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Target Detection in SAR Images using Morphological Filtering

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ABSTRACT

This project proposes a novel saliency-based SAR target detection method that employs morphological filtering to enhance the accuracy and reliability of target detection. The proposed method first calculates the saliency of each pixel in the SAR image, based on the contrast and similarity of neighboring pixels. The saliency map is then thresholded to select the most salient pixels as potential targets. To reduce false alarms and improve target localization, morphological filtering is applied to the saliency map, using a set of structuring elements of different sizes and shapes. The filtered saliency map is then segmented using a threshold, and
the resulting regions are labeled as targets or clutter. The proposed method is tested on a variety of SAR images, and the results demonstrate its effectiveness in detecting targets with high accuracy and low false alarm rates, even in complex scenes with multiple targets and clutter. The proposed method is computationally efficient and can be applied in real-time SAR target detection applications.

KEYWORDS: SAR Images, Image Processing, Morphological Filtering, Bayesian Inference.

1.INTRODUCTION

With the quick development of synthetic aperture radar (SAR) imaging technology, the resolution of SAR images becomes higher and higher. Target detection, the first stage of the SAR automatic target recognition , is widely used in the military and civilian fields. However, target detection in high-resolution SAR images still faces some difficulties, especially in the complex scenes, such as urban areas. The constant false alarm rate (CFAR) which resorts to the pixel-level intensity differences between the targets and clutter, is commonly used for target detection in SAR images . A widely used CFAR is the two-parameter CFAR , which assumes the background clutter obeying the Gaussian distribution. The performance of the two-parameter CFAR is good in some simple scenes with high signal-to-clutter ratio (SCR), e.g., in situations where a single target is located in the homogeneous background, however, it may suffer from the performance degradation in some complex scenes with low SCR, e.g., in multitarget situations and urban areas. Moreover, the detection performance of CFAR is easily affected by the speckle noise, since CFAR is a pixel-based detection method. Some studies have been devoted to reduce the speckle noise of SAR images . Yue and Jiang despeckled the SAR images in the nonsubsampled contourlet transform domain based on

maximum a posteriori and nonlocal constraint. Xu et al. filtered the SAR images in the nonlocal principal component analysis domain. Both Yue and Xu denoised the SAR images in a nonlocal manner, which can improve the speckle filtering performance. The nonlocal filters are different from the classical local filters, such as Gaussian filters, in two aspects. First, the nonlocal filters use the patch centered at the pixel rather than the single pixel for filtering, which can include some regional information of the pixel. Second, the nonlocal filters select the homogeneous pixels,i.e., the pixels which are similar to the current pixel to be filtered, for filtering from a nonlocal area, rather than from a local area surrounding the current pixel. Recently, Yu et al. proposed a superpixel-based CFAR target detection method for SAR images. Yu et al. did not use any speckle noise reduction methods to preprocess the SAR images, instead, they introduced the superpixels into their target detection method, which is robust to the speckle noise. However, both the conventional CFAR and superpixel-based CFAR have the following disadvantages. First, it is difficult to choose an appropriate clutter statistical distribution for target detection, especially in the complex scenes, and an inappropriate model will lead to a poor detection performance. Second, it is difficult to eliminate the numerous man-made clutter false alarms, such as buildings, with only considering the intensity differences between the targets and the clutter. Third, it is difficult to detect the targets which have low local contrasts but high global contrasts by just using the background clutter surrounding the targets.

2. LITERATURE SURVEY

[1] **J. -C. Ni, Y. Luo, D. Wang, J. Liang and Q. Zhang, Saliency-Based SAR Target Detection via Convolutional Sparse Feature Enhancement and Bayesian Inference, in IEEE Transactions on Geoscience and Remote Sensing, vol. 61, pp. 1-15, 2023, Art no. 5202015, doi: 10.1109/TGRS.2023.3237632.**

In this paper, to improve object detection performance withsparse SAR images as input, we propose a different difference method to meet Bayesian salience detection requirements.The propose Bayesian salience co-detectionmethod consists of the following three steps: First, we propose a convolutional L1 method to obtain sparse SAR images with regular contours and fewer holes in the object area. Secondly, an optimization method is quickly provided to get a constant confirmation that the search is clear. Finally, object detection results are obtained with a superpixel-based Bayesian saliency joint detector. Many experiments have found that the proposed method can improve the accuracy of SAR target detection in challenging backgrounds.

[2 **Z. Wang, L. Du and H. Su, Target Detection via Bayesian-Morphological Saliency in High-Resolution SAR Images,in IEEE Transactions on Geoscience and Remote Sensing, vol. 55, no. 10, pp. 5455-5466, Oct. 2017.**

In this paper, we propose a new Bayesian morphological salience-based object detection method for high-resolution SAR images, which generally includes two steps: Bayesian saliency map construction and morphological saliency map generation. Through Bayesian salience maps, superpixel segmentation and Bayesian framework, it can obtain exact models of luminous objects, including objects of interest and some luminosity.In addition,morphological salience map can highlight objects of interest while removing natural and man-made clutter from previous knowledge of large objects. Experimental results on real miniSAR data show that the detection method is effective.

[3] **W.Yu,Y. Wang, H. Liu and J. He, Superpixel-Based CFAR Target Detection for High-Resolution SAR Images, in IEEE Geoscience and Remote Sensing Letters, vol. 13, no. 5, pp. 730-734, May 2016, doi: 10.1109/LGRS.2016.2540809.**

In this paper, a new superpixel-based constant alarm rate (CFAR) object detection algorithm is proposed for high resolution synthetic aperture radar (SAR) images. The detection algorithm has three stages: segmentation,detection and clustering. In the segmentation stage, SAR images are segmented using the superpixel rendering algorithm. In the detection phase, based on the superpixels produced, the clutter distribution parameters for each pixel will be estimated adaptively, even in the case of multiple objects. Two CFAR measurements can then be used for diagnosis. In clustering, superpixels are found together using hierarchical clustering to obtain matching objects. The

performance of the proposed method was demonstrated using miniSAR data.

[4] **Fei GAO, Aidong LIU, Kai LIU, Erfu YANG, Amir HUSSAIN, A novel visual attention method for target detection from SAR images, Chinese Journal of Aeronautics, Volume 32, Issue 8, 2019.**

This paper presents a visual model for detecting SAR objects, including low-level and high-level methods. In the bottom step, the Itti model is developed based on the difference between SAR and optical images. The top-downstep uses all of the previous information to identify

additional items. A comprehensive survey of motion detector and station object acquisition and verification (MSTAR) data shows that our model improves SAR objectdetection performance across multiple signals compared tovisual standards and other popular reconnaissance methods.conditions and scenarios. In addition, although the resultsobtained by using only the lower level are lower than the proposed methods, the efficiency and suitability of the upper strategy are fully revealed.In conclusion, our visualization theory can be considered a good resource for the SAR research community.

[5] **A. Shakin Banu, P. Vasuki, S. Md Mansoor Roomi, Target detection in SAR images using Bayesian Saliency and Morphological attribute profiles, Computer**

Communications, Volume 160, 2020.

In this paper, an automatic object detection method is proposed for SAR images, which is divided into three different steps: superpixel segmentation, morphological feature profiling,and Bayesian salience map.In the first stepthe SAR input image is divided into small areas by superpixels after a clustering process. In the second step, Bayesian salience maps are used to show objects and morphological feature profiles are used to constrain shadows and highlights. The experimental results of the MSTAR dataset were compared with some popular existing algorithms (superpixel CFAR, local CFAR, PR,global CFAR, MS, BS) which will show that the methods are pleasent good and powerful.

3. EXISTING SYSTEM

In existing project, they proposed to design a Saliency Based SAR Target Detection System using Convolutional Sparse Feature Enhancement and Bayesian Interface to improve the target detection performance using sparse SAR images as input. In this project, we proposed to increase the SAR target detection accuracy by using sparse feature enhancement images as input data. We designed a convolutional sparse feature enhancement method for SAR image saliency detection and established a modified superpixel Bayesian saliency target detector. We analyzed the specific requirements of Bayesian saliency detection for SAR images, which can be listed as follows: first, the speckle noise level of a given image should be low. Second, the intensity difference between the foreground and background of the image should be large. Third, the prior map must be as accurate as possible, and the superpixels corresponding to the target area must be consistent with the real target contour. Following the above requirements, we proposed a convolutional sparse feature enhancement method specifically designed to meet the demands of Bayesian saliency maps. We added a convolution process to the objective function of L1 regularization to reduce holes and preserve the contour of the target, all helpful in the calculation of superpixels. In addition, they proposed a regularization parameter optimization method to automatically obtain optimal regularization parameters for Bayesian saliency detection. The update process of the regularization parameter was correlated with the statistical characteristics of Target Detection In SAR Images Using Morphological Filtering the input MF SAR image and changes in the Bayesian prior map. The proposed method could reduce the number of iterations while maintaining the target detection performance through parameter optimization.We proposed a saliency-based SAR target detection method using sparse feature enhancement-derived SAR images as input. We established a convolutional sparse feature enhancement method specifically designed for Bayesian saliency detection. Adding a convolution operation could reduce holes in the target area and better retain contour information of the target.Through sparse feature enhancement, the image background could be effectively suppressed, and the pixel value of the image foreground could be averaged, resulting in a more accurate Bayesian prior saliency map. In addition, we could obtain better superpixel results by using only intensity information of sparse SAR images. There was no need to design a complex superpixel segmentation model based on the

statistical characteristics of MF SAR images. Thus, the computational complexity of Bayesian saliency detection was reduced. They proposed a regularization parameter optimization method for Bayesian saliency detection. The regularization parameters were updated iteratively, allowing the background noise to be quickly suppressed.The iteration process was stopped when the detection ability of the prior saliency map remained unchanged. This could greatly reduce the iteration number of the sparse feature enhancement process. Through the above innovations, the proposed algorithm can effectively reduce the false alarm rate and improve the target detection performance, especially for images with sparse scenes.

DISADVANTAGES OF EXISTING SYSTEM

- Accuracy of SAR Target Detection is Low.
- Computationally very complex.
- Efficiency of SAR Target Detection is very less.
- Ambiguous Decision making in SAR target detection.
- Highly sensitive to false alarms

4. PROPOSED SYSTEM

Saliency-based SAR (Synthetic Aperture Radar) target detection using morphological filtering is a technique that aims to identify and highlight significant features in SAR images that correspond to potential targets of interest.The proposed method involves the following steps:

Image Preprocessing: The SAR image is preprocessed to remove noise and enhance the contrast of the target features.

Saliency Map Generation: A saliency map is generated using a saliency algorithm that identifies the most important features in the SAR image. The saliency map can be generated using various techniques such as frequency-based methods,contrast-based methods, or machine learning-based methods.Morphological Filtering: Morphological filtering is applied to the saliency map to enhance the target features. Morphological filters such as erosion, dilation, opening, and closing are used to remove noise and enhance the contrast of the target features.Thresholding: A threshold value is applied to the Morphological Filtering: Morphological filtering is applied to the saliency map to enhance the target features. Morphological filters such as erosion, dilation, opening, and closing are used to remove noise and enhance the contrast of the target features.filtered saliency map to binarize the image and identify the potential target regions. The threshold value can be set based on the desired sensitivity and specificity of the detection algorithm.Post-processing: The binary image is post-processed to remove false detections and refine the location of the target regions.Overall, the proposed method for saliency-based SAR target detection using morphological filtering is a promising approach that can enhance the accuracy and efficiency of SAR target detection, especially in complex and cluttered scenes. However, the performance of the method may depend on various factors such as the quality of the SAR image, the choice of saliency algorithm, and the selection of appropriate.

A.Proposed method block diagram

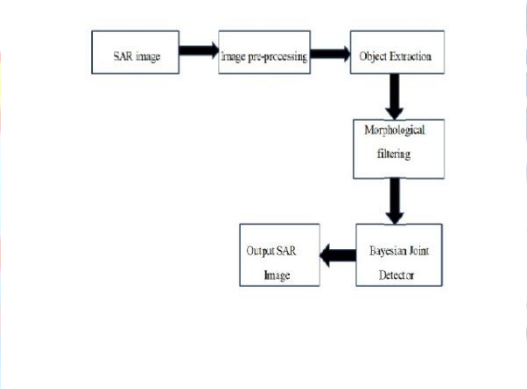

Fig. 1 Block Diagram

B. Introduction to SAR Images

SAR (Synthetic Aperture Radar) images are remote sensing images that are acquired using radar technology. These images are used for a variety of applications, including land and ocean surface monitoring, disaster management, military surveillance, and environmental monitoring. Unlike optical remote sensing images, SAR images can be acquired day or night and in all weather conditions, making them highly useful for many applications.

SAR images are typically grayscale images with high contrast and a distinctive texture. The radar sensor emits electromagnetic waves that are reflected back from the target objects on the ground, and the returning waves are recorded by the sensor. The recorded waves are then processed to produce an image that shows the reflected energy, which is proportional to the target's physical

properties such as surface roughness and moisture content.

Software tool
• MATLAB

Programming Language
• MATLAB Programming Language

5. SIMULATION RESULTS

The name MATLAB stands for Matrix Laboratory. The software is built up around vectors and matrices. This makes the software particularly useful for linear algebra but MATLAB is also a great tool for solving algebraic and differential equations and for numerical integration. MATLAB has powerful graphic tools and can produce nice pictures in both 2D and 3D. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. These factors make MATLAB an excellent tool for teaching and research.

INPUT SAR IMAGE

Fig 2: Input Image

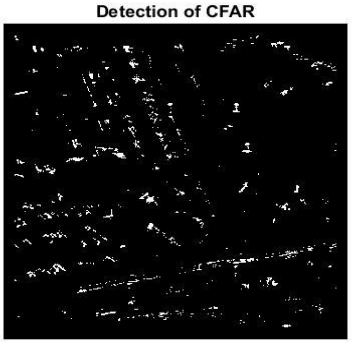

Fig 3: Existing Method Image

PROPOSED METHOD IMAGES

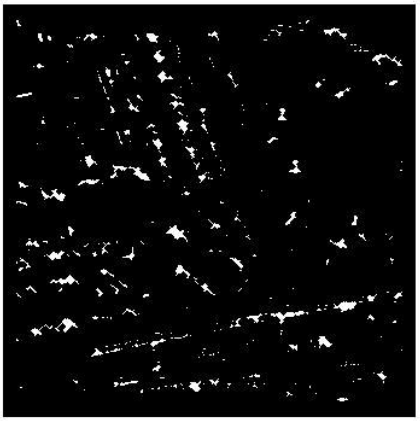

Fig 4: Object Extraction

Fig 5:Morphological Filtered Image

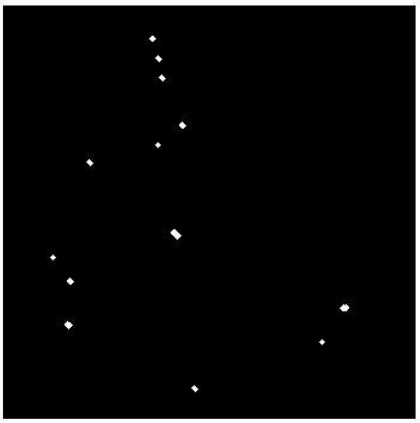

Fig 6:SAR Image with Target Detection

6. CONCLUSION

The saliency-based SAR target detection using morphological filters is an effective approach for detecting targets in SAR images. This approach involves generating a saliency map to identify the most prominent regions in the image and applying morphological filters to extract potential targets. This approach has several advantages, including the ability to suppress noise and clutter, preserve the shape and size of the target, and improve target recognition.

However, this approach also has some limitations, such as the potential for missed targets or false detections if the saliency map is not accurate or if the parameters used for the filters are not optimized. To overcome these limitations, further research is needed to optimize the parameters used for the saliency map and morphological filters, as well as to evaluate the performance of this approach on a larger dataset of SAR images.

7. FUTURE WORK

Further work will reduce the false alarms occurring in the method when the input SAR image exhibits a very complex background, and the computational efficiency of the algorithm will be improved for input images containing large scenes. Some new prior information like edge penalty can also be considered to add to algorithm to further improve the accuracy of super pixel segmentation.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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