# Remote Sensing Image Segmentation using OTSU Algorithm

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## ABSTRACT
In recent years, extraction of information from remote sensing images is an active topic of research. Feature extraction from an image is performed by image segmentation by dividing the image into distinct and self-seminar pixel groups. In remote sensing images, large quantity of texture information is present. So, it is difficult and time consuming process to segment objects from the background in remote sensing images. Many algorithms have been proposed for the purpose of segmentation of remote sensing images. Thresholding is a simple technique but effective method to separate objects from the background. A commonly used method, the Otsu method, improves the image segmentation effectively. It is the most referenced thresholding methods, as it directly operates on the gray level histogram. In this project, Otsu thresholding algorithm is used to segment the roads and residential areas from the vegetation areas in remote sensing images.

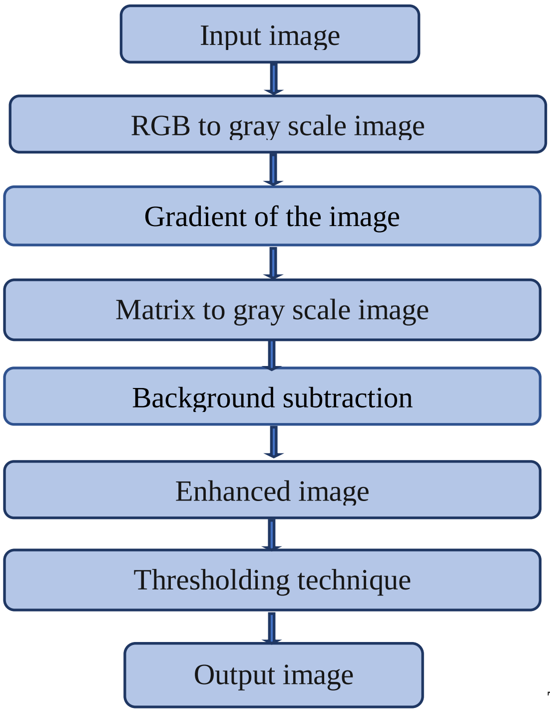
## Keywords
Thresholding techniques, Otsu method, image segmentation, optimal threshold, selection range, minimum variance ratio, remote sensing.

## 1. INTRODUCTION
The process of dividing an image into groups of pixels[1-2] which are homogeneous with respect to some criterion is called image segmentation. Extraction of various features in an image is the main objective of image segmentation. It is the first step in image analysis and pattern recognition. The segmentation deals with partitioning an image into meaningful regions. Image segmentation is classified into two types. They are: 1). Local Segmentation and 2). Global Segmentation. Local Segmentation deals with segmenting sub images. Global Segmentation deals with segmenting a whole image. Image segmentation is a classic and vital issue in image processing which takes an important position in linking image processing to image analysis. Therefore, seeking a new segmentation algorithm or a combination of various methods becomes an inevitable trend for remote sensing image processing. Many techniques thus were proposed to reduce time spent on computation and still maintain reasonable thresholding results. Among many image segmentation algorithms, the Otsu algorithm is a threshold-based segmentation algorithm which is proposed by Otsu in the year 1979. It uses the image histogram to get a corresponding binary image relying on the greatest variance[3] between the target and background class so as to determine the image segmentation threshold value. Otsu's method was one of the better threshold selection methods for general real-world images with regard to uniformity and shape measures. However, Otsu's method uses to evaluate the criterion for maximizing the between-class variance.

## 2. LITERATURE SURVEY
An image is considered as a set of points or pixels distributed over a two– dimensional finite space. Segmentation, in precise form, can be considered as the process of assigning the label to each pixel in an image, such that all the pixels having same label share some common visual characteristics. Thresholding is the simplest method for image segmentation. Segmentation is performed by assigning pixels having gray levels below the threshold to the background, and assigning those pixels having gray levels above the threshold to the objects or vice versa. Image segmentation plays a crucial role in many computer vision applications. In computer pattern recognition, as its name suggests, is an artificial intelligence system that recognizes certain patterns such as characters, human faces, lines and their structures. But these simple tasks which are easy for our human recognition system are not so easy for a computer although the later has great capacity of computation. The features of these patterns have to be extracted from the distorted, blurry or faint images. It is an important task in pattern recognition because it is the basis of the recognition process and a good thresholded image is the essential step for efficient and accurate recognition. Though thresholding is a simple and old problem, a robust and comprehensive solution is yet to be investigated.

### Global versus Local Threshold-based Methods:
Many thresholding methods have been developed. They can be classified into two groups: local and global. A local thresholding method selects different threshold values for different regions, or even for each pixel. Tsai suggested selecting a threshold at which the resulting binary images have the same first three moments. Local techniques are mostly time consuming because the threshold has to be calculated for each pixel according to the gray scale information around the pixel. Many local thresholding techniques have been developed such as Nil black's method[4]. This technique achieves good results on document images with uneven background noise.

## 3. IMPLEMENTATION




The flowchart of our proposed model has been shown below and every step in the flowchart is explained in detail.

### 3.1 Input image:

The first stage in the proposed model is image acquisition. Image acquisition is the process of acquiring images from the data base or from internet. The images are captured from the satellites. In general, most of the satellite images are in the RGB color model and hence our input image is also a RGB color model.

**Fig 1. Input satellite image**

### 3.2 RGB to gray scale image:

The RGB color model is an additive color in which red, green and blue light are combined together in various ways to form a broad array of colors. The main aim of the RGB color model is for the sensing, representation and display of images in electronic systems, such as televisions and computers, though it has also been used in conventional photography. Our algorithm works on gray scale image. Hence, the input image i.e RGB image is converted to gray scale image.

**Fig 2. Gray scale image**

### 3.3 Gradient of the image:

Information from images can be extracted using this method. It gives us the information in the form of magnitude and direction. An image gradient[5] is a directional change in the intensity or color in an image. The gradient of the image is one of the fundamental building blocks in image processing. In graphics software for digital image editing, the term gradient or color gradient is also used for a gradual blend of color which can be considered as an even gradation from low to high values, as used from white to black in the images to the right. Another name for this is color progression.

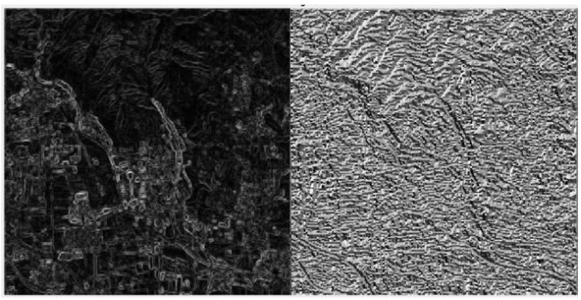


**Fig 3. Magnitude and direction of the image**

### 3.4 Matrix to gray scale image:

There is a relation between matrices and digital images. A digital image in a computer is represented by pixels matrix. On the other hand, there is a need to present matrix with an image. Image and its matrix: A digital gray scale image is presented in the computer by pixels matrix. Each pixel of such image is represented by one matrix element i.e integer from the set {0,1,2, ,255} . The numeric values in pixel presentation are uniformly changed from zero (black pixels) to 255 (white pixels).

**Fig 4. Matrix to gray converted image**

## 3.5 Background subtraction:

As the name suggests, background subtraction calculates the foreground mask performing a subtraction between the current frame and a background model, containing the static part of the scene or, more in general, everything that can be considered as background given the characteristics of the observed scene. The basic scheme of background subtraction is to subtract a reference image that models the background scene from the original image. Typically, the basic steps of the algorithm are as follows: Background modelling constructs a reference image representing the background. Threshold selection determines appropriate threshold values used in the subtraction operation to obtain a desired detection rate.

**Fig 5. Background subtracted image**

## 3.6 Enhanced image:

Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further image analysis. For example, you can remove noise, sharpen, or brighten an image, making it easier to identify key features. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories:

1. Spatial domain techniques, which operate directly on pixels.
2. Frequency domain techniques, which operate on the Fourier transform of an image.

**Fig 6. Enhanced image**

## 3.7 Thresholding technique:

Histogram based technique:

In an image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values. Histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. Remember that each column in the histogram represents how many pixels in the photograph have the pixel value represented by the column. However, keep in mind that the histogram does not tell you where those pixels are located within the image. As a result, two different images can result in the same histogram.

Image histograms are present on many modern digital cameras. Photographers can use them as an aid to show the distribution of tones captured, and whether image detail has been lost to blown-out highlights or blacked-out shadows. This is less useful when using a raw image format, as the dynamic range of the displayed image may only be an approximation to that in the raw file.

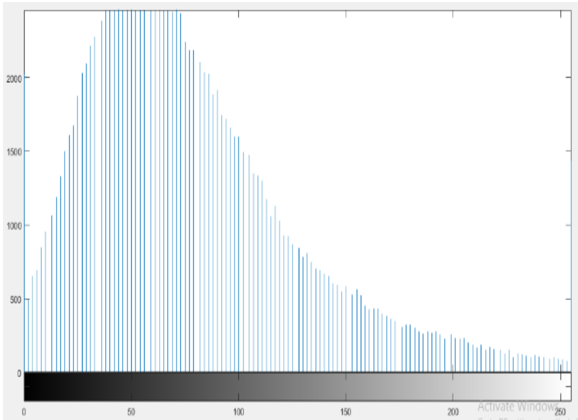



**Fig 7. Histogram for the enhanced image**

**Threshold Selection based on Otsu's method:**

This method is used to overcome the drawback of iterative thresholding[6] i.e. calculating the mean after each step. This method identifies the optimal threshold by making use of histogram of the image. Otsu's method is aimed in finding the optimal value for the global threshold. The main drawback of Otsu's method of threshold selection is that it assumes that the histogram is bimodal. This method fails if two classes are of different sizes and also with variable illumination.

In computer vision and image processing, Otsu's method, named after Nobuyuki Otsu is used to automatically perform clustering-based image thresholding or, the reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pair wise squared distances is constant), so that their inter-class variance is maximal. Consequently, Otsu's method is roughly a one-dimensional, discrete analogy of Fisher's Discriminant Analysis[7]. Otsu's method is also directly related to the Jenks optimization method[8]. In Otsu's method, we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

The weighted within–class variance is:

$$\sigma_{wc}^2(t) = k_1(t)\sigma_1^2(t) + k_2(t)\sigma_2^2(t) \quad (1)$$

Weights k1 and k2 are the probabilities of the two classes separated by a threshold t, $\sigma 1$ *and* $\sigma 2$ are the variances of these two classes.

The class probabilities $k_1(t)$ and $k_2(t)$ are computed from the L bins of histogram:

$k_1(t) = \sum_{i=0}^{t-1} p(i)$ (2)

$k_2(t) = \sum_{i=t}^{L-1} p(i)$ (3)

Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance: $\sigma_{bc}^2(t) = \sigma^2 - \sigma_{wc}^2(t)$ (4)

We can express the total variance as:

$\sigma^2 = \sigma_{wc}^2(t) + k_1(t)[1 - k_1(t)][\mu_1(t) - \mu_2(t)]^2$ (5)

IV. RESULTS:

Results for differentiating the grass and land areas:

**Fig 1.Input satellite image**

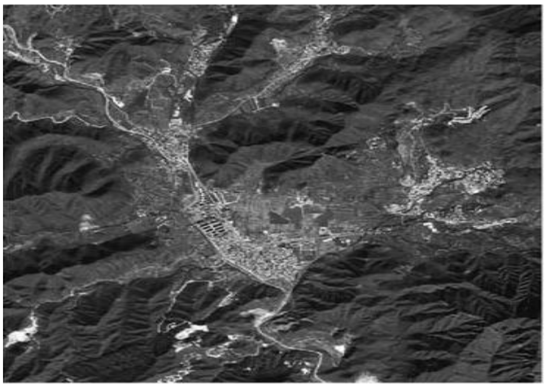


**Fig 2. Gray scale image**

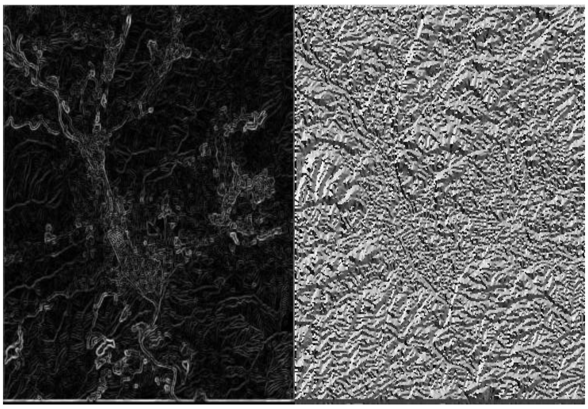


**Fig 3. Magnitude and direction of the image**

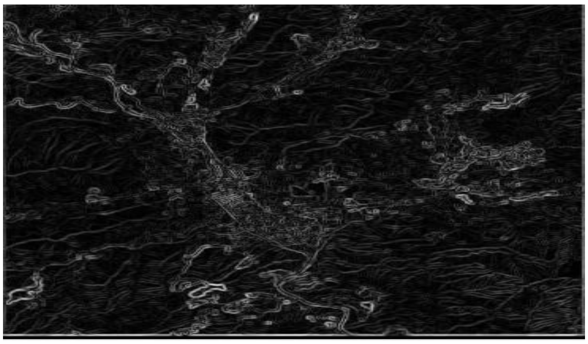


**Fig 4. Matrix to gray converted image**

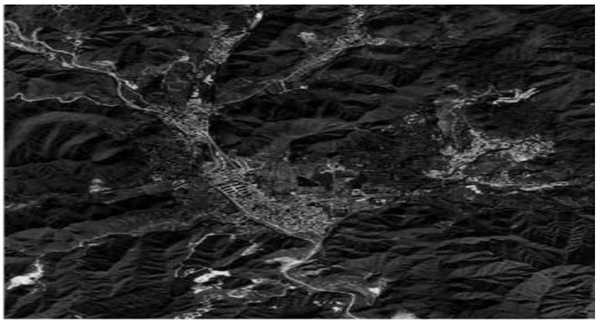


**Fig 5. Background subtracted image**

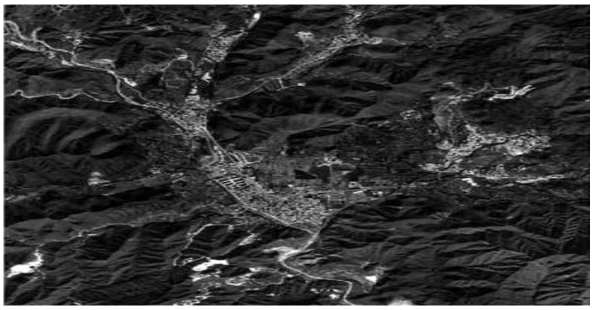


**Fig 6. Enhanced image**

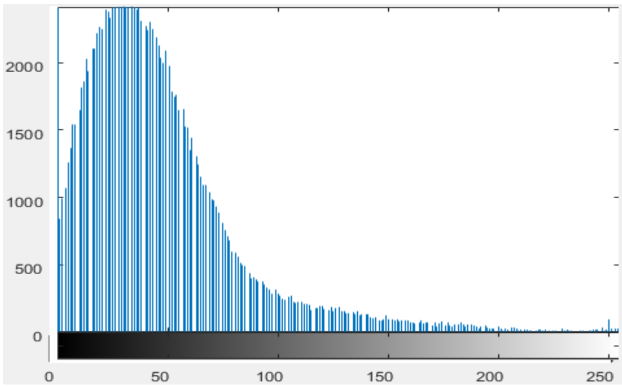



**Fig 7. Histogram for the enhanced image**

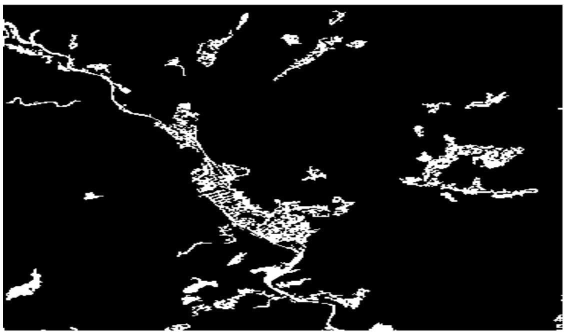


**Fig 8.Grey Threshold image**

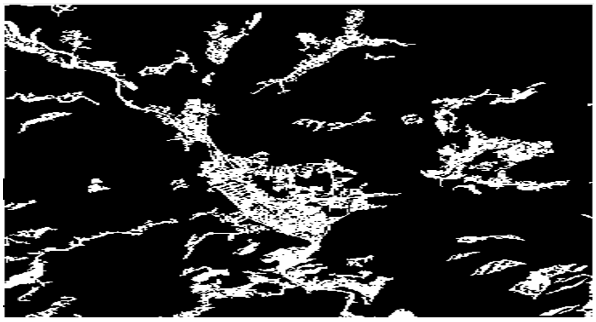


**Fig 9.Otsu output image**

**Comparision of methods**

| S. No | Image | Parameters | Gray level method | Otsu method |
|---|---|---|---|---|
| 1. |  | Accuracy | 71.43 | 92.73 |
| | | Precision | 0.71 | 0.92 |
| 2. |  | Accuracy | 41.67 | 53.49 |
| | | Precision | 0.34 | 0.53 |
| 3. |  | Accuracy | 42.22 | 51.96 |
| | | Precision | 0.35 | 0.51 |

# 4. CONCLUSION:

In Remote sensing image segmentation using Otsu algorithm, we differentiate the low intensity areas like grass and the high intensity areas like land areas, water bodies, etc. in satellite images. This is already done by previous methods like gray thresholding but, by using Otsu thresholding technique we can get the better accuracy and the precision than the existing methods. In the previous methods, the threshold values are taken manually but, in proposed method, the threshold values are taken on the basis of count of the histogram of the enhanced image. Hence this method is more accurate than the other methods.

# 5. REFERENCES

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