Thresholding Techniques applied for Segmentation of RGB and multispectral images

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ABSTRACT
Image segmentation is a process of partitioning an image into a set of non-overlapping regions. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. In this paper we have segmented a RGB image and a multispectral image. The image has been segmented through three threshold techniques (i.e. Iterative threshold techniques, Otsu's threshold technique, Local Threshold Technique). Thresholding techniques are computationally simple and never fails to define disjoints regions with closed boundaries. Threshold technique is one of the important techniques in image segmentation. Thresholding techniques converts a colored image or gray scale image into binary or bimodal image (foreground and background image). The advantage of obtaining binary image through Thresholding technique is that it reduces the complexity of the data and simplifies the process of recognition and classification.

Keywords
Image segmentation, thresholding, iteration, Multispectral image and Binary image

1. INTRODUCTION
Image segmentation is a process of partitioning an image into a set of non overlapping regions.Image segmentation is the division of an image into regions or categories, which correspondto different objects or parts of objects. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. Its purpose is to decompose an image intoimage that is meaningful with a particular application. A good segmentation is typically one in which:

- pixels in the same category have similar greyscale of multivariate values and form a connected region,
- neighbouring pixels which are in different categories have dissimilar values.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image . Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color intensity, or texture.[1][7]

2. METHODS OF SEGMENTATION
There are three general approaches to segmentation, termed thresholding, edge-based methods and region-based methods.

In the thresholding process, individual pixels in an image are marked as "object" pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as "background" pixels otherwise.

Edge-based segmentation: In edge-basedsegmentation, an edge filter is applied to image, pixels are classified as *edge* or *non-edge* depending on the filter output, and pixels which are not separated by an edge are allocated to the same category.

Region-based segmentation:In region-based segmentation algorithms operate iteratively by grouping together pixels which are neighbours and have similar values and splitting groups of pixels which are dissimilar in value.[2]

3. THRESHOLD TECHNIQUES
Thresholding techniques are computationally simple and never fails to define disjoints regions with closed boundaries. Threshold technique is one of the important techniques in imagesegmentation. This technique can be expressed as:

T=T[x, y, f(x, y), p(x, y)] (1)

Where:

T is the threshold value.

x, y are the coordinates of the threshold value point.

p(x,y) ,f(x,y) are points the gray level image pixels.

Threshold image g(x,y) can be define:

$$g(x,y)= \begin{cases} 1 & if \quad f(x,y) > T \\ 0 & if \quad f(x,y) \le T \end{cases} \quad (2)$$

Threshold segmentation techniques can begrouped in three different classes:

1. Local techniques are based on the local properties of the pixels and their neighborhoods.
2. Global techniques segment an image on the basis of information obtain globally (e.g. by using image histogram; global texture properties.)
3. Split, merge and growing techniques use both the notions of homogeneity and geometrical proximity in order to obtain good segmentation results. Finally image segmentation, which is a field of image analysis, is used to group pixels into regions to determine an image's composition.

Threshold techniques can be categorized into two classes:

Global threshold and local (adaptive) threshold.In global threshold, a single threshold value is used in the whole image. In local threshold, a threshold value is assigned to each pixel to determine whether it belongs to the foreground or the background pixel using local information around the pixel. Because of the advantage of simple and easy implementation, global threshold has been a popular technique in many years.[5][7]

In this paper we have applied three types of threshold techniques.

3.1 Global Iterative Threshold Technique:

In this technique following steps are followed:

- An initial threshold (T) is chosen; this can be done randomly or according to any other method desired (such as mean or median method).
- In the next step, the image is segmented into object and background pixels as described above, creating two sets:
- G_1 = {f(m,n):f(m,n)>T} (object pixels)
- G_2 = {f(m,n):f(m,n)<=T} (background pixels) (note, f(m,n) is the value of the pixel located in the m^{th} column, n^{th} row).
- The average of each set is computed as:
- m_1 = average value of G_1
- m_2 = average value of G_2
- After that a new threshold is created that is the average of m_1 and m_2
- $T = (m_1 + m_2)/2$
- Go back to step two, now using the new threshold computed in step four, keep repeating until the new threshold matches the one before it.

3.2 Global Otsu's Threshold Method:

Otsu's method is used to automatically perform histogram shape-based image thresholding or the reduction of a graylevel image to a binary image. The algorithm of Otsu's method assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram(e.g. foreground and background) that calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal.[2]http://en.wikipedia.org/wiki/Otsu%27s_ Method - cite_note-Otsu-1

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance, which is defined as a weighted sum of variances of the two classes:

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t)$$

Where weights ω_i are the probabilities of the two classes separated by a threshold t and σ_i^2 variances of these classes.Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance:

$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t)\left[\mu_1(t) - \mu_2(t)\right]^2$$

which is expressed in terms of class probabilities ω_i and class means μ_i.

The class probability $\omega_1(t)$ is computed from the histogram as t:

$$\omega_1(t) = \Sigma_0^t p(i)$$

While the class mean $\mu_1(t)$ is:

$$\mu_1(t) = \Sigma_0^t p(i) * x(i)$$

where $x(i)$ is the value at the center of the ith histogram. Similarly, we can compute $\omega_2(t)$ and μ_t on the right-hand side of the histogram for bins greater than t.The class probabilities and class means can be computed iteratively. This idea yields an effective algorithm. [6]

Algorithm for Otsu's Method

- Compute the histogram and the probabilities of each intensity level
- Set up initial $\omega_i(0)$ and $\mu_i(0)$ level.
- Step through all possible thresholds t=1…. maximum intensity
  - Update ω_i and μ_i
  - Compute $\sigma_b^2(t)$
- Desired threshold level corresponds to the maximum $\sigma_b^2(t)$.

3.3 Local Threshold Technique:

Adaptive local thresholding typically takesa grayscale or color image as input and, in the simplest implementation, outputs a binary image representing the segmentation. For each pixel in the image, a threshold has to be calculated. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value.There are two main approaches to finding the threshold:

(i)The Chow and Kaneko approach and

(ii) Local thresholding.

The assumption behind both the methods is that smaller image regions are more likely to have approximately uniform illumination, thus being more suitable for thresholding operation.

An alternative approach to finding the local threshold is to statistically examine the intensity values of the local neighborhood of each pixel. The statistic which is most appropriate depends largely on the input image. Simple and fast functions include the *mean* of the *local* intensity distribution.The size of the neighborhood has to be large enough to cover sufficient foreground and background pixels, otherwise a poor threshold is chosen. On the other hand, choosing the regions which are too large can violate the assumptions of approximately uniform illumination.

Like global thresholding, adaptive thresholding is used to separate desirable foreground image objects from the background based on the difference in pixel intensities of each region. Global thresholding uses a fixed threshold level for all pixels in the image and therefore works only if the intensity histogramof the input image contains neatly separated peaks corresponding to the desired subject(s) and background(s). Hence, it cannot deal with images containing, a strong illumination gradient. [7]

4. EXPERIMENTAL METHODOLOGY

4.1 Testing procedure:

The threshold segmentation was performed using MatlabR2010a and tested the segmented techniques on simple RGB image and on a multispectral image of Bareilly region

[Image obtained from the website of IRSA] as illustrated in figure 1 and figure2 respectively.

Fig1: Threshold segmentation on RGB image

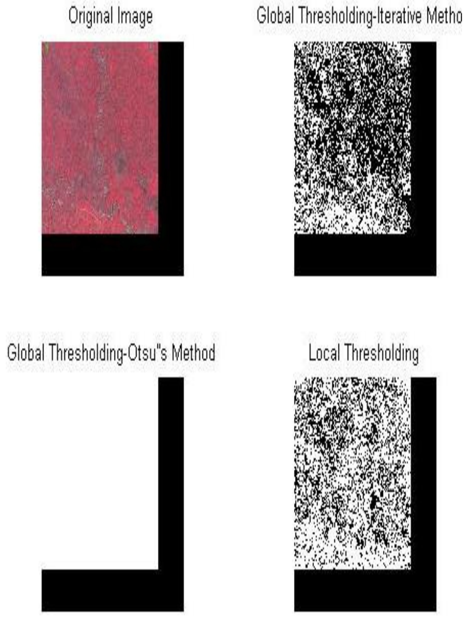


Fig 2: Threshold segmentation on multispectral image of Bareilly region.

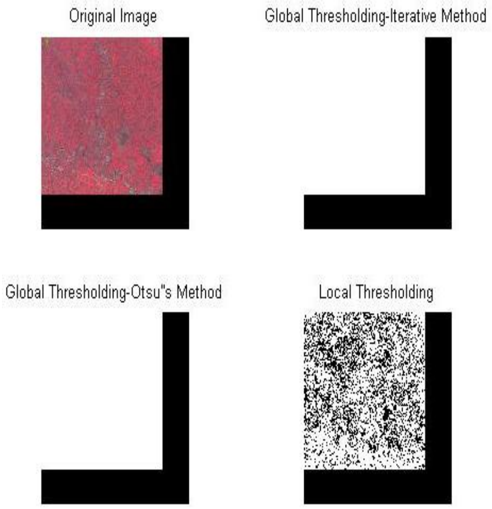
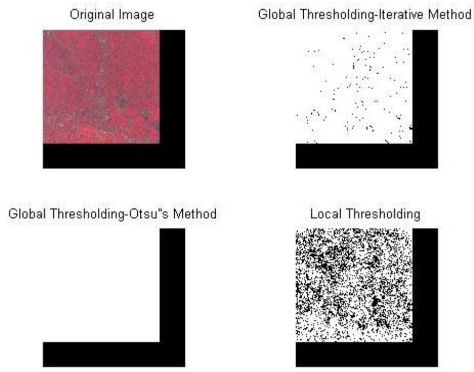


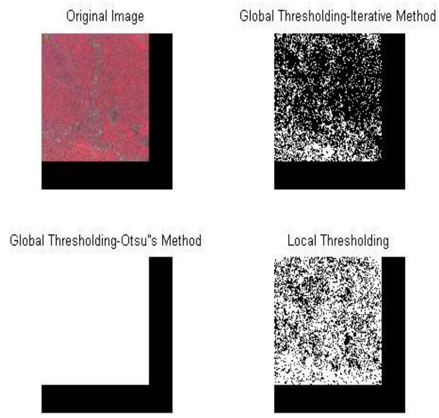
Fig 3: Resultant threshold value and corresponding threshold segmented multispectral image

(A) T=0.2336, Th=0.2314, Thr=.0588

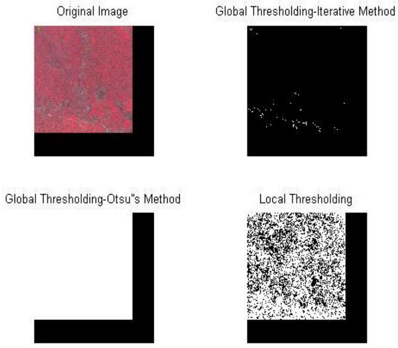
(T-Iterative threshold level, Th-Otsu’s threshold level, Thr-local threshold level)



(B)T=0.3600, Th=0.2314, Thr=0.0588



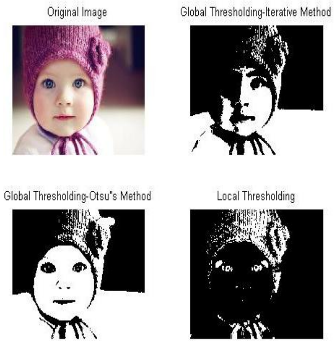
(C)T=0.4572, Th=0.2314, Thr=0.0588



(D)T=0.5770, Th=0.2314, Thr=0.0588

Fig 4: Resultant threshold value and corresponding threshold segmented RGB image.

(A)T=0.4972, Th=0.5333, Thr=0.1647



(B)T=0.7046, Th=0.5333, Thr=0.1647

5. CONCLUSION

In these three mentioned thresholding techniques, iterative thresholding, local threshoding, and Otsu's thresholding techniques, different segmented images can be obtained by choosing a different threshold levels.Thresholding techniques converts a colored image or grayscale image into binary or bimodal image. The pixels of original image get converted and treated as foreground and background pixels.In case of thresholding techniques, a threshold value may work well in one region of an image, but may perform poorly in another region.This makes it difficult to select thresholds based on global information. The advantage of obtaining binary image through Thresholding technique is that it reduces the complexity of the data and simplifies the process of recognition and classification.

Otsu's method do not give any result when it is applied to multispectral image, it is very difficult be applied to multispectral image though may be applied to other mono-spectral and RGB Images.

6. REFERENCES:

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