Target Detection in Satellite Images

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***Abstract-* In this paper, a Block-based approach, i.e., rectangular regions with prefixed block size is used for segmenting a high-resolution satellite image by histogram thresholding. An unsupervised segmentation approach is employed to classify the pixels into homogenous objects and subsequent labels without prior knowledge. An optimal automatic thresholding method for the selection of threshold is proposed for segmentation. Morphological dilation is used for the creation of ROI mask image. To validate the presence of real targets in the ROI image, template matching is performed using the mask image. One of the prime solutions for matching two sub-images is the use of cross-correlation coefficient. In this paper, template matching phenomena is proposed based on correlation score. The experimental results are noted for satellite images pertaining to various military domains in MATLAB. The algorithm is able to perform segmentation and detection of ROI more effectively with less missed targets.**

***Keyword-* Histogram threshold, unsupervised segmentation, correlation score.**

I. INTRODUCTION

Satellite images are rich in providing geographical information. Therefore, there is a strong requirement of powerful and streamlined mechanisms to extract and explicate valuable information from massive satellite images for military applications. The satellite image contains various features, textures and shadows and it can be very hard to detect the region of interest (ROI). Therefore, segmentation is performed on an image. Segmentation of an image is the operation of assigning a label to every block in an image such that blocks with an identical label share certain visual characteristics [1]. Thus, covering the whole image or a set of contours extracted from the image. Unsupervised segmentation and classification of interested targets from satellite images is one of the most studied and demanding field in military applications. The pixels with constant window size in the image are separated into the different groups according to the intensity of the pixel and thus assigned with different labels [7]. Thresholding is one of the convenient techniques to perform segmentation on the basis of different intensities or colors in the foreground and background regions of an image [5]. The approach is based on the assumptions that object and background pixels in the image can be distinguished by their gray level threshold. Histogram thresholding is one of the inexpensive and swift techniques for unsupervised image classification [2]. The concept of histogram segmentation is to classify an image using an optimal threshold value. To achieve this, a non-parametric approach such as minimum error criterion is employed.

It is necessary to define a similarity measure between two or more different objects or images in many image analysis problems. Template matching is a classic and elementary method used to calculate similarities between objects using certain algorithms. In object recognition or pattern matching applications, template window is slided pixel-by-pixel basis in a large scene image and computes the correlation coefficient between them [4]. The highest value or peak of the correlation indicates the matches between a template and sub-images in the scene.

This paper proposes the use of unsupervised histogram segmentation technique to detect the ROI in the optical satellite image employed in military scenarios. Further template matching is performed to validate the presence of targets. The rest of the work is organized as follows: Section 2 presents the proposed system and the process of the model in detail. Section 3 demonstrates the experiment and results. The final section gives a conclusion of the work.

II. PROPOSED WORK

Spatial resolution is a prime aspect to be considered while using the satellite images for target detection. The aim of the proposed work is to develop an efficient algorithm for automatic detection and classification of the targets from high-resolution satellite images. The overall system block diagram is shown in Figure 1.

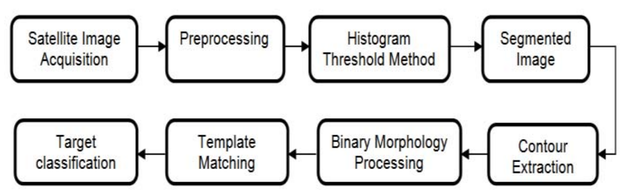


Fig.1. Block diagram of the proposed work.

A. Satellite Image Acquisition

The main two steps involved here are reading the raw satellite high resolution image in .jpeg format and resizing the image for further processing [5]. The importance of resizing the image will reduce the processing time.

B. Preprocessing

The second step involves conversion of color image into a grayscale image. However, some images collected by satellites have low signal-to-noise ratio [7]. In order to enhance the quality of images, they must be processed to reduce distortions or enhance some features required for further processing. Noise reduction or contrast enhancement techniques like histogram equalization and intensity adjustment techniques are of great interest in image analysis that improve image quality [6].

C. Histogram Threshold Method

The key parameter in the thresholding process is the selection of the threshold value. A new optimal threshold selection for image segmentation is found automatically by using Kittler and Illingworth Algorithm [8]. This minimum error thresholding method outperforms all the other existing methods like Otsu, Kapur thresholding etc., in their computational speed and also by defining fine and sparse details of the image under consideration [1].

In many practical applications, in an intensity image that is considered for target detection, foreground and background have different range of gray levels. Such images usually have a bimodal histogram.

The algorithm is as follows:

Step 1- Let us assume that pixels in the bimodal histogram of a gray-level image $h(g)$ is normally distributed. Normal distributions are defined by their means μ_i, standard deviations σ_i and a priori probabilities P_i .

Step 2- For a case of two different classes (i = *1, 2*) the background and foreground and given a threshold T, the parameters can be estimated from the following:

$$P_i(T) = \sum_a^b h(g) \tag{1}$$

$$\mu_i(T) = \frac{1}{P_i(T)} \sum_{g=a}^b h(g)g \tag{2}$$

$$\sigma_i^2(T) = \frac{1}{P_i(T)} \sum_{g=a}^b h(g)(g-\mu_i(T))^2 \tag{3}$$

Where, $a = \begin{cases} 0 & i=1 \\ T+1 & i=2 \end{cases}$ and $b = \begin{cases} T & i=1 \\ n & i=2 \end{cases}$

Step 3- The criterion function is given by,

$$\begin{aligned} J(T) &= 1 + 2[P_1(T)\log\sigma_1(T) + P_2(T)\log\sigma_2(T)] \\ &- 2[P_1(T)\log P_1(T) + P_2(T)\log P_2(T)] \end{aligned} \tag{4}$$

Step 4- The minimum error threshold can be computed by minimizing the criterion $J(T)$.

D. Image Segmentation

The main focus of the approach discussed here is to partition the image into segments using intensity property of the pixels without prior knowledge of the classes [1-3]. An unsupervised approach employed here is by thresholding technique which uses membership criterion to segment the image satisfactorily.

The algorithm is explained briefly as follows:

Step 1- Select a Threshold (T) by Kittler's method.

Step 2- Select a block with measurement vector x_1.

Step 3- First block is taken as first cluster with center Z_1.

Step 4- Select next block from the image x_2.

Step 5- Compute the membership criterion defined by,

$$D_i(x) = \sum_i^M \sum_j^N |x_1 - x_2| \tag{5}$$

Where M x N is the size of the original image.

Step 6- Compare $D_i(x)$ with T. If $D_i(x) < T$, then assign appropriate label beginning from label1 else return to step 4 until all pixels are assigned to a class.

Step 7- After all pixels have been assigned to a cluster center, recompute $D_i(x)$ and assign the labels appropriately.

The final image is purely segmented with different labels associated with the image obtained.

E. Contour Extraction

The segmented image consists of numerous labels associated with various contour representations. In this step, the labels pertaining to large and small contours are nullified. The pseudo code for redefining the segmented label array in obtaining the labels of interest is mentioned below. The binary image pixels are reassigned with the intensity value '1' (white) if the pixels are in ROI areas, whereas other pixels are replaced with the value '0' (black) if they are categorized as the not interested area. Thus, this process gives contour image associated with several targets and less background details.

The Pseudo code is as follows:

```
for i ← 1: maximum of segmentlabelarray
labelcount ← find in segmentlabelarray
end for
// Removal of labels associated with minimum label count.
A = sort labelcount in descending order
for ii ← 1: minimum counted labels
segmentlabelarray(ii) ← 0
end for
// Removal of labels associated with maximum label count.
for iii ← 1: length of labelcount/2
segmentlabelarray(iii) ← 0
end for
```

F. Binary Morphology Processing

The binary contour image still contains many unwanted objects. In this paper, a parameter based on area of contours is used to remove contours larger than the template. Thus, a detailed contour image containing the ROI is obtained. This image is further subjected to Dilation to obtain the mask image [2]. Morphological Dilation enlarges the boundaries of the extracted contours (i.e. white pixels) on a binary image. The next step is to overlay the extracted targets onto the original image. Overlaying of the result helps to illustrate the accuracy of the target extraction. In order to accomplish this operation, rectangular bounding box based on the contours is drawn around the target in yellow color.

G. Template Matching

In this paper, Template Matching is based on normalized form of correlation (correlation coefficient) [4][6]. It will calculate the mean value of each image and then by calculating correlation score it will match the template image with source image.

The correlation coefficient (r) is given by,

$$r = \frac{\sum_m \sum_n (A_{mn} - \overline{A})(B_{mn} - \overline{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \overline{A})^2\right)\left(\sum_m \sum_n (B_{mn} - \overline{B})^2\right)}} \tag{6}$$

Where, A_{mn} = Source image of prefixed size m x n.

B_{mn} =Template image of prefixed size m x n.

$\overline{A}$ and $\overline{B}$ = mean of Aand B respectively.

The algorithm is explained in the following steps below:

Step 1: Load Template Image with predefined window size.
Step 2: Load source Image.
Step 3: Load ROI Mask Image.
Step 4: Convert both Input images to gray image
Step 5: Find the mean and correlation coefficient values of template and source images of equal size.
Step 6: Check in entire binary mask image if Correlation coefficient value > 0.9. If so, then template is matched and target is confirmed.
Step 7: Draw Bounding Box around the target in red.

H. Target Classification

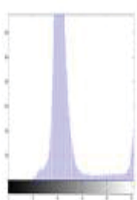
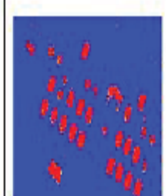
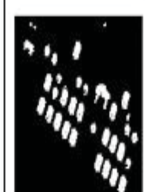
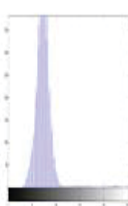
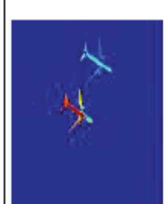
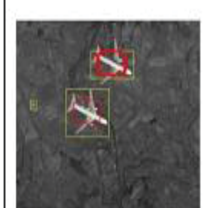
This is the last step of the proposed work, where the ROI image and the template matched images are compared [7]. If the targets present in both the images are same, then it is classified as true target. If any of the targets are missed in the ROI image they fall under missed target category. The rest of targets are classified under false target category. In addition, the efficiency of the true targets detected is computed.

III. EXPERIMENT RESULTS AND ANALYSIS

In this paper, performance of the proposed approach is evaluated with scenes obtained from Google Earth pertaining to military scenarios. Image 1 corresponds to satellite image of artillery battalion of Russian military; having size of 256 x 256 is used for the study. Two template images of size 16 x 24 and 17 x 10 corresponding to two different army camps are used for template matching purpose. Image 2 corresponds to satellite image covering a Russian military aircraft having size of 444 x 352 is used to demonstrate the performance over a vast land area. Template image of size 32 x 32 is used for template matching purpose. Table I shows the intermediate results used to extract targets of the corresponding input images. It is observed that, most of the manmade structure boundaries are detected. Thus, a qualitative analysis of the results shows that the proposed algorithm is successful in extracting the targets with reduced false alarms. The CPU time as tabulated in table II is solely based on the image size under consideration.

The segmented images are evaluated using the performance measure -Region Non-Uniformity (NU) [8]. This measure is defined as

TABLE I
EXPERIMENTAL RESULTS FOR TARGET EXTRACTION

	Original Image	Histogram Image	Segmented Image	ROI Image	Mask image	Template Image	Target classified Image
Image 1							
Image 2							

$$NU = \frac{|F_{fg}|}{|F_{fg} + B_{bg}|} \frac{\sigma_{fg}^2}{\sigma^2} \tag{7}$$

Where, σ^2 is the variance of the whole image.

σ_{fg}^2 is the foreground variance.

A well-segmented image is expected to have a NU measure close to 0. Table II shows NU measure for images under consideration. It is found that NU for Image1 is closer to zero. Hence a better segmented image compared to Image2.

The quality of segmented image is measured by statistical parameter- Peak Signal to Noise Ratio (PSNR) [1]. It is defined as,

$$PSNR = 10\log_{10}(MAX_i^2 / MSE) \tag{8}$$

Where, MAX_i is the maximum pixel value of the image.

MSE (Mean Squared Error) is the cumulative squared error between the segmented and the original image.

Finally, the accuracy of the true targets detected by the proposed method is calculated. Here, the results are compared with the ground truth derived manually.

$$Accuracy = \frac{EV}{OV} \times 100 \tag{9}$$

Where, EV is the Exact Value detected manually from ground truth image.

OV is the Obtained Value after applying the designed methodology.

The accuracy of detecting true targets from the proposed approach is high as shown in through the results tabulated in Table II. It is observed that, accuracy is lower for images having lesser targets when compared to images with more number of targets.

TABLE II
PERFORMANCE MEASURES FOR THE IMAGES UNDER CONSIDERATION

Images	T	NU	PSNR	CPU time(s)	EV	OV	Accuracy
Image 1	152	0.0056	0.2607	22	30	34	88.2
Image 2	116	0.0839	0.3741	107	2	3	66.3

I. CONCLUSION

The main contribution of this paper is the histogram based unsupervised image segmentation technique to extract the objects of interest in the satellite image by using ROI automatic detection. The ROI automatic detection is a novel approach to define the area of an image that contains information of interest. The algorithm introduced is automatic one. It requires only very little interaction from the users. It is observed that there is no perfect method for segmentation because the result of image segmentation depends on many factors i.e., pixel color, texture, intensity, similarity of images, image content and problem domain.

The important and key parameter of this algorithm is based on automatic thresholding algorithm. It is found that Kittler and Illingworth's thresholding algorithm provides a good automatic threshold. Thus, segmenting the image with less NU value.

The study focuses on extracting the ROI from satellite images purely concerning to military applications. This algorithm can be employed to extract different types of targets based on the application. Since extraction of targets discussed in this paper is solely based on intensity, some of the regions similar to the targets are also being extracted. This is because the locations also have the same pixel intensity values as that of targets. The algorithm is found to perform segmentation and detection of ROI more effectively with less missed targets. In addition, template matching based on masks reduces the computation time. The accuracy of obtaining true targets from target classified image by this proposed algorithm is seen to be highly effective.

II. REFERENCES

[1] K.Suresh Manic, R.KrishnaPriya and V.Rajnikanth, "Image multithresholding based on kapur/tsallis entropy and firefly algorithm," *Indian Journal of Science and Technology*, vol.9(12), ISSN:0974-5645, 2016.

[2] Warinthorn Kiadtikornthaweeyot, Adrian R.L. Tatnall, "Region of Interest detection based on Histogram segmentation for satellite image," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol.XLI-B7, pp: 249-255, 2016.

[3] Zhongwen Hu, Qingquan Li, Qian Zhang and Guoseng Wu, "Representation of block-based image feature in a multi-scale framework for built up area detection," *Journal on Remote Sensing and Application*, vol.8, pp:1-20,2016.

[4] Girish Kumar Tanwar, Shiv Kumar, "Analysis of Template matching method using correlation score," *International Journal of Engineering and Technical Research*, ISSN: 2321-0869, vol.3, Issue 12, 2015.

[5] Aarti Sharma, "Automatic vehicle detection using various object detecting algorithm and thresholding methods, "*International Journal on Future Revolution in Computer Science and Communication Engineering*, vol.1, Issue 1, pp: 16 – 28, 2015.

[6] K.Sankar, Dr. M. Prabakaran, "An efficient template matching algorithm for lung cancer detection using multi resolution histogram based image segmentation," *International Journal of Enhanced Research in Science Technology and Engineering*, vol.3, Issue 1, pp:71-75, ISSN: 2319-7463, 2014.

[7] Lizy Abraham and M.Sasikumar, "Vehicle detection and classification from high resolution satellite images, "*ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol.II-1,pp:17-20,2014.

[8] T. Kalaiselvi and P. Nagaraja, "A robust Thresholding technique for image segmentation from gray images," *Proceedings of the International Conference on Applied Mathematics and Theoretical Computer Science,* pp: 183-188, ISBN: 978-93-82338-35-2, 2013.