Fingerprint Recognition Using Phase-Based Image Matching

CS663 COURSE PROJECT

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The problem statement is to match two given fingerprints using Band-Limited Phase-Only Correlation (BLPOC) algorithm. But before using BLPOC, translational and rotational alignments of the images are required. After the fingerprints are aligned the common region is extracted from both the fingerprints and fed into the BLPOC function. The maximum absolute value of the BLPOC function gives the matching score. A threshold value is required to be set on the matching score to declare if the fingerprints are matched. Following is the flowchart of the algorithm:

f(n1,n2) and g(k1,k2) are given input images to be matched

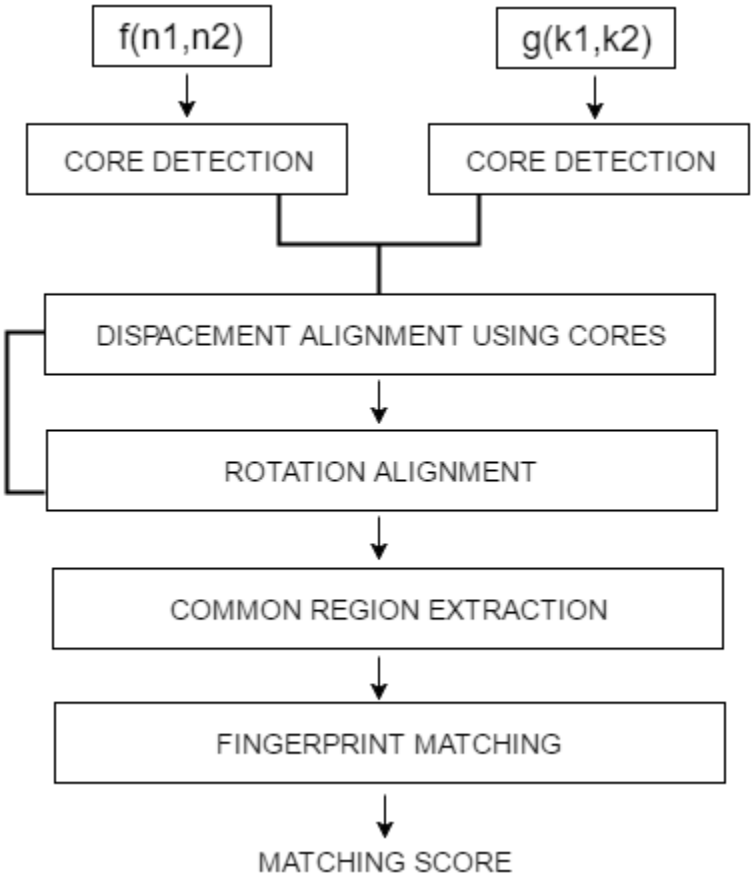

Fig. 1: Flow diagram of the algorithm

1. Core detection and displacement alignment : The cores of the given image is detected using complex filter method.

Fig. 2: a)original fingerprint of 310dpi b)showing core point in fingerprint

The complex filter method detects symmetric parts in the complex orientation field by applying complex filters for the core point. On applying complex filter on the image, the pixel with maximum response gives the core point.

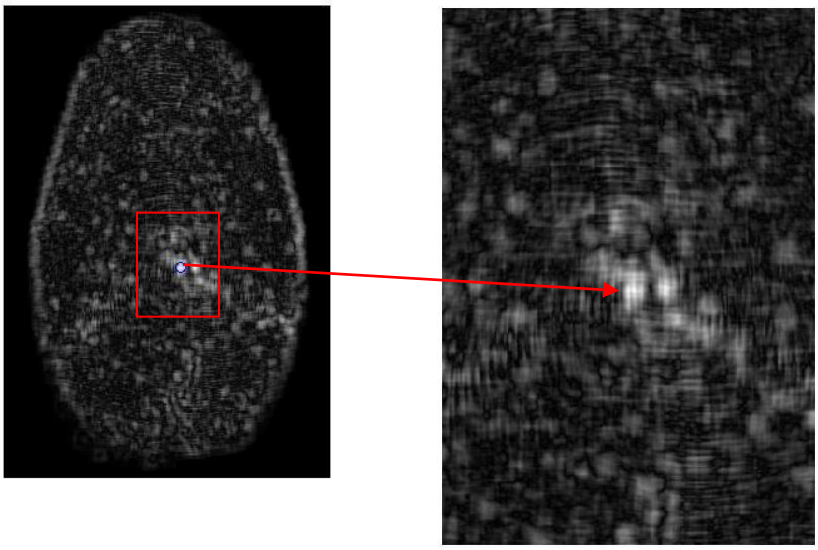

Fig. 3 : a)Core point detection of the image in figure 2 (**310 dpi**) b) zoomed in of Fig. 3a

However when core point detection is not so accurate for images with less dpi**. Database used has images with 96 dpi.**

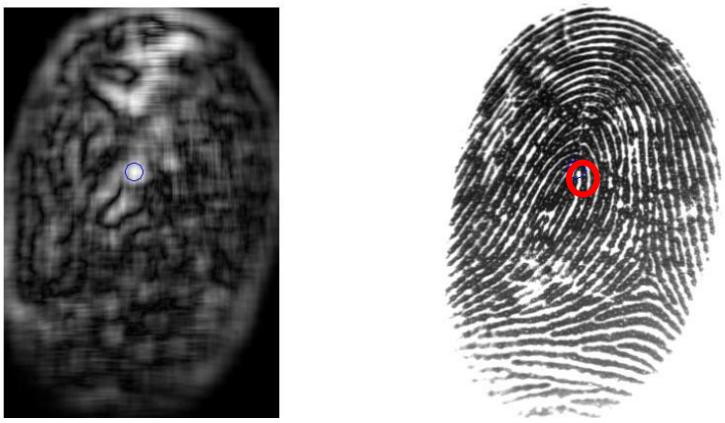

Fig. 4 : Core point **detected correctly** for a fingerprint image of **96 dpi**

Fig. 5 : Core point **detected correctly** for a fingerprint image of **96 dpi**

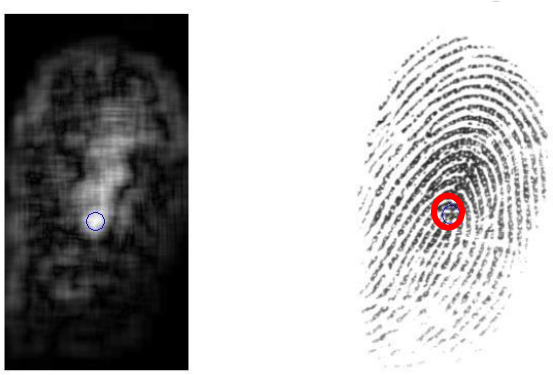

Fig. 6 : Core point **detected correctly** for a fingerprint image of **96 dpi**

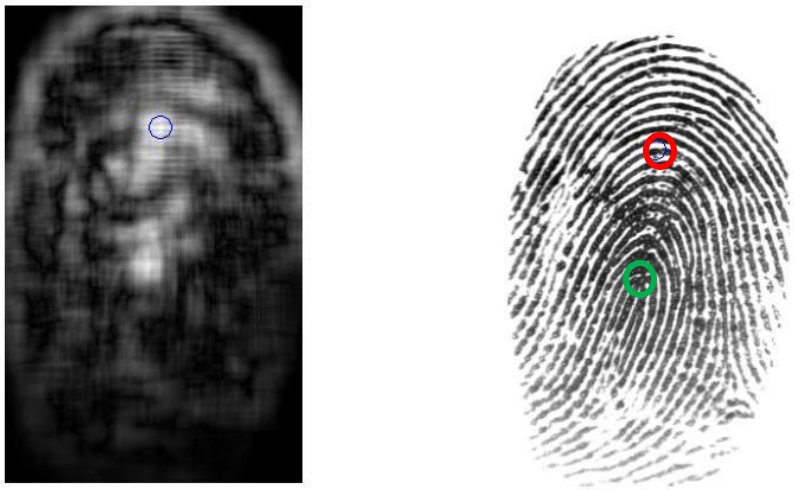

Fig. 7 : Core point **detected incorrectly** for a fingerprint image of **96 dpi**

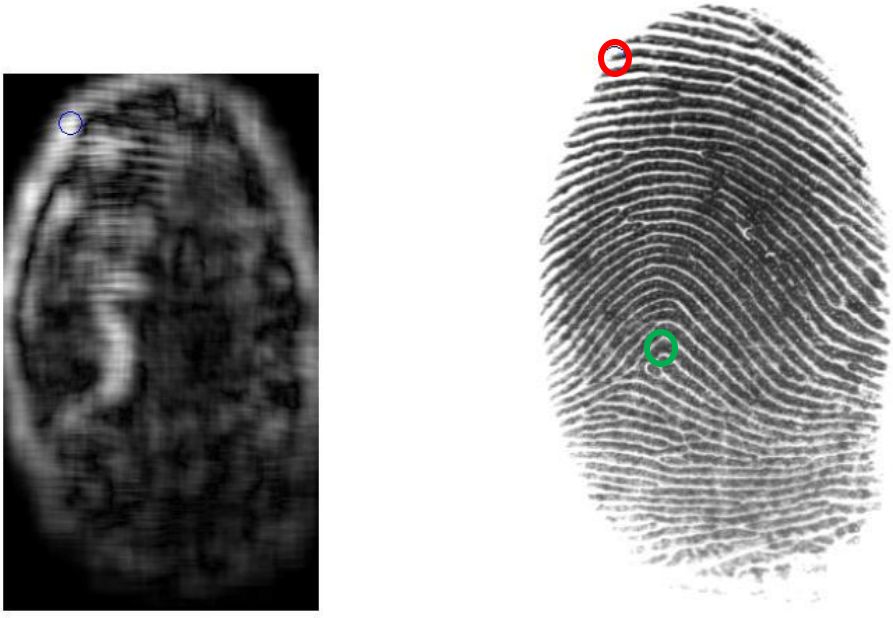

Fig. 8 : Core point **detected incorrectly** for a fingerprint image of **96 dpi**

If the core point is detected incorrectly the displacement alignment would be wrong, hence giving a wrong matching score even if both the fingerprints are same.

Once displacement alignment is done, rotational alignment is required.

2.Rotation alignment : Image is rotated around the core point for $-10° \leq \theta \leq 10°$ using bi-cubic interpolation. For each θ the matching score is calculated using the BLPOC function, θ giving the maximum matching score is used for rotation alignment.

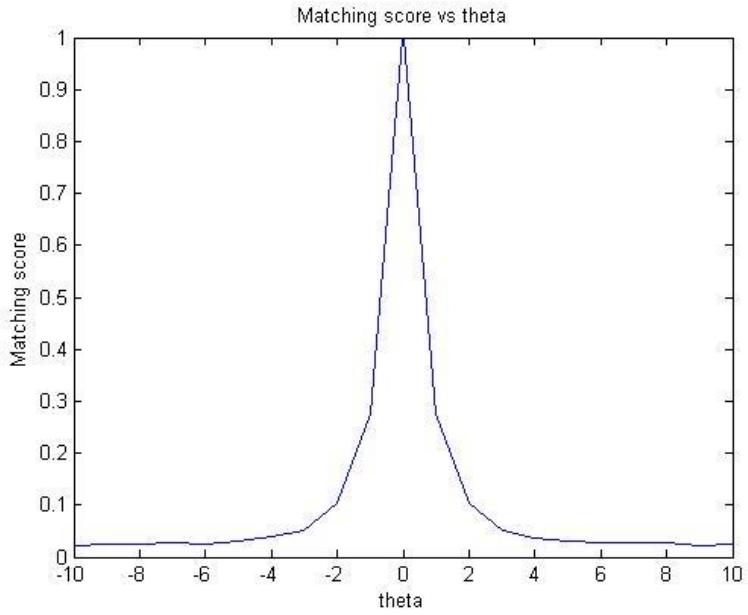

Fig. 9: Fingerprint image in Fig.1 is rotated for $-10° \leq \theta \leq 10°$ and matching score is calculated against the same image for each θ. Since both images are same, for $0°$ the matching score is maximum.

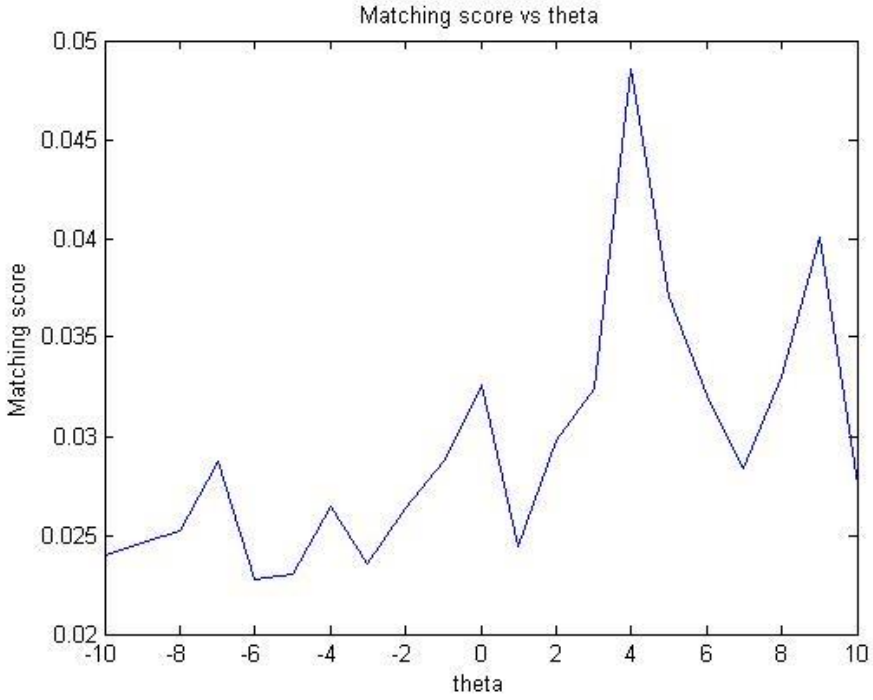

Fig. 10: Matching score for $-10° \leq \theta \leq 10°$ between images '104_4.tif' and '104_5.tif' in the database. Maximum score found to be at $\theta = 4°$

3.Common region extraction : Next step is to extract the overlapped region (intersection) of the two images. This process improves the accuracy of fingerprint matching, since the non-overlapped areas of the two images become the uncorrelated noise components in the BLPOC function.

4.Fingeprint matching: BLPOC function is calculated between the two images. The BLPOC function may give multiple correlation peaks. Thus the matching score is calculated as the sum of top two peaks.

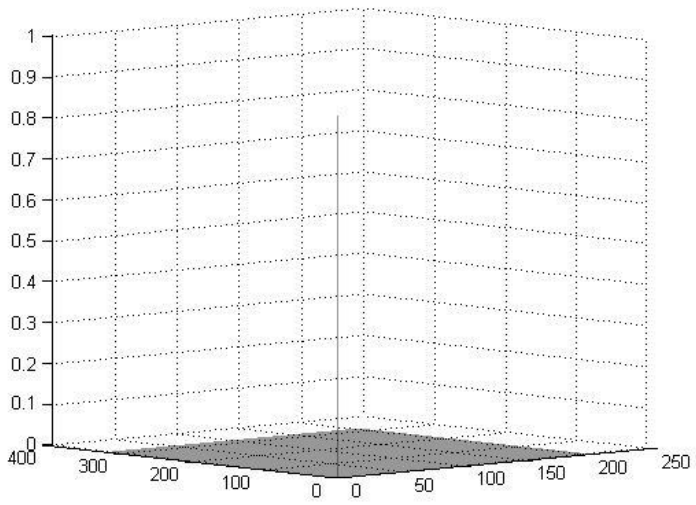

Fig. 11: BLPOC function for fingerprint image in figure 1 calculated against the same image. Both the fingerprints are the same. A **matching score of 1 is obtained**. Thus 100% match.

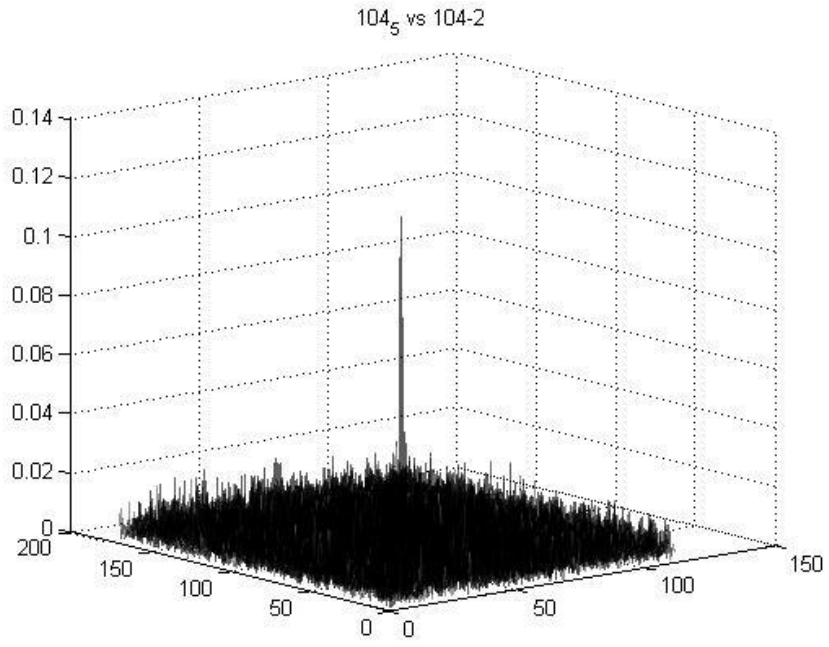

Fig. 12: BLPOC function for fingerprint 104_5 and 104_2. A distinct peak is obtained implying both the fingerprints are of the same individual.

RESULTS

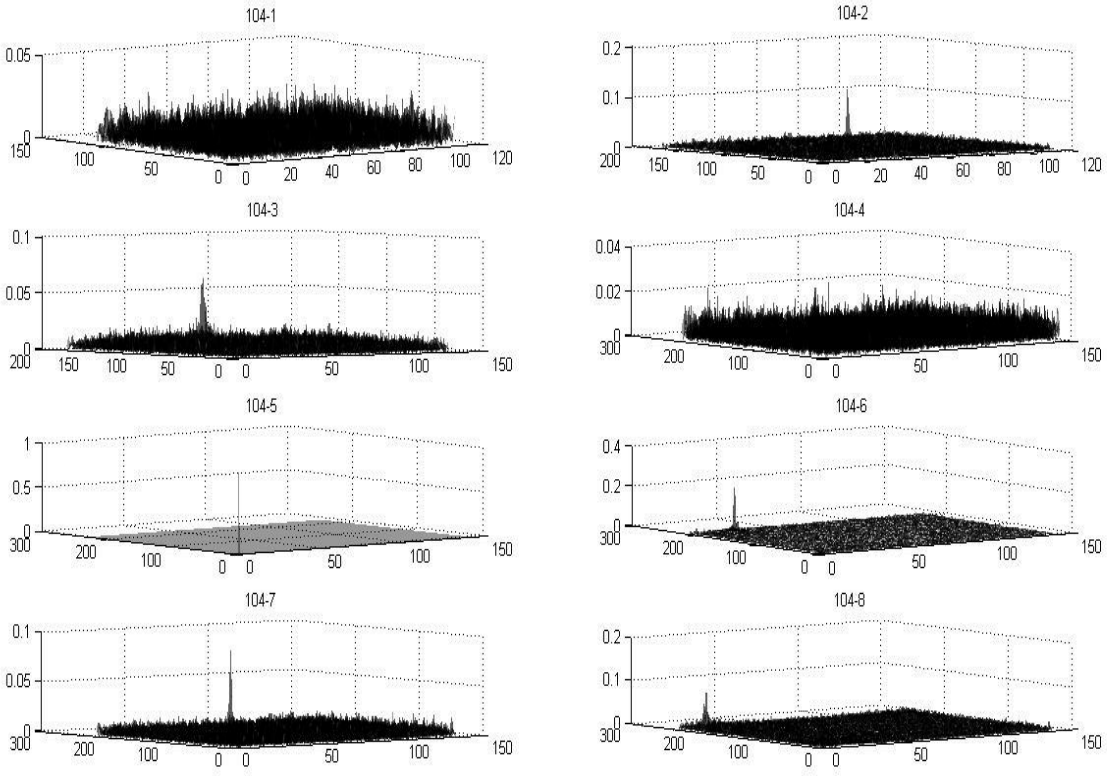

Fig. 13: Fingerprints 104_5 matched with images 104_1,104_2,.....104_8. All fingerprints are of the same individual. Clear peaks are observed in 104_2, 104_3, 104_5, 104_6 , 104_7, 104_8. Thus 6 out of 8 images are matched.

Matching score table 1: Base fingerprint is 104_5 (All fingerprints are matched to 104_5)

Fingerprint	Rotation alignment angle	Matching score
104_1	3	0.0790038797428572
104_2	6	0.250812323270555
104_3	2	0.129079425614075
104_4	4	0.0658507948003756
104_5	0	1
104_6	3	0.474681335114885
104_7	-4	0.182085485754056
104_8	2	0.164060965159311

Now matching fingerprint 104_5 with fingerprints of 102

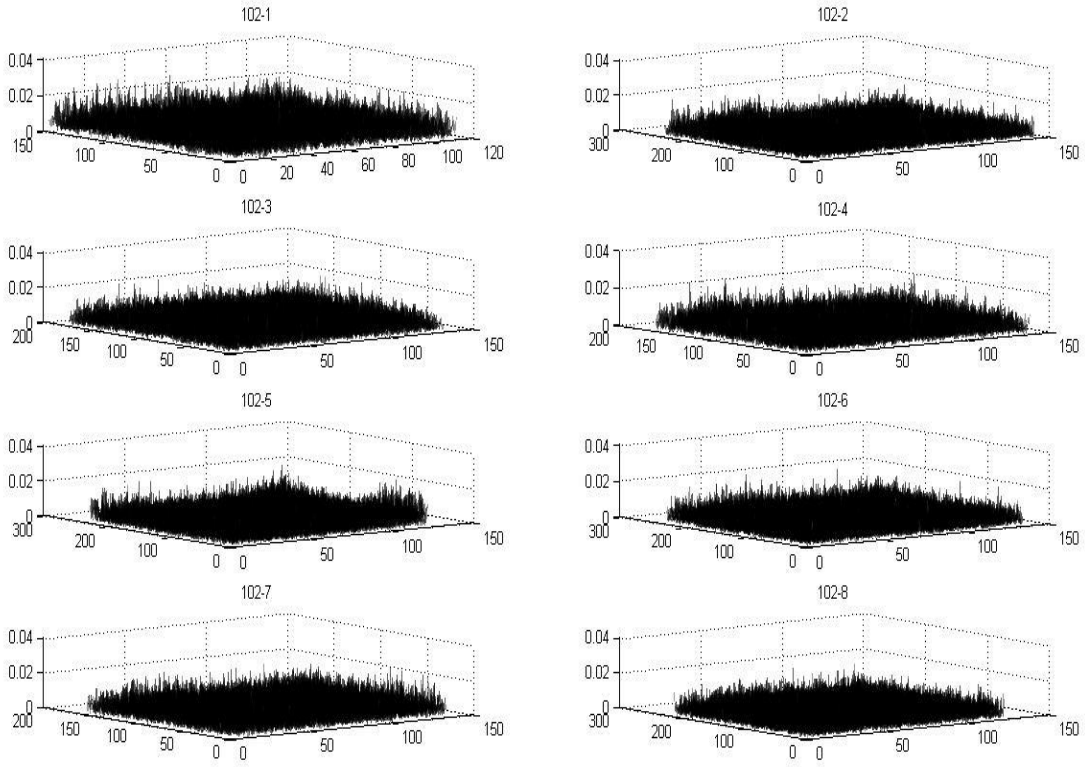

Fig. 14: Fingerprints 104_5 matched with images 102_1,102_2,.....102_8. No clear peaks are observed as they are of different individuals.

Matching score table 2: Base fingerprint is 104_5 (All fingerprints are matched to 104_5)

Fingerprint	Rotation alignment angle	Matching score
102_1	2	0.0700420089168267
102_2	-10	0.0499883446984272
102_3	-8	0.0544145991118453
102_4	-8	0.0597846461854907
102_5	-3	0.0556321186750584
102_6	-6	0.0551748115745818
102_7	-2	0.0578212252721386
102_8	-10	0.0566355852885343

Fingerprint	Rotation alignment angle	Matching score
106_1	2	0.103081996655705
106_3	-10	0.0505851557290280
106_4	-8	0.0895431137784868
106_5	-8	0.0620954965910487
106_6	-3	0.108160079071374
106_7	-6	0.0733816605196456
106_8	-2	1
106_2	-10	0.112697345972792

Matching score table 3: Base fingerprint is 106_8 (All fingerprints are matched to 106_8)

In table 1 and table 2, fingerprint of individual 104 is matched with 104 and 104 respectively. It is evident that by setting a threshold value on matching score fingerprints of an individual can be identified or differentiated.

Results for threshold value= 0.10

All the images in the database (72) are matched to fingerprint of each individual to identify number of False positives and False negatives

Total fingerprints=72

Table 3

Fingerprint matched	False negatives	False positives	Images matched
104_5	2	0	6 out of 8
101_7	5	0	3 out of 8
102_8	5	0	3 out of 8
103_4	7	0	1 out of 8
107_4	6	0	2 out of 8
108_3	7	0	1 out of 8
108_6	4	0	4 out of 8
109_1	6	0	2 out of 8
109_7	5	0	3 out of 8

103_7	4	0	4 out of 8
103_2	6	0	2 out of 8
101_2	4	0	4 out of 8
102_2	5	0	3 out of 8
105_2	7	0	1 out of 8
105_6	6	0	2 out of 8
110_1	4	0	4 out of 8
110_7	3	0	5 out of 8
104_3	7	0	1 out of 8
106_3	7	0	1 out of 8
108_7	7	0	1 out of 8
102_7	7	0	1 out of 8
101_6	7	0	1 out of 8

The Fingerprint matched column indicates the fingerprint used to match with all the fingerprints in the database. False positives come out to be zero as there will be no correlation between 2 different fingerprints. However the False negatives have varied a lot.

Best recognition percentage =75.0%

Worst recognition percentage =12.5%

BLPOC removes the high frequency components to remove unnecessary noise which differentiates it from POC. This helps in improving the peaks in BLPOC function.

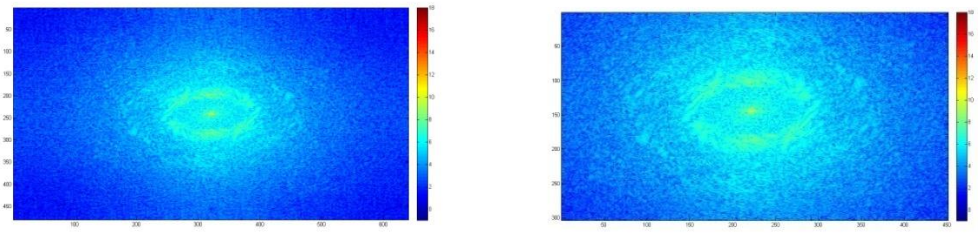

Fig. 15 : a) Discrete Fourier Transform of the given input image. b) Discrete Fourier Transform after removing high frequency components.

CONCLUSION/OBSERVATIONS/CRITIQUES

1. The paper implemented here uses Poincare index method to detect the core of fingerprint. At times the Poincare index method leads to multiple cores when image is of less dpi. Core detection has been determined correctly or not cannot be automated under a single function. To solve this issue I have used a complex filter based method which detects the core point more accurately compared to Poincare index method.

2. It is interesting to note why specifically BLPOC function is used. BLPOC function has the following properties
    a) Shift invariant
    b) Brightness invariant
    c) Noise immunity
    d) Removes high frequency components that contributes to noise

    Thus after rotation and displacement alignment it gives a distinct peak. If both fingerprints are identical, the BLPOC function would be Kronecker delta thus giving a peak value equal to 1.

3. The core detection is an essential part in the matching. If this goes wrong, the algorithm ahead can give weird results. For e.g. if 2 same images are matched with wrong core detection. Instead of a match value equal to 1 the matching value can be less than even the threshold value. Also the core detection is more accurate for images with higher dpi.

4. After obtaining the common region of both images, interpolation methods can be used to resize the smaller fingerprint image to enhance the BLPOC method.

5. Matching score is calculated before and after the common region extraction. There is an increase in the matching score generally which is expected. However the matching scores decrease by a very small value (~0.001) after common region extraction in some cases.

6. The algorithm is robust with False positives. False positives are always zero for the database used.

REFERENCES

1. Ali Ismail Awady and Kensuke Babaz : **Singular Point Detection for Efficient Fingerprint Classification**

2. Kochi Ito, Ayumi Morita, Takafumi Aoki, Tatsun Higuchi, Hiroshi Nakajima, and Koji Kabayashi**:** **Fingerprint Recognition Using Phase-Based Image Matching for Low Quality Fingerprints**

3**.** Lukasz Wieclaw **: Gradient Based Fingerprint Orientation Field Estimation**