Fingerprint Recognition using phase-based Image Matching for Low Quality Fingerprints

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Why phase-based methods?

- Phase components of the 2D Discrete Fourier transform of images capture information better than the naive feature based matching.
- Phase Only Correlation or Band-Limited Phase Only Correlation measures are employed to measure the similarity scores.

Normalisation, Other Pre-Processing

- Morphological filtering removes the sensor noise and events where the fingerprint ridges are too thick
- Block wise normalisation helps alleviate the intensity variation in an image due to variation in finger pressure

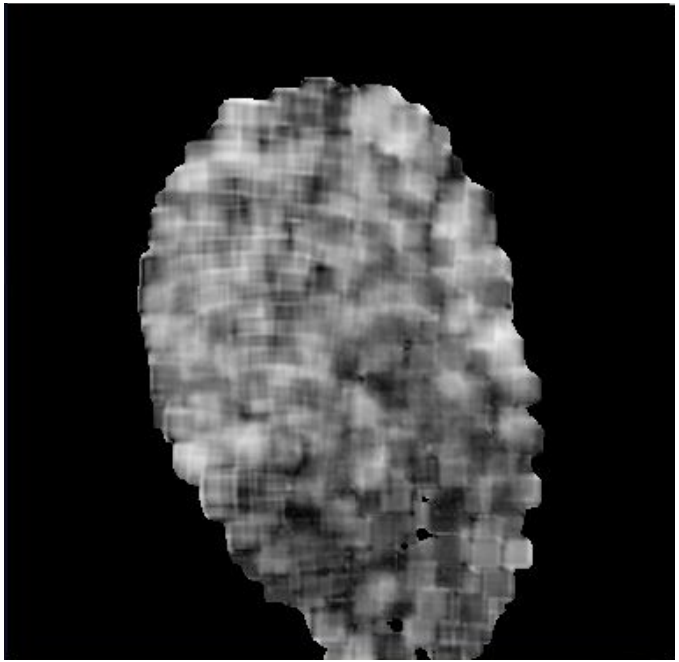
Original Fingerprint Image

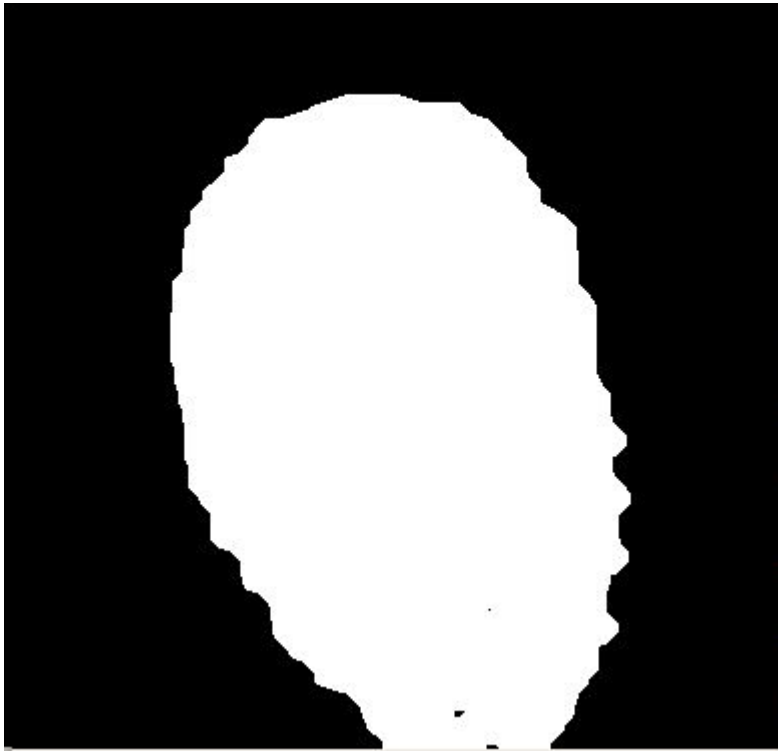
Normalized Image

Coherence Orientation Field

- Gradients are calculated on a gaussian de-noised image to obtain the direction of the ridges in the fingerprint
- The smoothed gradients are then used to find the orientation field
- The orientation field is then used to segment the foreground from the background

Block Coherence

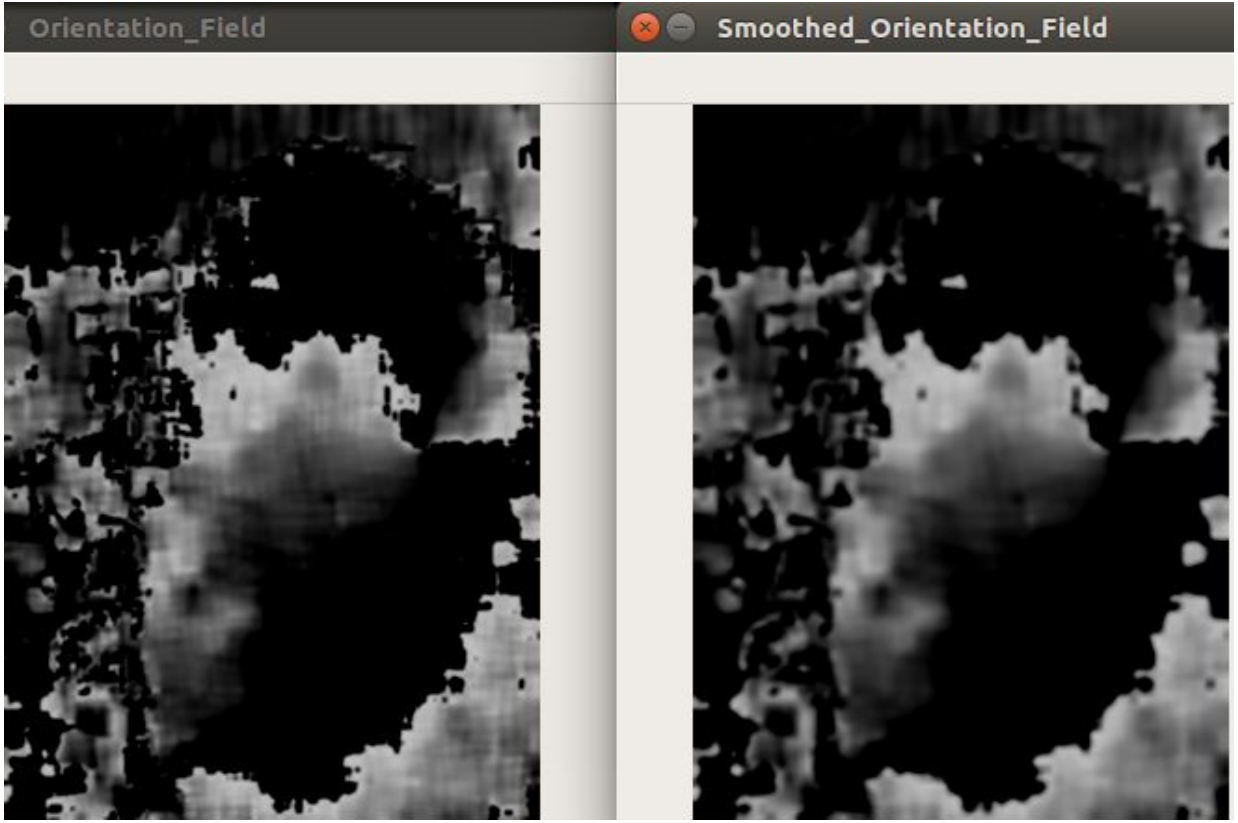




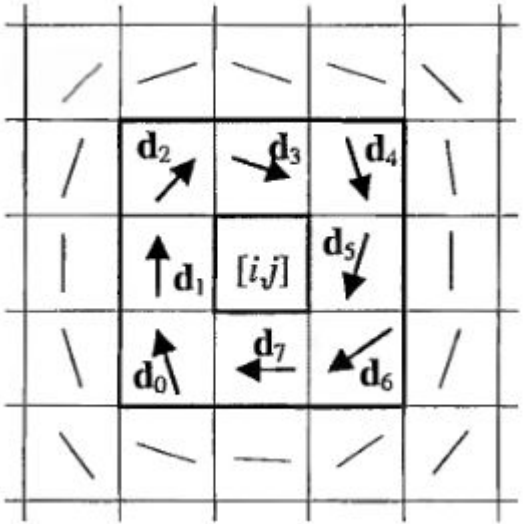
Foreground Mask

- To separate the foreground (high gradient region) from the background (low gradient region), we use a certain threshold and the largest area with gradient more than threshold is taken as the foreground
- An advantage of this method is that it distinguishes between constant gray regions and isotropic gradient gray noisy regions

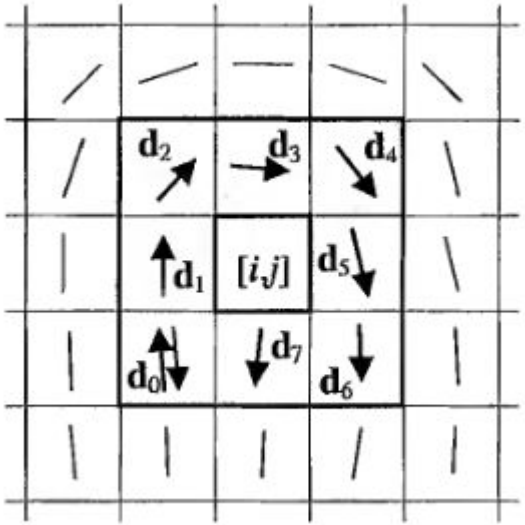
Direction Estimation



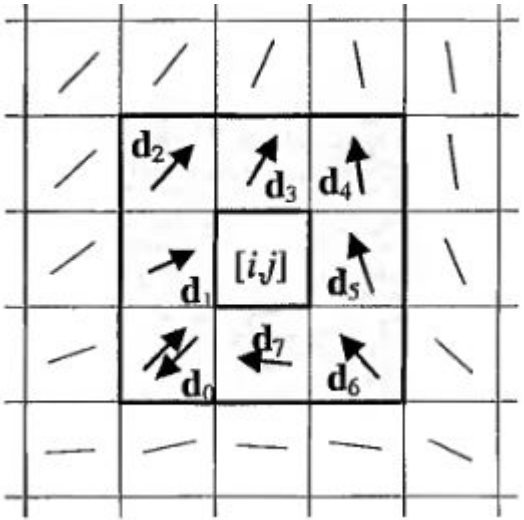
Gradient Variation for different Singularities



Poincare Index = 1
Feature: **Whorl**

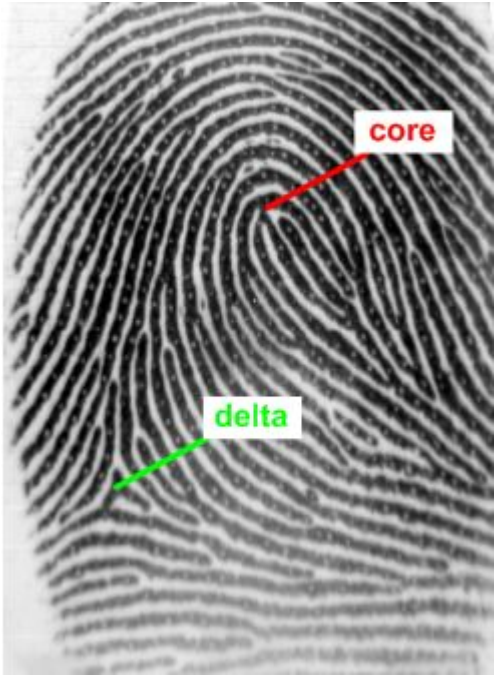


Poincare Index = 0.5
Feature: **Core**



Poincare Index = -0.5
Feature: **Delta**

Core Detection



The core is defined as a singular point in a fingerprint image that exhibits the maximum ridge line curvature.

Core Detection

Pre-Thresholding

Post-Thresholding

Band-limited Phase Only Correlation

f(x, y) is the registered image and g(x, y) is the test image. F(x, y) and G(x, y) are their respective 2D Discrete Fourier Transforms. R_{FG} is the Phase Only Correlation between the two images.

In BLPOC, we remove some meaningless high frequencies for better accuracy.

$$
\begin{aligned}
R_{FG}(k_1, k_2) &= \frac{F(k_1, k_2)\overline{G(k_1, k_2)}}{|F(k_1, k_2)\overline{G(k_1, k_2)}|} \\
&= e^{j\theta(k_1, k_2)},
\end{aligned}
$$

Displacement & Rotation Alignment

- The coordinates of the cores, if present are used to align the test and registered image translationally
- **Band-limited Phase Only Correlation (BLPOC)** measure is used to find the perfect rotational displacement of the registered image wrt the test image

Test Image, Red point denotes the singular point

Coordinate = (188, 262)

Translated Registered Image, Red point denotes the singular point

Coordinate = (182, 261)

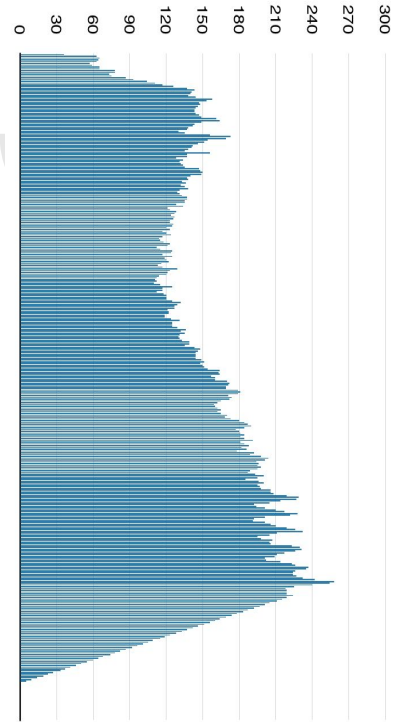
Test or input image

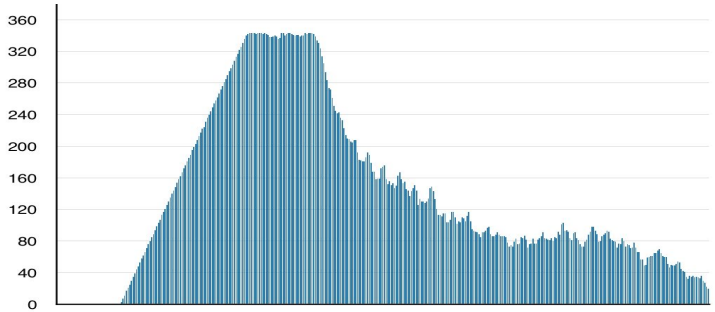
Translated Image using coordinates of cores

Rotated Image using BLPOC measure

Common Region Extraction

- Rotation of images results in some unwanted black regions which when used reduce the accuracy of matching due to non-overlapping and uncorrelated regions
- Therefore, the images are segmented to obtain only the overlapping regions followed by **BLPOC**





Histogram of row sum

Histogram of col sum

Segmented Input Image after applying row and column axis projection

Segmented Registered Image after applying row and col axis projection

Hyper-Parameters Used :

Number of subjects = 10

- number of rotations = 80
- **K_1 = 150 (Frequencies in BLPOC FFT range from -150, 150 row wise)**
- **K_2 = 150 (Frequencies in BLPOC FFT range from -150, 150 col wise)**
- **K1_1 = Tells which frequencies have to be present in segmented image's BLPOC FFT = 0.7*rows**
- **K2_1 = 0.7*cols**
- cutoff = 0.2
- Number of test images/subject = 2
- Number of registered images/subject = 6

Further Improvements

- Pressure Differences
  - Ridge Completion
  - Ridge Thinning
  - Normalisation
- Alignment
  - BLPOC measure not giving perfect results
- Better Segmentation Methods

After 

Here we are..

Thank you for your patience!