반점 노이즈 제거를 통한 YOLOv7 기반 SAR 영상 내 선박 탐지 향상

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Improvement of YOLOv7-Based SAR Ship Detection with Speckle Noise Removal

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Abstract

Synthetic aperture radar (SAR) is one of the most important active imaging technologies in remote sensing. SAR images can provide useful and complementary information for many applications including climate change, environmental and ship monitoring. Unlike optical images, it is challenging to directly apply object detection methods to SAR. Speckle noise in SAR images will seriously interfere with the detection of ship targets especially in inshore scene. In order to further reduce the problem caused by speckle noise interference, we propose a SAR ship detection method based on YOLOv7 with the fusion of speckle denoising. The experimental results in SAR ship detection dataset show that the proposed method can effectively detect ships, which proves the feasibility of the method.

Ⅰ. Introduction

In recent years, synthetic aperture radar (SAR) imaging technology has played an important role in monitoring and rescue due to its all-day, all-weather working, coherent imaging and other desirable characteristics [1]. SAR imaging technology makes up for the inability of optical imaging technology to map surface objects at night and under severe weather conditions. Ship detection in SAR images has broad prospects in both military and civilian fields.

Traditional SAR ship detection methods have certain difficulties in detecting small ships and avoiding complex background interference near the shore. Convolutional neural network (CNN)-based methods are widely used for ship detection in optical remote sensing images. In the process of image generation and transmission, due to the interference of the device itself and the transmission channel, the collected data will contain some noise, which seriously affects the quality of the collected images. Speckle noise is a key issue in SAR image construction due to the coherent demodulation of reflected waves from the many elementary scatterers present in the cell, which interfere in constructive or destructive ways. Most areas in the inshore scene contain distributed speckle noise, which greatly interfere with ship detection.

In this paper, based on the YOLOv7, we integrate the speckle denoising algorithm to achieve more accurate, reliable and fast ship target detection. The experimental results prove the powerful learning ability of the YOLOv7 model and the feasibility of the proposed method.

Ⅱ. Main Method

The you only look once (YOLO) is a single-stage target recognition and localization algorithm based on the deep neural network, which has the advantage of fast processing and can be used in real-time system [2].

Block-matching and 3D filtering (BM3D) is a 3D block-matching algorithm used primarily for noise reduction in images. It is one of the expansions of the non-local means methodology [3]. There are two cascades: a hard-thresholding and a Wiener filter stage, both involving: grouping, collaborative filtering, and aggregation. By matching with adjacent image blocks, several similar blocks are integrated into a three-dimensional matrix, filtered in 3D space, and then the result is inversely transformed into two-dimensional to form a denoised image. The denoising effect of this algorithm is remarkable, and the high peak signal-to-noise ratio (PSNR) can be obtained.

As shown in Fig. 1, we propose a YOLOv7-based SAR ship detection scheme. The proposal steps are divided into pre-processing, data augmentation, YOLOv7-based model training, ship detection prediction and results analysis. Among them, in the inference part, we use BM3D to do speckle denoising first and then predict the ship.

The YOLOv7 is the latest version of the YOLO series [4]. The network is designed with a trainable bag-of-freebies that enables real-time detectors to greatly improve the accuracy without increasing the cost of inference. The YOLOv7 consists of input, backbone, head and prediction as shown in Fig. 2. The backbone is the feature extraction network and feature pyramid network (FPN) is the

enhanced feature extraction network. And the path aggregation network (PANet) is used for combining feature information of different scales. The extended efficient layer aggregation network (E-ELAN) is a framework that enables continuous improvement of the learning capabilities of the network by implementing various feature such as shuffle, expand, and merge cardinality.

The work of the whole YOLOv7 network is feature extraction, feature strengthening, prediction of the object situation corresponding to the prior frame. The overall loss function is consistent with the YOLOv7, composed of a classification loss, a regression loss and an object loss.

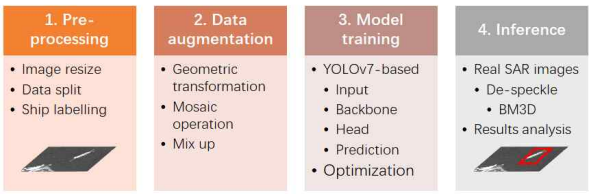

Fig. 1. The proposed YOLOv7-based SAR ship detection scheme.

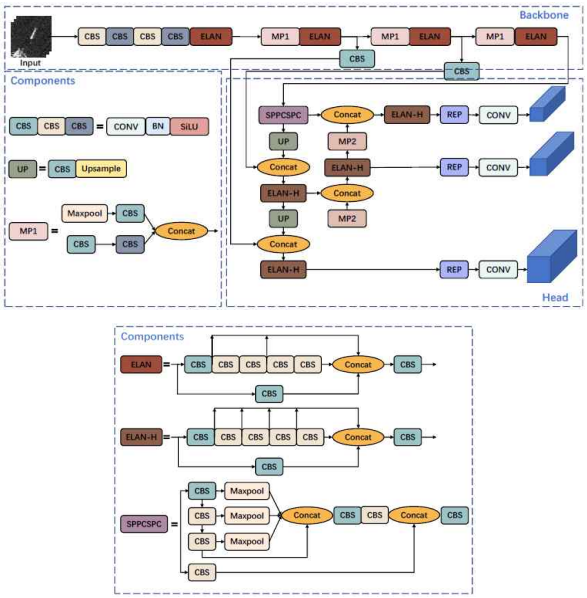

Fig. 2. The network architecture of the original YOLOv7.

Ⅲ. Experimental Results

We use high resolution SAR images dataset (HRSID) as training dataset consists of 5,604 images with 16,591 ship targets [5]. The experiment is run under PyTorch framework of Python. The batch size is set to 8 and training epoch is set to 300. The training process is pre-processed by data augmentation and transfer learning in order to increase the robustness of the network. We use the SAR ship detection dataset (SSDD) [6] to verify the performance of the proposed method. Figure 3 visualizes some sample results. The left column shows ground truth images, the middle column shows the detection results of the original YOLOv7, and the right column shows the YOLOv7 detection results with the speckle removal. These sample results show that the YOLOv7-based method operated by speckle denoising processing can accurately identify most ship targets in complex backgrounds.

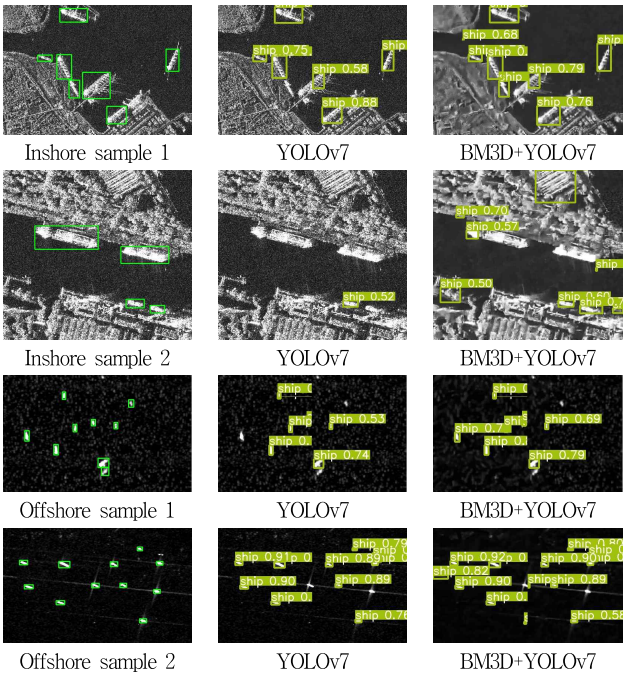

Fig. 3. Sample results of ship detection in the SSDD.

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REFERENCES

[1] A. Moreira, P. Prats-Iraola, M. Younis, G. Krieger, I. Hajnsek, and K. P. Papathanassiou, "A tutorial on synthetic aperture radar," *IEEE Geosci. & Remote Sensing Mag.*, vol. 1, no. 1, pp. 6-43, Mar. 2013.

[2] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You only look once: Unified, real-time object detection," *Proc. IEEE CVPR 2016*, pp. 779-788, Las Vegas, USA, Dec. 2016.

[3] K. Dabov, A. Foi, V. Katkovnik, and K. Egiazarian, "Image denoising by sparse 3-D transform-domain collaborative filtering," *IEEE Trans. Image Process.*, vol. 16, no. 8, pp. 2080-2095, Aug. 2007.

[4] C. Wang, A. Bochkovskiy, and H. Liao, "YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors," *arXiv preprint arXiv:2207.02696*, July 2022.

[5] S. Wei, X. Zeng, Q. Qu, M. Wang, H. Su, and J. Shi, "HRSID: A high-resolution SAR images dataset for ship detection and instance segmentation," *IEEE Access*, vol. 8, pp. 120234-120254, June 2020.

[6] T. Zhang, X. Zhang, J. Li, X. Xu, B. Wang, X. Zhan, Y. Xu, X. Ke, T. Zeng, H. Su, I. Ahmad, D. Pan, C. Liu, Y. Zhou, J. Shi, and S. Wei, "SAR ship detection dataset (SSDD): Official release and comprehensive data analysis," *Remote Sensing*, vol. 13, no. 18, pp. 3690, Sept. 2021.