COMPARATIVE STUDY OF FEATURE EXTRACTION APPROACHES FOR SHIP CLASSIFICATION IN MODERATE-RESOLUTION SAR IMAGERY

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1. Introduction

Ship classification using SAR imagery is a key application in maritime surveillance

- In classification, feature extraction is a crucial step
- Current feature extraction methods are designed and evaluated for high-resolution SAR imagery
- **Problem:** High-resolution imagery provides narrow spatial coverage which limits monitored area
- **Solution:** Use moderate-resolution imagery which provides wide spatial coverage and reasonable resolution
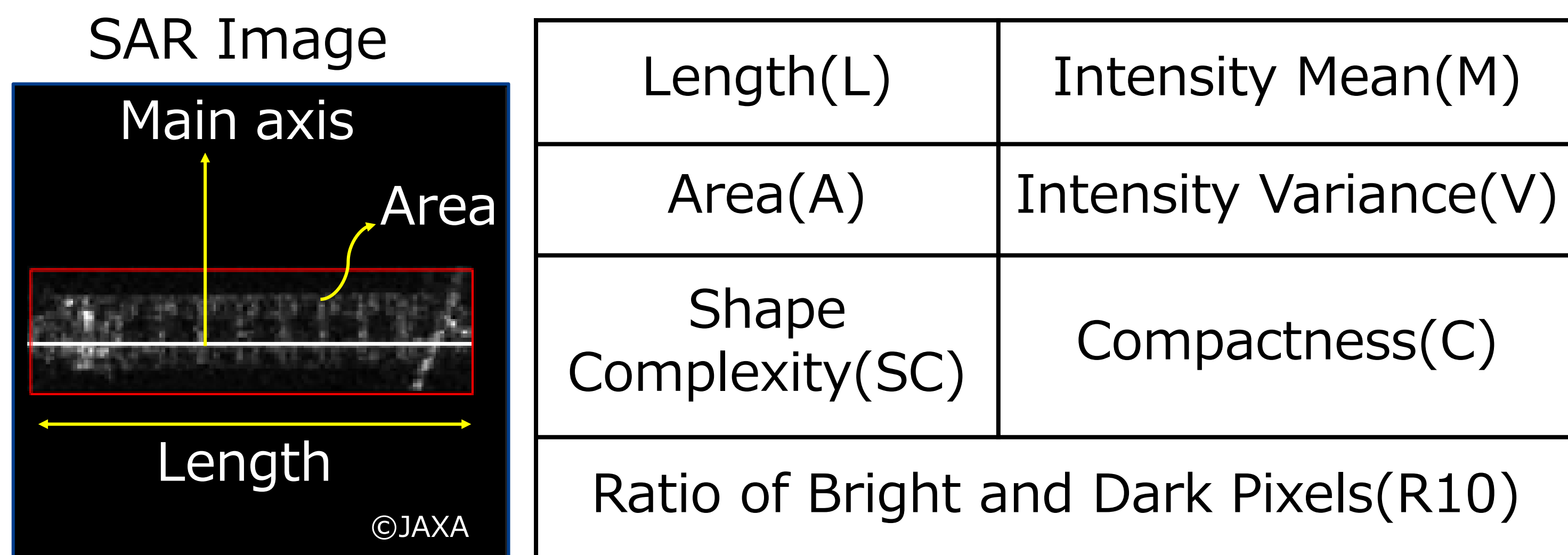
	High-resolution	Moderate-resolution
Resolution	$1\ m$	$6\ m$
Spatial Coverage	Narrow (25x25 km^2)	Wide (70x70 km^2)

Objective
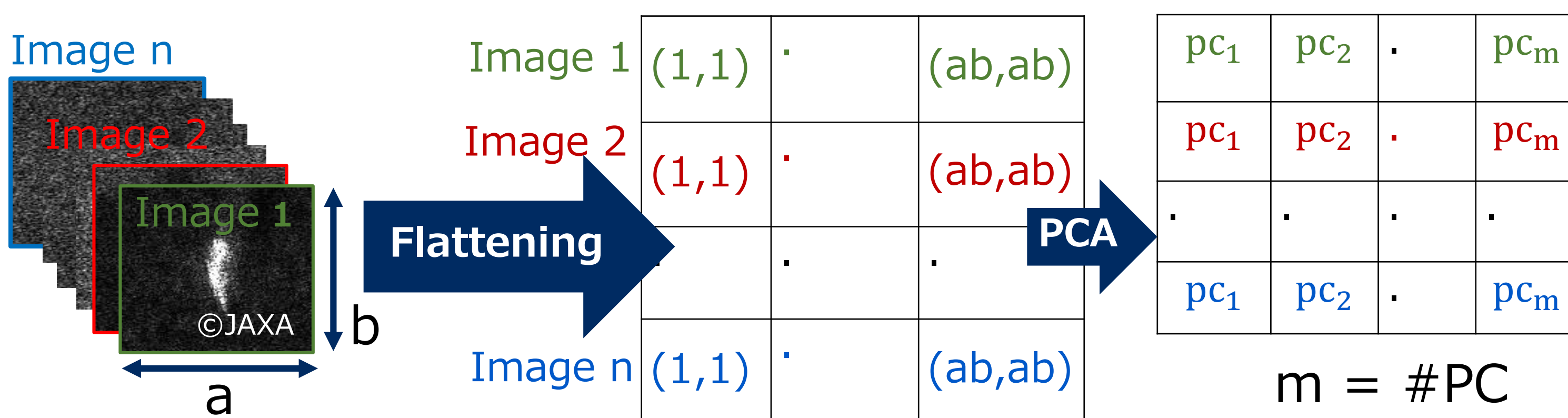### To evaluate the feature extraction methods for moderate-resolution SAR imagery

2. Feature Extraction Methods
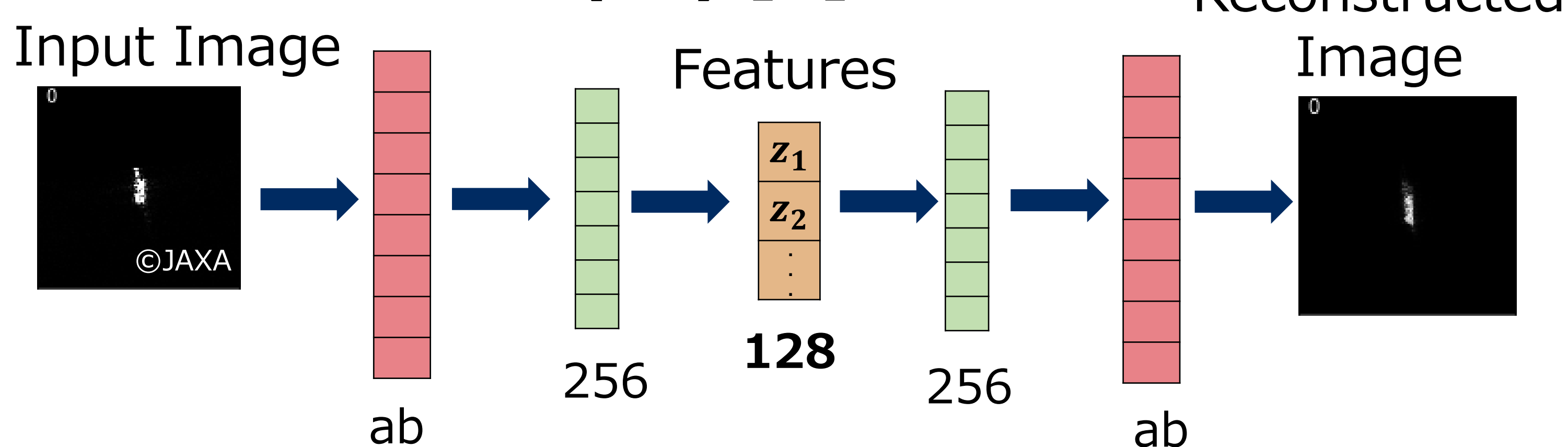
1. Hand-crafted Features (HCF) [1]

SAR Image

Main axis
Area
Length
©JAXA

Length(L)	Intensity Mean(M)
Area(A)	Intensity Variance(V)
Shape Complexity(SC)	Compactness(C)
Ratio of Bright and Dark Pixels(R10)	

Feature Vector : [L, A, SC, M, V, C, R10]

2. Principal Component Analysis (PCA) [2]

m = #PC

Feature Vector : $[pc_1, pc_2, pc_3, \cdots, pc_m]$

3. Auto-encoder (AE) [3]

Input Image
Features
z_1
z_2
Reconstructed Image
ab   256   **128**   256   ab
©JAXA

Feature Vector : $[z_1, z_2, z_3, \cdots, z_{128}]$

3. Evaluation

Ship Classification Procedure

SAR image → Feature Extraction → Classification → Class
Our focus!
SVM
©JAXA
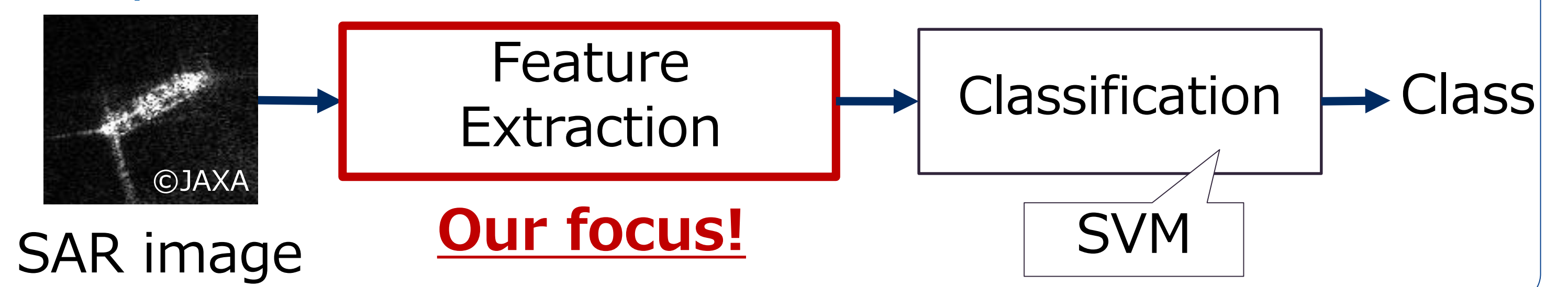
Evaluation Dataset

Class	Optical	SAR
Cargo		©JAXA
Tanker		©JAXA

Specifications

Satellite	ALOS-2
Sensor	PALSAR
Resolution	6 m
Polarization	HH
Image size	128x128
Total images	177
Ground Truth	AIS

Challenging Cases

(a) Small length ships
(b) Fast ships
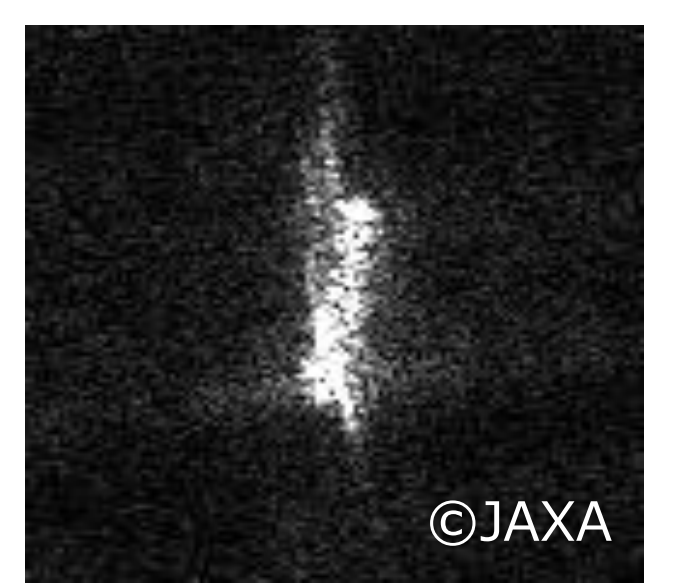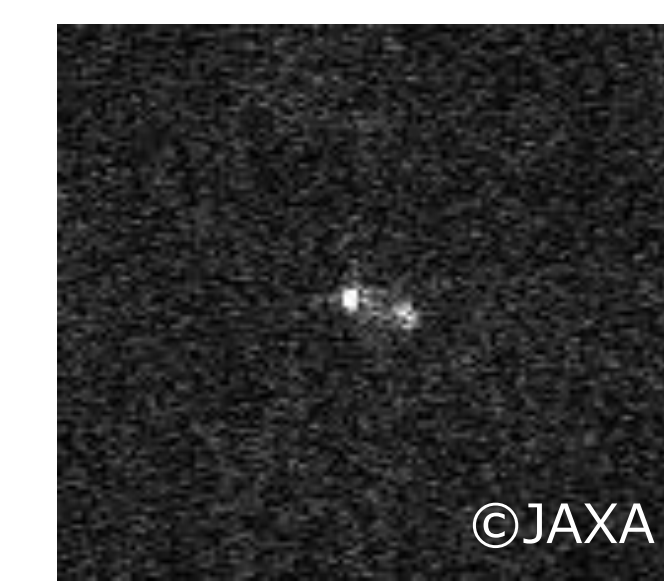
©JAXA   ©JAXA
(a) Less features!   (b) Blurring!

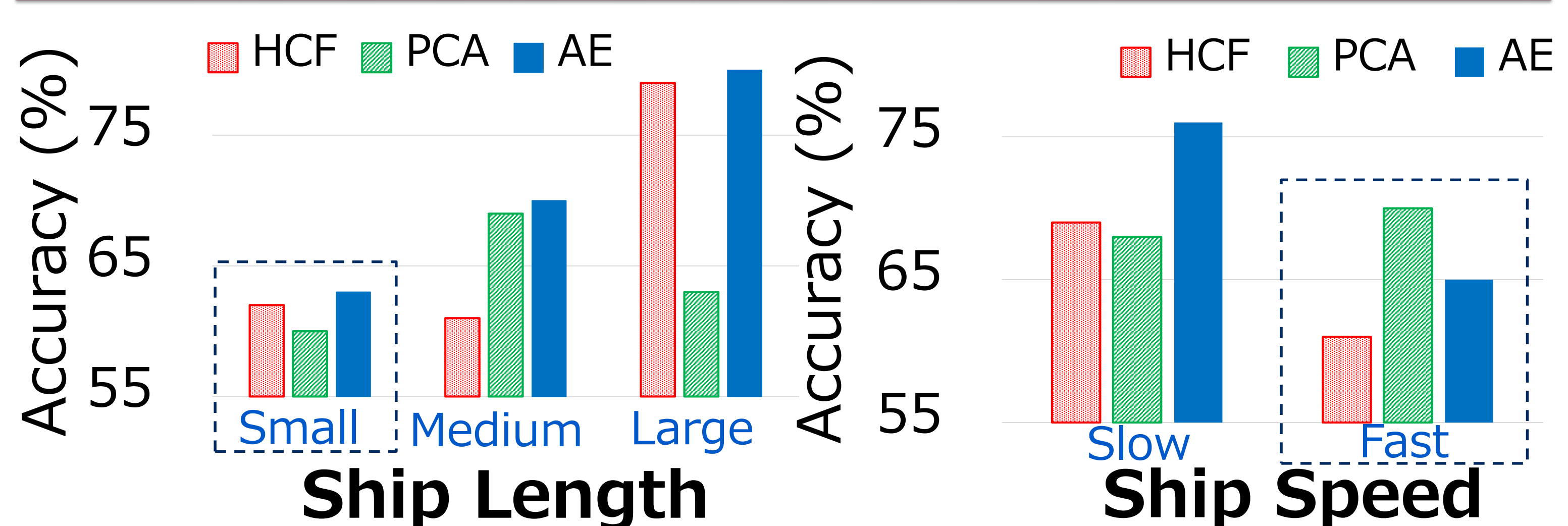### Evaluation Criteria

- Overall accuracy
- Accuracy based on ship properties

Length	Small <100 m	Medium 100-150 m	Large >150 m
Speed	Slow (<10 kn)		Fast (>10 kn)

4. Results

AE outperforms in overall accuracy

65.4   68.4   **70.2**
Accuracy (%)
HCF
PCA
AE
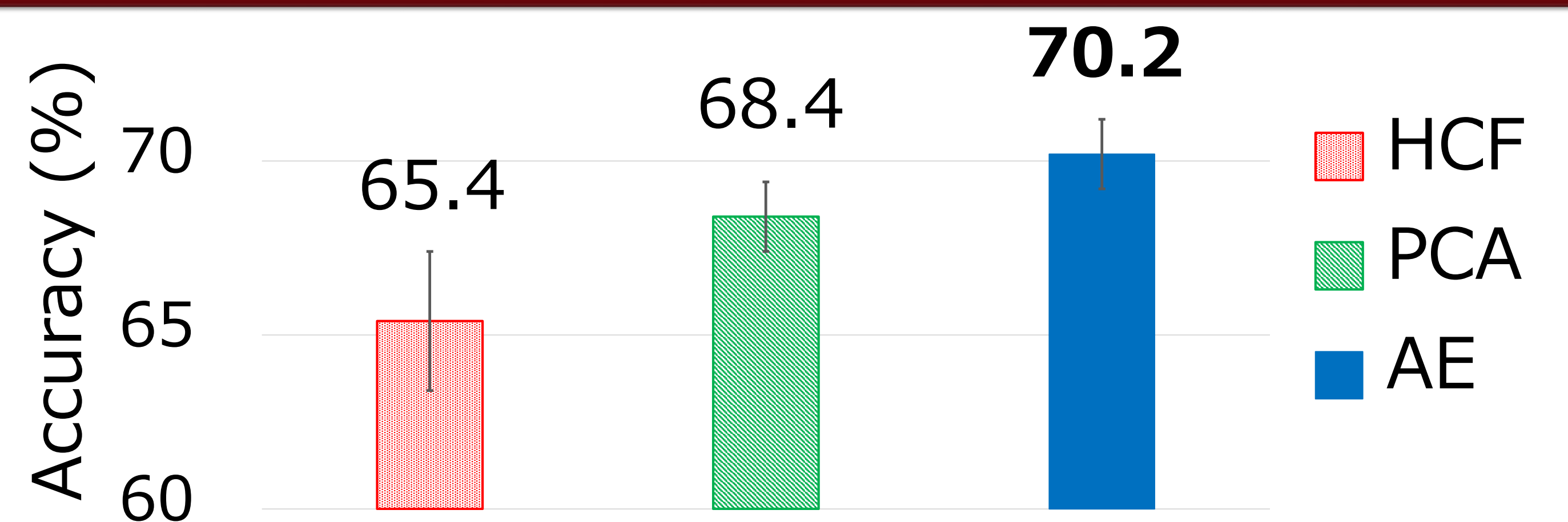
AE outperforms in small length ships, while PCA outperforms in fast ships

HCF PCA AE
Accuracy (%)
Small Medium Large
Ship Length

HCF PCA AE
Accuracy (%)
Slow Fast
Ship Speed

5. Conclusion

- Evaluation of feature extraction methods for moderate resolution SAR imagery has been conducted
- AE outperforms the HCF and PCA methods in overall accuracy by 7.5% and 2.6% respectively
- AE works best for small length ships but gives sub-optimal performance for fast ships

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] Gouaillier, and L. Gagnon, "Ship silhouette recognition using principal components analysis," *SPIE Proc,* vol. 3164, pp. 59-69, 1997.
[3] C. Bentes, et al., "Target classification in oceanographic SAR images with deep neural network: Architecture and initial results," *IGARSS, IEEE International*, 2015.