IMPLEMENTATION OF VARIOUS SEGMENTATION ALGORITHMS ON SIDE SCAN SONAR IMAGES AND ANALYSING ITS PERFORMANCE

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ABSTRACT

Side Scan Sonar Image Segmentation is an important process prior to object recognition. Extensive research has been carried in creating different algorithms and approaches for Sonar Image segmentation. But it is still difficult to find which algorithm suits well for side scan sonar image partition. In this paper we intend to evaluate the effectiveness of different segmentation algorithms on sonar image.

Keywords: sonar image, segmentation, fuzzy C-means, thresholding.

INTRODUCTION

Segmentation plays a vital part in image processing. Segmentation algorithms are used to partition entire image so that it is meaningful and easy to proceed further. The partitioned parts are joined again to form a meaningful and complete image. The segmentation is done based on predefined criteria such as colour, distance, intensity, size etc in the image. The aim of segmentation is to reduce the information for easy analysis.

Segmentation methods are divided into pixel based - groups the image based on similar features like color or texture, region based –groups the image into regions having homogenous characteristics and considering spatial connectedness and boundary based – objects surrounded by closed boundaries are grouped as pixels. Image segmentation is to form clusters based on some predefined criteria. The criteria for segmentation is 1) The adjacent regions should be different. 2) The pixels in a particular region should have similar characteristics and be uniform. In this paper we have discussed on segmentation algorithms like edge detection, thresholding, clustering using fuzzy C means.

LITERATURE SURVEY

In this section, literature survey on segmentation algorithms have been done.

Mohamad Awad, Kacem Chehdi, and Ahmad Nasri [1] compared the robustness and efficiency of the Iterative Self-Organizing DATA analysis method (ISODATA) and the SOM–HGA method. They found that ISODATA is 5 times faster than SOM–HGA. They suggested that SOM–HGA can be enhanced by using segmentation algorithm, such as FCM.

J. Driesen, P. Scheunders [2] provided groundwork for multi-components image partition. The ground-work is as follows: a) applying pixel based clustering methods1 b) model-based region-merging technique is used, where model parameters is estimated using Maximum Likelihood algorithm c) establishing multi-scale version by remaking the similar methods at different levels of resolution. e) establishing link between the levels which are not similar, by constructing a hierarchy between the regions.

Stéphane Derrode, Grégoire Mercier [3] in their work extended the Hidden Markov Chain (HMC) model for the unsupervised segmentation of multi-component images. They adopted Independent Component Analysis approach, while segmenting the authors considered the mutual dependences between the layers.

Licheng Jiao, Maoguo Gon, Shuang Wang, Biao Hou, Zhi Zheng, Qiaodi Wu [4] proposed MA- based approach, Memetic Image Segmentation Algorithm (MISA), and compared the new method with its genetic version (MISA without learning), the K-means, fuzzy c-means, graph-based and spectral clustering ensemble-based algorithm in partitioning natural images, remote sensing and artificial texture images.

Devis Tuia, Jordi Mun˜oz-Marı, Gustavo Camps-Valls [5] proposed a method which combined unsupervised and active supervised clustering. The proposed method is successfully estimated in remote sensing application: hyperspectral and multispectral (very high resolution) image segmentation.

Yongzheng Geng, Jian Chen, Li Wang [6] proposed a novel color image partitioning method. This method improves the JSEG (Joint Systems Engineering Group) algorithm, and it used the output of JSEG as the input of Ncut (Normalized Cuts). Experiments show that proposed algorithm yielded better result. It effectively overcame the computation problems. The final segmented boundary is more exact and correct. The proposed algorithm suffered from problems, such as complexity in computation.

Niket Amoda, Ramesh K Kulkarni [7] developed a novel Texture Gradient based Watershed Segmentation technique. The Watershed Transform is not suitable for textured image which is homogenous in nature. The concept of the Texture Gradient and Non Decimated Wavelet Packet Transform is introduced for proper segmentation. A marker is used to locate homogeneous textured or non textured regions. Watershed Trans-form combined with markers is used to partition the identified regions.

Md. Habibur Rahman, Md. Rafiqul Islam [8] proposed the threshoding and adaptive masking method on each colour channel. The proposed method ensured

VOL. 12, NO. 8, APRIL 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

accurate results and improved quality of the color images and thus overcame the problem in segmentation. The experimental results are obtained using image quality assessment (IQA) metrics such as Peak Signal to Noise Ratio, Mean Square Error, PSNRRGB and Color Image Quality Measure. The modified watershed method is faster and improved the image segmentation performance. This made it suitable for real-time application.

SEGMENTATION ALGORITHM

In this section we have discussed about the segmentation algorithms which we have used in the existing work and our work.

A. Existing work

- **Edge detection**

Edge Detection helps to identify the sharp change in intensity levels. That is transition from bright to dark. This helps to find the boundaries of the objects.[10]

B. Proposed work

- **Thresholding**

Thresholding is less complex method for partitioning the image. The thresholded values are calculated from the histogram of the edges of the original image. The computation in thresholding is fewer compared to other segmentation methods. Different types of thresholding methods are as follows.

- Global thresholding, uses an pertinent threshold value T_v:
  - $p(x, y) = 1$, if $g(x, y) > T_v$
  - $p(x,y)=0$, if $g(x, y) \leq T_v$

- Variable thresholding, threshold T_v value varies throughout the image.
  - Local or regional thresholding, threshold value T_v depends on neighborhood of (x, y).
  - Adaptive thresholding, where threshold T_v is a function of (x, y).

- Multiple thresholding:
  - $p(x, y) = a_1$, if $f(x, y) > T_v 2$
  - $p(x, y) = b_1$, if $T_v 1 < f(x, y) \leq T_v 2$
  - $p(x, y) = c_1$, if $f(x, y) \leq T_v 1$

- **Fuzzy C-means (FCM) clustering**

Fuzzy C-Means (FCM) clustering is a method which allows one piece of data to belong more than one clusters with certain degree based on color, or intensity as similar characteristics. This implies a datapoint which lies near to the cluster centre will have a high ranking of membership and otherwise it will have a low ranking of membership to that cluster.

FCM is aimed at minimizing the objective function:

$$f_n = \sum_{i=1}^{N}\sum_{j=1}^{C} m_{ij}{}^{n}\left\|y_i - c_j\right\|^2,\ 1\leq n<\alpha \tag{1}$$

thereby maximising the membership function.

- ‘n’ (real number)> 1, ‘N’ No of features, ‘C’ No of clusters
- ‘m_{ij}’ is membership degree of yi in the cluster j,
- ‘y_i’ is the i^{th} of d-dimensional measured data,
- ‘c_j’ is the d-dimension centre of the cluster, and
- ‖*‖ is any norm expressing the similarity between centre and any measured data. The algorithm is composed of the following steps:

1. Initialise fuzzy partition matrix $P=[m_{ij}]$ matrix, $P^{(0)}$
2. At k-step: calculate the centre vectors $C^{(k)}=[c_j]$ with $P^{(k)}$

$$c_j = \frac{\sum_{i=1}^{N} m_{ij}^{n} x_i}{\sum_{i=1}^{N} m_{ij}^{n}} \tag{2}$$

3. Update $P^{(k)}$, with $P^{(k+1)}$by the new computed m_{ij}.

$$m_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\|y_i - c_j\|}{\|y_i - c_k\|}\right)^{\frac{2}{n-1}}}$$

4. If $\left\|P^{(k+1)} - P^{(k)}\right\|<\varepsilon$ then stop otherwise return to step 2.

Compute the objective function according to equation 1. The cluster centre is renewed until the difference between the adjacent objective function in equation (1) is nearest to 0 or < (less than) a predefined small constant.

METHODOLOGY

The proposed work includes evaluating the effectiveness of different segmentation algorithms on sonar image. The main objective of Image Segmentation is to partition the image into parts for further study and to represent in meaningful form.

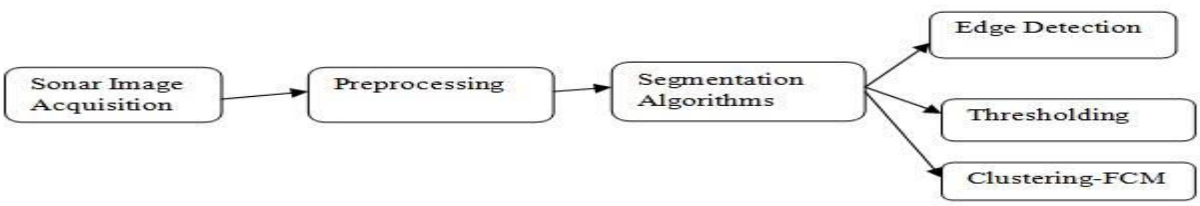

Figure-1. Block diagram for sonar image analysis using different segmentation techniques.

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EXPERIMENTAL RESULTS AND DISCUSSION

Various segmentation algorithms are implemented in the side scan sonar images. Figure-2 is the Side Scan.

Sonar image acquired from Edgetech website, Figure-3 is the resized image.

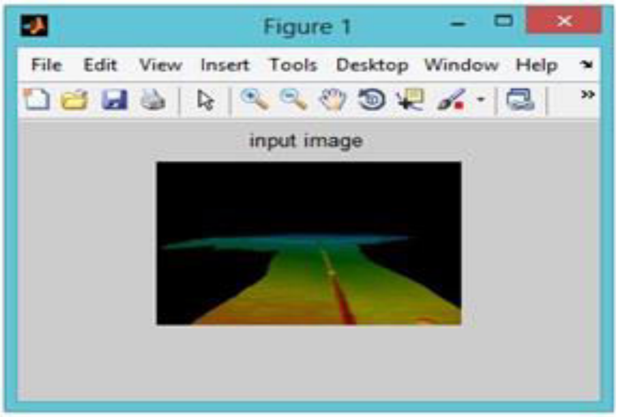

Figure-2. Sonar image.

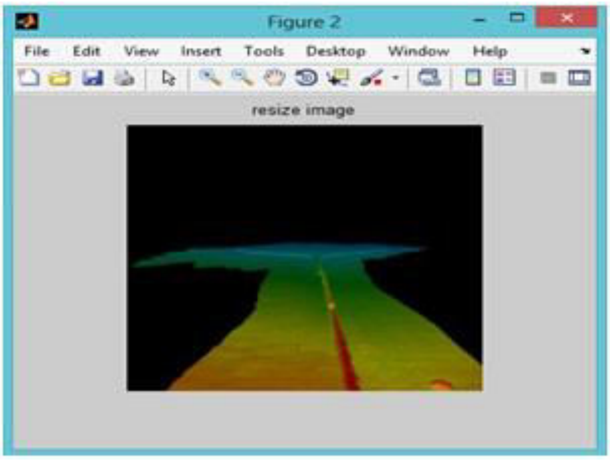

Figure-3. Resized image.

The resized image is converted into gray scale image in order to apply segmentation algorithm which is shown in Figure-4.

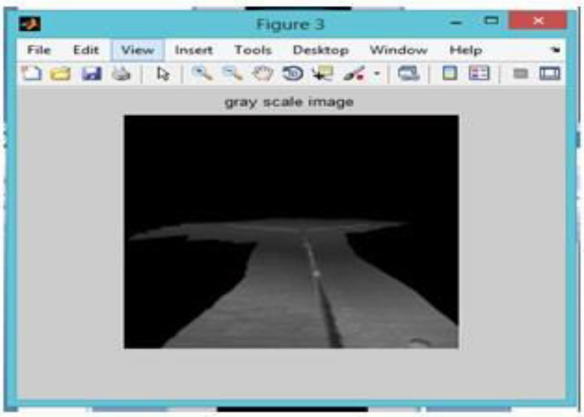

Figure-4. Gray scale image.

The side scan sonar image has specle noise we have used wavelet filtering to remove as a preprocessig shown in Figure-5.

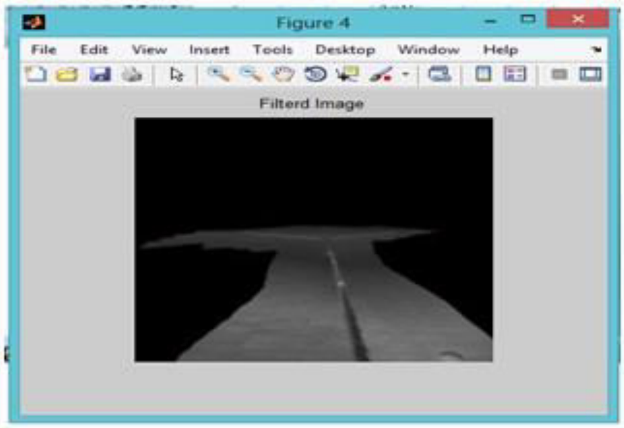

Figure-5. Filtered image.

Various segmentation algorithms are applied on sonar image. Figure-6, Figure-7, shown below is the image obtained after segmentation algorithms like edge detection, thresholding.

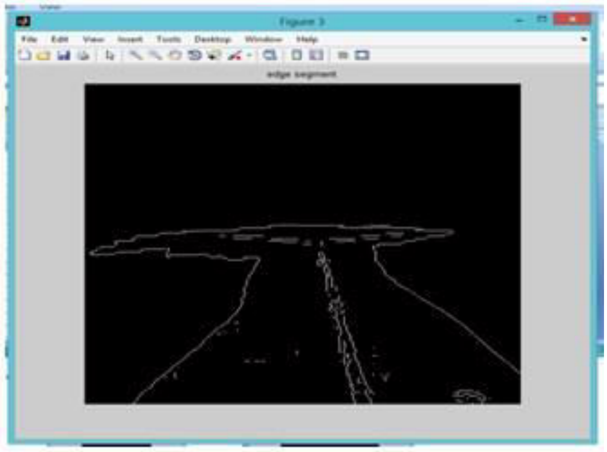

Figure-6. Edge detected image.

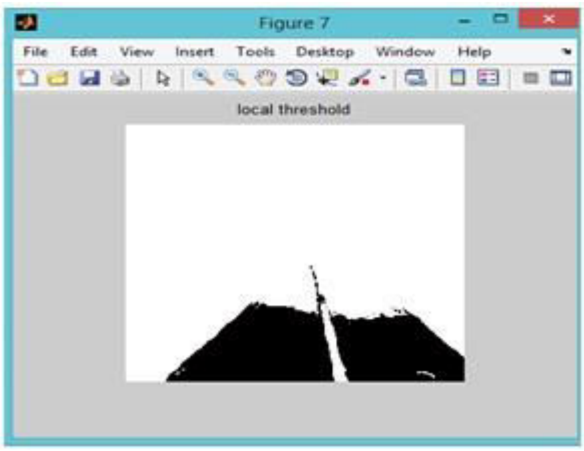

Figure-7. Thresholding.

VOL. 12, NO. 8, APRIL 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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Figure-8a, 8b, 8c is the image obtained after fuzzy c means clustering algorithm.

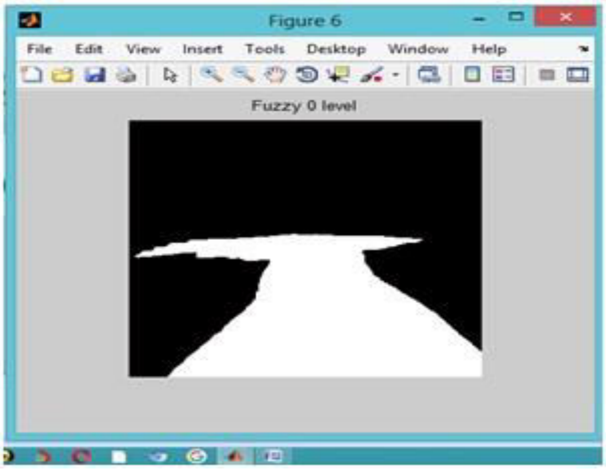

Figure-8a. Fuzzy segmented image 0 level.

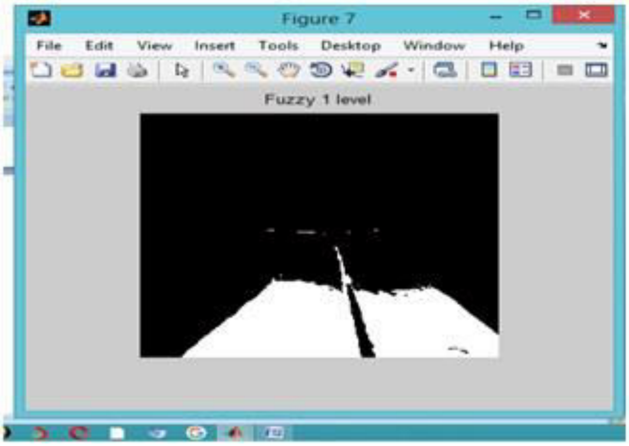

Figure-8b. Fuzzy segmented image 1 level.

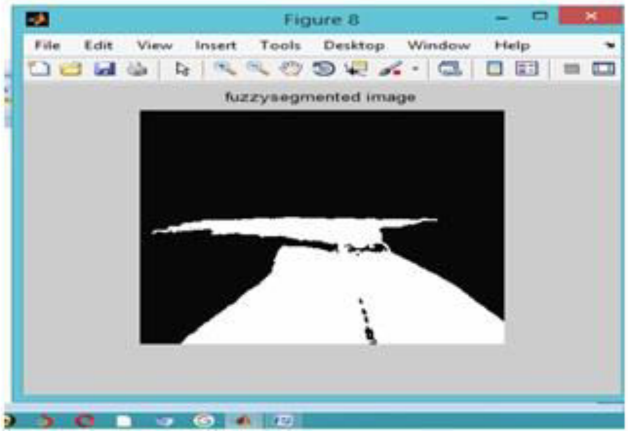

Figure-8c. Fuzzy segmented image.

Figure-8 displays FCM Clustering operation on the Sonar image Data. The function FCM takes desired number of clusters and datapoints and returns membership grades and optimal cluster centres for each data point.

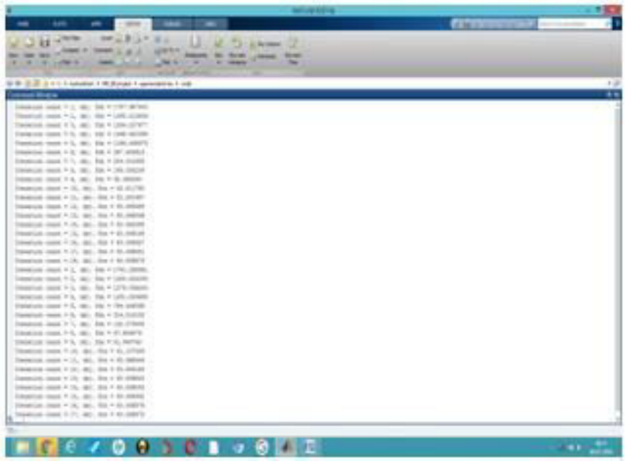

Figure-9. FCM clustering.

Table-1. Performance metrics of different segmentation algorithms.

Input Sonar Image 1	Peak Signal to Noise Ratio(PSNR)	Variation of Information(VOI)	Rand Index(RI)	Global Consistency Error(GCE)
Edge Segmentation	55.2346	0.2027	0.6432	0.0533
Thresholding	56.1325	0.2552	0.7654	0.123
FCM method	59.4562	0.1636	0.9566	0
Input Sonar Image 2				
Edge Segmentation	54.3176	0.2035	0.5672	0.0413
Thresholding	53.3243	0.3347	0.4769	0.2365
FCM method	59.1221	0.1543	0.9876	0

Table-1 depicts the performance metrics of different segmentation algorithms. For better results the PSNR and RI should be of high value. VOI and GCE should be of low value. The FCM segmentation has provided better segmentation results compared to edge detection and thresholding methods.

CONCLUSION AND FUTURE WORK

This paper summarizes various segmentation techniques. Thus segmentation is done to prior step to object recognition. Segmentation is applied to side scan sonar image. The existing edge detection and thresholding techniques may not provide better results for real time application. Because the PSNR and RI value is low, GCE and VOI is high when compared to the Fuzzy C means clustering algorithm. We may not obtain the same values for the similar algorithms in different images because the algorithms may have different effects. In side scan sonar image FCM algorithm has produced better segmentation results. Our future work is to analyse the performance of the segmentation algorithms either subjectively or objectively in real time application.

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