Guan-qing LI, Zhi-yong SONG, Qiang FU, 2020. A convolutional neural network based approach to sea clutter suppression for small boat detection. *Frontiers of Information Technology & Electronic Engineering*, 21(10):1504-1520. https://doi.org/10.1631/FITEE.1900523

A convolutional neural network based approach to sea clutter suppression for small boat detection

Key words: Convolutional neural networks; Class activation map; Short-time Fourier transform; Small target detection; Sea clutter suppression

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Motivation

1. Current methods for radar target detection usually work on the basis of high signal-to-clutter ratios.
2. Designing detectors or using sea clutter suppression methods based on the distribution density model are ineffective when the target and clutter cannot be divided in the time or frequency domain.
3. Deep networks have strong nonlinear fitting ability, and can learn the essential characteristics of clutter and target.

Main idea

1. We proposed a novel convolutional neural network based dual-activated clutter suppression algorithm, to solve the problem caused by low signal-to-clutter ratios in actual situations on the sea surface.
2. A sampling-based data augmentation method and an effective multiclass coding method are proposed to improve the prediction accuracy.

Method

1. Based on the traditional CFAR detection framework, a clutter suppression module based on a depth network is added. The features extracted from deep network are difficult to explain and the false alarm is uncontrollable. A dual-activation CNN based clutter suppression (DA-CCS) algorithm based on the convolutional neural network is proposed.

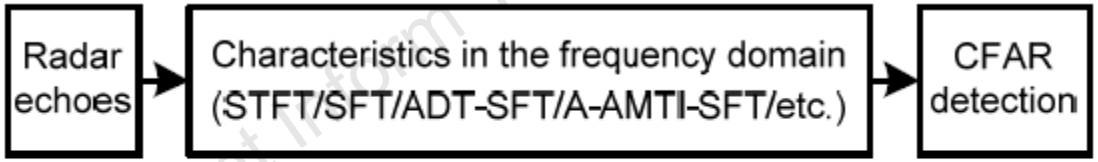


Fig. 2 Flowchart of radar target detection based on traditional methods

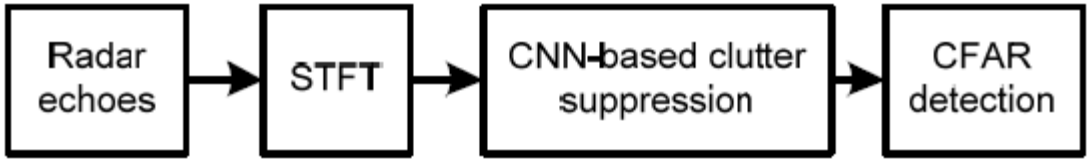


Fig. 3 Flowchart of radar small target detection based on the DA-CCS sea clutter suppression algorithm

Method (Cont'd)

2. The deep network is used to learn the essential features of sea clutter and target, and the feature map of transfer learning is put into the clutter suppression network.

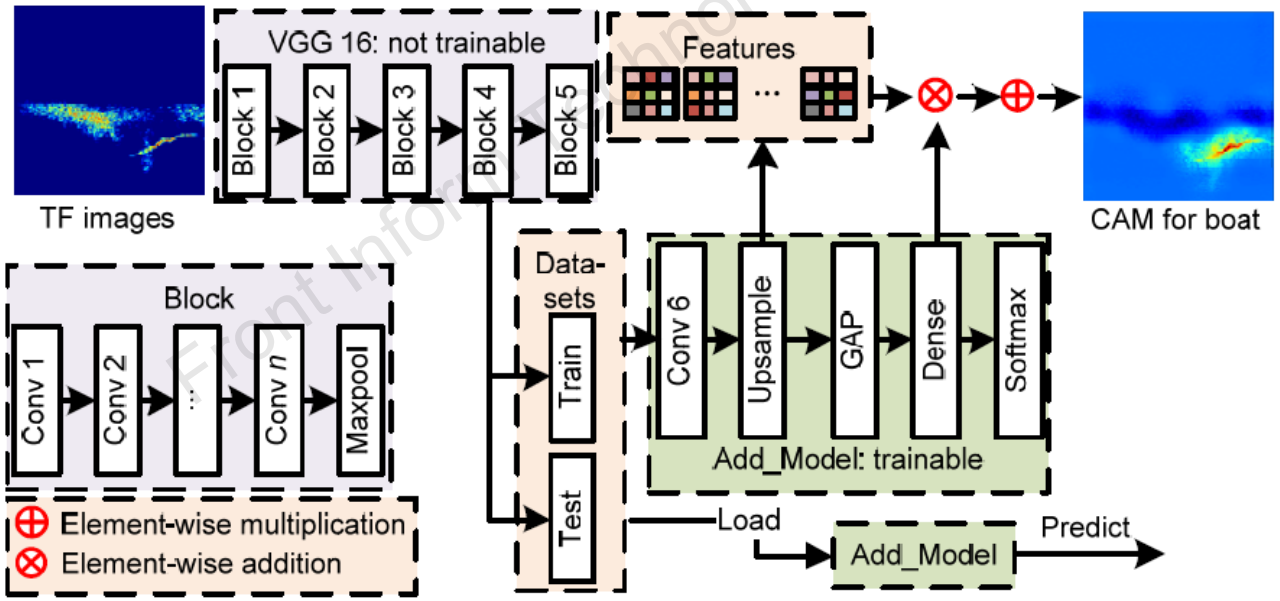


Fig. 1 Flowchart of radar small target detection based on the dual-activation CNN based sea clutter suppression algorithm (TF: time-frequency; CAM: class activation map)

Major results

Class activation map

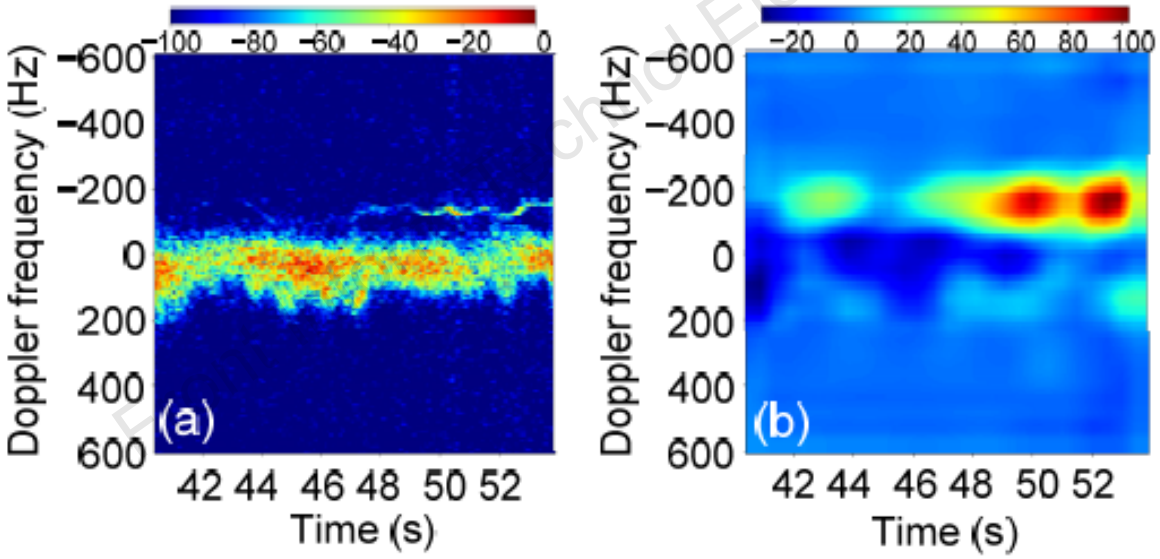


Fig. 11 Time-frequency image (a) and class activation map (b)

Major results (Cont'd)

Sea clutter suppression

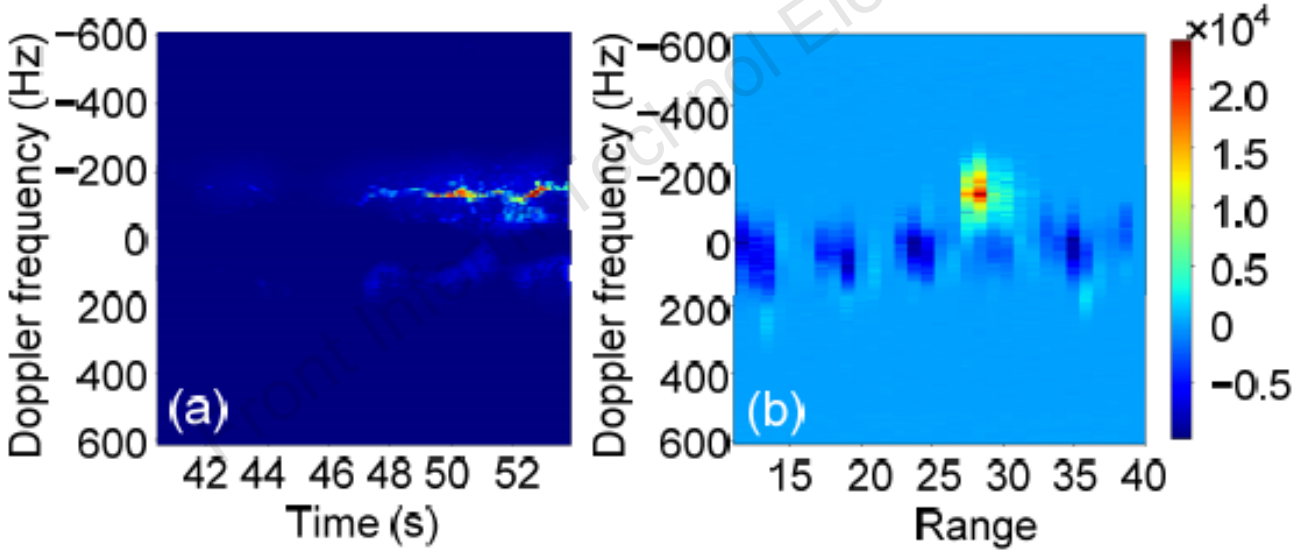


Fig. 12 Time-frequency image (a) and range-Doppler map (b) after sea clutter suppression

Major results (Cont'd)

Predicted trace

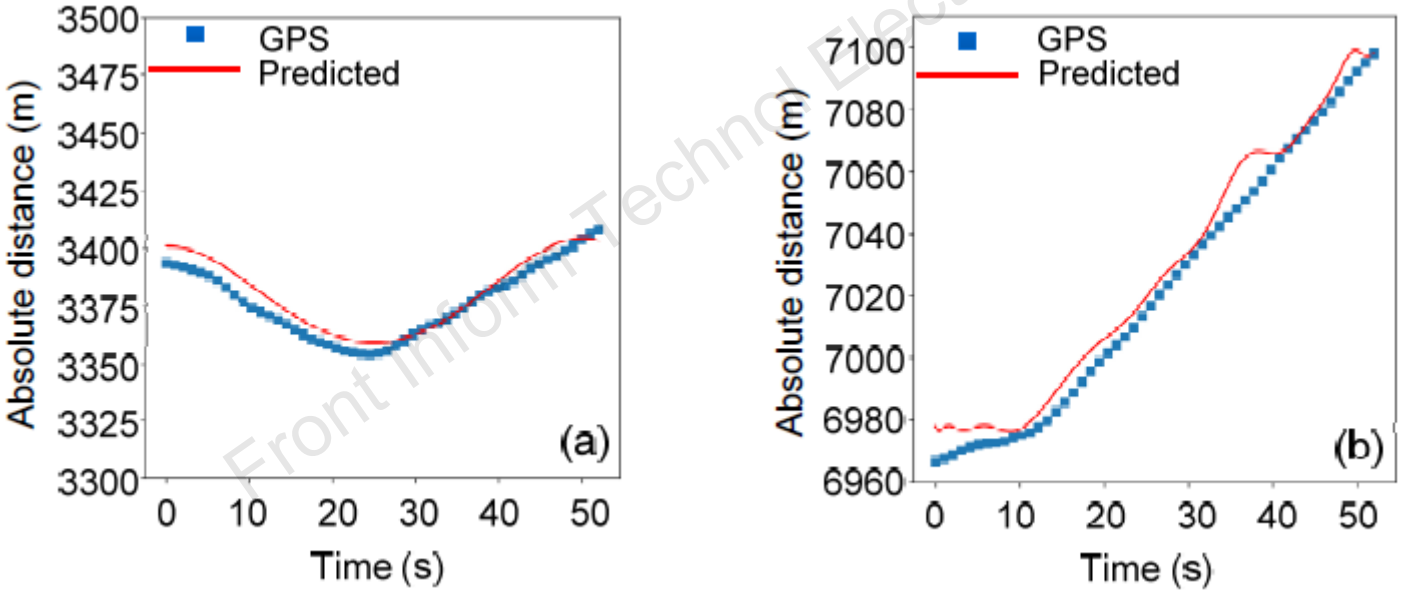
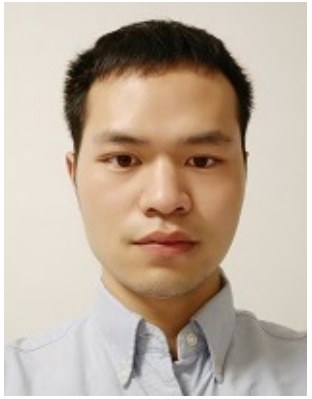


Fig. 21 Traces of the target: (a) TFC17002; (b) farther target

Conclusions

1. A dual-activation CNN based clutter suppression (DA-CCS) algorithm has been proposed for radar small boat detection on the sea surface.

2. The proposed method has excellent detection performance with high accuracy and few false alarms with measurement data.



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