Analysis of Template Matching Method Using Correlation Score

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Abstract— **Template Matching is a high level machine-vision technique that identifies a specific part of an image that matches a predefined template image. Template matching is an essential task in image processing in many applications, including remote sensing, computer vision, medical imaging, and industrial inspection. In Template matching, small object is compared to a stored set of images. The detection and recognition of objects in different images is the main research topic in the computer vision area. Template matching is a mostly used pattern recognition method, especially in industrial inspection. Another important use of template matching is face localization. Face localization is the first step in any automatic recognition system where it is a spatial case of face detection. In this paper, our main objective is to propose an efficient template matching method on the basis of correlation score and analyze it with the Normalized Cross Correlation Method.**

***Index Terms*—Computer vision, Correlation, Image Processing, Template Matching.**

I. Introduction

Template matching is a technique mostly used in classifying an object by comparing portions of images with another image. One of the main techniques in Digital image processing is template matching. Template matching is widely used for processing images and pictures. Some of its wide-spread applications are object to location, edge detection of images, to plot a route for mobile robot and in image registration techniques to a few. In general, a technique includes its unique algorithm or method, which compares the template image with input image and finds similarity between them.

Template matching is a major task for various computer vision applications. Two major categories of approaches are generally distinguished. Feature-based approach uses local features like points, line segments, edges, or regions. With these techniques it is possible to localize the object in the current image and to predict the feature positions in subsequent ones, according to a motion model and an uncertainty model. Pose search techniques are naturally less sensitive to occlusions, as they are based on local correspondences.

Cross correlation is used in proposed system. For continuous functions, Cross correlation[1] is defined as follows:

$$\rho_{XY}(\tau) = \sum[(X_t - \mu_X)(Y_{t+\tau} - \mu_Y)]/(\sigma_X\sigma_Y) \quad \text{.......Eq.1}$$

Where,

μ_X , σ_X => the mean and standard deviation of the process X_t.

μ_Y => Mean of Template image.

σ_Y => Standard deviation of Template image.

X_t => Source Image.

Y_t => Template image.

Whereas the formula for normalized cross correlation[1] is give below:

$$\frac{1}{n}\sum_{x,y}\frac{(f(x,y)-\overline{f})(t(x,y)-\overline{t})}{\sigma_f\sigma_t} \quad \text{..........Eq 2}$$

Where,

f => Source Image.

t => template image

n => the number of pixels in $t(x,y)$.

$\overline{f}$ => the average of f and σ_f is standard deviation of f.

$\overline{t}$ => the average of t.

II. Literature Survey

Many template matching approaches have been proposed over the past few decades. The NCC is widely used in template matching, but it is time consuming. Tsai and Lin [2], "Robust techniques for computer vision", proposed a sum-table scheme to reduce the computation cost for NCC method. In addition, the traditional NCC method is applied in the case of single template; therefore, Tanaka and Sano [3], "Red is the new black - or is it?" proposed a parametric template method for template matching. In this method, the parametric space is constructed from the given vertex images (multi-template) that contain rotation and scale variances, but it is a time consuming method.

Regarding the template matching, different research scholars proposed their own template matching methods. Rosenfeld [1982],[4] "Digital picture processing", proposed a method in which numerous techniques aimed at speeding up the basic approach have been devised. Ramrajgopal[5] "Pattern Matching Based on a Generalized Transform", presented a new algorithm for real-time scale invariant pattern matching. The proposed algorithm was based on the shift invariance property of a new transform. They have showed how to compute this transformation for a given set of basis signals.

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One advantage of the proposed approach is that any affine transform can be included as part of the algorithm. Transformed versions of the template image should be Halton sampled and these samples included in the estimation of the generalized transform. A continuation of this work would be to explore the relationships between the GT and other transforms, and study the application of the proposed pattern matching approach to image indexing.

Grayscale-based Matching is an advanced Template Matching algorithm that extends the original idea of correlation-based pattern detection enhancing its efficiency and allowing searching for pattern occurrences regardless of its orientation. Although in some of the applications the orientation of the objects is uniform and fixed (as we have seen in the plug example), it is often the case that the objects that are to be detected appear rotated. In Template Matching algorithms classic pyramid search is adapted to allow multi-angle matching, i.e., identification of the rotated instances of the pattern.. It has many applications ranging from computer animation and virtual reality to human motion analysis and human-computer interaction (HCI)[6].

Hannah [7] "A System for Digital Stereo Image Matching", suggested that a more accurate stereo solution would need to combine more than one approaches in a cooperative fashion. A practical approach of the combined approach is demonstrated by Baker [8].

In 1988 a survey of 15 institutions [9], " Results of Test on Image Matching", found that, many researchers were using combinations of more than one constraint for solving correspondence problem in stereo vision. The survey concludes that each of the different approaches had its relative merits and disadvantages dependent on nature of correspondence problem.

III. Problem Statement

The problem statement of matching data with template includes input data sets to analyze, specified template and sometimes search domain. It's very important to represent available input data in appropriate form and define matching criteria.

The main problem of the existing template matching algorithms is to load source image first and then template image to be matched i.e. larger image should be loaded first.

Template Matching techniques are expected to address the following need: provided a reference image of an object (the template image) and an image to be inspected (the input image). However, to find a specific part of a color image in different set of images is challenging in many aspects. The more specific problem is false results produced by system and causing less effectiveness.

IV. Objective

The main objectives of the proposed system are:

(i) Designing a Template matching algorithm on the basis of correlation score.

(ii) Implementing the Template matching algorithm and analyzing this algorithm on the basis of different correlation score.

(iii) Comparative analysis between the proposed system and Normalized Cross Correlation method on the basis of following parameters:

(a) Execution time

(b) Efficiency

V. Proposed System

Our Proposed system is mainly based upon one of the known method i.e. cross correlation. It will calculate the mean value of each image and then by calculating correlation score it will match the template image with target image. There are following steps to implement the proposed system

- Load Template Image
- Load Target Image
- Show Template Image & Target Image
- Declaration and call of corrMatching Module
- Convert Both Input image to gray image

If (Template Image > Target Image)

- Then Template Image = Template Image

Else

- Template Image = Target Image

EndIf

- Calculate The Mean of Both Images
- Find Corr1 Value
- Find Corr2 Value
- Calculate Correlation Score

If (correlation score > .95)

- Then Target Image Is found in Template Image
- Draw Bounding Box

Else

- Target Image is not found

EndIf

Algorithm for normalized cross correlation is as follows:

- Load Gray source Image First.
- Load Gray Template Image.
- If(Source Image > Template Image)

Then

- Calculate cross-correlation in the spatial or the frequency domain.
- Calculate local sums by pre-computing running sums.
- Use local sums to normalize the cross-correlation to get correlation coefficients.
- Do Template match using maximum correlation coefficient .
- Else

- Discard and Finish

Correlation is an important tool in image processing, pattern recognition, and other fields. The correlation between two signals (cross correlation) is a standard approach to feature detection as well as a building block for more sophisticated recognition techniques. Unfortunately the normalized form of correlation (correlation coefficient) preferred in many applications do not have a correspondingly simple and efficient frequency domain expression, and spatial domain implementation is recommended instead.

Correlation and Convolution are basic operations that we will perform to extract information from images. They are in some sense the simplest operations that we can perform on an image, but they are extremely useful. Moreover, because they are simple, they can be analyzed and understood very well, and they are also easy to implement and can be computed very efficiently.

There are following main preprocessing used in our proposed system:

1. Load Images: - Initially after launching the application, it asks for loading template image and target image.

2. BGR to Gray Conversion:- To reduce the complexity of image processing we convert both images to Gray conversion from BGR colors.

3. Image Mean Value Calculation:- After Gray conversion we calculate the mean values of both the images using convolution process. Convolution is nothing but the process of matrix multiplication of original matrix to kernel filter matrix.

We apply the mean value calculation method to calculate the average and mean value of given matrix vectors.

For Example: Mean(X), it will calculate the mean value of all elements in matrix X.

Mean value is calculated in two types:

- Row wise Mean value:

In Row wise Mean Value, the mean value is calculate by calculating mean of each rows.

- Column wise Mean value:

In Column wise Mean Value, the mean value is calculate by calculating mean of each columns.

For Example:

If X = [1 2 3;
3 3 6;
4 6 8;
4 7 7];

then mean(X,1){Row Wise Mean} is [3.0000 4.5000 6.0000] and

mean(X,2){Column Wise Mean} is [2.0000 4.0000 6.0000 6.0000].

4. Corr values:- After mean value calculation, two corr values are calculated i.e corr1 and corr2.

Corr1 value is calculated by applying 2D convolution on frame image(in which we have to search the target image) with the filter of size of difference of converted gray image and mean value.

Corr2 value is calculate by multiplying frame image to the sum of difference of target gray image and target mean image.

5. Correlation score:- Correlation score is the subtraction of Corr1 and Corr2 values. It is a 2D matrix of correlation coefficients.

6. Bounding Box:- On the given condition of correlation value, if the target image is found in template image we will draw a bounding box around appropriate area.

Bounding Box is drawn on behalf of max value.

- Max value in an image is aimed the maximum intensity value in a row or a column.

VI. Result and Analysis

Snapshots of the proposed system are as follows.

(A) To load Both images:

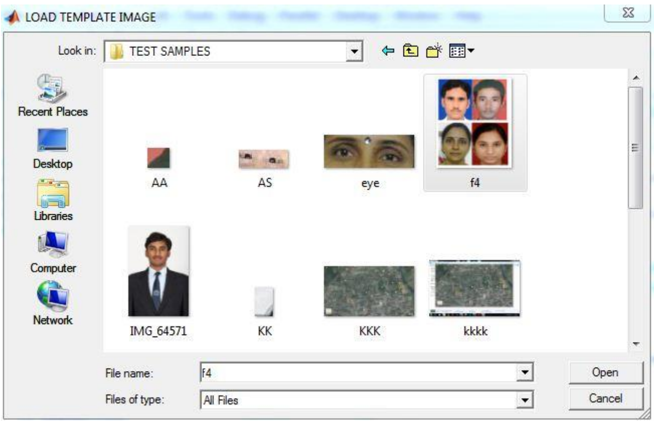


Figure 1: Load Template Image

In figure 1 the system asks for loading template image.here we select the template image in which we have to find the target image.

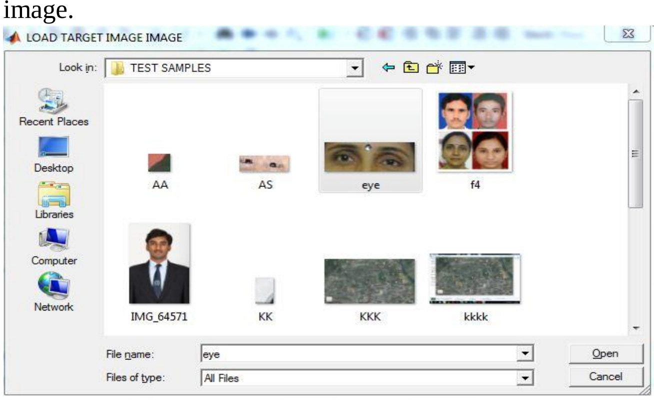


Figure 2. Load Target image

In figure 2 the system asks for target image.

(B) Result Window:

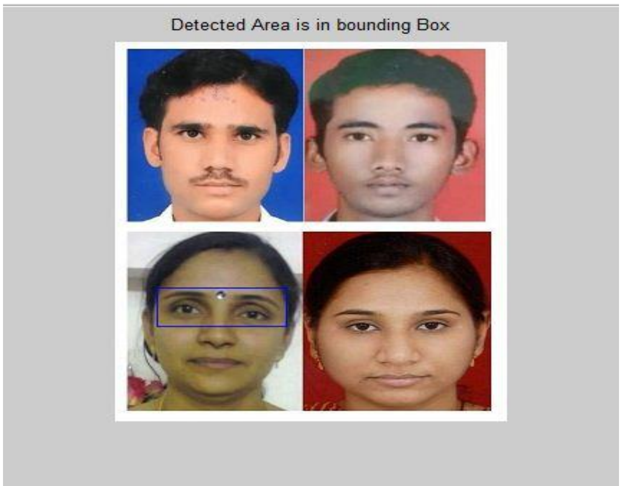


Figure 3. Result window

In figure 3 the result produced by system is shown. Here three windows are generated one is for matched image another is for source images and last is for correlation score.

Snapshots of result for cross correlation:

We took different kind of images and set the correlation score above .95 and the results produced by system are as follow:

(A) For nature Sceneries:

Source image template image Result

Figure 4: Result for nature scenes

(B) For Traffic scene:

Source image template image Result

Figure 5: output for traffic scenes

(C) For Wild animals:

Source image Template image Result

Figure 6: Output for wild animal scenes

(D) For General Scenes:

Source Image Template Image Result

Figure 7: Result for General Scenes

(E) For Book Covers:

Source image Template Image Result

Figure 8: Result for Book cover

(F) For Flowers:

Source Image Template Result

Figure 9: Result for flower

(G) For Fruits:

Source image Template Result

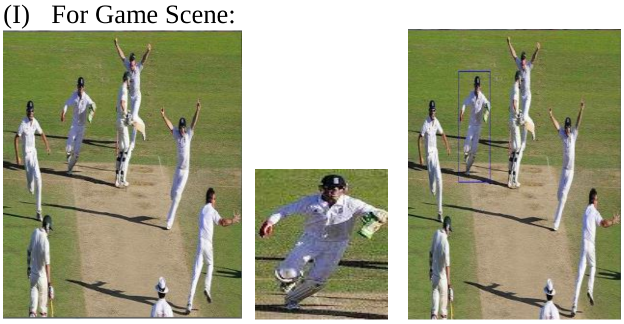
Figure 10: Result for fruits

(H) For House:

Source Image Template Result

Figure 11: Result for House

(I) For Game Scene:



Source Image Template Result

Figure 12: Result for Game Scene

(J) For Painting:

Source Image Template Result

Figure 13: Result for Painting

Similarly we have tested the system for other correlation score also.

Snapshots for NCC:

(A) For True matching:

Source Image Template Result

(B) False Match:

Source Image Template

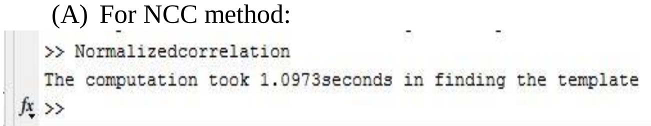
Figure 14: False result by NCC.

In figure 14 the true result and false result produced by NCC method is shown. We took different template image and it matched unrelated match area.

Execution Calculation:

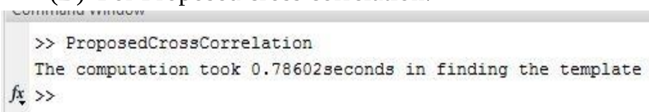
We used simple tic-toc command to calculate the overall execution time. By calculating execution times for different images, we calculate the average execution time. Here are the snapshots:

(A) For NCC method:



```
>> Normalizedcorrelation
The computation took 1.0973seconds in finding the template
fx >>
```

(B) For Proposed cross correlation:



```
>> ProposedCrossCorrelation
The computation took 0.78602seconds in finding the template
fx >>
```

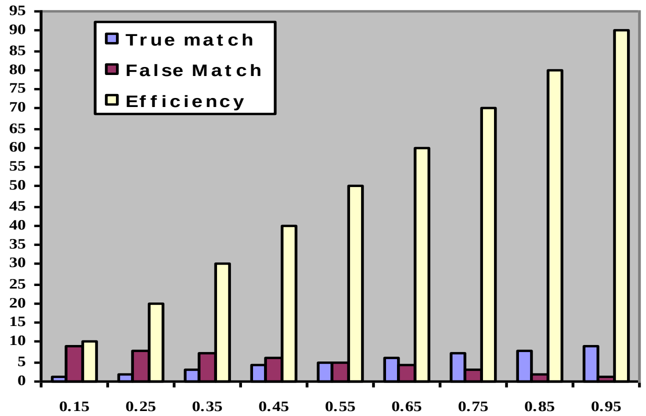
Figure 15: Execution time snapshots

In proposed system we applied different correlation value, and system produced different results accordingly. At different correlation score the efficiency of the system is discussed below in tabular format. Here we took 10 image samples to check the system efficiency.

Correlation score (>)	True Matching	False Matching	Efficiency (%)
.15	1	9	10
.25	2	8	20
.35	3	7	30
.45	4	6	40
.55	5	5	50
.65	6	4	60
.75	7	3	70
.85	8	2	80
.95	9	1	90

Table 1: Efficiency Vs correlation score

Graphical representation is depicted in following graph.



Graph 1: Efficiency Evaluation for Proposed Cross Correlation.

Efficiency is calculated on behalf of 10 image samples. Graphically we can draw a performance graph between correlation score and efficiency of the system.

From above graph we can see that efficiency and execution time in proposed cross correlation is far better than the conventional Normalized Cross Correlation.

We can conclude the following relation that efficiency is directly proportional to correlation score.

Efficiency α Correlation score……………………….Eq.3

Comparative Analysis Between Cross-Correlation and Normalized Cross-Correlation:-

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10 samples	Average Execution time (In seconds)		Average Efficiency %	
	Cross correlation	Normalized cross corelation	Cross correlation	Normalized cross corelation
Nature Scenerio	1.98	2.56	90	80
Wild Animals	1.74	1.91	90	80
General scenerio	.59	1.82	100	80
Traffic Scene	1.31	2.45	90	70
Paper Scene	.45	1.50	90	70
Fruit Scene	1.90	2.31	90	80
Flower Scene	1.51	1.94	90	70
House Pictures	2.40	3.45	100	70
Painting Scene	2.03	4.67	90	80
Game Scene	1.87	2.38	100	90

Table 2: Comparative analysis between proposed cross correlation and Normalized cross correlation(NCC)

Here we can see from above table that the proposed system is best suitable for general scenes and proposed system is far better than Normalized Cross Correlation in the terms of efficiency and execution time.

Comparative analysis of execution time between cross correlation and NCC:

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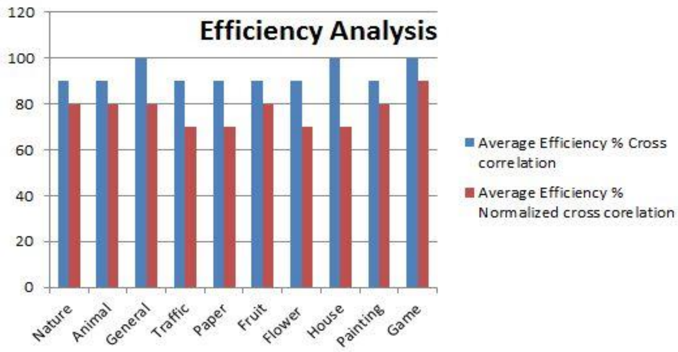
Graph 3: Execution time for NCC and Proposed Cross Correlation

Comparative analysis of efficiency between between cross correlation and NCC:



Graph :4 Efficincy Analysis

The proposed cross correlation method is much better then NCC in terms of efficiency and accuracy.

VII. Conclusion

Proposed System is more efficient in terms of efficiency as well as execution time in comparative to conventional Normalized Cross Correlation method. It also supports whether we load template image first or source image. At last we have seen that efficiency increases as correlation score increases. Proposed system also works in the condition of intensity or brightness variance.

VIII. Future work

In future, the template matching techniques may be used along with feature extraction in template recognition for scaled images. Thus we can resolve that issue. If the rotation of the part of image is not identical, we can also resolve that issue. If the above described issues are to be solved in future, then it can be very useful software in different areas, like crime branch, laboratory, Biotechnology etc.

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References

[1] https://en.wikipedia.org/wiki/Cross-correlation

[2] Peter Meer, *"Robust techniques for computer vision"*, Electrical and Computer Engineering Department Rutgers University .

[3] D. Austin and N. Barnes. "*Red is the new black - or is it*?" Australasian Conference on Robotics and Automation, December 2003.

[4] Rosenfeld A, Kak AC (1982) "Digital picture processing", vol 2. Academic Press, New York, pp 48–49

[5] Rama Rajgopal, "Pattern Matching Based on a Generalized Transform", National Instruments, Austin, TX 78759-3504.

[6] Nazil Perveen, Darshan Kumar and, Ishan Bhardwa, "An Overview on Template Matching Methodologies and its Applications" International

Journal of Research in Computer and Communication Technology, Vol 2, Issue 10, October- 2013.
[7] Hannah M.J., “A System for Digital Stereo Image Matching. Photogrammatric Engineering and Remote Sensing “1765-1770, 1989.
[8] Baker H.H., Depth from Edge and Intensity Based Stereo, Stanford AI Lab, Stanford University, 1982.
[9] Guelch E.,” Results of Test on Image Matching”. ISPRS WG III/4, Institute of Photogrammetry, University of Stuttgart,

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