

River and Sand Bank Regions Segmentation from Google Earth Imagery

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Abstract: Nowadays, extracting river information accurately from remotely sensed images plays a vital role in policy planning, hydrological planning and environmental planning. So, change detection from remotely sensed data is an essential for environmental monitoring. In change detection process, object segmentation from satellite imagery is a primary important step to obtain accurate classification results. Thus, this paper is proposed to segment river regions and sand bank regions from Google earth images. For these regions segmentation, heuristic rules are applied. In this system, Sobel operator is used to calculate the gradient value for the input grey scale image and then the river regions and sand bank regions are segmented by applying the thresholding approach and morphological approaches such as dilation, closing and extracted connected components. The proposed system obtained the 97.7 % accuracy for river regions segmentation and 72.1% accuracy for sand bank regions extraction. Experimental results approve the effectiveness of the proposed system. Thus, this system can provide the river detection, change detection and policy making.

Keywords: Google earth images, remote sensing, morphological processing and image segmentation

1. Introduction

Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change. Classification of remote sensing data has widely applied in various fields such as glacier monitoring, agriculture, land cover monitoring, change detection in land uses and land cover, study of environment, vegetation monitoring and burned area detection and hydrological planning etc. [1]. Moreover, remote sensing plays a major role in supporting decision-making and is probed to be crucial tool to support effective early warning for natural calamities and disasters.

All the supervised classifiers need sufficient and efficient training samples which are usually selected and labelled by visual inspection or field survey. However, acquiring labelled data for the classifier training is very difficult, time consuming and expensive in the area of remote sensing [2]. The learning-based segmentation has one disadvantage of the requirement of manual interaction for obtaining training data. On the other hand, the manual segmentation for precisely labelling process to training data set is time consuming and laborious.

Furthermore, rivers provide a large number of ecosystem services and riparian people depend directly and indirectly on water availability, quality and quantity of the river waters. As the Ayeyarwady river is the lifeline of Myanmar's population and the agriculture is also the major source of income of Myanmar, the water resources are most effect on people's livelihood in this region. Consequently, changing rivers and water surface can also impact the loss of residential and farm land, loss of agricultural productivity and other valuable properties. Thus, focusing the river changes and monitoring is an initial important step for environmental monitoring. To perform the river change detection, accurate river detection is important. Besides, the exact river detection process requires the precisely labelled training data. Moreover, accurate

image segmentation is needed for automatic labelling the training data set.

Image segmentation refers to dividing an input image into various non-overlapping homogenous regions and help to interpret the image more conveniently. The homogenous regions formed as a result of segmenting pixels having similarity in each region according to a particular selection criteria e.g. intensity, color etc. Segmentation plays an important role in image understanding, image analysis and image processing [3]. Thus, this paper is proposed for river and sand bank regions segmentation from Google earth RGB images.

This paper is organized in five sections. Section I introduces about the proposed system. In section II the river and sand bank regions segmentation is presented. Section III describes system methodologies and section IV presents the study area and the experimental results of the system. And, the system is concluded in section V.

2. Image Segmentation

In this section, image segmentation for river regions and sand bank regions are presented.

2.1 River Regions Segmentation

For river region segmentation, firstly acquired the input images from the freely available Google Earth Pro. Then the input images are converted from RGB images to grey scale image. After that calculate the gradient value of these grey scale image using Sobel kernel function. And assuming that the gradient value is greater than the value of 25 is the river region and then extract the largest region as the river segment. The flow of the river region segmentation is shown in Figure 1.

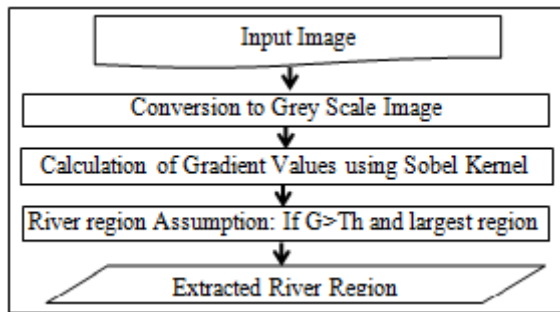


Figure 1: Flow of River Region Segmentation

<p>Algorithm: River region segmentation</p> <p>1: Inputs: RGB Google earth image</p> <p>2: Step 1: Convert RGB image to grey scale image.</p> <p>3: Step 2: Calculate gradient value using Sobel kernel</p> $ \nabla f \sqrt{G_x^2 + G_y^2}$ <p>4: Step 3: If $\nabla f > \text{Threshold}$ Assume: pixels are river region pixel value Extract the largest region</p>

<p>Algorithm: Sand bank region segmentation</p> <p>1: Inputs: RGB Google earth image</p> <p>2: Step 1: Convert RGB image to grey scale image.</p> <p>3: Step 2: Calculate gradient value using Sobel kernel</p> $ \nabla f \sqrt{G_x^2 + G_y^2}$ <p>4: Step 3: If $\nabla f > \text{Threshold}1$ Assume: pixels are sand bank region pixel value Extract the largest 8 regions from the resultant region</p> <p>5: Step 4: If $\nabla f > \text{Threshold}2$ Extract as sand bank region</p> <p>6: Step 5: Applying Morphological Operator for final sand bank extraction</p>

2.2 Sand Bank Regions Segmentation

In sand bank region segmentation, the input Google earth RGB images are firstly converted into grey scale images. Then also calculate the gradient value of these grey scale images using Sobel kernel. Afterward assuming the gradient value greater than 80 as the sand bank regions and extract the largest 8 regions as sand bank regions.

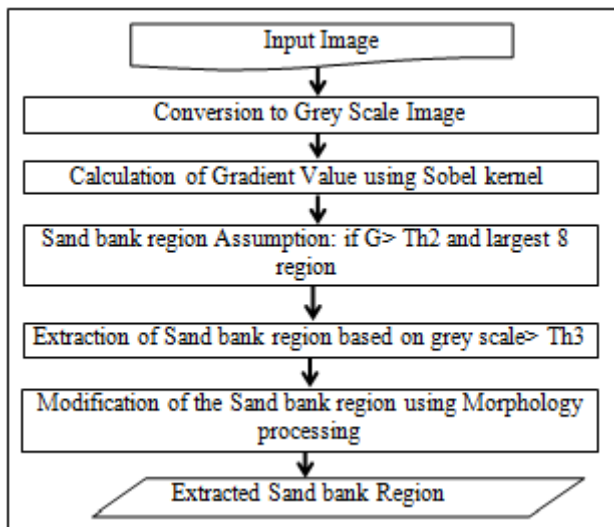


Figure 2: Flow of Sand Bank Region Segmentation

From that, the grey scale value greater than 170 is again extracted as sand bank region. The extracted sand bank regions are modified with morphological operator such as closing, connected component extraction and centroid finding. The flow of the sand bank regions extraction is illustrated in Figure 2.

3. Methodologies of the System

The methodologies used to segment river and sand bank regions are presented in this section.

3.1 RGB to Grey-scale Image Conversion

In this section, RGB color space of the input image can be converted to a grey-scale image using a simple transform. In many image analysis algorithms, the grey-scale conversion is the initial step that simplifies (i.e. reduces) the amount of information in the image. Grayscale images contain less information than color images, but most of the important feature related information such as edges, regions, blobs, junctions, etc. are maintained. Feature detection and processing algorithms are usually based on transformed grayscale version images. An RGB color image, I_{color} , is converted to grey scale, $I_{grey-scale}$, using the following transformation:

$$I_{grey-scale}(n, m) = \alpha I_{color}(n, m, r) + \beta I_{color}(n, m, g) + \gamma I_{color}(n, m, b) \quad (1)$$

Where (n, m) indexes an individual pixel within the grey-scale image and (n, m, c) the individual channel at pixel location (n, m) in the color image for channel c in the red r , blue b and green g image channels. As is apparent from Equation (1), the grey-scale image is essentially a weighted sum of the red, green and blue color channels. The weighting coefficients $(\alpha, \beta$ and $\gamma)$ are set in proportion to the perceptual response of the human eye to each of the red, green and blue color channels and a standardized weighting ensures uniformity ($\alpha = 0.2989$, $\beta = 0.5870$ and $\gamma = 0.1140$). Human eyes are sensitive to red and green light, of course. Therefore, these colors are given a higher weighting and it is guaranteed that the relative intensity balance in the resulting grayscale image is similar to that of the RGB color image [4].

3.2 Gradient Value Calculation

After converting input image to grey scale image, the gradient values of these images are calculated by convolving the image with a kernel (filter mask) yielding the image derivation in x and y direction. The magnitude and direction of the gradients can then be computed using those derivations. The horizontal edges are obtained by approximating a vertical gradient and then the vertical edges

are also acquired by transposing the filter. The Sobel filter mask is applied in this system. The Sobel operator consists of a pair of 3x3 convolution kernels as shown in Figure. 3.

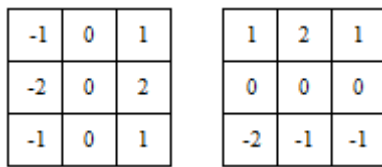


Figure 3: Sobel Operator Convolution Kernel

Afterwards the grey scale image is filtered/convolved with the Sobel kernel for both horizontal and vertical direction respectively, the gradient values of this image is calculated as following.

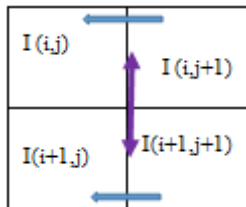
$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}, |\nabla f| = \sqrt{G_x^2 + G_y^2} \quad (2)$$

Where:

$\frac{\partial f}{\partial x}$ is the derivative with respect to x (gradient in the x direction)

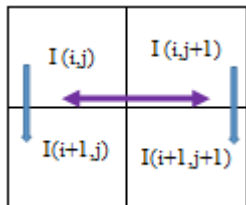
$\frac{\partial f}{\partial y}$ is the derivative with respect to y (gradient in the y direction).

The gradient of the image in x direction is calculated by computing change of each pixel with respect to x direction as the following.



$$\frac{\partial f}{\partial x}(i, j) = \frac{1}{2}((I(i, j + 1) - I(i, j)) + (I(i + 1, j + 1) - I(i + 1, j))) \quad (3)$$

The gradient of the image in y direction is also calculated as the following.



$$\frac{\partial f}{\partial y}(i, j) = \frac{1}{2}((I(i + 1, j) - I(i, j)) + (I(i + 1, j + 1) - I(i, j + 1))) \quad (4)$$

3.3 Morphological Processing

After extracting the river regions and sand bank regions according to the gradient value, morphological operator are applied to get the better sand bank regions.

3.3.1 Dilation

Dilation has the effect of broadening and thickening narrow regions and growing the feature around its edges. Dilation is applied to connect areas which are separated by smaller spaces than that of the structuring element used. In this system, dilation operator is applied for filling the holes of certain shape and size given by structuring element and to repair breaks and intrusions. The dilation operator has two data inputs. The first one is the image and the second one is the structuring element. The structuring element size of 4x4 is applied for dilation in this system. Mathematically, dilation is defined in terms of set operations. The dilation of A by B denoted $A \oplus B$ is defined as

$$A \oplus B = \left\{ z \left(\begin{matrix} \wedge \\ B \\ z \end{matrix} \right) \cap A \neq \phi \right\} \quad (5)$$

Where ϕ is the empty set and B is the structuring element. In words, the dilation of A by B is the set consisting of all the structuring element origin locations where the reflected and translated B overlaps at least some portion of A [4].

3.3.2 Extracting Connected Component

Continuous regions extraction are also important for image segmentation. Thus, the connected components are extracted in this section. In this process, the 8-connected components in the image are extracted after dilation process is performed to the object extracted by size. The connected component of a pixel is the set of all pixels which are connected to the given pixel. A group of pixels which are all connected to each other in this way is differentiate from others by giving it a unique label. Typically, the process of extracting connected components leads to a new image in which the connected groups of pixel (the objects) are given sequential integer values: the background has value 0, the pixel in the first object have value 1, the pixel in the second object have value 2 and so on. The steps to identify and label 8-connected components in an image is as follows

- Scan the entire image by moving sequentially along the rows from top to bottom
- Whenever arriving at a foreground pixel p, then examine the four neighbours of p which have already been encountered thus far in the scan. These are the neighbours (i) to the left of p, (ii) above p, (iii) the upper left diagonal and (iv) the upper right diagonal [4].

3.3.3 Closing

Closing operator is applied afterwards the connected components extraction in the image. Closing tends to remove the small holes in the foreground, changing small regions of background into foregrounds. It tends to join narrow isthmuses between objects. The closing of A by structuring element B is denoted as following

$$A \bullet B = (A \oplus B) \ominus B \quad (6)$$

Geometrically, $A \bullet B$ is the complement of the union of all translations of B that do not overlap A [4].

3.3.4 Opening

After closing operation is performed for sandbank filling, remove the small object less than a defined pixel values using opening operator in this system. The general effect of

opening is to remove small, isolated objects from the foreground of an image, placing them in the background. It tends to smooth the contour of a binary object and breaks narrow joining regions in an object. Opening is the name given to the morphological operation of erosion followed by dilation with the same structuring element [4]. The opening of image A by structuring element B is denoted as following equation

$$A \circ B = (A \ominus B) \oplus B \quad (7)$$

4. Study Area and Experimental Result of the System

4.1 Study Area

Magway Division is the second largest division in Myanmar. It is made up of the districts of Pakokku, Magway, Minbu, Thayet, and Gangaw involving 25 townships and 1,696 ward village-tracts. And, this region falls in the Dry Zone of Central Myanmar, bordering Mandalay Region on the east, Sagaing Region on the north, Chin State and Rakhine State on the west and Bago Region on the south.

The major economy of the Magway Region is the cultivation of sesame and groundnut. Moreover, crops such beans, potatoes, sunflower, millet, tobacco and onions are also produced. It covers about an area of 44818.96 square kilometers [5]. The study area lies between north latitude 18° 50' and 22° 47' approximately and between east longitude 93° 47' and 95° 55'. The Ayeyarwady river along the Magway Region is about 1,550 km (960 miles) long. The location map of study area is as shown in Figure. 4.

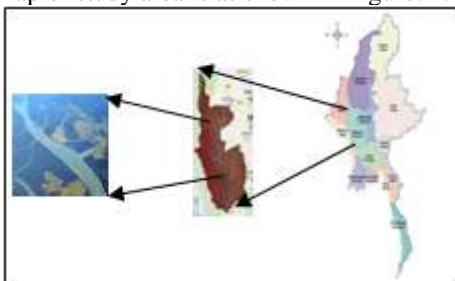


Figure 4: Location Map of Study Area

4.2 Experimental Results

In this system, initially the river area in Magway Region is manually segmented by 2 minutes latitude and longitude size images in Google earth pro. And, this segmented RGB images are taken as an input images. In preprocessing step, input image is firstly resized into 480×640 size. Then, this image is converted into grey scale image. Afterward the gradient values of the image are calculated from grey scale image using Sobel kernel filter.

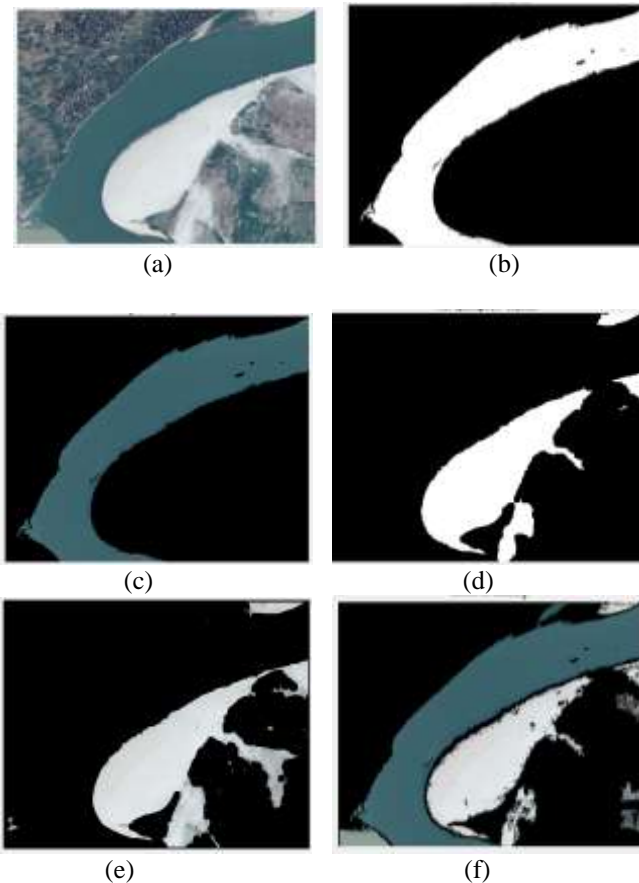


Figure 5: (a) The original river test image (b) River object extracted by size (c) Final extracted river region (d) Sand bank object extracted by size (e) Final extracted sand bank region (f) Final combination of river and sand bank region

River region are extracted according to gradient values. In that state, the gradient values greater than 25 are assumed as the river region and then extract the largest region. The result of river region extraction are illustrated in (b) and (c) of Figure.5, Figure. 6 and Figure. 7.

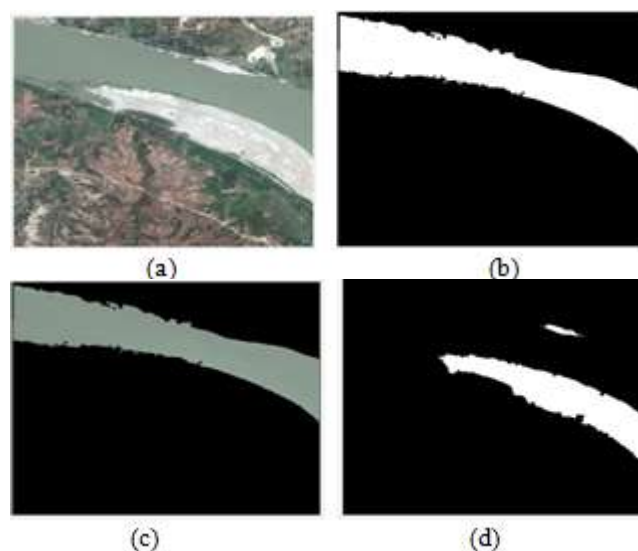




Figure 6: (a) The original river test image 2 (b) River object extracted by size (c) Final extracted river region (d) Sand bank object extracted by size (e) Final extracted sand bank region (e) Final combination of river and sand bank region

After river region extraction is performed, sand bank regions are pulled out from the image. As the sand bank region has the greater gradient values than the river region, the gradient value greater than 80 are initially extracted as sand bank region in this system. After performing morphological processing (dilation operator) on the extracted sand bank region for filling the holes and repairing the breaks and intrusions, the gradient value larger than 170 are again extracted as sand bank region. To reduce the small objects from that resultant image pixel value less than 50 are removed from the image using opening operator. The results of sand bank regions extraction are illustrated in (d) and (e) of Figure.5, Figure.6 and Figure7. Finally, segmented river regions and sand bank regions are combined for the next coming river detection step. This final combination results are as shown in (e) of Figure. 5, Figure. 6 and Figure.7.

Performance measures are evaluated to prove the quality of the proposed work. To test the performance of the proposed system, extracted river and sand bank regions are compared with manually drawn ground truth images. The evaluation of river and sand bank regions segmentation is observed by calculating the evaluation measures such as sensitivity, specificity and accuracy.

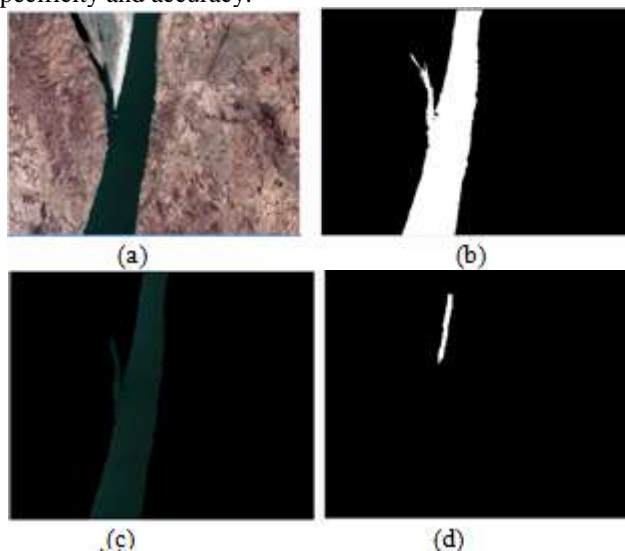


Figure 7: (a) The original river test image 3 (b) River object extracted by size (c) Final extracted river region (d) Sand bank object extracted by size (e) Final extracted sand bank region (e) Final combination of river and sand bank region

$$\text{Sensitivity} = \frac{TP}{TP + FN} \quad (8)$$

$$\text{Specificity} = \frac{TN}{TN + FP} \quad (9)$$

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (10)$$

Performance measurement of the river and sand bank segmentation from Google earth images are presented in Table 1.

Table 1: Performance Evaluation of the system

	Sensitivity	Specificity	Accuracy
River	89.15	99.4	97.7
Sand Bank	42.5	76.75	72.1

According to experimental result, river segmentation obtained the 89.15% sensitivity, 99.4% specificity and 97.7% accuracy. And, sand bank segmentation got the 42.5% sensitivity, 76.75% specificity and 72.1 % accuracy. However, there are some sand bank regions that are still missed. It may be seen that the gradient values of some sand bank regions are very similar to the gradient values of land in some regions. Thus, these sand bank regions are omitted to extract the sand bank regions. However, accuracy measures prove that the proposed work yields river and sand bank regions very closer to ground truth image.

5. Conclusion

This proposed system presents the river and sand bank regions segmentation using Sobel operator for gradient values calculation, thresholding approach and morphological processing. In this experiment, the performance of the proposed system is evaluated by comparing the results with ground truth images and performance measures such as sensitivity, specificity and accuracy are calculated. According to the testing result, the proposed system obtained the 97.7% accuracy for river region segmentation and 72.1% accuracy for sand bank region extraction. Traditionally, automatic annotation of remote sensing training data is crucially relies on accurate image segmentation. Thus, the performance measures demonstrate that the proposed system can help for labelling training data without manually. It also shows that the presented system can automatically label the training data for the future river detection work.

References

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