Comparative Study of Feature Extraction Approaches for Ship Classification in Moderate-Resolution SAR Imagery

Shreya Sharma   Kenta Senzaki   Hirofumi Aoki

Data Science Research Laboratories, NEC Corporation

1. Introduction

In maritime surveillance applications, ship classification is one of key functionalities because it provides important information about marine traffic. Synthetic Aperture Radar (SAR) is an effective tool due to its all-weather and day-and-night acquisition capability. A number of studies have reported that ship classification methods based on feature extraction efficiently work with high-resolution SAR images. However, the spatial resolution of practical SAR images for applications in maritime surveillance is limited to achieve wide-area coverage. Therefore, in this paper, we present comparative study on the effectiveness of major feature extraction methods to the ship classification in moderate-resolution SAR imagery, and clarify which approach is the most promising for practical SAR images.

2. Feature Extraction Methods

In this paper, we evaluate three feature extraction methods: hand-crafted feature extraction (HCF) [1], principal component analysis (PCA) [2] and autoencoder (AE) based on neural-network [3].

In HCF evaluated in this paper, seven discriminative features of a ship are empirically selected and employed, which describe its geometric and backscattering properties. The features are: length, area, shape-complexity, compactness, ratio of one-valued and zero-valued pixels along the ship main axis, mean and variance of pixel backscattering values.

In PCA, features are extracted automatically through dimensionality reduction. Each ship image of size $N \times N$ is flattened to a one-dimensional vector of size N^2 by concatenating all rows together. PCA is applied on the ship images to reduce the number of features from N^2 to 177 which is equal to number of ship images in our dataset.

In AE, we use a three-hidden-layer neural network, where the input is a ship image and the output is a reconstructed ship image. The objective is to learn a latent representation of the input image which can be used to reconstruct it. This latent representation is used as features. We empirically set the size of the latent representation equal to 128.

3. Experimental Results

The performance of the methods was tested on 177 ship images (67 tankers and 110 cargos) extracted from 11 SAR scenes acquired by ALOS-2 PALSAR in Stripmap mode. The azimuth and range resolution of the images is 6m x 6m. All ship images were labeled using the ground truth information provided by Automatic Identification System. Figure 1 shows the sample ship images from our dataset.

Table 1. Percentage correctly classified samples for different lengths (multiples of 100 m) and speeds, and accuracy (Acc.).

Method	Length (x100 m)			Speed (kn)		Acc.
	<=1	1-1.5	>1.5	<=10	>10	
HCF	62%	61%	79%	69%	61%	65.4
PCA	60%	69%	81%	68%	**70%**	68.4
AE	**63%**	**70%**	**83%**	**76%**	65%	**70.2**

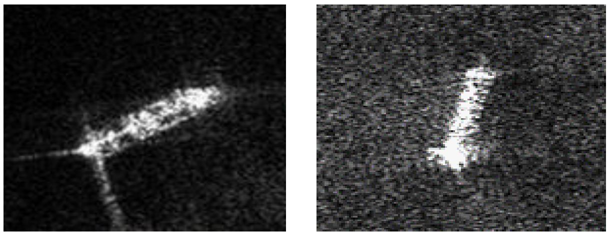

Fig. 1. SAR images of ships (a) tanker, (b) cargo.

Table 1 shows that AE gives the best accuracy which is 7.5% and 2.5% higher compared to that of HCF and PCA, respectively. It also shows that AE achieves the maximum percentage of correctly classified samples even for challenging cases such as small ships. Further analysis of the methods needs to be done for more challenging cases and a variety of resolutions.

4. Conclusion

This paper presented comparative evaluation of conventional feature extraction approaches for ship classification in moderate-resolution SAR imagery. The methods were compared quantitatively for two-class ship classification. The experiments demonstrate that AE-based feature extraction outperforms the other methods and is promising in moderate-resolution SAR images.

References

[1] H. Zhang, et al., “Merchant vessel classification based on scattering component analysis for COSMO-SkyMed SAR images,” IEEE *Geo. and Rem. Sen. Letters,* 2013.

[2] Y. Chen, E. Blasch, H. Chen, T. Qian, and G. Chen, “Experimental feature-based SAR ATR performance evaluation under different operational conditions,” *Proc. of SPIE,* 2008.

[3] C. Bentes, et al., “Target classification in oceanographic SAR images with deep neural network: Architecture and initial results,” *IGARSS, IEEE International*, 2015.