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Comprehensive Survey On Computer Aided SAR Image Segmentation and Classification Methods

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Abstract : Synthetic Aperture Radar (SAR)is a satellite imaging technology which uses radio waves for capturing the images. Here a RADAR(Radio Detection And Ranging) is mounted on a moving platform which emits radio waves and the reflected echoes from earth's surface is collected back. Signal processing of these backscattered echoes results in SAR images. The major advantages of SAR imaging is that it is unaffected by weather conditions and can penetrate through cloud and soil. Hence it has got wide range of applications in homeland security, environmental protection, traffic monitoring, 3D map generation, land resource management etc.SAR images are affected by Speckle noise which is multiplicative in nature and is difficult to remove. Therefore despeckling is carried out as a pre-processing step to SAR image segmentation and classification. . Here some papers related to SAR image segmentation and classification for last one decade is being reviewed. Image segmentation and classification are the crucial step for SAR image analysis. SAR image segmentation can be carried out by using either contextual or non-contextual method and from the analysis it is found that contextual segmentation technique is better than other techniques.SAR image classification can be carried out under supervised and unsupervised techniques. And from the analysis it is found that supervised classification methods for SAR image produces better result as compared to unsupervised methods.

Keywords: SAR, RADAR, Despeckling, Segmentation, Classification.

1. INTRODUCTION

SAR imaging consists of large volume of data which are processed over some space-based platform. Therefore it requires fast and robust algorithms for processing and analysis of such type of data. As in many coherent imaging techniques, SAR image have multiplicative noise called speckle. The speckle originates from the interference of the random backscatters with the signals in a resolution cell. The speckle makes it difficult to estimate the image parameters during the segmentation and classification process. So the speckle removal is an important preprocessing technique in the SAR image classification. In this paper Section 2 reviews the various SAR image segmentation methods carried in the last 10 years. Section 3 review the supervised and unsupervised classification approaches of SAR images in the last 10 years. This would help to compare the recent techniques of SAR image segmentation and classification.

2. SEGMENTATION

Image segmentation consists of extracting information from the input image, marking labels to the individual pixel and separating them according to their region types. For extracting maximum information and to reduce data loss , filtering and denoising are used. Segmentation method transfers the large and complex

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image into simple groups based on the features of the given input image. Image segmentation can be carried out by using either contextual or non-contextual method. Generally there are three approaches for segmentation, termed threshold based method, edge-based method, and region-based method. Threshold based segmentation can be directly applicable to all images but it perform segmentation by combining with other processing techniques. Edge based segmentation method is applicable to grey scale images. The edges are identified on the basis of irregularity in the intensity value. Partitions occurred in edge based method are based on sudden changes. Region based segmentation is done on the basis of continuity. Region based algorithm are generally simple and more resist to noise as compared to edge based method.

2.1. Survey on Sar Image Segmentation

In this section we are reviewing some papers related to SAR image segmentation in chronological order.

Yongfeng et al.(2005)[1] introduced the segmentation method for SAR images based on Maximisation of Posterior Marginal(MPM). Here model parameters are computed using algorithms such as Expectation maximization (EM) and Iterative Conditional Estimation (ICE).The Segmentation results were obtained in the form of percentage of misclassified pixels. This method is more accurate in calculating model parameters but it takes more time for segmentation.

Guillaume et al.(2006)[2]introduced a region based SAR image segmentation method using stochastic complexity minimization by a non-parametric noise model. This method uses polygonal grid which facilitates choosing regions with arbitrary shapes. Here the average number of misclassified pixels, the classical Hausdorff distance and the number of estimated regions are studied and given as a function of the input image. This method is useful for segmenting different speckle images with underlying textures.

Gui-song et al(2006)[3] introduced a SAR image segmentation method using region based Markov Random Field (MRF) model. The input given is an over segmented SAR image using watershed algorithm .Multi Level Logistic model is used to label the region classes and marginal distribution of each class in the SAR image is done by Gamma distribution. This method is fast approach and obtains better segmentation result based on the characteristics of local statistics but it is time consuming compared to other techniques.

Fang et al(2007)[4]proposed an unsupervised method of segmentation for polar metric SAR images. Here cluster centres are formed by combining with H/α/A. Hierarchical clusters are obtained using Wishart test and thereby forms different number of cluster. Data log Likelihood determines the correct number of classes. This method obtains better segmented result and preserves the detailed structure. The disadvantage of this approach is that the segmentation performance is affected by number of classes.

Haiyan et al(2008)[5]introduced a threshold based SAR image segmentation method by using PCNN method. PCNN is time consuming process which consists of many iterations. So unit linking PCNN with only one parameter is used in this paper. Traditional segmentation algorithm provide a weak performance due to poor quality of SAR image, whereas this method is insensitive to noise intensity. This method is more accurate and fast compared to PCNN.

Qiyao al. (2008) [6] have introduced an iterative region growing segmentation method based on semantics. Here using MRF ,objective functions are formulated and solutions are defined using Iterative Region Growing using Semantics (IRGS). Here images are represented using hierarchical representation. Using domain knowledge and region features the accuracy of segmentation can be further improved. This method, provides much more accurate segmented output as compared to other method.

Frederic et al.(2009)[7]proposed a fast segmentation method for high-resolution SAR images by proposing homogeneous regions. This unsupervised method is based on Fisher Probability Distribution Function (PDF) .Here homogeneous region are segmented with the help of polygon boundaries. During the process PDF parameter is estimated and analyzed for obtaining the accurate segmented result. This method is fast and more robust and disadvantage is that it is only applicable to high resolution SAR images.

Fucheng et al.(2009)[8] introduced a segmentation method based on multi polarisation image fusion. Here images are averaged and region merging is carried out. A novel method for finding out the Ratio Of Averages (ROA) was introduce to developing the image gradient by using the gradients of multi-polarization SAR images. Watershed algorithm is used for initial segmentation and the final segmentation is developed by using region merging with the help of multi polarisation .

Kaan et al.(2010)[9]introduced a novel method based on graph partitioning. Information about edge and matrix of coherence are utilized for accurate segmentation through MSC algorithm that develop an optimum solution. This proposed method is applied on two data sets. This method provide accurate segmented result and disadvantage is that it takes more time for computation.

Yu Li et al.(2010)[10]introduced a novel method for SAR image segmentation on the basis of Voronoi tessellation by using Reversible Jump Markov Chain Monte Carlo (RJMCMC) algorithm.SAR image is partitioned into set of polygons and related components are labelled. Polygon will be having identical intensity values and they follow a gamma distribution. This method is used to reduce the speckle noise effect for the segmentation. This approach improves the precision of segmentation but it is applicable only to SAR image.

Dirk et al.(2010)[11]introduced a SAR image segmentation having high computational efficiency. This method preserves all types of regions in the input image. The initial step in segmentation is taking transform and converting the image into intensity values. This is followed by clustering using region-growing segmentation followed by model-based agglomerative clustering and expectation-maximization. This method is more accurate as compared to other techniques and applicable to only RADAR image segmentation.

Gonzalez et al.(2011)[12]introduced a segmentation method based on Binary Partition Trees(BPT). BPT consist of homogeneous regions of several levels. The development procedure for BPT consists of constructing the region models having homogeneous regions, estimating the similarities between the regions and identifying their difference between the regions. This method has better performance with smooth and more accurate segmented result.

Biao et al.(2012)[13]introduced a segmentation method based on a Maximization of Posterior Marginals(MPM) algorithm with feature extraction and context model. First features are extracted using Gabor wavelet. The intraclass and interclass similarities are calculated. Then the regions are reduced within the same class based on statistical properties to improve the reliability. The segmented result is more efficient and effective as compared to other methods.

Hang et al.(2013)[14] introduced a segmentation method by using context based hierarchical unequal merging. Using Gestalt laws, three rules are designed to guide the superpixel in feature extraction. Extracted features are brightness, edges and textures. Algorithm proposed in this method keep balance between segmentation accuracy and computation speed. This method gives better segmented output and reduce running time.

Fengkai et al.(2014)[15]introduced a SAR image segmentation method based on statistical region merging(SRM) algorithm. This method reduces the noise effect and it doesn't depend on other distribution. SRM is applicable to both RGB and gray images having additive or multiplicative noise. Final result of this method is more accurately segmented output but requires more number of iteration for getting the output.

3. CLASSIFICATION

Satellite image classification techniques classify images mainly into forest, urban, agricultural, water body and other type of features. Image classification can be mainly carried out in three ways-Supervised, Unsupervised and Object Based classification techniques. When the user chooses samples ie. the training set for each class in the image then it is called the supervised classification. In the unsupervised classification first the pixels are grouped and are known as clusters which is based on the reflectance statistics of pixels.

After the cluster generation computer techniques are used to determine which pixels are related to which class. The user will also specify the algorithm in which the user should have knowledge of the area being classified. Object-Based (or Object-Oriented) classification uses the multiple bands for multiresolution segmentation and classification. After identifying the sample site for each, the classification is performed. The software used in the object based classification, classify the object based on this concern and their resemblance to the training sets.

3.1. Survey on Sar Image Classification

In this paper we are reviewing some papers related to SAR image classification in last 10 years in chronological order.

Lihai et al. (2006) [16] introduced a novel classification algorithm using Maximum A Posteriori (MAP) criteria via Expectation Maximization (EM) algorithm by combining the joint Gaussian density model. EM algorithm is good choice for incomplete-data problems ,but the correct convergence is close to overlap measure of mixture density. The stable factor and momentum item ensure correct convergence and accelerate the convergence respectively.

Fulong et al. (2007)[17] introduced the Case-Based Reasoning (CBR) method of classification with the help of auxiliary information. The first step in multitemporal SAR images classification is construction of case library which removes fake cases to ensure high accuracy. This is followed by case-based classification depending on similarity assessment. Then an object-oriented post-classification method is carried out by taking into account the shape of land.

Chamundeeswari et al.(2007)[18] introduced an unsupervised classification of SAR images by block based segmentation and contour tracing. Here the image is divided into blocks and each block is checked for homogeneity of gray levels, textural patterns and edges. These locks are grouped and labeled based on the regions. The isolated homogeneous or edge blocks with small regions are labeled as undecided during the process. During the final step the undecided blocks which are assigned to the neighboring homogeneous regions.

Celine et al. (2007)[19] introduced a three step process for classification namely information extraction, fusion and correction . In the first step the image is converted into high level information using filtering and object based classification. In the second step a height map is obtained by merging the new images with the Markovian framework. Third step by computing layover and shadow from the estimated Digital Surface Model(DSM) and finally classification.

Zhe et al (2008)[20] introduced a Contourlet transform and a minimum distance classifier based texture classification method for the SAR images. Here image is first decomposed into first order statistical features and the texture feature vector is constructed. The Euclidean distance is used for measuring the texture similarity. Here classification is carried out by minimum distance classifier.

Vijaya et al.(2009)[21] introduced an unsupervised SAR image classification in various land areas like water, urban and vegetation. The textural features are fused using Principal Component Analysis (PCA), to make the algorithm adaptable and principal components are used for classification purposes.

Jian et al.(2010)[22] introduced the scattering center model based SAR image classification method. Here a matching scheme between the regional features extracted from SAR images and the scattering center templates are carried out. Experiments using data predicted by electromagnetic code verify the validity of this method.

Jie et al. (2011)[23] introduced an effective fused feature sets for local feature representation formulated in Bag-of-Visual-Words(BOV). From these low level feature words more suitable visual are chosen. Clonal Selection Algorithm(CSA) is used to optimize the prediction error of *k*-fold cross-validation. At last classification is carried out using these learned visual words.

Mery et al (2011)[24] include a statistical model G0 application in the classification process along with Markovian segmentation. G0 models the areas which have heterogeneity with different degrees. Parameters are estimated using an iterative conditional estimation method.

Pierre et al(2011)[25] introduced a method for classification based on a statistical test of equality of covariance matrices. Here classification is carried out in heterogeneous clutter using the Spherically Invariant Random Vector (SIRV) model. Different distance measures are compared.

Gerard. et al(2011)[26] introduced a method for SAR image classification based on Fuzzy Logic (FL) decision rule. The first stage is radar signature isolation done by clustering and analyzing the reflexivity histogram. Then parametric vector (P) estimation is done and the measured vector are correlated by evaluating the decision rule with FL. In the last stage decision rule is evaluated with FL so that the measured vector P is correlated with the vectors associated with a set of reference categories.

Daniela et al.(2012)[27] introduced a scheme using the two levels of Bayesian inference which is an evaluation of two despeckling and texture extraction model-based methods such as Gauss–Markov random field and Auto-Binomial Model (ABM) .Determining the best model using an evidence maximization algorithm and calculating a maximum a posteriori are done by both the methods. Supervised classification, Unsupervised classification and confusion matrices are used for determining the accuracy of modeling and characterization of texture.

Koray et al(2013)) [28] introduced a model based classification combining amplitude and texture statistics of the SAR images. In a finite mixture model the class amplitudes bring together the Nakagami densities and to model the texture of classes a 2-D auto-regressive texture model with *t*-distributed regression error is used. Expectation-Maximization algorithm is used for classification.

Yifang et al(2013)[29] introduced an Edge-Aware Region Growing and Merging (EARGM) algorithm. For integrating all edge images a majority voting approach is used and an edge detection is done using a Sobel filter. During segmentation process it is ensured that the segments do not grow over edges. The support vector machine is used for performing the classification.

4. CONCLUSION

This paper reviews few papers related to image segmentation and classification from 2005 to 2015 in a chronological order. The aim of image segmentation is to partition the large images into different regions. Image segmentation depends on the various factors such as homogeneity, spatial dependency of the image, shape of the image and data content in the image. Segmentation process also depends upon quality of the given input image. As future directions , it is preferable to perform despeckling prior to segmentation and classification in the case of SAR images. From the current analysis all segmentation process has its own advantages and disadvantages. From all analysed methods region based method is simple to implement and more resistant to all type of noise. From the analysis of the review ,it is found that local methods used for image segmentation are not immune to the noise. In future, segmentation can be done by adopting more advanced algorithms. Similarly from the survey of classification approaches the supervised classification is found to be more accurate but it heavily depend on skills of the image specialist . The prior knowledge such as personal experience with the region and experience with thematic maps are required for perfect classification. For future classification process, supervised classification method is preferred as it produces better results as compared to unsupervised classification.

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