Gurupjit Singh Brar, Amandeep Kaur / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 5, September- October 2012, pp.1742-1747

Analysis Of Rotation Invariant Template Matching Techniques For Trademarks

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ABSTRACT

As every product has the trademark and for matching process of that trademark, we need a template matching technique. Further, a trademark can be rotated through any angle and for this rotation; invariant template matching techniques are used. For getting the best technique, we are analyzing the ring projection transformation and orientation techniques. In ring projection, transformation process the template is converted to a 1D level signal as a function of radius and then the matching is performed. Another process which is used in the analyses is orientation codes. It is based on the utilization of the gradient information in the form of orientation codes as the feature for approximating the rotation angle as well as for matching.

Keywords: Ring projection transformation, orientation codes, trademarks, rotation invariant.

1. INTRODUCTION

In the image processing systems, the input image is first preprocessed, which may involve restoration, enhancement, or just proper representation of the data. After this, some features are extracted for segmentation of the image into its components. Then the image classification is done that maps different regions or segments into one of the several objects, each which is identified by a label. The most significant problem in image analysis is the detection of presence of an object within a given scene or an image. Such problem occurs in trademarks classification and other areas like remote sensing for monitoring growth patterns within urban areas, weather prediction from satellite, target detection from radar or from the fighter plane, etc. For this purpose, template matching or template detection is the most commonly used technique.

Template Matching is one of the most common techniques used in Image Processing. It is the process of determining the position of sub image inside the large image. The two terms template and matching to have their technical meanings: template is anything that is fashioned, shaped, or designed to serve as a model from something is to be made, and matching is the process of comparing in respect of similarity so that we can examine their likeness or their difference. It is the process of moving the template within the large image at every position in which template has to be searched by evaluating the similarities between the template and the image region over the template's position and then determining the position based on the similarity measure.

In conventional template matching cross correlation is the most commonly used algorithms. The method is simple to implement and understand, but it is one of the slowest methods. Furthermore, if the object in the image is rotated, the tradition method can fail. Thus to solve this type of problem, we use rotation invariant template matching techniques.

Using rotation invariant template matching the object of interest can be easily searched even if it is rotated at any angle within the query image. Rotation invariant template matching is used in many applications like, trademark detection, character recognition, fingerprint identification, biomedical imaging, remote sensing and feature tracking. There are a number of techniques that are being used for rotation invariant template matching such as normalized invariant moments [1], Radon transform[4], wavelet decomposition [6], ring projection transformations [13][14] and orientation codes [15][16][17]. In this paper we analyze two techniques i.e. Ring Projection Transformation and Orientation Codes for rotation invariant trademark detection. These techniques are simple to implement and give high accuracy for applications like character recognition.

In the field of image processing a lot of work has been done on template matching techniques that are invariant to rotation. Goshtasby A. [1] proposed a rotationally invariant template matching using normalized invariant moments. It is shown that if normalized invariant moments in circular windows are used, then template matching in rotated images becomes similar to template matching in translated images. Schmidt W. et al. [2] considered the higher order neural networks that are robust in terms of target detect ability. Wavelet decomposition approach for rotation invariant template matching is proposed by Du-Ming T. et al. [6]. They first decompose the image into different multi-resolution levels in the wavelet-transformed domain, and use only the pixels with high wavelet coefficients in the decomposed detail sub images to compute the normalized correlation between two compared patterns. To make the matching invariant to rotation, they further use the ring-projection transform. Kim H. Y. et al. [8] considered the grayscale template matching problem, invariant to rotation, scale, translation, brightness and contrast. They proposed a technique that substantially accelerates this searching while obtaining the same results as the original brute force algorithm. Their algorithm consists of three cascade filters. Xia L. et al. [9] proposed a learning-based logo recognition method to detect and classify the logos in the natural image. In this they first applied the SIFT matching solution in a set of training data to reliably detect the interest region in images and extract the discriminate features. Second, the approximate nearest neighbor searching strategy is built up by formulating the data into a tree-based structure, for efficient matching. Finally, to recognize the logos in the test image, the corresponding SIFT features will be computed in the interest regions of test image and matched in the database which is achieved in the training stage.

Further the research has also been done on the techniques like Ring projection transformation and orientation codes for the purpose of Rotation invariant template matching. Lin Y-H. et al. [13] proposed a new method for template matching, invariant to image translation, rotation and scaling. In the first step of the approach, the ring-projection transform (RPT) process is used to convert the 2D template in a circular region into a 1D gray-level signal as a function of radius. Then, the template matching is performed by constructing a parametric template vector (PTV) of the 1D gray-level signal with differently scaled templates of the object. Lee W-C. et al. [14] proposed an algorithm for rotation invariant template matching method. The algorithm consists of two stages process. In the first stage, the scene image and template are reduced in resolution. Then the features from the sub image covered by the template are extracted using RPT method. The normalized correlation formula is used to select the matching candidates in the coarse search stage. These candidates will be recovered to original position and determine the searching range. In the second-stage process, Zernike moments based on the matching candidates are used to determine the optimal matching point. Ullah F. et al. [15] proposed a new method for rotation-invariant template matching in gray scale images. It is based on the utilization of gradient information in the form of orientation codes as the feature for approximating the rotation angle as well as for matching. Orientation codes-based matching is robust for searching objects in cluttered environments even in the cases of illumination fluctuations resulting from shadowing or highlighting, etc. A two-stage framework for realizing the rotation-invariant template matching is used in their paper; in the first stage, histograms of orientation codes are employed for approximating the rotation angle of the object and then in the second stage. Matching is performed by rotating the object template by the estimated angle. Matching in the second stage is performed only for the positions which have higher similarity results in the first stage, thereby pruning out insignificant locations to speed up the search. Experiments with real-world scenes demonstrate the rotation and brightness invariance of the proposed method for performing object search. Zhonghai L.I. et al. [16] present the concept of relative orientation code, and designed a template matching method based on relative orientation code in order to improve accuracy and real time ability. This method first selects candidate target points using relative orientation codes histogram matching, then calculates the rotation angle of candidate sub image and rotates the sub image, finally match the relative orientation codes in the sub image. Their results show that this method is robust when the image is rotated by any angle, and the candidate points are selected and matched accurately, and the computing time is less than original method. Urano et al. [17] proposed a fast and rotation invariant template matching using an orientation code difference histogram (OCDH). The method is effective in presence of some irregularities like shading, highlighting, occlusion or their combination. This method is based on Orientation code matching (OCM) and orientation code histogram.

2. ROTATION INVARIANT TECHNIQUE IN BRIEF

2.1 Ring Projection Transformation (RPT)

In order to make our technique rotation invariant we use Ring Projection Transformation Technique [13, 14] which reduces the 2D image into 1D feature vector that is used for matching. For applying this process, a template T(x,y) is defined whose size is M×N. The RPT of the template is calculated as follows: Firstly, the center point of the template T(x,y) denoted as (x_c, y_c) is derived, and subsequently, the Cartesian frame template T(x,y) is transformed into a polar frame based on the following relations:

$$x = r\cos\theta$$
$$y = r\sin\theta$$

where $r = (\text{int})\sqrt{(x - x_c)^2 + (y - y_c)^2}$, $r \in [0, R]$

$$R = \min(M, N), \theta \in (0, 2\pi]$$

The RPT value of the template T(x,y) at radius r is denoted as $P_T(r)$, which is defined as

$$P_T(r) = \frac{1}{S_r}\sum T(r\cos\theta, r\sin\theta)$$

Where S_r is the total number of pixels falling on the circle of radius r. According to the formula of P_T (r), it is easily seen that PT (r) is defined as the mean of pixel intensities along the circle centered on the template T(x,y). RPT values at the radius r, r∈[0,R], can be regarded as features with equal importance in the computation of correlation. The RPT process is constructed along circular rings of increasing radii. The derived one dimensional ring projection template is invariant to rotation of its corresponding two-dimensional image template.

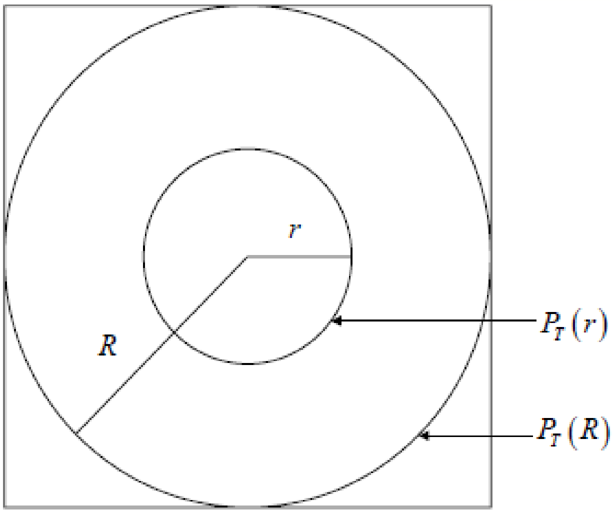

Fig. 1 The ring projection of template [13]

2.2 Orientation Codes

The orientation codes, for discrete images, are obtained as quantized values of gradient angle around each pixel by applying differential operator for computing horizontal and vertical derivatives like Sobel operator, and then extracting the gradient angle as follows:

$$\theta = (\partial f/\partial y)/(\partial f/\partial x)$$

The orientation code for a pixel location (i,j), for a preset sector width Δ_θ is given as follows:

$$C_{ij} = \begin{cases} \left[\frac{\theta_{ij}}{\Delta_\theta}\right], & |\nabla I_x| + |\nabla I_y| > \Gamma \\ N, & \text{otherwise} \end{cases}$$

Where [·] is the Gaussian operation. If there are N orientation codes then $C_{(ij)}$ is assigned values {0,1,……,N − 1}. Code N is substituted for low contrast regions (defined by the threshold *Γ)* for which it is not possible to stably compute the gradient angles. For a separate image O = {C_{ij}} (referred to as an orientation code image hereafter). The threshold *Γ* is important for suppressing the effects of noise and has to be selected according to the problem at hand; very large values can cause suppression of the texture information.

Orientation Code Matching (OCM) has proved to be robust for template matching in the presence of many real world irregularities, such as illumination variation due to shading, highlighting, and in the presence of partial occlusion. The first stage estimates the approximate rotation angle of the object image by using histograms of the orientation codes and the second stage searches for the true position by performing match only on the candidates filtered out in the first stage and rotating the template by the closest angle of rotation also estimated in the first stage.

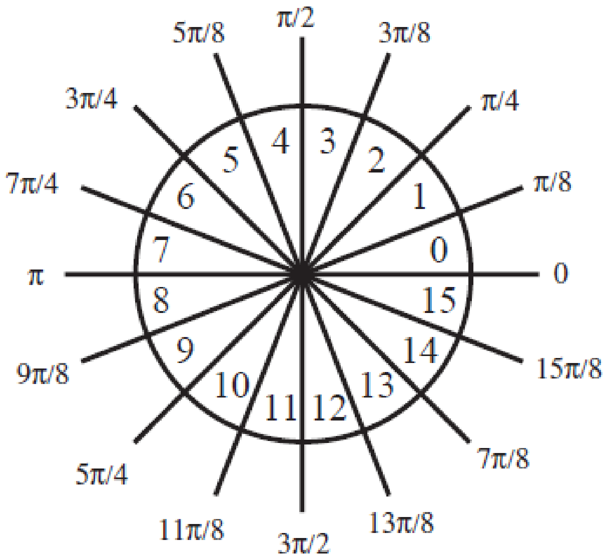

Fig. 2 Illustration of orientation Codes [15]

3. IMPLEMENTATION

3.1 Ring Projection Transformation (RPT)

The RPT process is constructed along circular rings of increasing radii. The derived one-dimensional ring projection template is invariant to rotation of its corresponding two-dimensional image template.

After calculating the RPTs of the template, we traverse the template on the image pixel by pixel and correspondingly calculating the RPTs of the region within the image which is traversed by the template at that point of time. Then simultaneously compare the RPTs of the template with the RPTs of that region within the image and calculate the difference. After getting all the differences while traversing template on the image, we find the minimum difference value and corresponding to that, we get the match of the template which we were finding.

Following is the steps that are followed for this technique:

Step 1: Read the input image and the template that is to be found.

Step 2: Calculate the radii at each pixel position on the template. For instance, if we are having the template of the size 5x5 pixels, then the radius at each pixel of the template will be:

4	3	3	3	4
3	2	2	2	3
3	2	1	2	3
3	2	2	2	3
4	3	3	3	4

Step 3: Then the RPT values of the template is calculated by taking the sum of the pixel values at the particular radius divided by the number of pixels on that radius.
Step 4: Traverse the template on the image pixel by pixel and correspondingly calculate the RPT values within the sub window of the image which is traversed by the template at that point of time.
Step 5: Compare the RPT values of the template with the RPT values of sub window of the image and calculate the sum of absolute differences.
Step 6: Find the minimum of the sum of absolute difference and highlight the corresponding area as the region of the desired template.

3.2 Orientation Codes

The first stage estimates the approximate rotation angle at the object image by using histograms of the orientation codes and the second-stage searches for the true position by performing match only on the candidates filtered out in the first stage and rotating the template by the closest angle of rotation also estimated in the first stage.
Following are the steps that are followed for this technique:
Step 1: Read the input image and the template image that is to be found.
Step 2: Compute the horizontal and vertical derivatives and then compute the gradient angle of the template.
Step 3: Calculate the orientation codes for all pixel locations and then form the orientation code histogram of the template.
Step 4: Overlap the starting point of the image by template and correspondingly form the orientation code histogram of the each sub window overlapped by calculating the gradient angle and the orientation codes of the sub window of the image.
Step 5: Shift the histogram of the sub window one by one and correspondingly calculate the absolute difference between the histograms of the template and the sub window overlapped by the template. Find the minimum difference between the two histograms.
Step 6: Traverse the template on the image pixel by pixel and repeat the steps 4 and 5.
Step 7: Find the minimum difference of the values obtained in step 6 and correspond to that find the index and highlight the corresponding area as the region of the desired template.

4. RESULTS

Experiments have been performed to test the proposed algorithms and to measure the accuracy of the algorithms, 52 grayscale images of various trademarks collected are used for testing the techniques. All the trademark images have been obtained from the internet, and all the trademarks are normalized to 64x64 for fast processing. Query images are synthesized by adding a number of trademark images rotated through different angles. All the query images are of size 256x256. Trademarks are then searched in the query images. Different results are obtained while performing the Ring Projection Transformation and Orientation codes technique.

The visual results for query image shown in Fig 3 and template image Fig 4 are shown in Fig 5 for the RPT method and Fig 6 shows the results for OC method. It is clear from the visual results that RPT method gives more accurate results than OC method for Trademark images where the background is not cluttered and there are no non uniform illumination effects.

Fig. 3 Query Image

Fig. 4 Trademark

Fig. 5 Resulting Image for RPT image. The detected trademark is enclosed in a square.

Fig. 6 Resulting Image for OC image. The detected trademark is enclosed in a square.

The methods were tested using 52 test images. For the RPT the accuracy was 100% and for OC method the accuracy was below 70%.

5. CONCLUSIONS

From above experimental results we have found that Ring Projection Transformation process is better than Orientation Codes for matching the rotated trademarks. The results will be further tested using standard database of trademark images having natural images with distortions like noise clutter and non uniform illumination effects.

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