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Analysis of PCB Images Based on Triclass Thresholding Technique for Segmentation

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Abstract: The iterative triclass thresholding technique is a parameter free technique. It is based on Otsu's method where the Otsu's threshold is obtained, which minimizes the intra-class variances of the segmented images, but instead of classifying the histogram of that image into two classes, the iterative method separates it into three classes. This triclass is defined as: 1) foreground class, 2) background class, 3) to-be-determined (TBD) region, obtained from the respective means of the other two classes. Iteratively the Otsu's method is applied onto the TBD region until the preset criteria is met keeping the foreground and background regions unchanged and finally their respective unions are formed for final result. The proposed work is to use this method and another method called Window based thresholding in order to reveal the fine structures in the Printed Circuit Board (PCB) in a minimal computational cost and achieve better accuracy for the same.

Keywords: Triclass, Printed Circuited Boards (PCB), segmentation, Threshold, Otsu's method, Window based thresholding, Binarization.

INTRODUCTION

In Image processing, image segmentation process is one of the eminent preprocessing technique. It is basically a process of partitioning color or gray scaled images, which are nothing but digitalized images, in different set or number of segmented images in order to represent it into more meaningful and easy way to analyze. Segmentation technique can be generally categorized into two different frameworks namely, edge based [1]-[3] and region based [4]-[6] approaches.

It is very widely used in pattern recognition, document binarization [7]-[12] and computer vision [13]. Image segmentation has vast applications and is used in many fields. It enhances clarity in the algorithms and innovating new methods of analysis is interested region and supports better object recognition. There are number of various image segmentation algorithms which are currently used and applied for different purposes. As in many applications it happens that the gray levels of pixels belonging to the objects are a bit different from the gray levels of the pixels that belong to the background of that image. Thresholding then becomes an effective and simple tool to separate objects from background. The Otsu method is widely used method for image segmentation [23].

The Otsu method searches for the threshold that minimize the intraclass variance of the segmented images and can achieve better results when the histogram of the original image has the two distinct peaks, where one belongs to the background whereas the other belongs to the foreground, it is searched across the whole range of the pixel values until intraclass variance of image reaches its minimum. The Ostus method may give sub-optimal results when the histogram of the gray scaled image has more than the two peaks or if one of the class have the larger variance. In this experimental work described in this paper, we are going to use two methods namely the Ostus method in iterative way for triclass thresholding and the other is the Window based thresholding method in order to obtain better accuracy in revealing the fine structures and weak objects in the PCB images, with minimum computational cost.

This experimental paper is organized as follows. We describe the related work done in Section II. The Section III briefly describes and introduces the method with its system architecture. The dataset is specified in Section IV. The mathematical model is described in Section V. The Section VI represents the results obtained from the experimental work and Section VII presents conclusion of the experimental work.

RELATED WORK

Over these many years, the researchers have been proposing many new methods in order to improvise the application of standard Ostu method. In the [15], Cheriet et al. has proposed a recursive approach, which was also based on Ostu technique which focused on the brightest homogeneous objects in the image. It is based on the statistical as well as spatial information with histogram of only Gaussian distributions.

But despite knowing the fact that grey-level distributions, small objects, and object overlapping are some of the complicated issues that generate several challenging problems for the multilevel threshold selection process in images, so a thresholding technique must be enabled to

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segment the digitized image into various objects having same properties. In correspondence to this, an extension of the Ostu approach as a general technique is used for image segmentation and to limit the scope of the problem to document images. This new approach was beyond segmentation of only single bright object from the image to a method that would recursively segment the brightest object at each and every recursion, leaving the darkest objects in the given digitized image. This recursive method was developed without any rules on the number of objects in the digitized image. A quad-tree method was developed to segment the images by combining two methods namely centroid clustering and boundary estimation methods but this method only worked under the assumption of the histogram consisting of Gaussian distributions only [16]. In [17], the authors have added a weight term which is to force the resultant threshold value to reside either at the valley of the two peaks or to reside at the bottom rim of a single peak.

Then the standard bi-level thresholding techniques has also been extended to use multilevel thresholding in [18]-[20]. As in the standard Ostu method 1D histogram was used for binarization and the methods were been proposed to extend the histogram to the two dimensions (2D) that is by considering the gray levels and the average, but the 2D implementation is more computationally intensive. It has been shown theoretically in [21] that the function called the objective function of Ostu method is similar to that of K-means method in the multilevel thresholding as given in [13]. A very fast search scheme is shown for finding a single and the multiple thresholds that would maximize the interclass variance between the two regions namely the dark and bright regions.

In the original formulation of the problem by Otsu it suggested a very exhaustive search. The current method is in orders of magnitude which are faster and it uses a function called criterion function for its search scheme. That criterion function is derived by assuming the continuous probability function for the histogram of gray level. There are several examples presented to illustrate the performance of the proposed scheme. And in terms of speeding computations, a very fast search implementation of the threshold was proposed and presented by Reddi et al in [22].

METHOD

Ostu Method

The otsu's method differs from the standard application in a very important way. It is an iterative method. Firstly, the otsu method is applied to an image in order to obtain the otsu's threshold and also the means of the two classes which are in turn separated by the threshold similar to the standard application.

Then, it classifies the image into two classes, which are separated by otsu's threshold and then separate the image into three classes, which are derived from the respective means of the two classes. Here, the three classes are defined as foreground, which determines the pixel values greater than the larger mean, the background, which determines the pixel values lesser than the smaller mean and the third derived class is called as the to-be-determined region, which determines the values that fall between two class means.

In the next iteration, the previous foreground and background regions unchanged and again applies the otsu method on the TBD region only. This is just to, again separate the TBD region into three classes again in similar fashion. This continues until the preset criteria is met and then last TBD region is separated into two classes, which are foreground and background respectively instead of three.

Then finally, a logical union is done, of all the previously determined foreground and background region. This is a parameter free method except the stopping rule for the iterative process and with minimal added computational cost. As shown in the Fig. 1, the foreground region having pixel values greater than 1 is depicted in yellow color whereas, the background region having pixel values less than 0 is depicted in blue color, and the third region, which is called the TBD region, is depicted in red color. The superscript here, denotes the number of iteration taken by the algorithm.

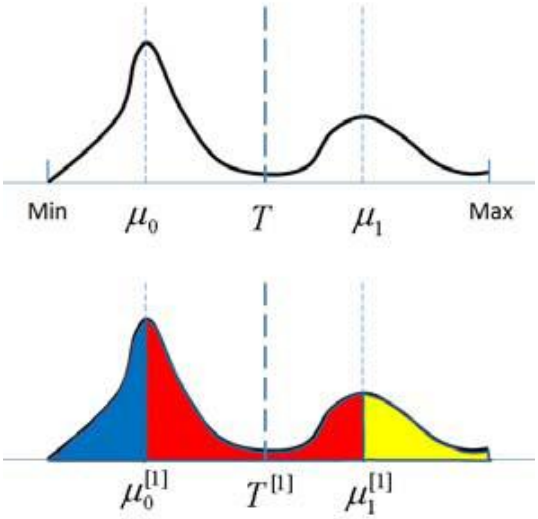

Fig. 1. Iterative Otsu's method

Sytsem Architecture

This section discusses about the system architecture of the method.

This is a general architecture which describes the overall flow as shown in Fig .2. Here, the input is given as a PCB image, which contains a picture of a bare PCB image and it is a bitmap image. Then, the gray scale conversion is done on the same, which is results into generation of gray scaled images, of which histogram is determined.

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Then, Ostu method, in iterative manner and Window base thresholding algorithm is applied on that gray scaled image. Finally, the output that we get is vector of segmented images, revealing the fine objects in image in a more precise and simple way.

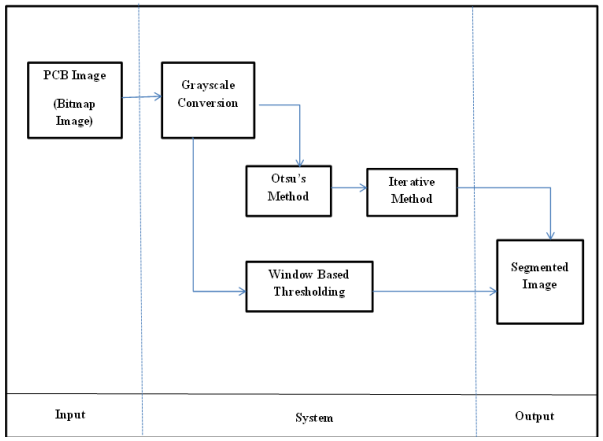

Fig 2 System Architecture

Window Based Thresholding Algorithm
The window based thresholding algorithm is a widely used segmentation algorithm. It uses the window size as its parameter, below is the detailed steps of the window based thresholding algorithm.

The inputs needed to the algorithm are as follows:
i.'G' is Gray Scale image vector.
ii.Set threshold value 'threshold'.
iii.Set window size 'W'
The output generated by the algorithm is as follows:
i. BI - for segmented binarized image vector.

The steps of the algorithm are as follows:
1. for each row 1 to height –W
2. for each column 1 to width –W
3. Curr_Pixel= G [row, column];
4. If (Curr_Pixel < avg – threshold)
5. Label BI [row, column] = 0;
6. Else
7. Label BI [row, column] = 1;
8. End of column for loop;
9. End of row for loop;
10. Return segmented binarized image BI.

Where,
Curr_Pixel - refers to the current pixel of the image.
avg – refers to the average value of pixels of the image.
This algorithm is used to reveal the fine structures in the PCB images given as an input to the system. This is just to get better accuracy.

MATHEMATICAL MODEL

Set Theory:
Let S be a technique to identify fine structures in PCB image using segmentation.

Such that S= {I, F, O} Where,

I represents the set of input:
I= {I1, I2}
I1= PCB image
I2= Gray Scaled Image

And F is set of functions:
F= {F1, F2, F3, F4, F5}
F1= Gray scale Conversion
F2= Otsu method
F3= Iterative method
F4= Window based thresholding
F5= Segmentation

And O is set of output:
O= {O1, O2}
O1= Gray Scaled Image
O2= Segmented Image

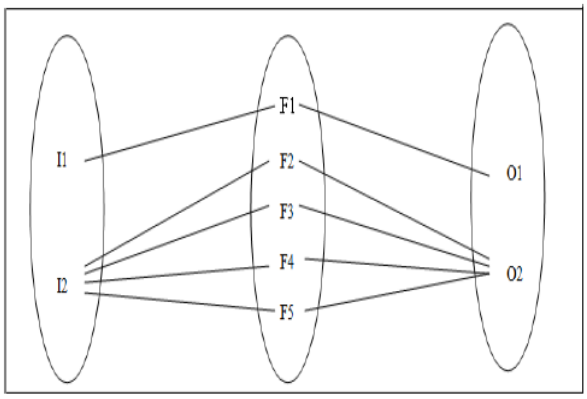

Fig. 3 Functional Dependency

DATASET

The experimental work uses the bare PCB images dataset. The dataset consists of various PCB images.

RESULTS

This section depicts the results obtained from the above discussed experiment.

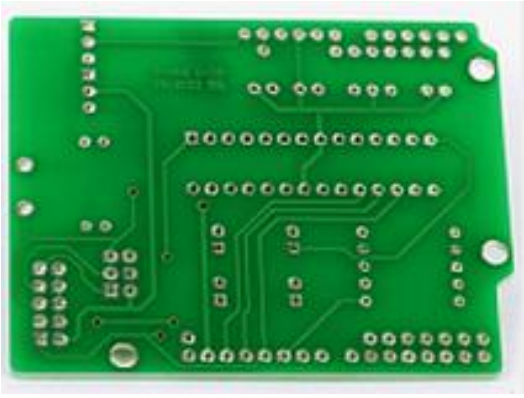

Fig. 4a Bare PCB Image

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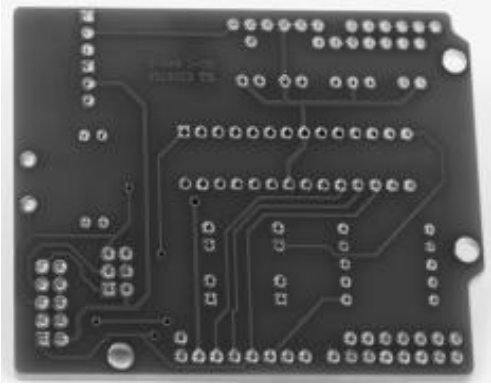

Fig. 4b Gray scaled Image

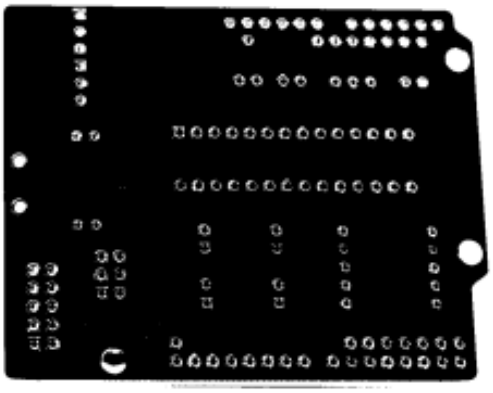

Fig. 4c Otsu method's output

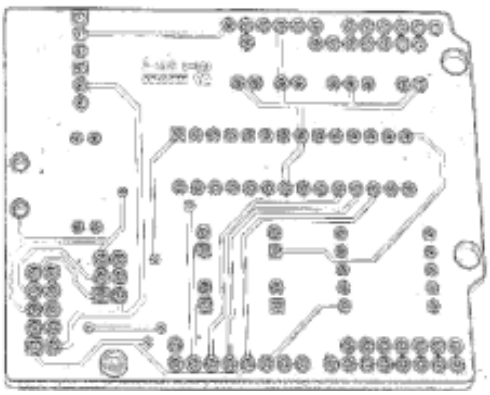

Fig. 4d Window based thresholding method's output

In the above figures, the original images of the bare PCB image is given as an input to the system as shown in Fig. 4a and then it is converted into a gray scaled image using the gray scale conversion algorithm as shown in Fig. 4b, for the further pre-processing.

The figures 4c and 4d are the result images obtained after applying the two algorithms otsu's method and windows based thresholding method respectively. Where the otsu,s method is used in a iterative fashion to obtain the desired result as shown in Fig 4c the ostu's method reveals the fine structures in the PCB image, whereas the other method windows based thresholding method also does the same so, we can say that both the methods work efficiently and give better results.

CONCLUSION

As Otsu's method is widely used as a pre-processing step to segment images for further processing, it is important to achieve a high accuracy to reveal weak structures and fine objects in PCB images. The experimental work contains the application of two segmentation algorithms namely Otsu method, which varies in its standard application and window based thresholding algorithm. Thus, we lead to achieve accuracy in revealing and identifying the fine objects using the iterative triclass thresholding technique and window based thresholding algorithm, we are done with the experimental work and have obtained the accurate segmented output, with minimum computational cost.

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