Multiple Object Detection in Images using Template Matching

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ABSTRACT: Template matching is an application in computer vision for finding similar objects between the images. Template matching is a key component in image analysis process for mapping similar patterns between images. The detection and matching of objects has gained widespread application in quality control, manufacturing and medical applications. The major challenges in template matching process are occlusion, background noise and non-rigid transformation particularly in medical images. The present work proposes a template matching method based on correlation analysis techniques to detect multiple objects occurrence in an image. The method has been experimented for various real-time applications. In medical images, the proposed method gave an accuracy of 86% in detecting the nodules in lung CT images.

Keywords: Template matching, Correlation analysis, Hadoop framework, OpenCV.

I. INTRODUCTION

Image processing is a computer based technology used for interpretation and manipulation of images. It is mainly used to improve the quality of an image, for detecting or highlighting parts of the image. Primarily image processing techniques are applied to boost the standard of an image and to perform feature extraction and classification for various applications. Template matching is used in automation process to detect objects and for improving the quality of the searching process. It is effectively utilized in medical imaging, meteorology, astronomy, remote sensing, and many other connected fields for locating the target object from an image. It is a technique under image processing, where a particular object is taken as a target to be detected and that is mapped with the original image. Many techniques are applied for matching the images and in that, Greyscale-based matching and Edge-based matching are the most widely used techniques. Greyscale-based matching is the extension of correlation-based template matching, regardless of the orientation of the image. Greyscale-based method identifies both the template position and orientation so that we can detect images even from multiple angles. Edge-based matching is similar to greyscale based method but here rather than computing the whole image, the edges from the image are detected and matched only with the nearby pixels. These techniques can be applied to many real-time applications like, in medical image analysis for finding nodules and tumors from CT scans, mapping objects in the automobile industry as a part of quality control, in biometrics for fingerprint matching, etc.

II. RELATED WORKS

In recent years, many systems for template matching have been proposed for various applications. Some of those existing models are discussed below.

Serhat Ozekes et al., [1] proposed a system for detecting lung nodules. A nodule template-based algorithm was employed to categorize the region of interest, instead of detecting the ROIs using density value of the pixels in the CT image.

Dai-Duong Truong et al., [2] proposed a model to overcome the drawbacks of existing template matching like edge and feature-based detecting systems by using an arbitrary shape with the idea of coarse-fine and refining interest regions.

Bohong Wei et al., [3] proposed a system using Ring projection transform and Orientation codes for developing a fast rotation-invariant template matching system. It has two stages, the first is Ring projection method which is used to convert 2D images to 1D and then orientation codes are used to perform the template matching process on a limited number of candidates selected.

Hirokazu Ishizuka et al., [4] used steganography which replicates the data of original image as watermark information without changing the characteristics of the original image. This method does not require pre-processing for feature extraction at decoding. This model can be applied for medical images, where the doctor can pick similar images from the database and refer to the treatment through images.

Xia Jun-bo et al., [5] proposed a model for improving the tracking speed of traditional template matching by proposing a round template by using gradient search which reduces the matching time that can be used in real-time detection.

Ma, L., Sun, Y et al., [7] proposed an algorithm called image fast template matching algorithm based on projection and sequential similarity detection. In this, first the images are projected to one-dimensional data and the sketch of the image is taken and maximum similarity is obtained from it and then the template images are mapped.

Monisha, M et al., [8] proposed a system for recognizing the behavior of a person in real-time. Both live and recorded videos can be provided as input to the system. Then the system uses a template matching algorithm to detect and identify the action of the human from the video frame directly. ARM CORTEX and A8 processor is used and OpenCV is used for implementation.
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Sha S., Chen Jianer et al., [9] proposed a fast matching algorithm based on K-grey degree cluster for improving the correctness and performance of real-time applications in image matching. In this, a template image is provided with an irregular shape. This algorithm divides the image into blocks of a certain size and clusters them into a k-degree template and the mean greyscale value of the image is calculated. Then the k-degree template is searched with original from coarse to fine for matching the template.

Nguyen et al., [10] proposed a system which improves the speed of matching the templates specifically with large size images. The idea of the algorithm is to use pruning method to remove unwanted or unmatchable objects from the image and then match the template image. This is the way that increases the speed of matching with high accuracy rate. Dai-Duong Truong, et al., [11] proposed a system for arbitrary-shaped template matching by using the idea of coarse-fine matching and refining interesting region. By using this technique the dissimilarity measure can be changed easily.

Most of the existing systems gave a good accuracy rate, that is, it detects the template image accurately without any false positives on the original image. Even then, there exist some common limitations in these methods like occlusion and matching of multiple objects.

III. PROPOSED WORK

The current work proposes a model for template matching using the correlation technique, integrated with Hadoop framework. This method overcomes one of the limitations of the existing models mentioned above. The limitation of matching multiple objects at the same time has been overcome here. Template matching is all about mapping template image or an image with a targeted object against the source image. Fig. 1 shows an example to describe the outline of the model. In the example, the source and template images are taken and mapped against each other using template matching algorithm to find the target image, which is shown as the output. The source image is divided into n x n grids. Once it has obtained the maximum matching matrix value, it marks that object in the image using a rectangular box or bounding box. The methodology behind the template matching is detailed below.

![Fig. 1. Outline of Template Matching System](image)

IV. METHODOLOGY

The complete workflow or process of template matching system is shown in Fig. 2.

![Fig. 2. Workflow Diagram of Template matching system](image)
Using the sliding window technique each grid of the source image is matched with the template image. A matrix value will be generated for each grid. From those matrix values the maximum matching value is considered as the presence of target object.

Finally, the mapped object on the source image is marked as the target object using a bounding box for displaying the output. The complete working of template matching algorithm is shown in Fig. 3. The algorithm for the template matching process is given below.

**A. Algorithm:**

Step 1: Load original image.
Step 2: Load template image.
Step 3: Applying correlation technique.
Step 4: Convert original image and template image into grey image.
Step 5: Calculating the size of the images;
   if (size of template image > size of original image)
   then resize template image
   else
       proceed to correlation process
   end if
Step 6: Calculate similarity metric.
   6.1: Divide images into n x n blocks.
   6.2: Calculate similarity metric of each block using window sliding.
   6.3: Similarity metric is noted in matrix form.
   6.4: Highest match is selected;
       if (Correlation value > 0.75)
           Then the template image is found and matched.
       else
           Template image not matched.
       end if
Step 7: Display the matched template image using bounding box.
Step 8: Stop.

The principle objective of the proposed method is to find the target object using maximum matching or similarity between the original image and the corresponding template image provided to the system.

The image that is provided as input are converted into grey scale image and divided into blocks of some n x n matrix size. Then, the sliding window process is used for measuring the similarity between the images. The sliding window slides across each block one by one and calculates the similarity metric value and stores it as a matrix value. Once all the blocks on the image are done with measuring the metric value a complete matrix value of the image is made. From that, the block which has maximum matching value with the template image is considered as the target object on the source image. If the source image contains more than one target object the maximum matching value will be assigned for more than one block that contains the target object. In that case, more than one object is detected as the target object using the bounding boxes. The equation (1) is used to find the best matching value. If the correlation value is greater than 0.75, the template is found otherwise it is not.

\[
\text{Cor} = \frac{\sum_{i=0}^{N-1} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=0}^{N-1} (x_i - \bar{x})^2} \sqrt{\sum_{i=0}^{N-1} (y_i - \bar{y})^2}}
\]

(1)

where,

- \(x\) is grey template image.
- \(\bar{x}\) is the average grey level in template image.
- \(y\) is the grey source image.
- \(\bar{y}\) is the average grey level of binary image.
- \(N\) is template image size

By using this equation the correlation value is found for the matching we have done. If the correlation value is more than 0.75, it is considered as the best match and the object detected as the target image is accurate.

**V. EXPERIMENTS AND RESULTS**

The proposed method was experimented in various real-time application images. This model can be used in many applications like biological science, finding the infectious leaf, finding the missing tools, in medical images for finding nodules from the CT scan and in other general search process. Some of the experimented images where shown in Fig 5 and 7. The proposed system was experimented using an image from the manufacturing field for detection. This application is used as a part of quality control in manufacturing places. By using template matching, the search for missing tools or any other defect detection can be done.
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Fig. 4 shows the source and the template images. The images in Fig. 4(a) and 4(b) are the source and template images of tools respectively. In that the source image contains three target objects and four objects similar to target object. Our algorithm accurately detects all the three multiple target objects from the source image excluding the similar non-target objects nearer to it, which is shown in Fig. 5 as output. The yellow bounding boxes represent the target objects.

![Source and Template Image of Tools](a) ![Template Image of Tools](b)

**Fig. 4. Source and Template Image of Tools**

The system was experimented in medical application for detecting nodules. This application can be used in the medical field for detecting nodules, tumors from the CT scan. Fig. 6 shows the source and the template images. The image from a CT scan is taken as the source shown in 6(a) and the nodule image is given as the template shown in 6(b) and the model detects the presence of nodule in the source image using the template. The detected nodule is bounded with a green bounding box which is shown in Fig. 7.

![Source and Template Image from CT Scan](a) ![Template Image from CT Scan](b)

**Fig. 6: Source and Template Image from CT Scan**

**Fig. 5: Detection of Tools in Quality Control**

The proposed method was experimented using 100 CT scan image with nodules and the system produced an accuracy of 86% in matching the target object.

**VI. CONCLUSION**

The current research work proposes a method for template matching using correlation technique. The method has found to be accurate in many real-time applications, with detecting nodules in lung CT images as the major experiment. The method has found to be promising in overcoming the challenges of background noise in images, non-rigid transformation. The method overcomes the limitations in existing works in detecting multiple occurrence of the target object in the image. The method has been implemented using OpenCV integrated with Hadoop framework to process the data.
This adaptation of the advanced computing technique enables to apply the method for large volume of data and improved processing capacity. The method has been found to be reliable, robust and accurate in varied applications.

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