Performance Analysis of Template Based Object Recognition Using Matching Parameter

Kavita Ahuja
Mtech Scholar, Computer Science & Engg
Disha Institute of Management and Technology
Raipur, India

Preeti Tuli
Reader, Computer Science & Engg
Disha Institute of Management and Technology
Raipur, India

Abstract— Given some knowledge of how certain objects may appear and an image of a scene possibly containing those objects, results which objects are present in the scene and where. The goal was in [19] to realize the ability of current object recognition techniques to find similar objects when input is entirely in image form using template matching techniques. In this present work, analysis of template based object recognition is done i.e. what percentages of images are matching correctly using corr2 function in Matlab.

Index Terms— Object Recognition, Phase Angle, Correlation, Normalized cross correlation, Template Matching, Correlation Analysis

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 detection attracts lots of interests in the field of image analysis, recognition and tracking generally, the common algorithm for object detection is template matching (TM) [22] [23].

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 [19].

Correlation Analysis: It is a statistical measure which shows relationship between two or more variable moving in the same or in opposite direction.

Template Matching: It is a Technique used to categorize objects. A template is a small image (sub-image). Jianbin Xie, Tong Liu, Zhangyong Chen and Zhaowen Zhuang [22], further categorized the Template Matching algorithm into two parts: firstly feature based methods in which the features of objects are invariable to the position, scale and rotation but feature extraction is easy in limited situations.

Image Segmentation is the process of partitioning/subdividing a digital image into meaningful regions or set of pixels regions with respect to a particular application [25]. In [24], Segmentation techniques employed in order to isolate different objects from each other and background. It is primary step to be performed in image analysis for object detection, recognition and identification. Various segmentation techniques have been focused Edge detection methods, Histogram based, watershed transformation and so on but concluded segmentation techniques are ad hoc in nature i.e. it can’t be predicted any general algorithms that will work for all images. Feature-based matching methods are usually applied, when the structural information matches than the intensity information. They can also handle image distortions [26]. As in [22], feature based template Matching is implemented in [27] for recognizing chess board images, where matching between features is carried out based on Euclidean distance metric.

Normalized cross correlation methods are best suited for the templates which have no strong features with image, since they operate directly on the bulk of values. Matches are estimated based on the intensity values of both image and template [26]. Combination of feature detection and feature matching can also be performed. C. Saravanan, M. Surender in [28], proposed a face matching algorithm based on Normalized Cross-Correlation for matching the extracted face of the person from one image, with the different images of same person concluded Normalized Cross-Correlation (NCC) is the best approach for Face matching.

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 [19]. 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, and 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.

II. METHODOLOGY

A. Correlation

When two variables co-vary, there exists relationship between them. Correlation Analysis is one of the most widely used and reported statistical methods in summarizing medical and scientific research data. Richard Taylor et al [20], emphasize on the Interpretation of Correlation Coefficient. It is often useful to determine if a relationship exists between the two variables. If so, how significant or how strong is this association? For example, is there is association between years of service as a sonographer and the scores achieved on the registry examination? The correlation coefficient or $r$ coefficient is the statistic used to measure degree or strength of this type of relationship.

The sample correlation coefficient ($r$) measures the degree of linearity in the relationship between $X$ and $Y$. or strength and direction of linear association between two variables. 

![Fig 1](image)

The correlation of a pair of indiscriminate variables is a dimensionless number, range between +1 and -1. The nearer the absolute value is to 1, the stronger the association. The coefficient can be either positive or negative [21].

$$\text{r} = \frac{\text{cov}(x, y)}{\sigma_x \sigma_y}$$

$$r = \frac{\sum x \cdot y}{\sqrt{\sum x^2 \cdot \sum y^2}}$$  \hspace{1cm}  Eq. 1

Where,

$$x = X - \bar{X}$$  \hspace{1cm}  Eq. 2

and

$$y = Y - \bar{Y}$$  \hspace{1cm}  Eq. 3

$r = 0$ indicates no linear relationship exists.

Direct Method for Calculating ‘r’:

$$r = \frac{N \sum XY - \sum X \sum Y}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$  \hspace{1cm}  Eq. 4

B. Normalized cross correlation

Normalized cross correlation is a well-liked method for finding 2D patterns in images. These methods are used for the easy implementation of hardware and processing image for real time applications [26].

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

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

with

$$X(i,j) = x(u+i,v+j) - \bar{X}$$

$$T(i,j) = t(h+i,w+j) - \bar{T}$$

Where, $\bar{T}$ is the mean of the feature, $T(i,j)$ is reference template used for matching, $\bar{x}$ is mean of image in the region under template $t$. Template window size is $(2h+1) \times (2w+1)$.

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

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

Eq. 6

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

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

$$\text{and} (2h+1)(2w+1)\bar{x}$$

Eq. 7

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
Then the numerator becomes

\[ t \approx \sum_{i \in A} \alpha_i \phi_1 . \quad \text{Eq. 8} \]

This can be computed using \( |A| \) multiplications and \( 4 |A| - 1 \) additions [2].

C. 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 [4]. 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, and 17]. Given two images \( f_1 \) and \( f_2 \); which differ by translation \( (dx, dy) \), i.e.

\[ f_2(x, y) = f_1(x - dx, y - dy) \quad \text{Eq. 10} \]

Their corresponding Fourier transform \( F_1 \) and \( F_2 \) will be related by Eq. 11

\[ F_2(w_x, w_y) = e^{i[w_x dx + w_y dy]} F_1(w_x, w_y) \quad \text{Eq. 11} \]

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.

\[ e^{i[w_x dx + w_y dy]} = \frac{F_2(w_x, w_y)}{F_1(w_x, w_y)} F_2^*(w_x, w_y) \quad \text{Eq. 12} \]

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 images are 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 \leq x, y \leq 0.5 \quad \text{Eq. 13} \]

### III. Results and Discussions

#### A. Template Matching with Original Templates and Recognized Output Part of Phase Angle Method

<table>
<thead>
<tr>
<th>Image</th>
<th>Image Template</th>
<th>Phase Angle Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toys</td>
<td>Temp14</td>
<td>90%</td>
</tr>
<tr>
<td>Data1</td>
<td>Temp_data1</td>
<td>82.8%</td>
</tr>
<tr>
<td>Image31</td>
<td>Temp_31</td>
<td>80%</td>
</tr>
<tr>
<td>scene</td>
<td>Temp21</td>
<td>70%</td>
</tr>
</tbody>
</table>

![Fig 2 Toys Image](image2.png)

![Fig 3 Data1 Image](image3.png)

![Fig 4 Image31](image4.png)

![Fig 5 scene Image](image5.png)
B. Template Matching with Original Templates and Recognized Output Part of Correlation Method

<table>
<thead>
<tr>
<th>Image</th>
<th>Image Template</th>
<th>Correlation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toys</td>
<td>Temp14</td>
<td>92.7%</td>
</tr>
<tr>
<td>Data1</td>
<td>Temp_data1</td>
<td>84%</td>
</tr>
<tr>
<td>Image31</td>
<td>Temp_31</td>
<td>99.1%</td>
</tr>
<tr>
<td>scene</td>
<td>Temp21</td>
<td>83%</td>
</tr>
</tbody>
</table>

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 Correlation method is more accurate to recognize the objects maximum up to 99% accuracy while Phase angle method recognize objects accurately varies minimum 70% to maximum 96% for same images. This variation in matching parameter clarifies that correlation method performs much accurate object recognition task as compared to phase angle method for same set of images. We come to this conclusion after performing corr2 function in Matlab between output image and image template used for object recognition i.e. recognized part versus reference part of an image and calculates the percentage after multiplying result with 100.

V. FUTURE WORK

This work will be extended for images after rotating up to certain degree to check their matching accuracy in percentage for phase angle and correlation method on set of images from database. Procedure will be same except templates will be at some degree rotated to perform correlation analysis as done in this paper for resulting recognized output image and rotated template image.

REFERENCES

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BIOGRAPHY

Kavita Ahuja did Bachelor of Engineering in 2011 in Computer Science & Engineering (Honors) from DIMAT, Raipur, and pursuing Masters of Technology in Information Security from DIMAT, Raipur.

Preeti Tuli did Bachelor of Engineering in 2000 in Computers from Shri Govind Ram Sakseria Institute of Technology and Science, Indore, and M.Tech (CSE) from RCET, Bhilai.