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Object Recognition by Template Matching Using Correlations and Phase Angle Method

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Abstract: Object recognition in computer vision is the task of finding a given object in an image or video sequence. The aim of object recognition is to correctly identify objects in a scene and estimate their pose (location and orientation). The goal is to realize the ability of current object recognition techniques to find similar objects when input is entirely in image form. In this present work, template matching techniques is used to recognize the object using correlation and Phase Angle Method.

Keywords: Object Recognition, Phase Angle, Correlation, Normalized cross correlation, Template Matching, Fourier Transform

I. INTRODUCTION

Object recognition in computer vision is the task of finding a given object in an image or video sequence. Humans recognize a large amount of objects in images with little effort, regardless of the fact that the image of the objects may differ somewhat in different viewpoints, in several different sizes /scale or even when they are translated or rotated [1]. Objects can even be recognized when they are partially obstructed from view. This task is still a challenge for computer vision systems in general.

Object recognition can be observed as a learning problem. To start with the system is trained on sample images of the target object class and other objects, learning to differentiate them. Subsequently, when new images are fed the system can sense the presence of the target object class
The object recognition problem can be separated into two basic blocks: low level and high level vision. The low level vision task can be seen as to isolate objects and regions from the given image and similarly extracting other characteristic features from an image. The high level vision means the interpretation of these objects or features in the frame of a reference scene

Correlation is a measure of the degree to which two variables agree, not necessary in actual value but in general behavior. The two variables are the corresponding pixel values in two images, template and source.

Template Matching: It is a Technique used to categorize objects. A template is a small image (sub-image) .The goal is to find occurrences of this template in a larger image that is, you want to find matches of this template in the image. Template matching techniques compare portions of images against one another. Sample image may be used to recognize similar objects in source image

Template matching has been a classical approach to the problems of locating and recognizing of an object in an image. Template matching technique, especially in two dimensional cases, has many applications in object tracking, image compression, stereo correspondence, and other computer vision applications [6,7,8,9]. Even now, it is a fundamental technique to solve them. Among several matching methods, Normalized Cross Correlation (NCC) and square root of Sum of Square Differences ~SSD) have been used as the measure for similarity. Moreover, many other template matching techniques [6,7,8] , such as Sum of Absolute Differences (SAD) and Sequential Similarity Detection Algorithm (SSDA) have been adopted in many applications for pattern recognition, video compression and so on. In addition, template matching has been extensively used in various applications, for example, extraction of container identity codes [10], image segmentation, [11] and so on.

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II. METHODOLOGY

A. Normalized cross correlation

Normalized cross correlation is a well-liked method for finding 2D patterns in images. An $(2h+1) \times (2w+1)$ template **t** is correlated in opposition to an image **x**. At the image location (u, v), the normalized cross correlation is computed as

$$\mathbf{c}(u,v) = \frac{\sum_{i=-h}^{h}\sum_{j=-w}^{w} X(i,j)T(i,j)}{\sqrt{\sum_{i=-h}^{h}\sum_{j=-w}^{w} X(i,j)^2}\sqrt{\sum_{i=-h}^{h}\sum_{j=-w}^{w} T(i,j)^2}}$$

with

$$X(i,j) = \mathbf{x}(u+i, v+j) - \overline{\mathbf{x}}$$
$$T(i,j) = \mathbf{t}(h+i, w+j) - \overline{\mathbf{t}} \qquad (1)$$

In [12], a fast algorithm was developed to compute the denominator term

$$\sum_{i=-h}^{h}\sum_{j=-w}^{w}(\mathbf{x}(u+i, v+j) - \overline{\mathbf{x}})^2 \qquad (2)$$

This is achieved by observing that this term can be decomposed into three parts:

$$\sum_{i=-h}^{h}\sum_{j=-w}^{w}\mathbf{x}(u+i,v+j)^2, \quad \overline{\mathbf{x}}\sum_{i=-h}^{h}\sum_{j=-w}^{w}\mathbf{x}(u+i,v+j),$$
$$\text{and } (2h+1)(2w+1)\overline{\mathbf{x}}. \qquad (3)$$

The first two terms can be computed efficiently using integral images of the original image and the squared image. To speed up the numerator computation, we can decomposed the template into box basis function so that

$$\mathbf{t} \approx \sum_{i\in\Lambda} \alpha_i \phi_i . \qquad (4)$$

Then the numerator becomes

$$\mathbf{x}(u,v)\mathbf{t} = \sum_{i\in\Lambda} \alpha_i (\phi_i \mathbf{x}(u,v)) \qquad (5)$$

This can be computed using $|\Lambda|$ multiplications and4 $|\Lambda| - 1$ additions [2].

B. Fourier Transform and Phase Correlation

The Fourier transform has several properties that can be exploited for image registration. Translation, rotation, reflection and scale all have their counterpart in Fourier domain [13]. Moreover, using the frequency domain, it is possible to achieve excellent robustness against correlated and frequency dependent noise. An elegant method used to register two images which are shifted relative to one another is to use phase correlation [14]. Phase correlation relies on the translation property of the Fourier transform better known as the shift theorem [13, 15, 16, 17]. Given two images f1 and f2; which differ by translation (dx, dy), i.e.

$$f_2(x,y) = f_1(x - dx, y - dy) \qquad (6)$$

Their corresponding Fourier transform F1 and F2 will be related by

$$F_2(w_x, w_y) = e^{(w_x d_x + w_y d_y)} F_1(w_x, w_y) \qquad (7)$$

Two images have the same Fourier magnitude but a phase difference honestly related to their displacement. Because of the shift theorem this phase difference is corresponding to the phase of the cross
power spectrum.

$$e^{w_x d_x + w_y d_y} = \frac{F_1(w_x, w_y) F_2^*(w_x, w_y)}{|F_1(w_x, w_y) F_2^*(w_x, w_y)|} \qquad (8)$$

where * is the complex conjugate. The inverse Fourier Transform of the phase difference is a delta function centered at the displacement, which in this case, is the point of registration. [4] Shows the block diagram of image registration algorithm using LPT and phase correlation. The Fourier Transform assumes a periodic function and the image is truncated, it is crucial to apply a window-function, like the Hanning window, to the input images. Another implementation--n difficulty consists of the numerical instability for coordinates near to the origin; here we used a filter with the following transfer function:

$H(x,y) = (1.0 - \cos(\pi x)\cos(\pi y))(2.0 - \cos(\pi x)\cos(\pi y))$,
With : $-0.5 \le x,y \le 0.5$ (9)

III. RESULTS AND DISCUSSIONS

A. Template Matching with Orignial Templates

TABLE I

Image	Phase Angle Method	Correlation Method
Butterfly	0.622999 sec	1.093026 sec
Scene	16.729855 sec	10.076400 sec
Nature	97.757421 sec	143.055132 sec
Room	8.146782 sec	4.345018 sec
Toys	0.502068 sec	0.501874 sec

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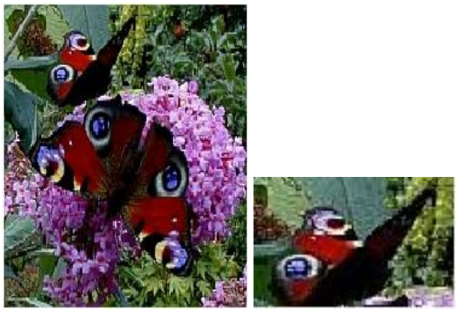

Input Image Input Template

Template Matching Using Phase Angle Method   Template Matching Using Normalized Correlation Method

Fig. 1 Butterfly Image

Input Image Input Template

Template Matching Using Phase Angle Method   Template Matching Using Normalized Correlation Method

Fig 2: Scene Image

Input Image Input Template

Template Matching Using Phase Angle Method   Template Matching Using Normalized Correlation Method

Fig 3: Nature Image

Input Image Input Template

Template Matching Using Phase Angle Method

Template Matching Using Normalized Correlation Method

Fig 4: Room Image

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Input Image Input Template

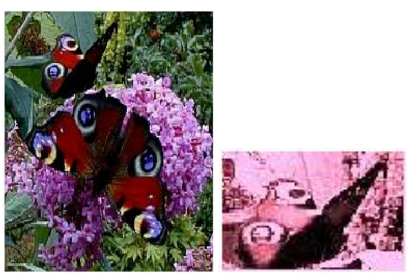
Template Matching Using Phase Angle Method Template Matching Using Normalized Correlation Method

Fig 5: Toys Image

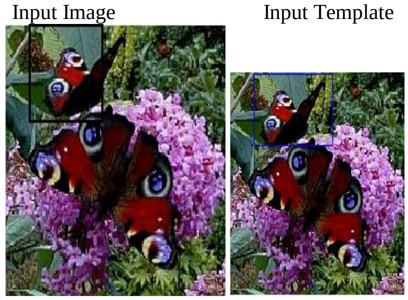
B. Template Matching with modified Templates at different angles and variation in color

TABLE II

Image	Angle of Rotation	Phase Angle Method	Correlation Method
Butterfly	0 to 1°	0.622999 sec	1.093026 sec
Scene	0.4°	16.729855 sec	10.076400 sec
Nature	0 to 1°	97.757421 sec	143.055132 sec
Room	1 to 2°	8.146782 sec	4.345018 sec
Toys	>2°	0.502068 sec	0.501874 sec



Input Image Input Template



Template Matching Phase Angle Method Template Matching Using Normalized Correlation Method

Fig 6: Butterfly Image

Input Image Input Template

Template Matching Using Phase Angle Method Template Matching Using Normalized Correlation Method

Fig 7: Scene Image

Input Image Input Template

Template Matching Using Phase Angle Method Template Matching Using Normalized Correlation Method

Fig 8: Nature Image

Input Image Input Template

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Template Matching Using Phase Angle Method

Template Matching Using Normalized Correlation Method

Fig 9: Room Image

Input Image

Input Template

Template Matching Phase Angle Method

Template Matching Using Using Normalized Correlation Method

Fig 10: Toys Image

IV. CONCLUSION

This work carried out is experiment of object recognition using phase angle and correlation methods. From the study and analysis of table after applying on number of images of database, came to conclusion that Phase angle method takes less time in seconds to recognize the objects up to an extend after that when size of image increases and more compact images correlation takes less time to recognize objects in an image .On rotating same images, correlation method takes less time for most of images to recognize same objects in it.

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