Article

Synthetic Aperture Radar (SAR) image segmentation by fuzzy c-means clustering technique with thresholding for iceberg images

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Received 27 December 2013; *Accepted 5 February 2014*; *Published online 1 June 2014*

Abstract
Fuzzy c-means (FCM) clustering algorithm is widely used for image segmentation. The purpose of clustering is to identify natural groupings of data from a large data set, which results in concise representation of system's behavior. It can be used to detect icebergs regardless of ambient conditions like rain, darkness and fog. As a result SAR images can be used for iceberg surveillance. In this paper we have investigate FCM with thresholding for iceberg image segmentation for Synthetic Aperture Radar (SAR) images. The results showed that the assessment parameters; mean and entropy have lower values for efficient segmentation.

Keywords Synthetic Aperture Radar (SAR); fuzzy c-means clustering; thresholding; image segmentation.

Computational Ecology and Software
ISSN 2220-721X
URL: http://www.iaees.org/publications/journals/ces/online-version.asp
RSS: http://www.iaees.org/publications/journals/ces/rss.xml
E-mail: ces@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Image segmentation is a preliminary step in pattern recognition and scene analysis understanding. It partitions the image into its constituent regions and objects. Image processing is effected by illumination conditions, environmental disturbances, noise and temperature fluctuation. Under some severe conditions of unexpected and improper illumination, the blurring of images makes it very difficult for target recognition, so under such conditions segmentation is necessary. The SAR system is used in investigating environmental and ecological activities (Hussain, 2012). SAR images are not affected by clouds, sunlight, day and night effects. The satellites and airplanes equipped with SAR are used to monitor icebergs. SAR is an active microwave that captures images (Topouzelis, 2008). One of the most important applications of SAR system is to collect the data from the ground surface through image reconstruction. The ground surface has different areas such as roads, deserts, pounds, buildings, grassland and cultivated plants, so those areas have to be segmented according to the applications. Thus segmentation problem arises and because of this various segmentation methods have been proposed. Correct segmentation is an important issue in SAR image segmentation. Several methods are used for SAR image segmentation such as clustering algorithms, threshold methods and morphological methods. This paper reexamines the approach of SAR clustering based image segmentation. Fuzzy clustering has a potential application in the fields of image processing and pattern recognition. Some of the recent research includes an Improved FCM Algorithm Based on the SVDD for Unsupervised Hyperspectral Data Classification (Niazmardi et al., 2013), Fuzzy C-Means Algorithms for Very Large Data (Havens et al., 2012), Weighted Fuzzy C-Means Clustering Algorithm for Remotely Sensed Image Classification (Chen et al., 2011), Unsupervised Subpixel Mapping of Remotely Sensed Imagery Based on Fuzzy C-Means Clustering Approach (Zhang et al., 2014), A Multiple-Kernel Fuzzy C-Means Algorithm for Image Segmentation (Chen et al., 2011), and Change Detection in Synthetic Aperture Radar Images based on Image Fusion and Fuzzy Clustering (Gong et al., 2012).

Clustering is commonly used in pattern recognition, machine learning, biomedical and image analysis. In fuzzy logic FCM is a technique of clustering that allows one piece of data belongs to two or more clusters (Pal and Bezdek, 1995).

This paper is organized as follows: section 2 represents the need for image segmentation. Section 3 discusses the proposed FCM algorithm for the segmentation of SAR iceberg images with thresholding. The simulation results and evaluation of the reconstructed image are represented in section 4 and section 5. Finally, in section 6 conclusions are given.

2 Iceberg Image Segmentation

Image segmentation is used to locate the boundaries and objects in images. One of the most practical applications of image segmentation is to locate the objects in SAR images (roads, buildings, forests etc.) image processing is effected by random noise, environmental disturbances due to atmospheric pressure or temperature fluctuations and illumination conditions, so image segmentation is necessary that divides an image into regions of different characteristics.

SAR image segmentation falls into two categories, a) Segmentation based on grey levels b) Segmentation based on texture. Image segmentation thresholding techniques can be found in (Sahoo et al., 1988). This paper deals with SAR image segmentation based on grey levels with global thresholding technique.

3 Investigating Fuzzy C-Mean Clustering With Thresholding

The investigation is based upon the combination of FCM clustering with thresholding algorithm. Clustering of data is a technique by which large sets of data are grouped into smaller ones.

3.1 Fuzzy clustering sets of clusters of similar data

The partition should have two properties, (a) homogeneity inside clusters: the data, which belong to one cluster, should be as similar as possible; (b) heterogeneity between clusters: The data, which belongs to different clusters, should be as different as possible. Many techniques have been used for clustering data; in this paper fuzzy c-means clustering is used (Sahoot et al., 1988). FCM was developed by Dunn in 1973 (Dunn, 1973), improved by Bezdek in 1981 (Bezdek, 1981), and further developed by many researchers (Cannon et al., 1986; Lyer et al., 2002; Wang et al., 2006; Hussain, 2012).

In 2010, Krinidis and Chatzis proposed research incorporating local spatial information into FCM algorithm to get improved clustering performance (Krinidis, 2010).

3.2 FCM algorithm

FCM divides a set of S-dimensional vectors $X = [X_1,\ldots\ldots,X_n]$ into c clusters. Each cluster is a fuzzy set defined by the sample space $X = [X_1,\ldots\ldots,X_n]$. The i^{th} cluster is presumed to have the center vector $v_i = [v_{i1}, \ldots, v_{is}]$, where $X_j = [x_{j1}, \ldots, x_{js}]$ represents the jth sample for ($j=1, \ldots, n$). FCM determines the fuzzy partition matrix U and cluster centers v_i (1,2,..,c) by minimizing the objective function J which is defined by (1).

$$J(U, v_1,v_2,\ldots,v_c ; X) = \sum_{i=1}^{c} \sum_{j=1}^{n} u^m_{ij}\, d^2_{ij} \quad (1)$$

m in equation (1) adjusts the weighting effect. Large values of m increases the fuzziness where d_{ij} is the Euclidean distance and is defined

$$d_{ij} = \sqrt{\sum_{K=1}^{S} (v_{ik} - x_{jk})^2} \quad (2)$$

v_i and u_{ij} is given by

$$v_i = \sum_{j=1}^{n} u_{ij}{}^m X \Big/ \sum_{j=1}^{n} u_{ij}{}^m \quad (3)$$

$$u_{ij} = 1 \Big/ \sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)} \quad (4)$$

where m≠1

3.3 Thresholding

In fuzzy c-means clustering the segmented part of SAR image is not visible clearly. Thusthresholding is applied on the segmented image (Otsu, 1979; Gonzalez, 2002). There are two techniques of thresholding: local and global thresholding. In local thresholding the image is divided into no of sub-images, the threshold for each sub-images depends upon the local properties of the point. In global thresholding the entire image is segmented with one or more values.

We have used global thresholding method. The thresholded image g(x,y) is defines as

$$g(x,y) = \begin{cases} 1 \text{ if } f(x,y) \geq T \\ 0 \text{ if } f(x,y) < T \end{cases} \quad (5)$$

where T is constant, this approach is called global thresholding (Dunn., 1973).

4 Evaluation of the Reconstructed Images

To evaluate the accuracy of the segmented image following steps are followed.

(1) Iceberg image is taken as input.

(2) Segmentation algorithm is applied on the image.

(3) Assessment parameters are applied for fuzzy c-means clustering algorithm.

The proposed algorithm is applied by using MATLAB .The images are resized to 256x256, performance of the algorithm is evaluated by following assessment parameters. 1) Mean 2) Entropy. Mean and entropy must be a less values for a better segmentation algorithm.

Entropy is the amount of information based on the probabilistic occurrence of the picture elements. These probabilities can be found from the image histogram. Entropy describes the average information of every pixel. The more gray levels are present in the image, the higher the entropy. Suppose that two images have probability functions *p* and *q*, the entropy of *p* with respect to *q* is given by (6).

$$d = \sum_{i=1}^{k} p(i)\log_2 \frac{p(i)}{q(i)} \tag{6}$$

5 Results and Discussion

From the figure 1 the difference between the fuzzy c-means clustering and fuzzy c-means threshold for iceberg images can be observe. The fuzzy c-means threshold gives better representation of the image as compare to fuzzy c-means cluttering.

(a) (b) (c)

Fig. 1 (a) original image (b) FCM (c) FCM with thresholding.

Table 1 FCM with hresholding for Fig. 1.

S.No.	STASTICAL PARAMETERS	ORIGINAL IMAGE	FCM	FCM WITH THRESHOLD
1	MEAN	98.4815	0.4413	**0.2169**
2	ENTROPY	7.3351	4.0313	**0.7545**

(a) (b) (c)

Fig. 2 (a) original image (b) FCM (c) FCM with thresholding.

Table 2 FCM with thresholding for Fig. 2.

SNO	STASTICAL PARAMETERS	ORIGINAL IMAGE	FCM	FCM WITH THRESHOLD
1	MEAN	97.4866	0.4707	**0.1869**
2	ENTROPY	7.4895	7.0259	**0.695**

From Table 1 and 2, the less values of assessment parameters like mean and entropy shows that the fuzzy c-means threshold method is better for iceberg images when compare with fuzzy c-Means clustering. With the overall performance evaluation we can say that fuzzy c-means threshold method gives desirable results when compare to fuzzy c-means method.

6 Conclusion

Fuzzy c-means thresholding method has been tested on various SAR images. The scheme implemented here makes use of thresholding and fuzzy c-means clustering algorithm for image segmentations. This approach made it possible to segment patterns in SAR images, which could go undetected by conventional image clustering methods. This analysis demonstrates how new computational techniques help in satellite imaging for environmental and ecological monitoring.

Acknowledgments

We wish to thank Matthew R. Lopez from Sandia National Laboratories Albuquerque, NM, USA, Ellen O' Leary from Radar Data Center, Jet Propulsion Laboratory Pasadena, CA and J.C Bezdek for facilitating theoretical concepts, and to the Graduate School of Engineering Sciences and Information Technology, Hamdard University for their logistic support and services.

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