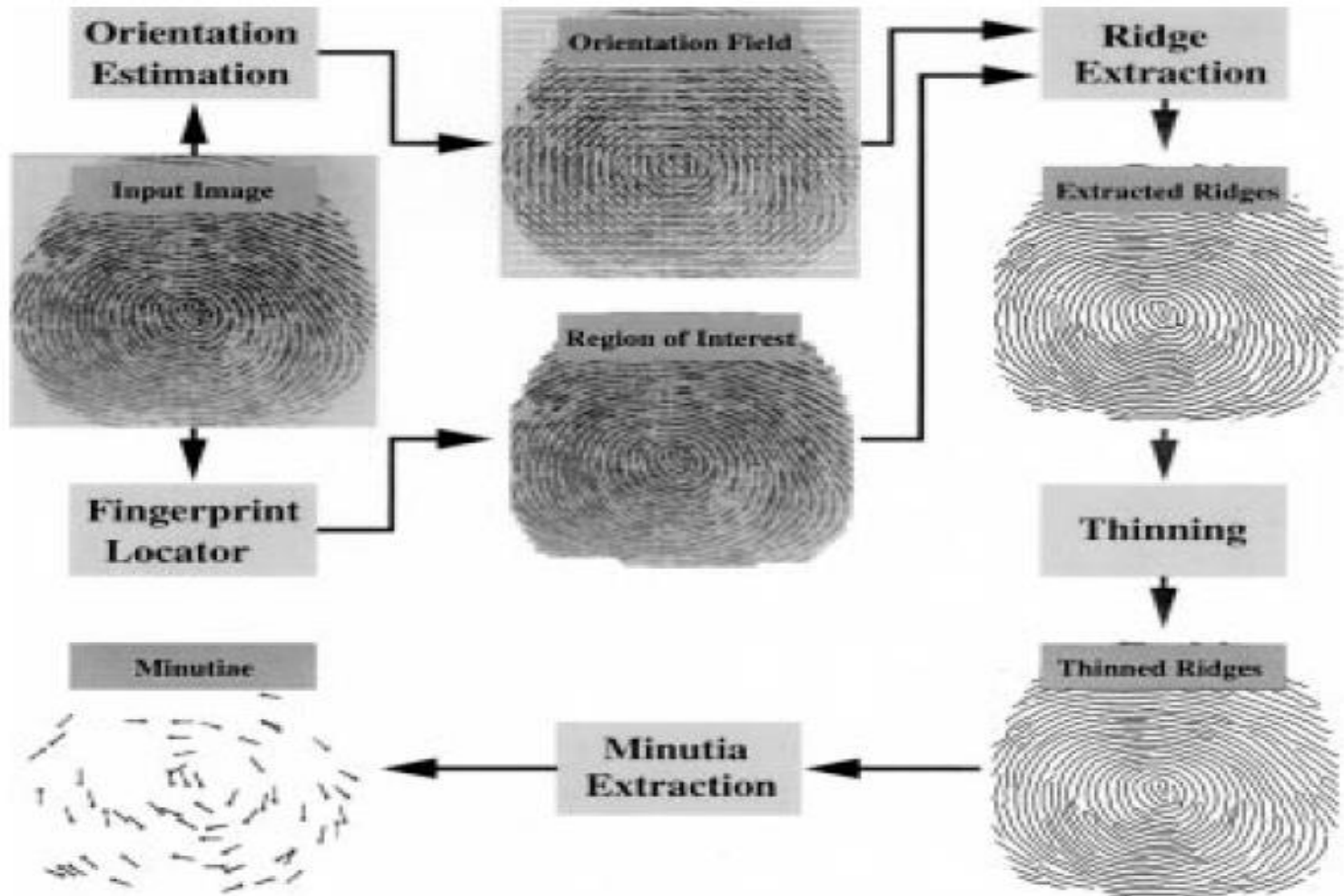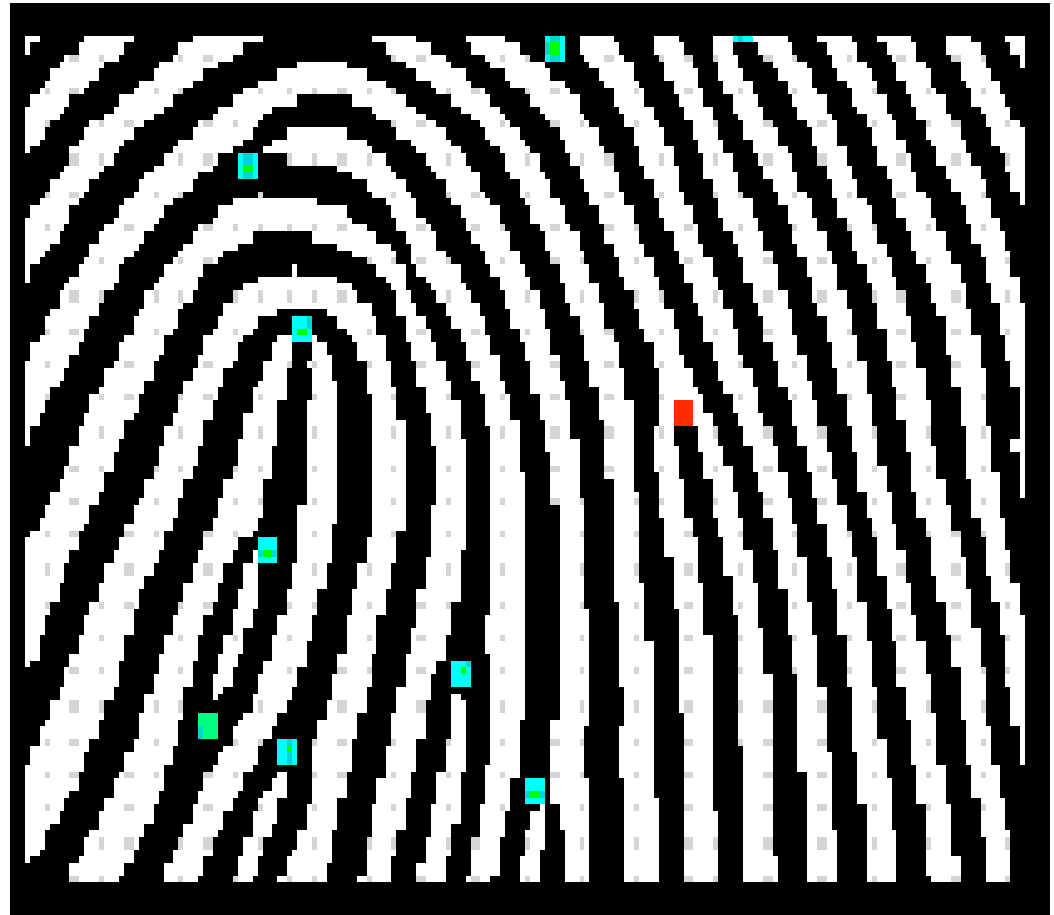   - matching score computation.

Figure 1

Minutiae Extraction

- **Feature Detection for Matching** Ridge ends and bifurcations (minutiae) within the skeletal image are identified and encoded, providing critical placement, orientation and linkage information for the fingerprint matching process.

- A selected fingerprint is mapped into a digital frame by a function f (minutiea type t, site l, neighborhood theta) =

  f(t, l, theta).

Map the selected minutiae

Disadvantages

- In real life you would have impressions made at separate times and subject to different pressure distortions.
- On the average, many of these images are relatively clean and clear, however, in many of the actually crime scenes, prints are anything but clear.
- There are cases where it is not easy to have a core pattern and a delta but only a latent that could be a fingertip, palm or even foot impression
- The method does not take into account the global pattern of ridges and furrows.
- Fingerprint matching based on minutiae has problems in matching different sized (unregistered) minutiae patterns.
- Local ridge structures can not be completely characterized by minutiae.
- The solution is to find an alternate representation of fingerprints which captures more local information and yields a fixed length code for the fingerprint.

Correlation based Processing

- Instead of only using the minutiae locations, it directly uses the gray-level information.

- Because a gray-level fingerprint image contains much richer, more discriminatory, information than only the minutiae locations

- The following steps involved

1. selects characteristic templates in the primary fingerprint.

2. Template matching is used to find the positions in the secondary fingerprint at which the templates match best.

3. Template positions in both fingerprints are compared in order to make the decision whether the prints match.

Advantages

- The method uses the much richer gray-level information of the fingerprint image instead of only positions of minutiae.

- The method is also capable of dealing with fingerprints of bad image quality from which no minutiae can be extracted reliably.

- False and missed minutiae do not decrease the matching performance.

- Unlike the minutiae templates, the template locations are already paired, which results in much simpler matching methods. When registering minutiae sets, it is not known in advance which minutiae from both sets should correspond.

- The first decision stage only classifies relative template positions. This method tolerates non-uniform local shape distortions in the fingerprint, unlike the minutiae templates for which the optimal global transform is searched.

Disadvantages

- Correlation-based techniques require the precise location of a registration point

- It is also affected by image translation and rotation.
  - The method is at the moment not capable of dealing with rotations of more than about 10 degrees.

Ridge Based Processing

- extracting ridge information of an inputted fingerprint.
- determining an identity between the inputted fingerprint and a reference fingerprint by comparing the ridge information
- Steps involved
1. Calculate Regions of inputted fingerprint and reference fingerprint
2. Calculate Overlapped region of the reference fingerprint and inputted fingerprint.
3. Calculate distance from inputted fingerprint and reference fingerprint
4. Determine identity between inputted fingerprint and reference fingerprint.

Pros of Fingerprint Recognition

- Finger tip most mature measure
- Accepted reliability
- High quality images
- Small physical size
- Low cost
- Low False Acceptance Rate (FAR)
- Small template (less than 500 bytes)

Cons of Fingerprint Recognition

- Requires careful enrollment
- Potential high False Reject Rate (FRR) due to:
  - Pressing too hard, scarring, misalignment, dirt
- Vendor incompatibility
- Cultural issues
  - Physical contact requirement a negative in Japan
  - Perceived privacy issues with North America