A Fingerprint Recognition Algorithm Using Phase-Based Image Matching for Low-Quality Fingerprints

Contributors

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Collected databases, coded translational and rotational image alignment and the main script for the algorithm

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Wrote codes for detecting the singular point from the images, extracting common region from aligned images

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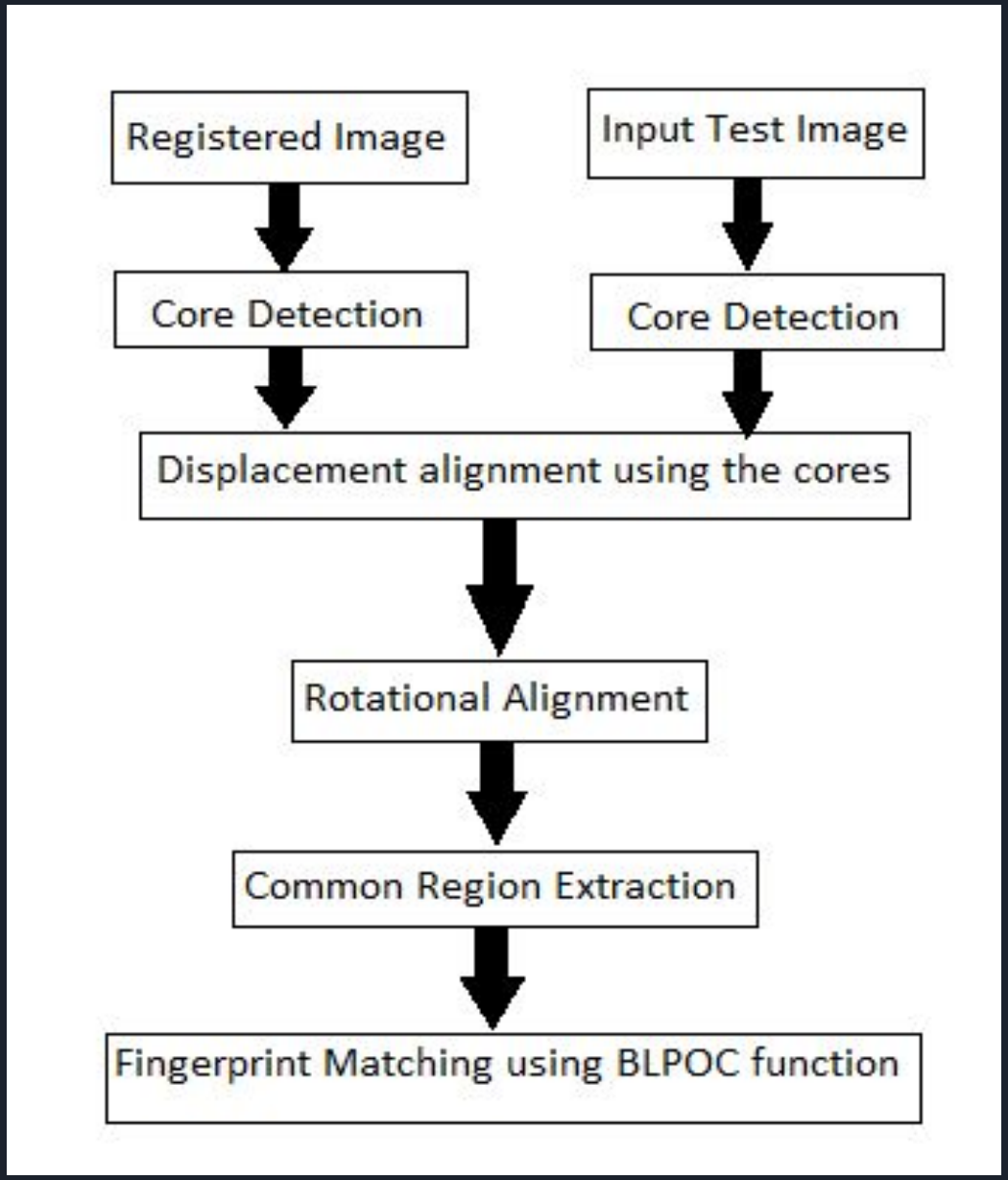
Coded the correlation function used for comparing images and analysed the performance of the algorithm

Feature-based Methods vs Phase Based Methods

- Phase Based Methods (2D Discrete Fourier Transforms) for fingerprint identification are more reliable than feature based methods for matching of low-quality fingerprints whose feature points are difficult to be extracted by image processing.
- In this project we are implementing the method for Fingerprint Recognition using Band Limited Phase-Only Correlation (BLPOC).

- The proposed algorithm consists of the four steps:
  - Core detection
  - Rotation and Displacement alignment
  - Common region extraction
  - Fingerprint matching.

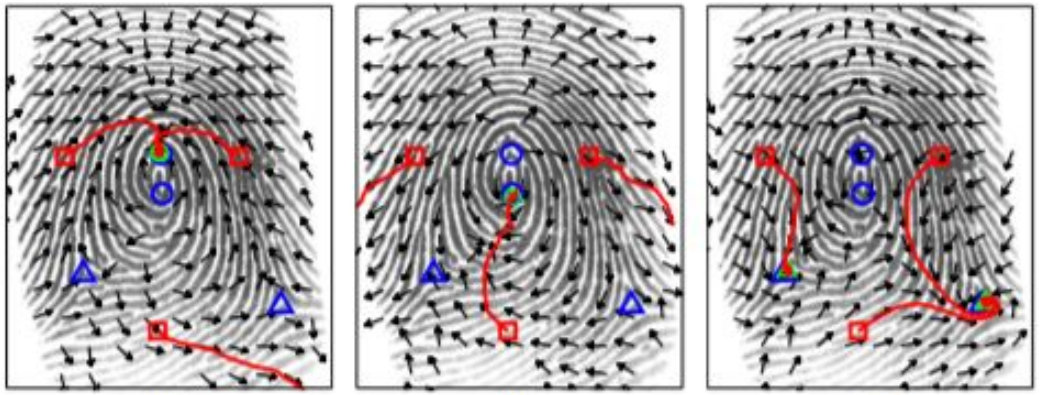


Flow diagram of the proposed algorithm

Walking Algorithm for Core Detection

- The core is the singular point in the image that exhibits maximum ridge line curvature.
- To do this we use the walking algorithm for singular point detection as it is more efficient than the poincare index method described in the paper.

Some examples of the process of walking from some given points to the corresponding singular points on WDFs are shown in Fig. 7. Apparently, if we can walk to the singular point from a proper starting point, the walking path will not be too long. While each step just need very simple calculation as described above, the whole process will be significantly fast.



Band Limited Phase only Correlation

- Defining f(x,y) to be the registered images and g(x,y) to be the input image, we can obtain the cross-phase spectrum as

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

- Where F(k1,k2) G(k1,k2) are the 2D DFTs of f and g and R_{FG} is the cross phase spectrum of the image

Band Limited Phase only Correlation

- The POC function is defined as the 2D Inverse DFT of the cross phase spectrum .

- The BLPOC function is the Band Limited version of the POC function and the idea is to improve the matching performance by eliminating meaningless high frequency components in the calculation of cross-phase spectrum.

Displacement and Rotational Alignment

- We first align the input and registered images translationally using the location of core point in both the fingerprints as a reference point .

- Rotational Alignment is performed by using the BLPOC function as a measure to find the correct rotational transformation between the both images

Reference Image

Input Image

Translational Transformation for aligning the cores

Translated Reference Image

Rotational Alignment using BLPOC

Rotated and Translated Reference Image

Common Region Extraction

- Translational and Rotational transformation of the two images results in some black regions which introduce low correlation and non overlapping parts which decreases the accuracy of the algorithm.
- To improve the accuracy of the model we need to find the overlapped region of the two images.

Example Result for Image Preprocessing

Input Image

Reference Ima

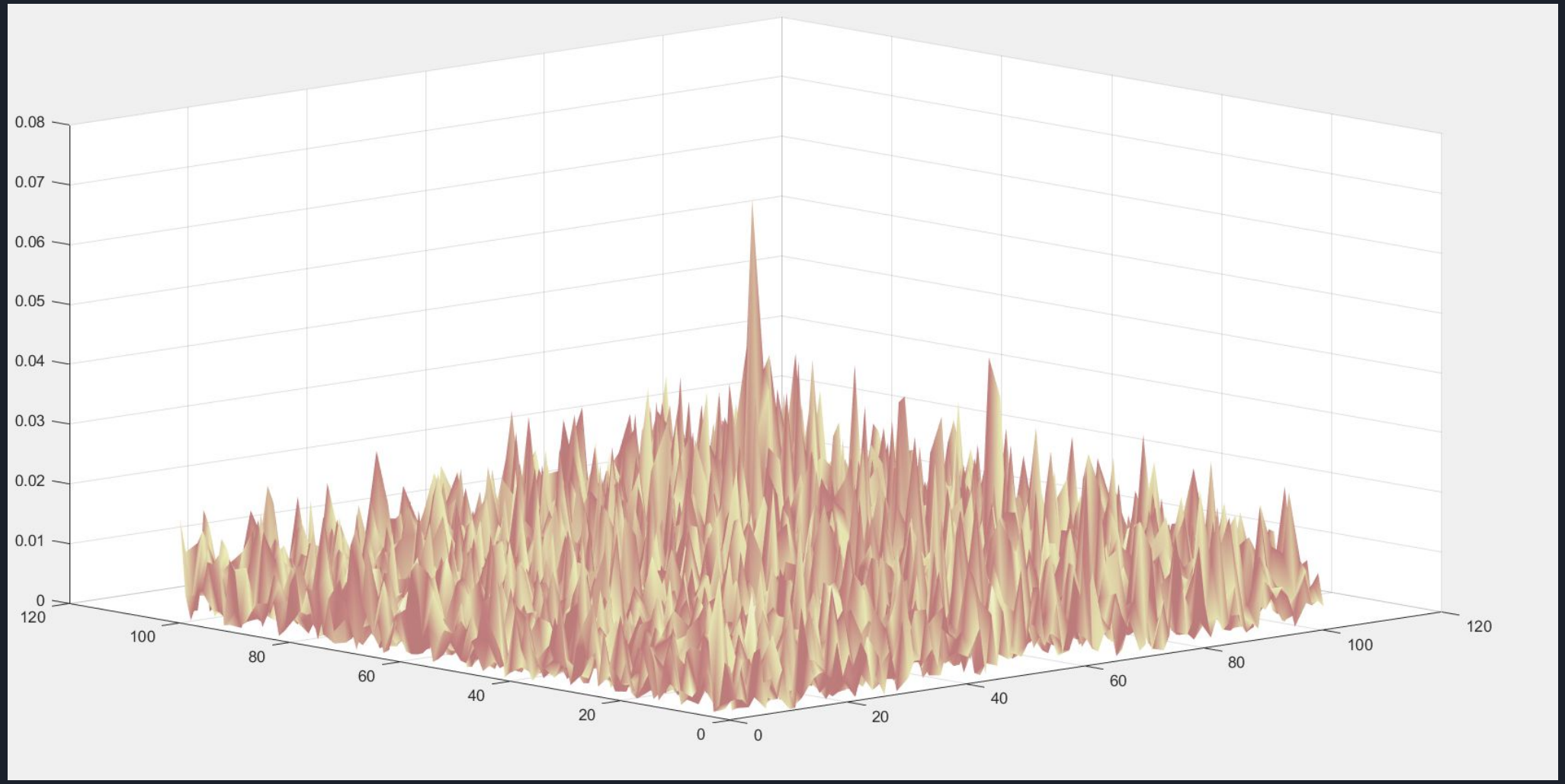
Translated Reference Image

Rotated and Translated Reference Image

input

registered

BLPOC of the aligned images



Error Evaluation

- Our database contains 48 fingerprints from 7 people taken at different vertical positions, rotations with high and low pressures against the sensor surface.

- We took one image from each person as a registered image and matched the remaining images with them using our algorithm.

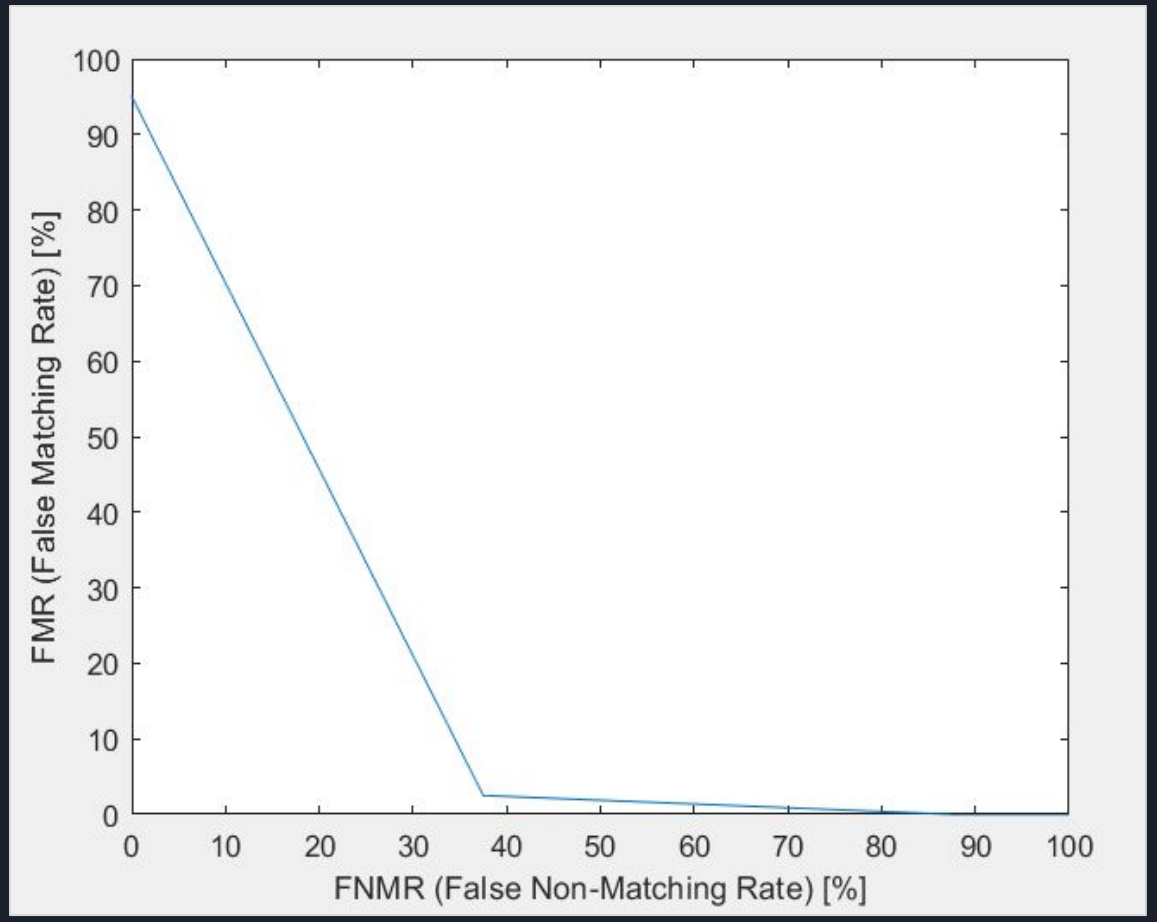
- Using the BLPOC function as a measure for correlation, we ended up with a matching error of 25%

Error Evaluation

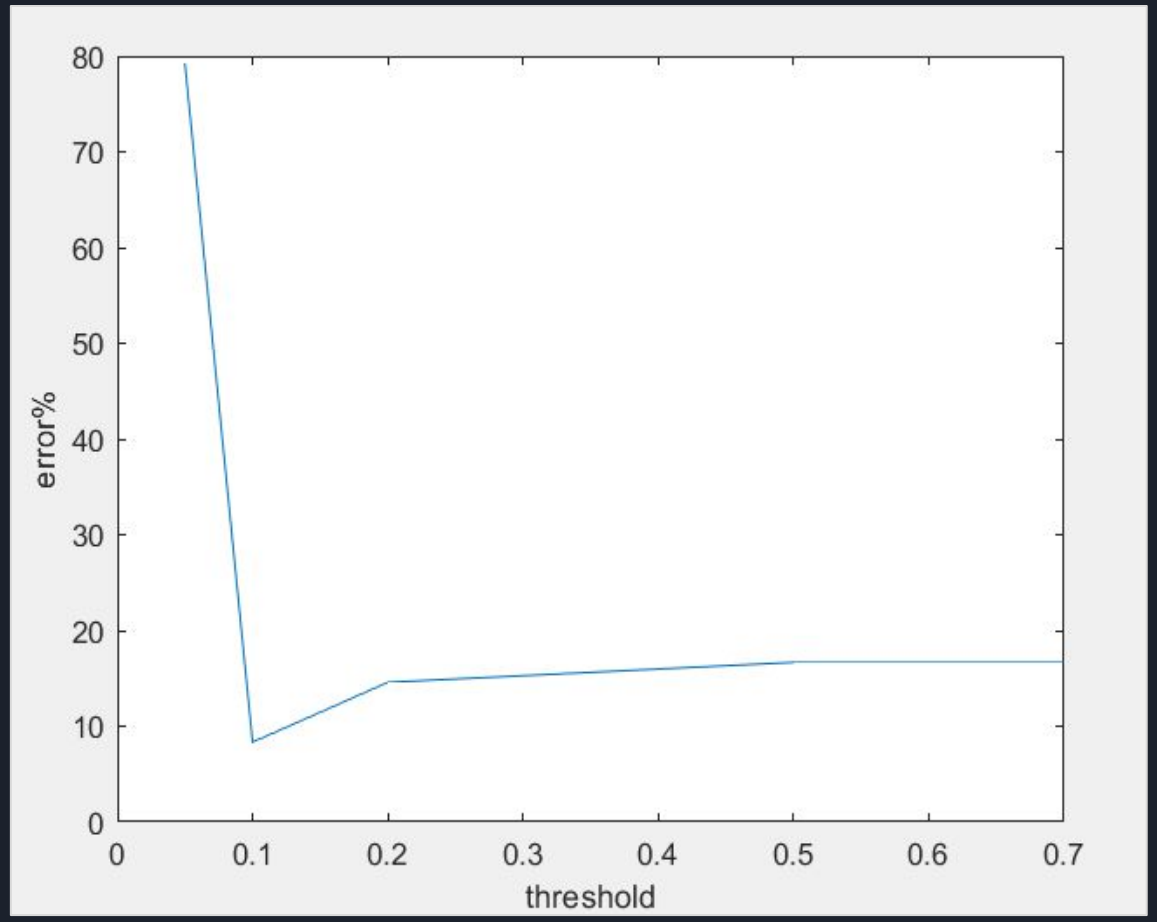
- A matching score can be defined as the sum of two highest values in the BLPOC of the aligned images

- The performance of the biometrics-based identification system is evaluated by the Receiver Operating Characteristic (ROC) curve, which illustrates the False NonMatching Rate (FNMR) against the False Matching Rate (FMR) at different thresholds on the matching score

Error Evaluation



Receiver Operating Characterisic (ROC) curve



error(%) vs threshold

References

- The original paper can be found here:
  - https://ieeexplore.ieee.org/document/1529984

- Walking to singular points algorithm:
  - https://www.researchgate.net/publication/297615926_Walking_to_Singular_Points_of_Fingerprints

When your fingers are a little greasy and your fingerprint scanner on your phone works