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Study of Object Detection in Sonar Image using Image Segmentation and Edge Detection Methods

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Abstract

The technique which uses sound waves to navigate, communicate or detect objects under the surface of sea water is commonly known as SONAR. Recognition and interpretation of objects is an important task in the sonar image processing. The resolution of the examined image is not adequate to classify the objects separately and is mainly affected by the multiplicative noise. The main focus of this work is to implement post-processing technique by entropy filter along with morphological processing for object identification. Relative analysis on the observed results with existing techniques of edge detection implies that the proposed work improves the result of target identification. Furthermore, removal of noise in the sonar image is also discussed in this paper.

Keywords: Edge Detection Operators, Entropy Filter, Morphological Processing, Object Recognition, SONAR

1. Introduction

In 1906, An American naval architect Lewis Nixon was invented the first sonar device to detect icebergs. A fan shaped sound waves are transmitted into the water using side scan sonar instrument and the reflected waves are recollected and converted into an equivalent image using the device[1,2]. Mainly there are two categories of sonar like side scan sonar (SSS) and synthetic aperture sonar (SAS). Due to cost effect, the SSS type is used conventionally. The sound frequencies in SSS usually range from 100 to 500 kHz; moreover high frequency wave yields better resolution but it covers less area. This type of images are used in many applications such as military for mine detection, fish localization, maritime archaeology, identifying stolen objects under the sea, defect identification in underwater pipelining system etc[3,4]. For all those applications, mainly it needed to identify or isolate the objects present in it. Many new techniques are developed for the object identification[5,6].

Edge detection is a method of detecting boundary for an object in an image. Pixel having abrupt change in its value is called edge pixel. By connecting all edge pixels of an object gives its boundary[7,8]. Various edge detection techniques are available in terms of mathematical model. Some of the standard edge detection techniques are sobel, prewitt, canny, Roberts etc. Canny is proved as best among all those techniques.

The process of partitioning an image into small segments called image segmentation. It helps us for analysis and interpretation. Segmenting an exact boundary for an object in images is very difficult. Therefore by selecting suitable method for specific application give appropriate result. Segmentation techniques are classified in to three types contextual, non-contextual and texture segmentation. Non-contextual segmentation carried out by

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thresholding. The pixels values below thresholding are considered as region pixels and above are taken as boundary pixels. But fixing of thresholding value for images are very difficult. Automatic selection of thresholding are also there however these system increases complexity. In contextual method, proximity between the pixels is measured for finding the region of objects in an image. Texture segmentation is much suitable for highly textured image.

Morphological processing is used to rectify the structural imperfections[9-11]. The two main operations are erosion and dilation[12]. Sonar images are always consider as highly textured image and therefore in this work, texture segmentation is implemented using entropy filtering method and the results are compared with the existing edge detection methods. In section 2, methods used in this work are discussed. In section 3, proposed work has been explained along with flow chart and section 4, describes about the results obtained.

2. Methodology

This work deals with the comparison of some standard edge detection techniques and texture segmentation technique for identification of objects in a sonar image. Since SSS category images are highly used in many areas, this effort has been preferred for those images. The image taken for test has been already filtered off using SRAD filter and that image has been used in this analysis[2].

2.1 Edge Detection

The proposed system is done with the help of Matlab software. Standard edge detector operators are readily available as Matlab operators[13-15]. The operators are nothing but a gradient mask of various size as given in the Table 1.

It moves over the image from top left corner to the bottom right corner and marks the edge pixels accordingly. The connection of those edge pixels represents boundary for an image. Generally there are three types of edges, horizontal, vertical and diagonal. Prewitt and sobel detects only horizontal and vertical edges.

2.2 Image Segmentation

Segmentation has been carried out with the help of a texture filter called entropy filter[16]. Each output pixel of an entropy filter which performed over number of blocks in an image, computes the information entropy values in each 9x9 blocks of neighborhood pixels in an image respectively[17,18]. At the image edge entropy uses smaller neighborhood block size. Entropy is calculated as given in equation 1.

$$E = -\text{sum}(p.*\log2(p)) \quad (1)$$

Where p is a pixel value (histogram counts) in an image.

2.3 Morphological Processing

It is a simple logical operation which performed on the basics of set theory over the binary input image. The two most familiar morphological operations are erosion and dilation. In erosion, every object pixel which is touching a background pixel is altered into a background pixel. In dilation, every background pixel which is touching an object pixel is changed into an object pixel. Therefore erosion makes the objects smaller, and can break a single object into multiple objects and dilation makes the objects larger, and can merge multiple objects into one[19,20].

3. Proposed Method

The given input side scan sonar image is first processed by the entropy filter and is converted into a binary image. Then remove the small components that are not connected with the image pixels. Apply morphological processing. Fill the inner gaps of the image with the surrounding pixel intensity. The final segmented output image consists of only the major object of an input image with white pixel intensity. The proposed method is shown in Figure 1.

4. Results and Discussion

Each stepwise output of the proposed work has been listed in Table 2. The final output of the proposed work has been compared with some standard edge detection methods for the detection of object in SSS image. From Table 2, object of the given input image is detected at step-3 itself in the proposed work. Further the process has been continued in order to get the finest result as mentioned as output in step-6.

The comparison of proposed method with other mentioned existing system is given in Table 3. In this type of application and its subjective analysis are only used for finding the efficiency of the output image.

Table 1. Edge detector operators

EMBED Equation.3 Operator Name	Canny	Sobel	Prewitt	Roberts
Row Gradient	$\begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$	$\frac{1}{4}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$	$\frac{1}{3}\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$
Column Gradient	$\begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$	$\frac{1}{4}\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$	$\frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$

Table 2. Stepwise output of the proposed work

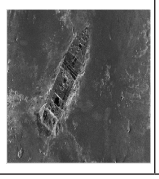
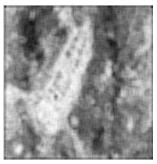
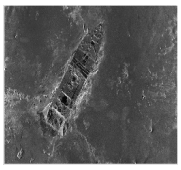
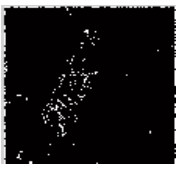
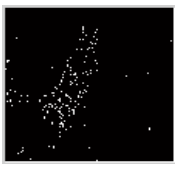
Steps involved in the proposed work	Input image	Entropy filter output	Converted Binary image	Removal of all small boundary objects	Morphological processing	Segmented output image
Output of each step						

Table 3. Comparison of proposed work output with the existing edge detection techniques output

Input Image	Canny	Prewitt	Sobel	Roberts	Proposed method
					

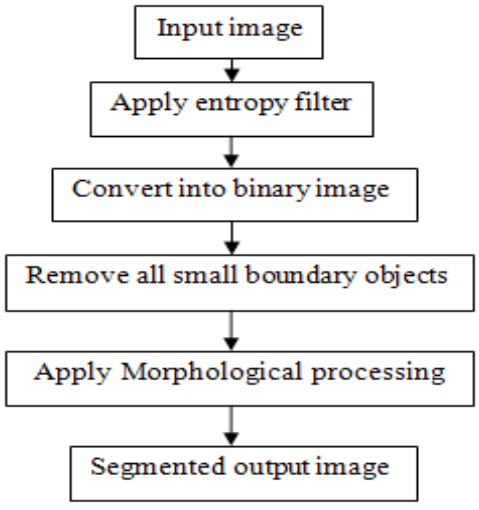


Figure 1. Flow chart for the proposed work.

5. Conclusion

As per the result shown in the Table 2, the proposed algorithm results in finest texture outcome of the entropy filter along with all other processing steps. Since no suitable quality evaluation metrics available for the comparison of those results, so we selected the subjective analysis. According to that analysis, with respect to Table 3, object detection of the proposed work gives better details than others. Therefore this work proved to be best among the standard edge detection techniques used for object detection.

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