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ScienceDirect

Procedia Computer Science 85 (2016) 782 – 789

Procedia Computer Science

International Conference on Computational Modeling and Security (CMS 2016)

Expectation–Maximization based image fusion algorithm for detection of Underwater targets from SONAR images

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Abstract

With the advancement of technology, the imaging sonars have become the reality and their usage has been extensive in the area of obstacle avoidance in respect of Autonomous Underwater Vehicle (AUV). The underwater environment being heterogeneous, the sonar images have a very complex background, low contrast, and deteriorative edges. To locate and identify the underwater objects from the Sonar images, the initial step needs to be undertaken is the segmentation. Several general purpose algorithms have been developed for segmentation of various images. In this paper the various existing image processing techniques in respect of the sonar images are reviewed. As there is no general solution to the image segmentation problem, making use of the available techniques two new algorithms for processing the underwater Sonar images are proposed. In first algorithm segmented images are combined to a single image called image fusion which performs better than the existing methods with PSNR of 38.006. But in this method also edges of the target are missing. Hence another algorithm is proposed in combination with Expectation maximization technique whose PSNR is 41.2634. Therefore, the proposed algorithm is best suitable to the underwater scenario and is also useful for navigation and guidance of underwater vehicles.

Keywords: Segmentation; Image Fusion; Noise; Expectation maximization

1. Introduction

The images received from the imaging sonar in general have low contrast, and deteriorative edges. Depending on the acquisition conditions, the Signal to Noise Ratio (SNR) can sometimes be very low. The presence of edges in sonar images is relatively rare. Sonar is mainly used for object recognition and obstacle avoidance of Autonomous

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Peer-review under responsibility of the Organizing Committee of CMS 2016
doi:10.1016/j.procs.2016.05.266

underwater vehicles (AUV's). The sound waves generated by the active Sonar travel through underwater to the target, and are returned as Sonar echoes to a hydrophone, which converts sound into electrical signals. With the advancement of technology there are Imaging Sonars who scan the area in front of the AUV and provide the images as output. The images in the Sector-scan sonar are produced by a sensor array which electronically scans a horizontally narrow beam to insonify an arc in a set direction. Because of time varying and space varying characteristic of underwater acoustic environment, the Sonar images have poor quality and noise, so traditional image segmentation methods are unable to achieve precise segmentation. In collision avoidance applications of Autonomous Underwater Vehicles (AUVs), identification of objects, extracting their motion parameters are to be carried out in a short period of time so as to avoid the obstacles in front of it for its safe maneuvering. Therefore the object recognition from the sonar images, especially complex object, is one of the important research topics in the field of sonar image processing. By keeping the time parameter as the constraint and also considering the noise characteristics of the Sonar images, we have proposed two algorithms. In first algorithm segmented images are combined to a single image called image fusion, which retains the important features of the images from individual segemented images. Using this technique, an image is processed to identify the possible objects present in it. But this method is failed to retain some of the edges of the target. In the second algorithm, expectation maximization technique is applied to the segmentation methods which performs better in retaining edges of the targets.

2. Edge Detection

Edges are the clues towards the analysis and interpretation of image information. Sudden, sustained changes in image intensity are called edges. Edge detection is the process of determining which pixels are the edge pixels. The result is an edge map. Using this technique, one can extract the features of the objects either statically or dynamically. Edge detection of an image reduces significantly the amount of data and filters out information that may be regarded as less relevant, preserving the important properties of an image. The edge detection methods can be grouped into two categories, search-based and zero-crossing based. The search-based methods detect edges by looking for maxima and minima in the first derivative of the image, usually local directional maxima of the gradient magnitude. The zero-crossing based methods search for zero crossings in the second derivative of the image. The various methods used in the edge detection can be classified as Gradient based Methods, Laplacian based methods or Diffusion based methods[1]. The edge detection methods based on difference operation are also used in image processing. It could detect the variation of gray levels, but it is sensitive to noise. In order to improve the ability of noise rejection, a ratio of gray levels between 2 successive image points is used to denote the variation of gray levels. The advantage of this detection method is that the sensitivity of edge detection can be adjusted easily. The results are shown in Fig.1.

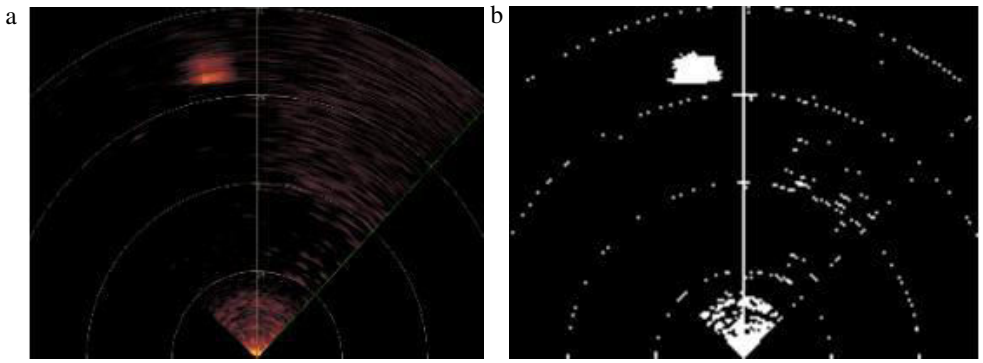

Fig.1. Results of the Edge detection method (a) Input Image; (b) Output Image