# Development of Phase Only Correlation (POC) based two class classifier for Dermatoglyphic patterns

[1] Mandeep Singh, [2] Oindri Majumdar
[1,2]Electrical and Instrumentation Engineering Department, Thapar University, Patiala, INDIA
[1] mandy_tiet@yahoo.com, [2] oindri_majumdar@yahoo.com

**Abstract:** The dermatoglyphical science analyses an individual's innate potentials and talents based on the study of their fingerprints, soles and feet skin ridges. Since the fingers are connected to different lobes of the brain, responsible for coordinating different functions, it is important to correctly acquire an image of the fingerprints. A phase only correlation based technique provides an easy and fast method for automatic pattern matching and classification of fingerprints.
**Keywords:** Dermatoglyphics, Fingerprints, Phase correlation.

## 1. INTRODUCTION

The correlation based analysis is one of the most inevitable parts of pattern matching. In the Dermatoglyphic analyses [1], an automatic pattern recognition method is highly desirable. However, most of the available algorithms take minutiae and singular points into account for establishing a pattern. That method increases the computational complexity of the matching technique. It may also include false minutiae for matching. Hence, a more robust technique needs to be applied.

An image is a display of colours, whether the frequency component lying in VIBGYOR or truecolor range or 8 bit grayscale range. It is an inevitable means of finding correlation between frequency components of each and every pixel of the test image and find the score of matching to the pixel wise frequency component of template image. The most efficient form of correlation is the normalized cross correlation.

Mathematically, cross correlation measures the lag between the phase angles of a function at two different time periods. Since frequency is related to time, the lag concept can be applied to the frequency term also. Hence, when there are two images, one smaller than other or both are of same sizes, then the relative phase lag is calculated. If the two images are equal in size, then the template is placed over the test once, and every pixel is compared to its counterpart on the other image. When the template is smaller than test, then it is moved over the image as long as all the pixels have not been covered. In general, the correlation is the analysis of how much two identical functions are shifted or translated from each other in a particular axis. Maximum correlation is achieved when the shift has been nullified and both images are superimposed. Then, each and every point of the test image corresponds to the similar point on the template image. It is to be noted that, correlation can only be found in real valued functions and that imaginary quantities are not physically realizable for any matching. If by any chance, the function happens to be having any imaginary component, then conjugate of template image is taken for correlation calculation. As a result, conjugate of the template image shall result in positive aligned peaks corresponding to imaginary components.

## 2. METHODOLOGY

### A. Data acquisition

The fingerprints were acquired using 500 dpi resolution, CMOS sensor based Futronic FS-80 fingerprint scanner. The images are obtained through scanner system software FingerPrintScan. About 180 finger print scans were taken. Out of them, 68 clean images of whorls and loops were taken arbitrarily. The sizes of all the images are 320 by 480 pixels.

### B. Pre-processing and Image Enhancement

#### i) Colour to grayscale conversion

Since we are solely interested in the count and formation information of ridges, the texture is not of major significance. As a result, the truecolor RGB (Red-Green-Blue) needs to be converted into grayscale. This is accomplished by removing the hue and saturation and retaining the illumination. Also, the calculation complexity reduces. If the input is also a grayscale image but in single precision, then the same command can be used to convert the intensity image into a double image.

#### ii) Binarization

A grayscale image is having a chance of having 256 shades of grey. There is very minute rate of change in grayscale shades across the pixels of the image. Hence, it becomes cumbersome to realize the gradient calculating filters for ridge detection. Hence, binarization operation [2,3] is applied all over the image. A certain threshold level is chosen. Any pixel having illumination intensity level equal or greater than the specified level, is given numeric value 1, while remaining all are assigned 0. As a result, the whole image is segregated into pixels having either o (absolute black) or 1 (absolute white) as intensity levels. The ridges can be observed clean. Unnecessary portions of the fingerprint image with intermediate illumination are left out.

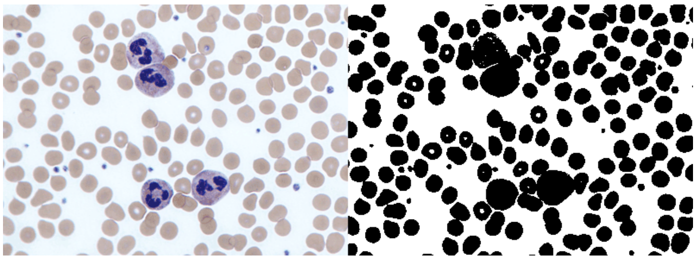


Fig 1: Binarization

## C. Low pass Sobel filtering

The Sobel kernel is one of the high intensity variation edge detecting filter for image enhancement [4-6]. It works by convolving with the test image in either horizontal or vertical direction. The kernel of Sobel filter has all integer values. A 3*3 sized kernel has been used. The kernel values determined have been mentioned below

$$\text{sob} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

A Sobel filter can be decomposed into a differentiator and an averaging filter. They are low pass smoothing filters and find derivative of the intensity level variation along the direction the kernel moves. While calculating the derivatives, there are two components of the gradient at each pixel of the image, one horizontal, $G_x$, and one vertical, $G_y$. The magnitude of the resultant gradient is the root of squares of both. While the angle is the arctangent of the slope of gradient.

$$\text{sob} = \sqrt{G_x + G_y}$$

$$\theta = \tan^{-1}\frac{G_y}{G_x}$$

## D. Normalized cross correlation

The process of cross correlation [] is similar to correlation except the fact that it includes two random variables, whereas autocorrelation is the correlation calculated between two equal functions, having some time or phase lag. Cross-correlation [7-9] can be compared to convolution in a way that it is the convolution between a functions, one of whom is an inverted version of the complex conjugate of the original image. If f and g are two functions that need to be cross-correlated, then the correlation between them can be represented as

$$f * g = f^*(-t) * g(t)$$

After the cross correlation has been done, it becomes clear at what point of time, the two signals align best. As a result, the relative shift in time (or frequency) can be determined. Normalization is done so that the variations in illumination and brightness can be ignored. The process limits the correlated values into a limited range of [0,1]. The normalized cross correlation method [10-12], illustrated in figure 2, is equal to the Pearson product moment correlation coefficient except the fact that it is in two dimensions while Pearson is a single dimension method.

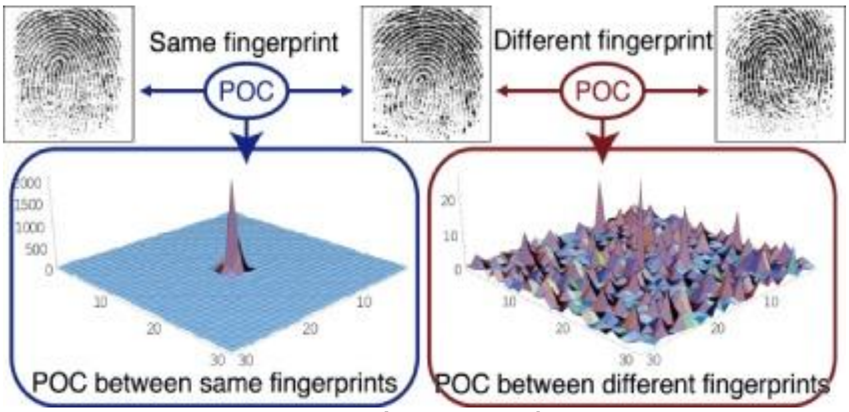



Fig 2: Correlation output graphics

### E. Noise removal using non-linear filter

The non-linear filter is useful because while removing the noises from all over the image, it preserves high gradient or intensity variations, that is, the edges. The nonlinear type of filter used here is the median filter. The command used in the MatLab is med2filt. Median filter is applied to every pixel on the image by applying a kernel which comprises of the neighbours of the pixel. For one dimensional signal, the kernel is formed of successive and predecessor pixels. While in case of images which are two dimensional functions, the kernel may either be box or cross shaped. The centre of kernel imposed image is replaced by the median of all the pixel values. However, nonlinear means bear the nonlinear quadratic moments. In some cases, these moments may nullify some correlations between random images functions. As a result, true negatives of "zero" correlation are formed. The effect a median filter has on an image, is much alike the smoothing filter, as displayed in figure 3. The two dimensional median filter has been used because it is better than Gaussian filter to remove small and medium level noises, like speckle and salt and pepper noise. Its speciality is that it effectively removes noises without altering the edges and preserves them.


Fig 3: Effect of Median filtering on images

### F. Curve fitting and comparison

A statistical method has been adopted for assessing the nature of similar patterns and finally validating them to be classified under same category. The quadratic polynomial concept has been applied to the curvature of each and every ridge of fingerprint images. The algorithm interprets the ridges as a polynomial. The chance of similar dermal patterns to have similar quadratic polynomial interpretation is high. However, some ambiguity lies in the case of whorls. More or less, the different whorl patterns display identical curvatures. Due to this reason, the curve fits are similar. This the reason, all whorls have been categorised under one class. The confusion matrix is drawn for each class separately. Under every curve fitting analysis, the curve fits of all the fingerprint images having the same class patterns are observed.

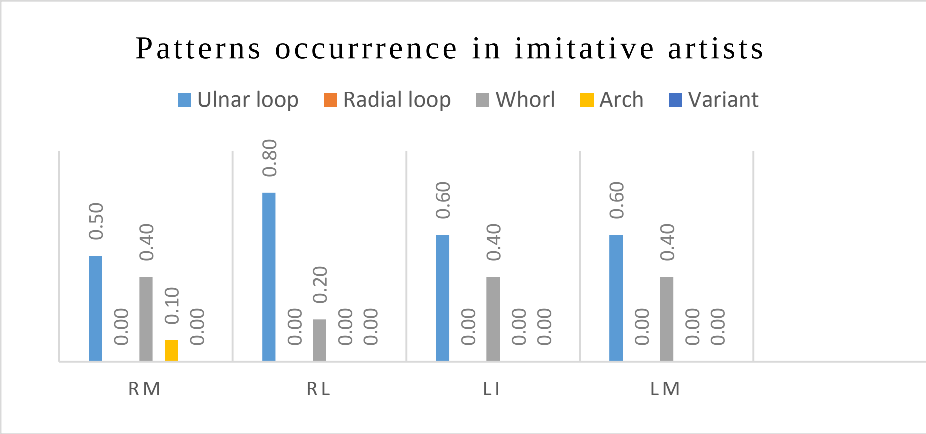
## 3. RESULTS

### A. Confusion matrix for loop – Accuracy tested!

Out of 24 loop patterns, 21 could be correctly recognised as loop patterns. The algorithm failed to recognise 3 out of 24 loop patterns to be loops and categorised them otherwise. Out of 34 whorl patterns, the automatic algorithm could correctly identify 28 as whorls. Six whorl patterns fell out of the class of categorisation. Hence, 85 percent accuracy is achieved.

| **Confusion matrix** | | **Display** | |
|---|---|---|---|
| | | **True** | **False** |
| **Patterns** | **Loop** | 21/24 | 3/24 |
| | **Whorl** | 28/34 | 6/34 |

Fig 4: Confusion matrix




**B. Trend in pattern occurrence on fingers corresponding to fine and gross artistic skills**

According to the texts that have been gone through, it is hypothesized that following fingers are related to the aforementioned skills and talents. To validate our assumptions, subjects who are recognized in the field of artistic intelligence, have been requested to provide their complete set of fingerprints. The per unit occurrence of all patterns, namely, ulnar loop, radial loop, whorl, arch and variant, has been computed. The results for imitative and creative artistic intelligence are displayed in charts 5 and 6 respectively.

**i. Imitative skill and proficiency**

i) Right middle finger (Finger movement)
ii) Right little finger (Observational skill)
iii) Left index finger (Spatial Intelligence)
iv) Left middle finger (Art and Rhythm sense)

**ii. Creative skill and proficiency**

i) Right middle finger (Finger movement)
ii) Left thumb (Creative ability)
iii) Left index finger (Spatial Intelligence)
iv) Left middle finger (Art and Rhythm sense)

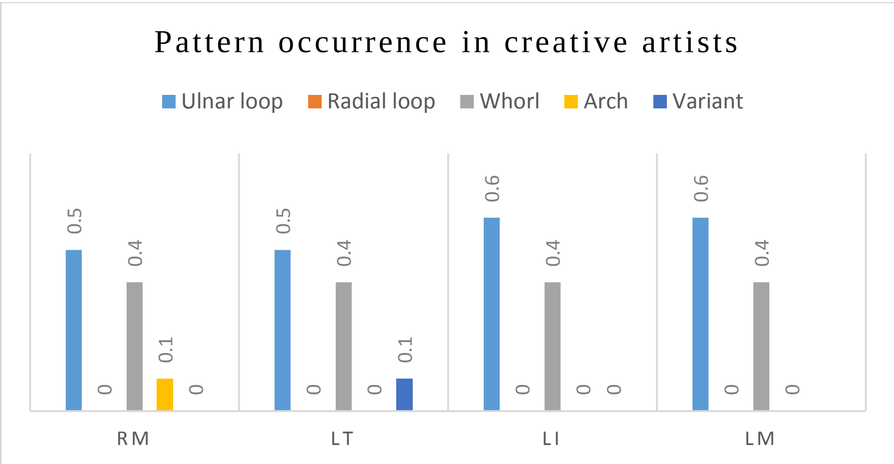



Chart 5: Pattern occurrence frequency in creative artist fingers

## C. CONCLUSION

It is found in the due course of this study that people with artistic bent of mind have ulnar loops and whorls as the most frequently occurring patterns on their artistic talentrelated fingers with a score of 42 ulnar loops out of 80 fingerprint patterns (52.5 percent). 30 of them are whorls (37.5 percent). Arches accounts for 2.5 percent of the total, while the variant patterns occur only in 1.25 percent of cases. It is concluded from the methodology that the POC method is a reliable classifier. However, the technique can be made more efficient for classifying higher order classifications. The two class classifier can be worked upon further to increase its accuracy. This can be done by choosing more precise polynomial functions to fit the pattern curves.

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