REVIEW OF PHASE BASED IMAGE MATCHING

Jaydeep Kale
Assistant Professor in CSE Dept (SRES COE,Kopargaon)
jaynkale@gmail.com

Abstract

This paper review the phase based image matching method. A major approach for image matching is to extract feature vectors corresponding to given images and perform image matching based on some distance metrics. One of the difficult problem with this feature based image matching is that matching performance depends upon many parameters in feature extraction process. So this paper reviews the phase based image matching methods in which 2D DFTs of given images are used to determine resemblance between given two images. This method has been successfully applied in IRIS recognition, fingerprint recognition successfully.

Index Terms—*Pattern recognition, Security, Biometrics, Phase based image matching*.

I. INTRODUCTION

Today security is important in access to restricted areas and also credit card fraud now costs many billion dollars annually. Also person identification is required in applications like passport control, bank automatic teller machines and protected access to premises or assets. So biometrics is important.
Biometrics is automated methods of recognizing a person based on a physiological or behavioral characteristic such as face, fingerprint and iris. One major approach for image matching is to extract feature vector from image and then match these feature vector by using some distance metrics. One problem which is observed in feature based image matching is that matching performance is affected by many parameters in feature extraction process. This paper reviews the phase based image matching method [1],[2],[3],[4],[5]. In this method phase components present in the 2D DFT of given images are used to find out similarity between them. This method make possible to achieve highly robust image recognition algorithm.
Section II describe the phase based image matching. Section III shows how phase based image matching is used in IRIS recognition. Section IV and V describe how phase based image matching is applied to fingerprint and palmprint recognition.

II. PHASE BASED IMAGE MATCHING

In this section, principle of phase based image matching is discussed. Consider two $N_1 \times N_2$ images $f(n_1,n_2)$ and $g(n_1,n_2)$, where the index ranges are $n_1=-M_1,\ldots\ldots,M_1$ $(M_1>0)$ and $n_2=-M_2,\ldots\ldots\ldots,M_2$ $(M_2>0)$.
Also $N_1=2M_1+1$ and.$N_2=2M_2+1$. Let $F(k_1,k_2)$ and $G(k_1,k_2)$ be the 2D DFTs of the two images. $F(k_1,k_2)$ and $G(k_1,k_2)$ are given by

$$F(k_1,k_2) = \sum_{n_1=-M_1}^{M_1} \sum_{n_2=-M_2}^{M_2} f(n_1,n_2) W_{N_1}^{k_1 n_1} W_{N_2}^{k_2 n_2} \quad \text{.................}(1)$$

$$G(k_1,k_2) = \sum_{n_1=-M_1}^{M_1} \sum_{n_2=-M_2}^{M_2} g(n_1,n_2) W_{N_1}^{k_1 n_1} W_{N_2}^{k_2 n_2} \quad \text{.................}(2)$$

Where

$$N_1 = 2M_1 + 1 \quad \text{and} \quad N_2 = 2M_2 + 1$$

$$W_{N_1} = e^{-j\frac{2\pi}{N_1}} \quad \text{and} \quad W_{N_2} = e^{-j\frac{2\pi}{N_2}}$$

Then we calculate cross phase spectrum $RFG(k_1,k_2)$ as follow-

$$R_{FG}(k_1,k_2) = e^{j(\theta_F(k_1,k_2)-\theta_G(k_1,k_2))} \text{.................................(3)}$$

Then POC function is given as

$$r_{fg}(n_1,n_2) = \frac{1}{N_1N_2}\sum_{k_1=-M_1}^{M_1}\sum_{k_2=-M_2}^{M_2} R_{FG}(k_1,k_2)W_{N_1}^{-k_1n_1}W_{N_2}^{-k_2n_2}$$

......................(4)

When two images are similar there POC function $r_{fg}(n_1,n_2)$ gives distinct sharp peak. If two images are not similar, the peak value drops significantly. The height of the peak can be used as a good similarity measure for image matching.

The original POC function $r_{fg}(n_1,n_2)$ emphasizes the high-frequency components, which may have less reliability. This reduces the height of the correlation peak significantly, even if the given two iris images are captured from the same eye. On the other hand, the Band Limited POC (BLPOC) function [1], [2], [3], [4], [5] allows to evaluate the similarity by using the inherent frequency band of the iris texture. Assume that the ranges of the inherent frequency band of iris texture are given by $k_1= -K_1,\ldots\ldots,K_1$ and $k_2= -K_2,\ldots\ldots,K_2$ where $0 \le K_1 \le M_1$ and $0 \le K_2 \le M_2$. Thus, the effective size of frequency spectrum is given by $L_1=2K_1+1$ and $L_2=2K_2+1$.

The BLPOC function is defined as

$$r_{fg}^{K_1K_2}(n_1,n_2) = \frac{1}{L_1L_2}\sum_{k_1=-K_1}^{K_1}\sum_{k_2=-K_2}^{K_2} R_{FG}(k_1,k_2)\times W_{L_1}^{-k_1n_1}W_{L_2}^{-k_2n_2}$$

$$r_{fg}^{K1K2}(n1,n2) = \frac{1}{L1L2}\sum_{k1=-K1}^{K1}\sum_{k2=-K2}^{K2} R_{FG}(k1k2)\times W_{L1}^{-k1n1}\ W_{L2}^{-k2n2}$$

$$r_{fg}^{K_1K_2}(n_1,n_2) = \frac{1}{L_1L_2}\sum_{k_1=-K_1}^{K_1}\sum_{k_2=-K_2}^{K2} R_{FG}(k_1,k_2)\times W_{L_1}^{-k_1n_1}W_{L_2}^{-k_2n_2}$$

....................(5)

Where $n_1 = -n_1, \ldots, n_1$ $n_1 = -K_1,\ldots\ldots,K_1$ and $n_2 = -K_2,\ldots\ldots,K_2$.

III. IRIS MATCHING

Kazuyuki Miyazawa et al has developed IRIS matching algorithm using phase based image matching [1]. The IRIS matching algorithm [1] consists of two stages: 1) the preprocessing stage and 2) the matching stage. The Preprocessing stage is used to localize the iris region in the captured eye image and to produce a normalized iris texture image with a fixed size (256×128 pixels). The preprocessing stage contains following steps:

- IRIS Localization
- IRIS Normalization
- Eyelid Masking
- Contrast Enhancement

IRIS Localization:

This step detects inner boundary (the boundary between the iris and the pupil) and the outer boundary (the boundary between the iris and the sclera) in the original gray-scale image [1]. The segmented iris has been shown in Fig. 1(b).

IRIS Normalization:

The next step is to normalize the extracted iris region to compensate for the elastic deformations in iris texture as shown in Fig. 1(c).

Eyelid Masking:

This process masks the irrelevant eyelid region in the normalized iris image. The detected eyelid region is masked as shown Fig. 1(d).

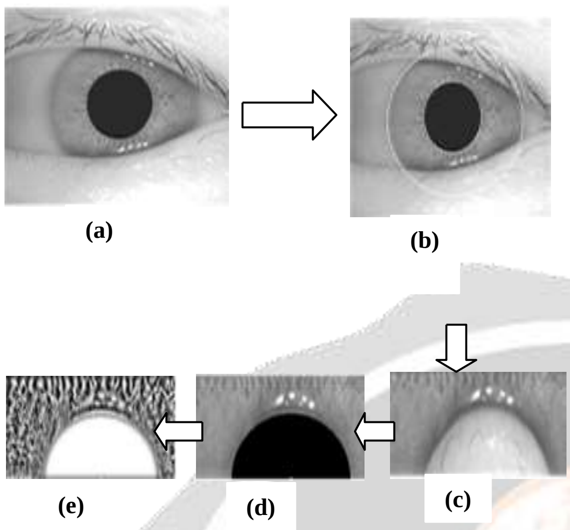

Fig 1: Iris image preprocessing (a) Original image (b)Detected inner and outer boundary (c) Normalized image (d) Normalized image with eyelid masking (e) Enhanced image

Contrast Enhancement:
In some situations, the normalized iris image has low contrast. In such case, local histogram equalization technique is used to improve the contrast. Fig. 1 (e) shows the enhanced image.

Then Baseline algorithm is used for matching two IRIS images. The Baseline algorithm contain following steps:

1. Effective region Extraction

Given a pair of normalized iris images $f_{norm}(n_1,n_2)$ and $g_{norm}(n_1,n_2)$$g_{norm}(n_1,n_2)$ to be compared, the purpose of this process is to extract effective regions of the same size from the two images [1]. Let images after effective region extraction are $f_{eff}(n_1,n_2)$ and $g_{eff}(n_1,n_2)$.$f_{eff}(n_1,n_2)$

2. Displacement Alignment

This step aligns the translational displacement (δ_1,δ_2) between the extracted images $f_{eff}(n_1,n_2)$ and $g_{eff}(n_1,n_2)$ $f_{eff}(n_1,n_2)g_{eff}(n_1,n_2)$. The rotation of the camera, head tilt, and rotation of the eye within the eye socket may cause displacements in normalized images. The displacement (δ_1,δ_2) $(\delta 1, \delta 2)$can be estimated from the peak location of the BLPOC function $r_{fg}^{K_1K_2}(n_1,n_2)$.

3. Matching Score Calculation

In this step, the BLPOC function is calculated $r_{fg}^{K_1K_2}(n_1,n_2)$ between the aligned images $f(n_1,n_2)$ and $g(n_1,n_2)$. Then the matching score is evaluated. In the case of genuine matching, if the displacement between the two images is aligned, the correlation peak of the BLPOC function $r_{fg}^{K_1K_2}(n_1,n_2)$ should appear at the origin $(n_1,n_2)=(0,0)$. $(n_1,n_2)=(0,0)$.

IV. FINGERPRINT MATCHING

K. Ito et al used phase based image matching algorithm for fingerprint recognition [2], [3], [4]. The fingerprint matching algorithm [2], [3], [4] consists of the three steps: (i) rotation and displacement alignment, (ii) common region extraction and (iii) matching score calculation with precise rotation.

1. Rotation and displacement alignment

It is necessary to normalize the rotation and the displacement between the registered fingerprint image f(n1,n2) and the input fingerprint image g(n1,n2) in order to perform the high-accuracy fingerprint matching.

2. Common region extraction

Next step is to extract the overlapped region (intersection) of the two images f(n1,n2) and g(n1,n2). This process improves the accuracy of fingerprint matching, since the non-overlapped areas of the two images become uncorrelated noise components in the BLPOC function.

3. Matching Score Calculation

In this step, the BLPOC function is calculated $r_{fg}^{K_1K_2}(n_1,n_2)$ between the fingerprint images $f(n_1,n_2)$ and $g(n_1,n_2)$. Then the matching score is evaluated. In the case of genuine matching, if the displacement between the two images is aligned, the correlation peak of the BLPOC function $r_{fg}^{K_1K_2}(n_1,n_2)$ should appear at the origin $(n_1,n_2)=(0,0)$. $(n_1,n_2) = (0,0)$.

V. PALMPRINT MATCHING

Koichi Ito et al successfully applied phase based image matching algorithm to palmprint. The palmprint matching algorithm [5] consists of the three steps: (i) rotation and displacement alignment, (ii) common region extraction and (iii) palmprint matching.

1. Rotation and displacement alignment

   It is required to normalize rotation and displacement between the registered image f(n1,n2) and the input image g(n1,n2) in order to perform the high-accuracy palmprint matching.

2. Common region extraction

   Next step is to extract the overlapped region (intersection) of the two images f(n1,n2) and g(n1,n2). This process improves the accuracy of palmprint matching, since the non-overlapped areas of the two images become the uncorrelated noise components in the BLPOC function.

3. Palmprint matching

   Finally BLPOC function is applied to evaluate the matching score. The matching score is the highest peak value of the BLPOC function.

VI. CONCLUSION AND FUTURE SCOPE

The phase based image matching algorithm is really effective for iris recognition, fingerprint recognition as well as palmprint recognition. The matching performance of feature based image matching is influenced by many parameters in feature extraction process. This problem is not observed in phase based image matching.

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