Towards Geospatial Intelligence with AI

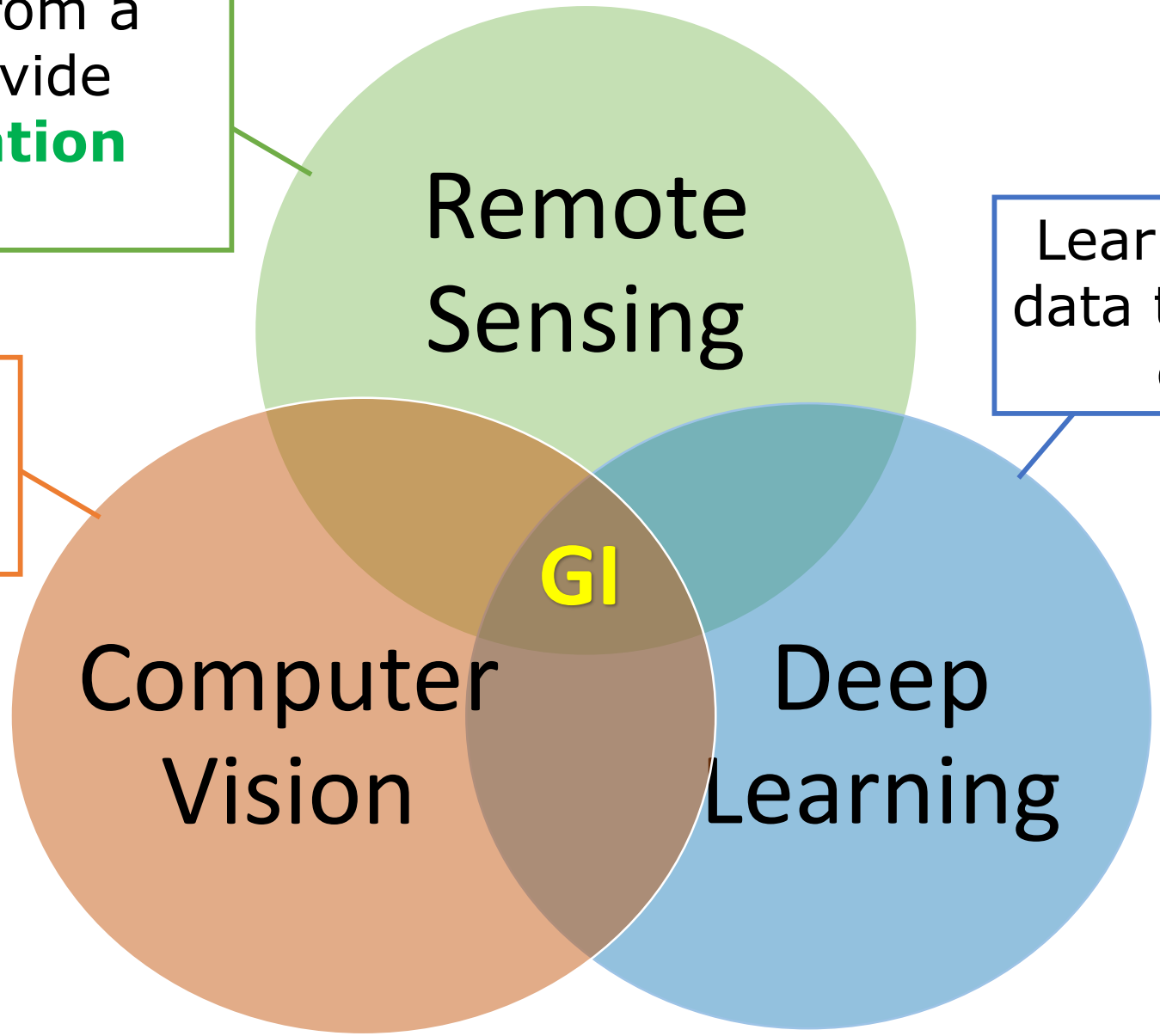
Shreya Sharma
Data Science Researcher
NEC Corporation

What is Geospatial Intelligence (GI) ?

Sensing Earth from a distance to provide **Earth Observation** images

Making **computers** see the world as humans

Learn **patterns** in data through lots of examples

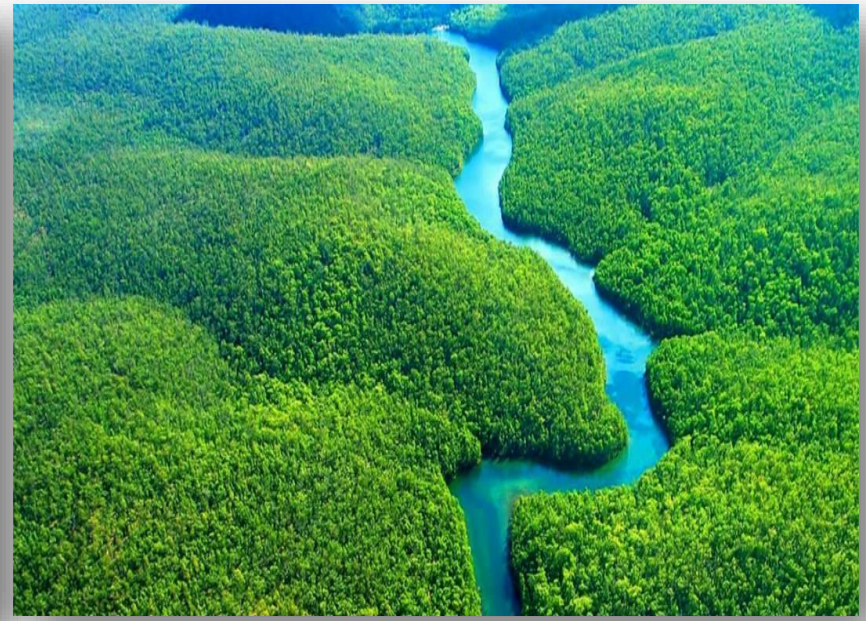


Why Earth Observation (EO) ?

- Currently **only 25%** of the Earth's surface can be seen by ground sensors
- Limits our capability to monitor the entire Earth

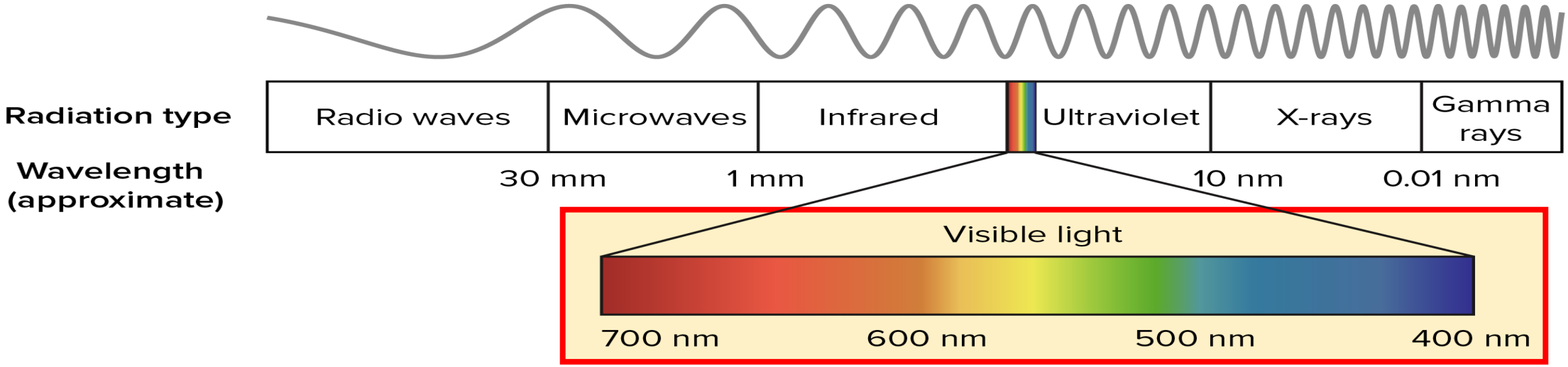
Satellite Earth Observation is 'Eye from the Sky'!





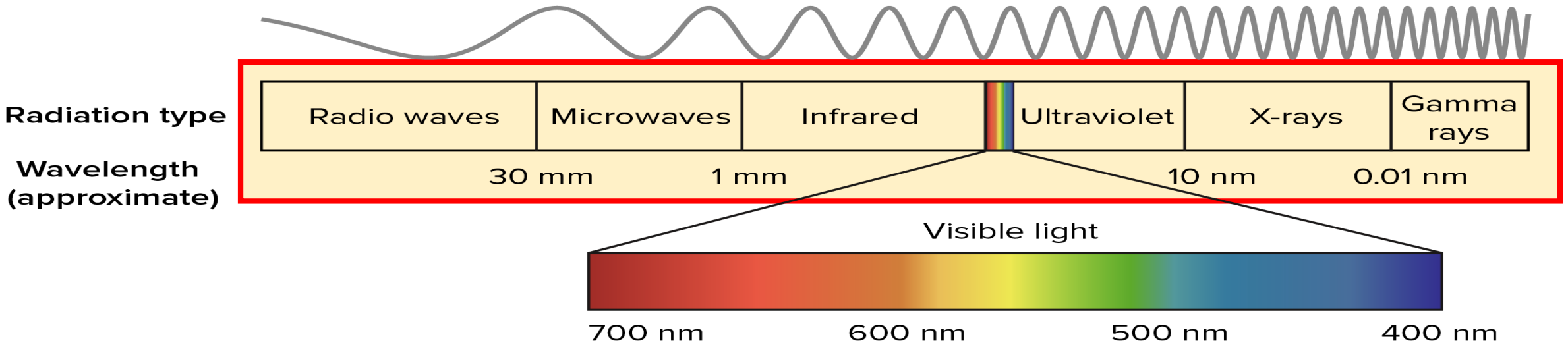
How we see Earth?

Electromagnetic Spectrum

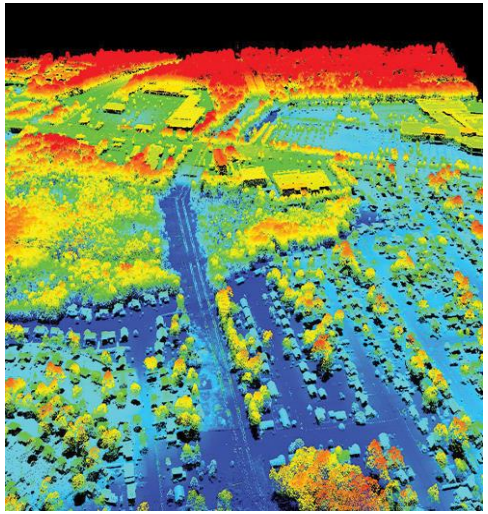


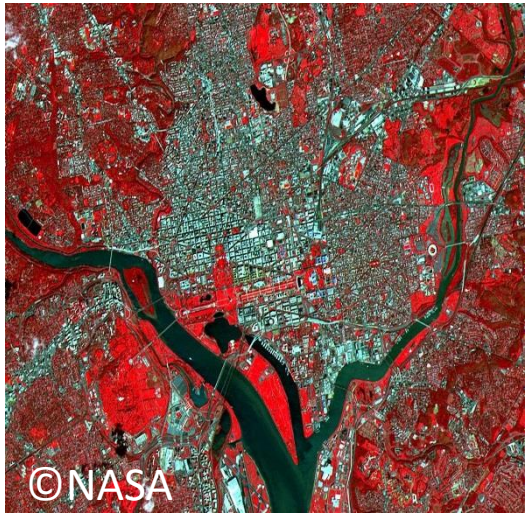
How satellite sees Earth?

Electromagnetic Spectrum



Microwave | LIDAR | Infrared | Visible | Panchromatic

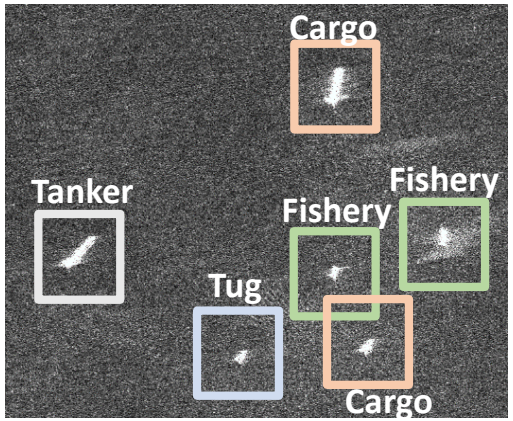




Applications

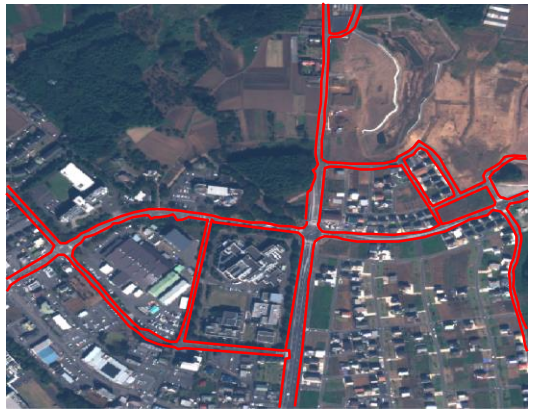
- Recently, so many Earth Observation datasets are coming up
- Deep learning is being used to understand the 'Patterns on our planet'!

Ship Classification



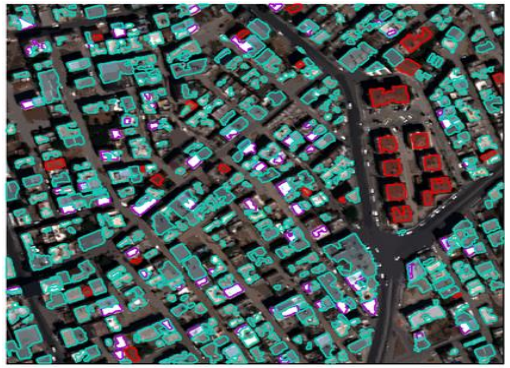
Change Detection

Road Extraction



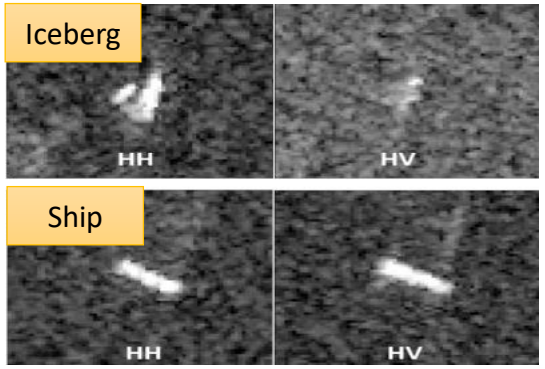
Tree Counting

Building Extraction



Land Classification

Iceberg-ship Detection



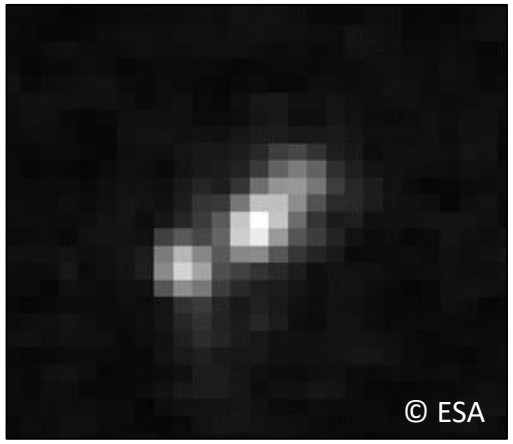
Disaster Response

Diverse applications across industries

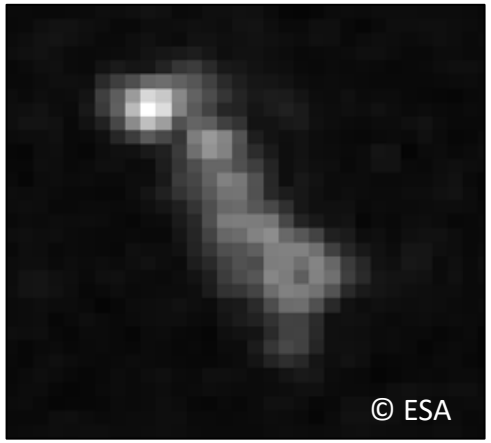
My Research Work : Microwave Images + Deep Learning

- Ship Classification

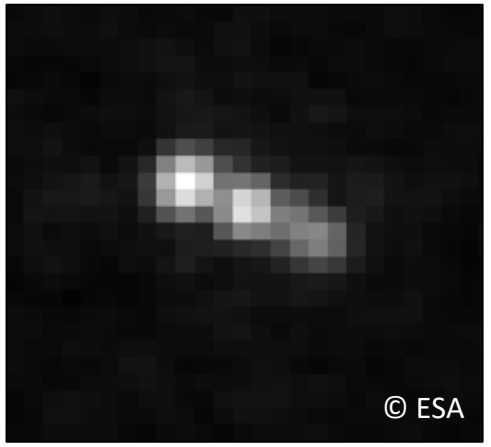
Container



Bulk-carrier



Tanker



- Change Detection

Image at time 1

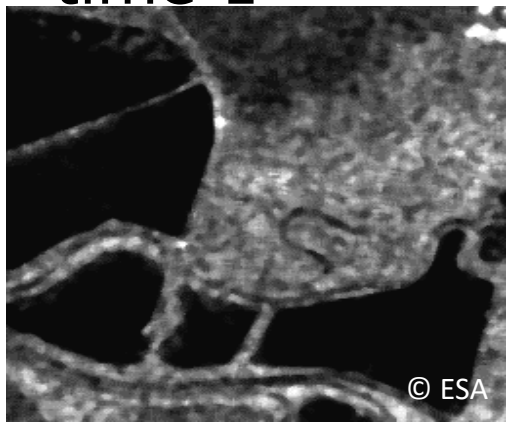
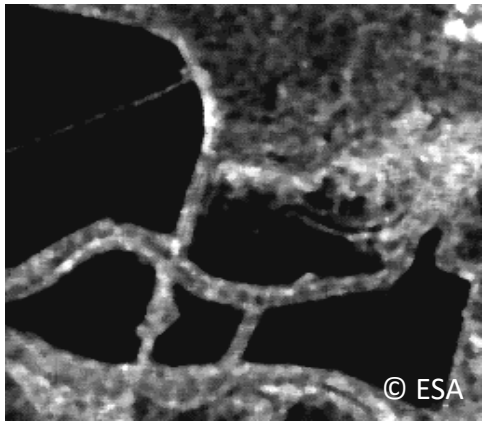
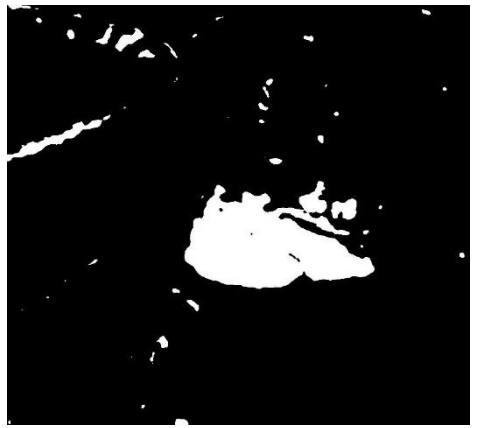


Image at time 2



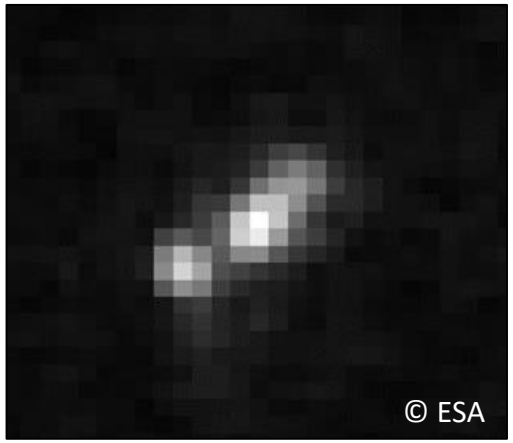
Change Map



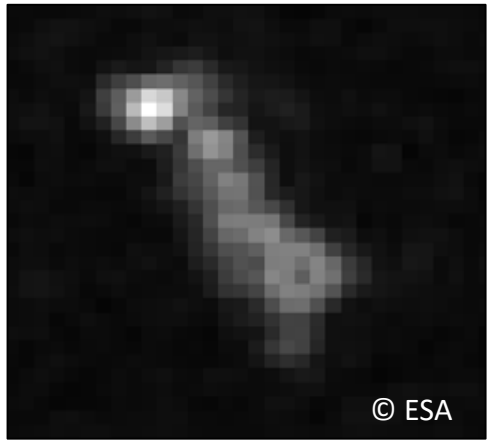
My Research Work : Microwave Images + Deep Learning

- Ship Classification

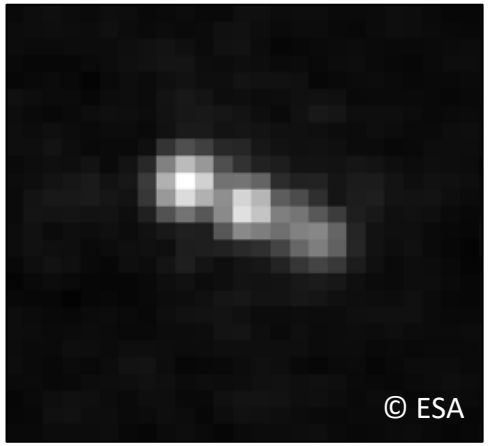
Container



Bulk-carrier



Tanker



- Change Detection

Image at time 1

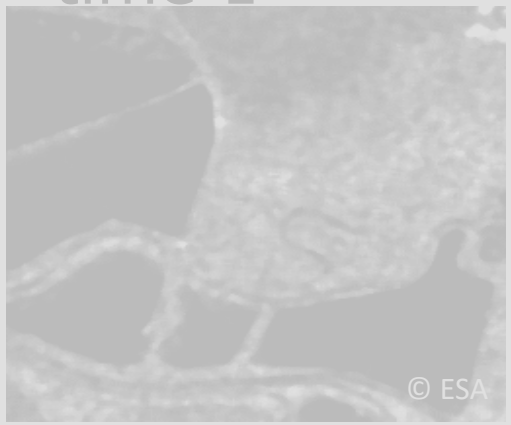
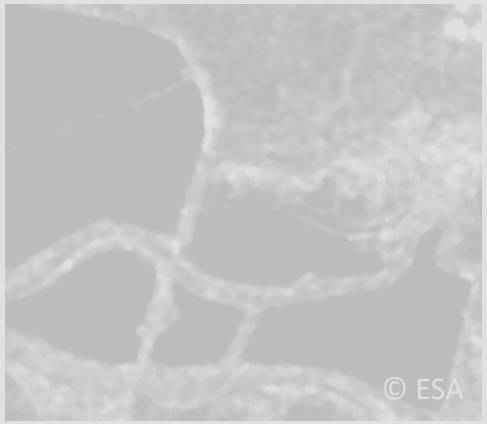


Image at time 2

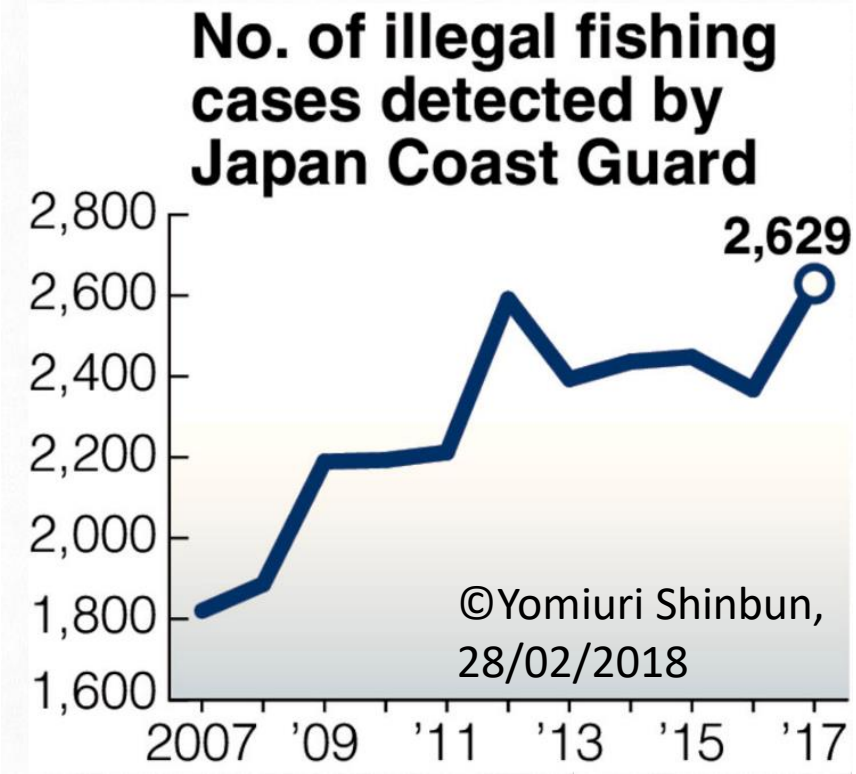


Change Map

Motivation

Ship Classification is a key application in maritime surveillance

Helps in quick identification of ships involved in illegal activities

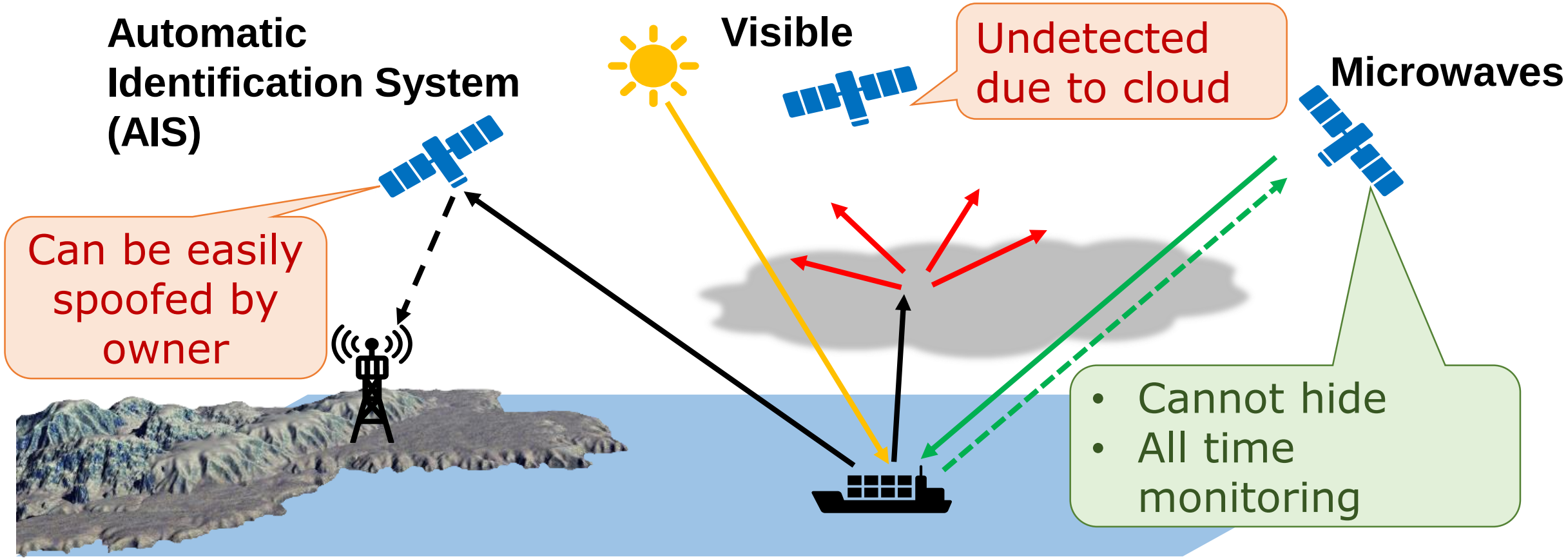


$US23 billion loss worldwide per year!

Ship Classification from Space

3 major sources of information : AIS, Visible and Microwaves

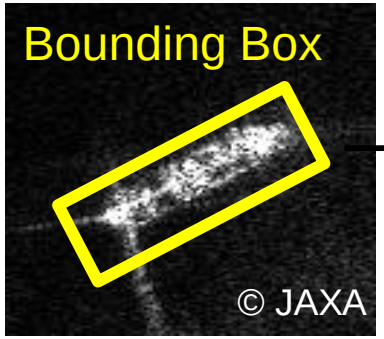
Microwaves can see ships undetected/spoofed by AIS and Visible



Microwave images are highly reliable for ship classification

Conventional Methods

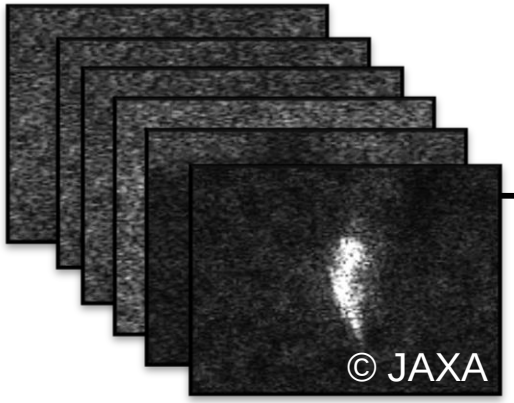
1. Hand-crafted feature (HCF)-based



Feature extractor* → Classifier (SVM) → Class

*Length, Area, Intensity, … etc.

2. Convolutional Neural Network (CNN)-based



CNN → Class

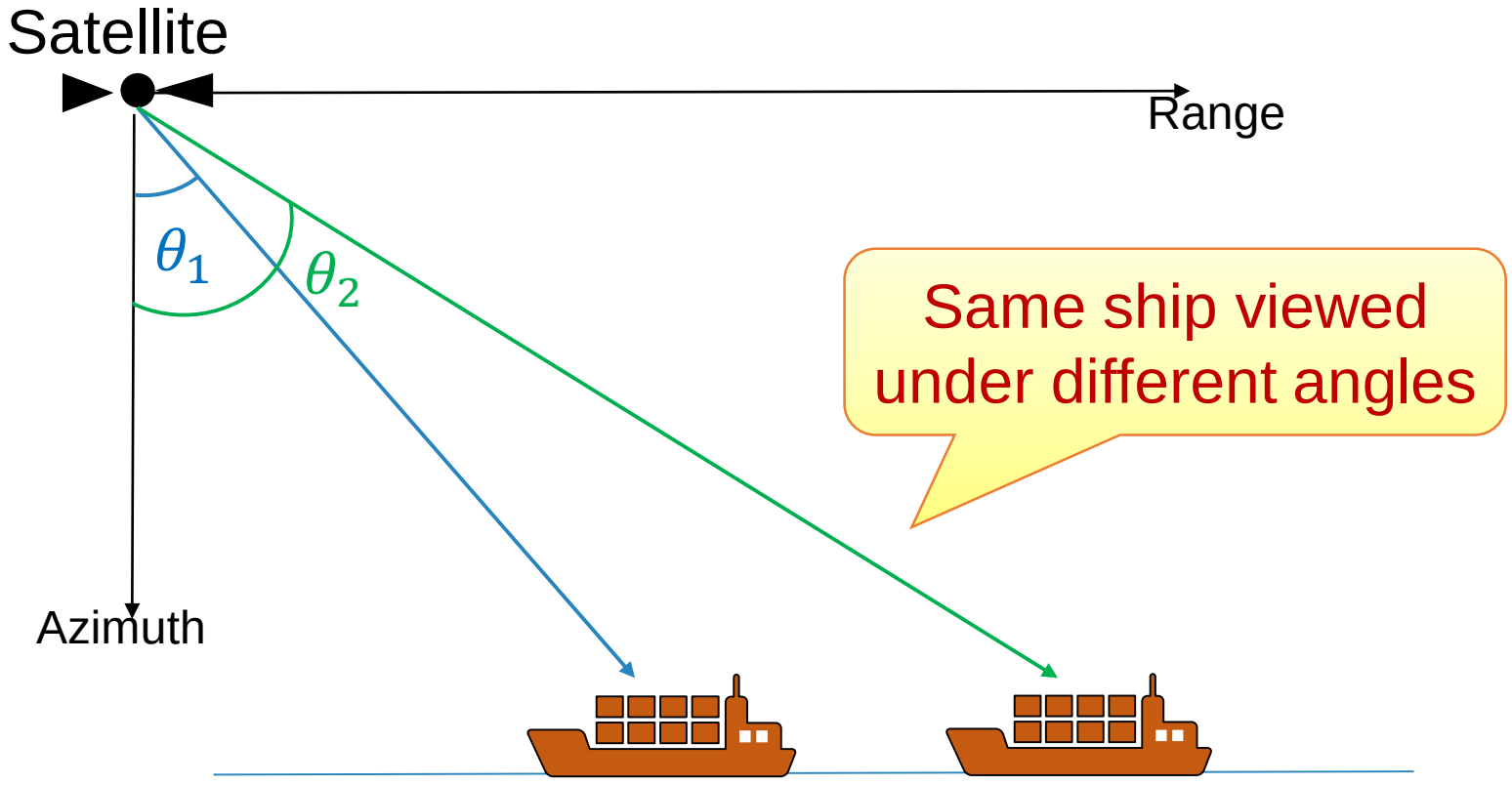
These methods classify a ship based on its appearance in image

Problem

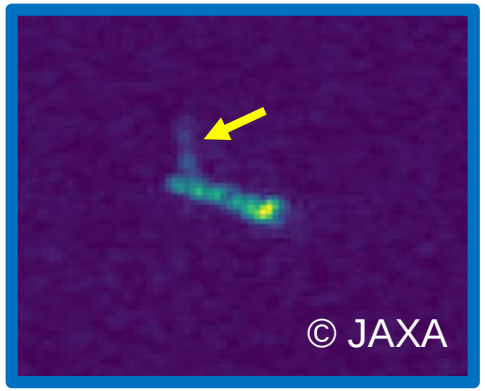
Appearance of a ship varies with satellite viewing angle

Labelled microwave images are very few to learn all possible variations

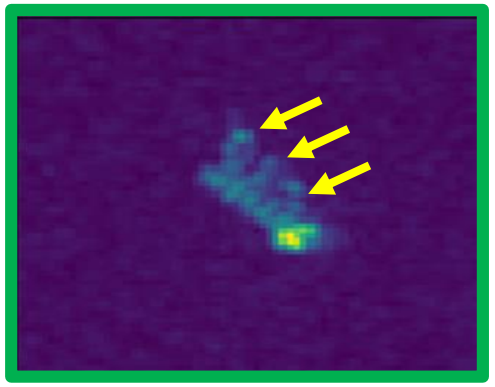
Example:



$\theta_1 = 30^\circ$



$\theta_2 = 40^\circ$

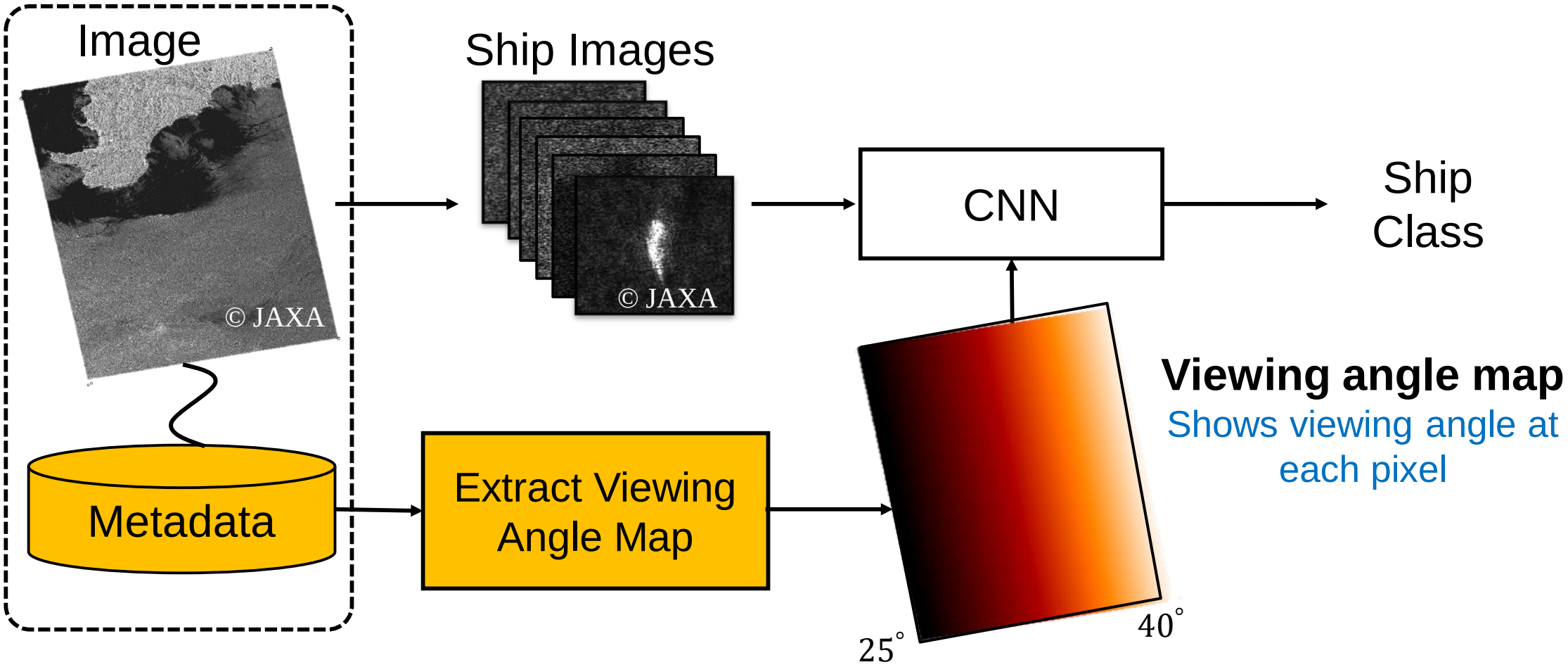


Only image information is insufficient for robust classification

Proposed Method

Use viewing angle as an additional information in a CNN

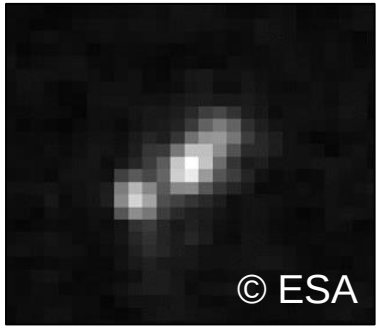
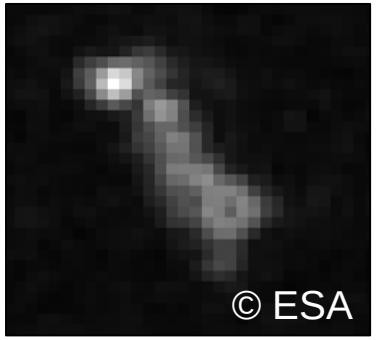
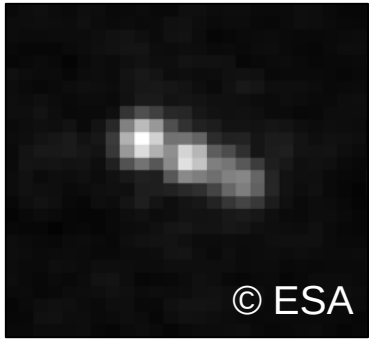
Helps the CNN to follow the appearance changes by learning a relationship



Sharma et al., CNN-based ship classification method incorporating SAR geometry information, SPIE RS 2018.

Experiments

Dataset: OpenSARShip*

	Reference	Microwave
Container		
Bulk-carrier		
Tanker		

*Huang, L et al., "OpenSARShip: A dataset dedicated to Sentinel-1 ship interpretation," IEEE Journal of Sel. Top. in App. Earth Obs. and Rem. Sen. 11(1), 195-208 (2018).

Specifications

Satellite	Sentinel-1
Resolution	20m
Image size	128 x 128
No. images	200 per class
Ground truth	AIS + Marine Traffic

Conventional Methods

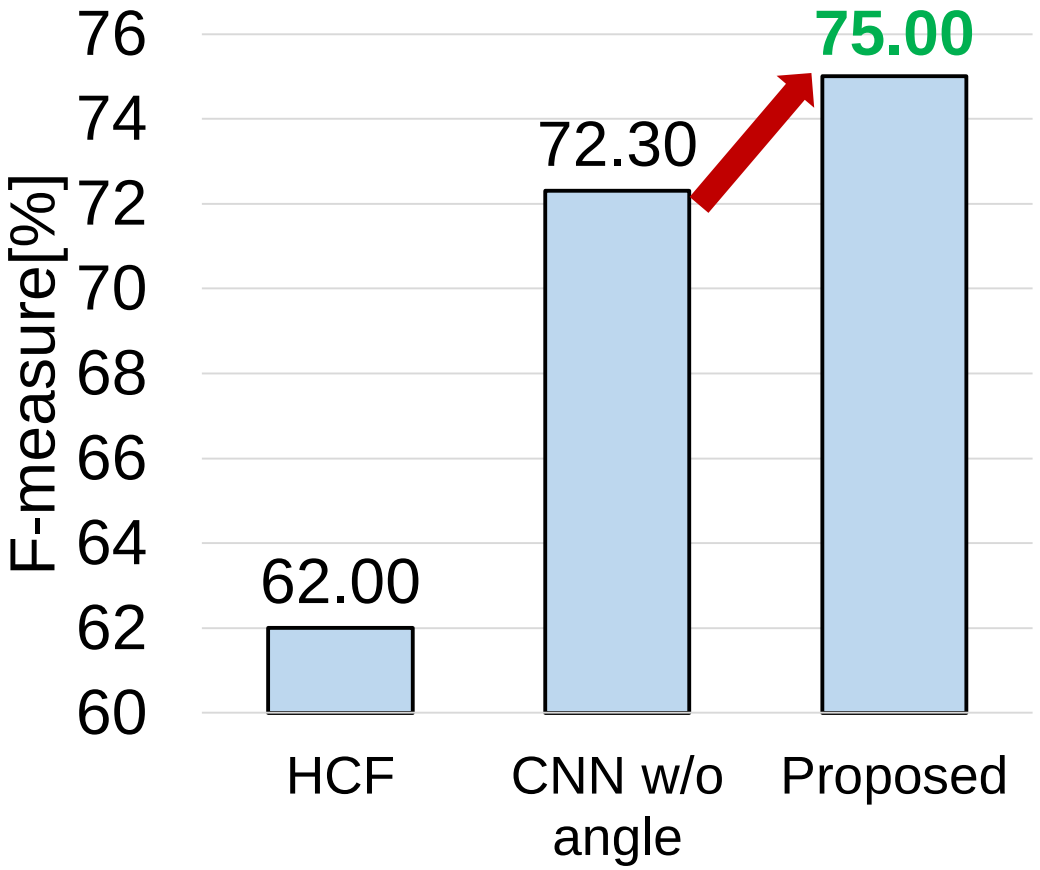
HCF	10 Features + SVM
CNN	w/o incident angle

Metrics

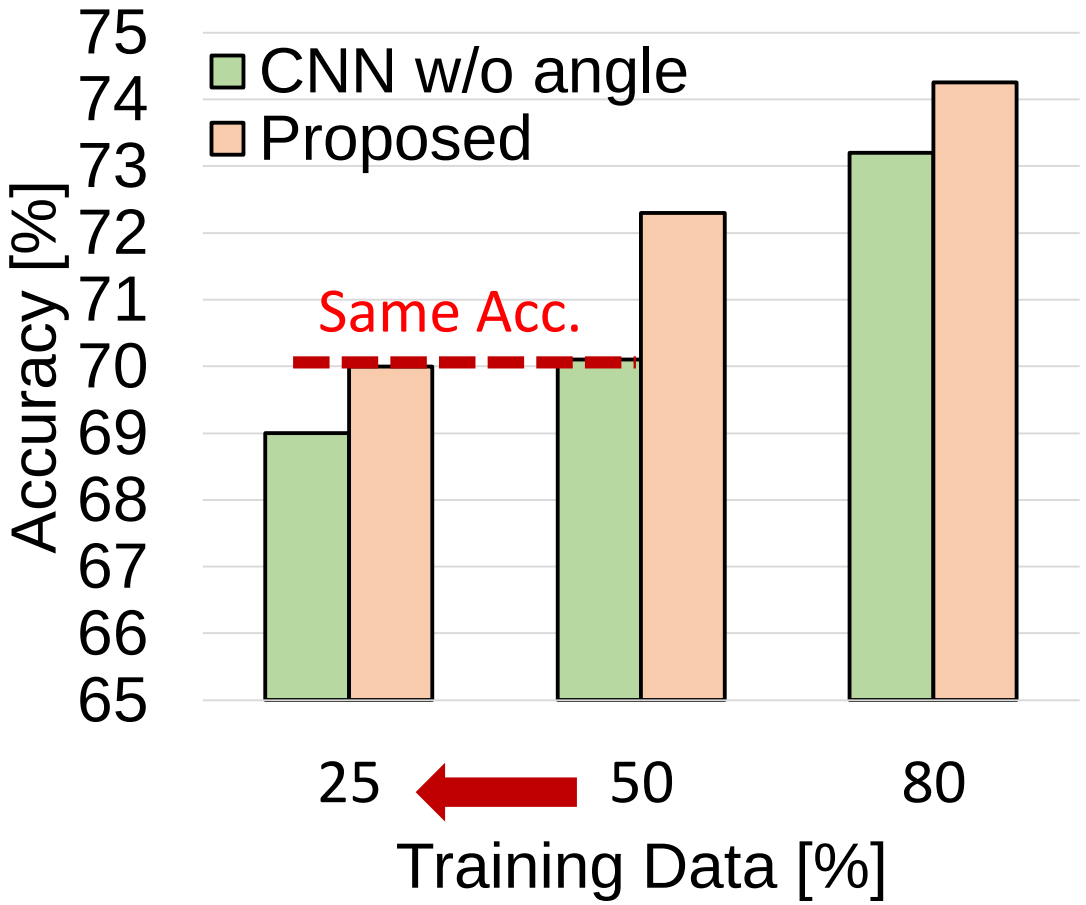
f-measure	Higher is better
#training data needed	Lower is better

Results

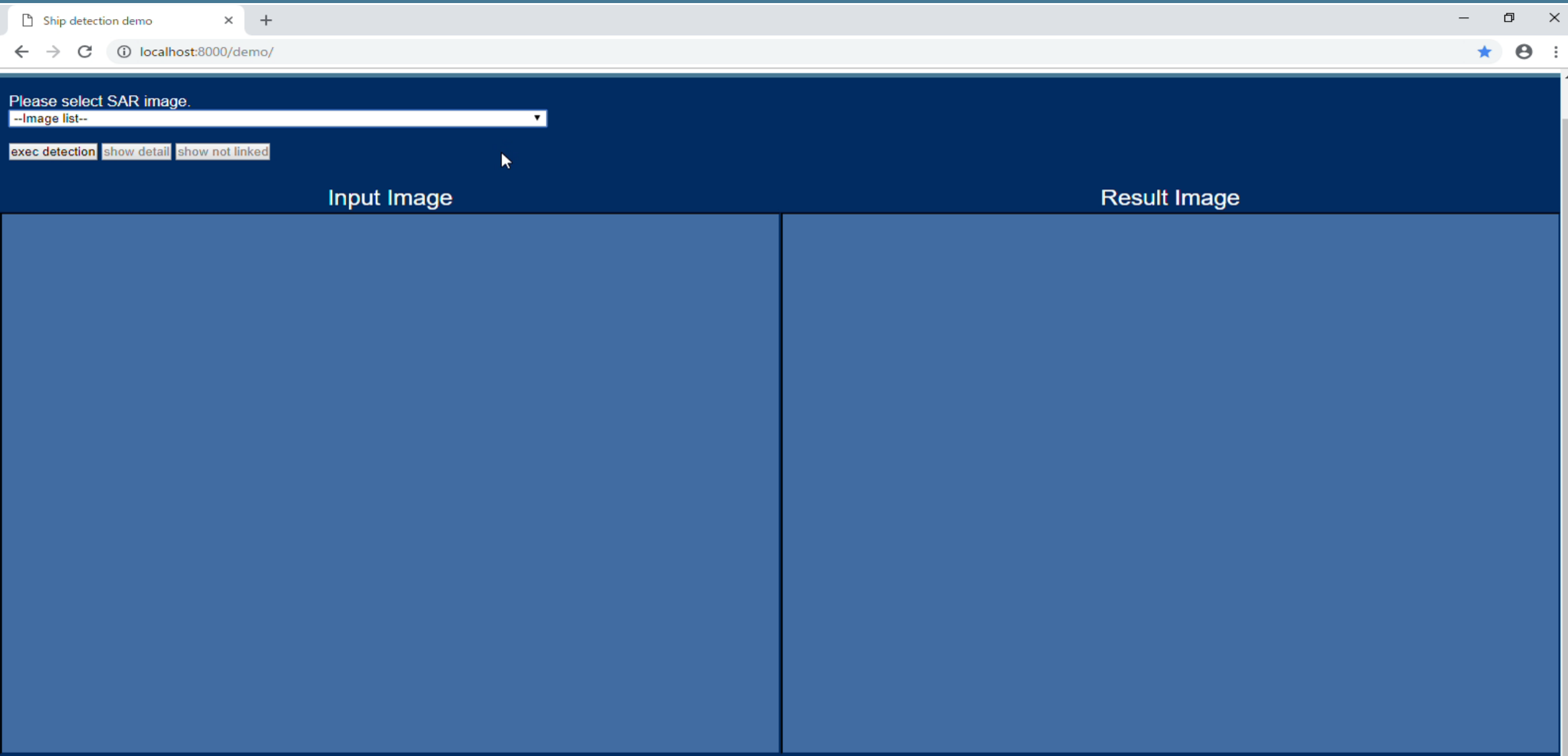
4.2% improvement in f-measure



25% reduction in training data requirement



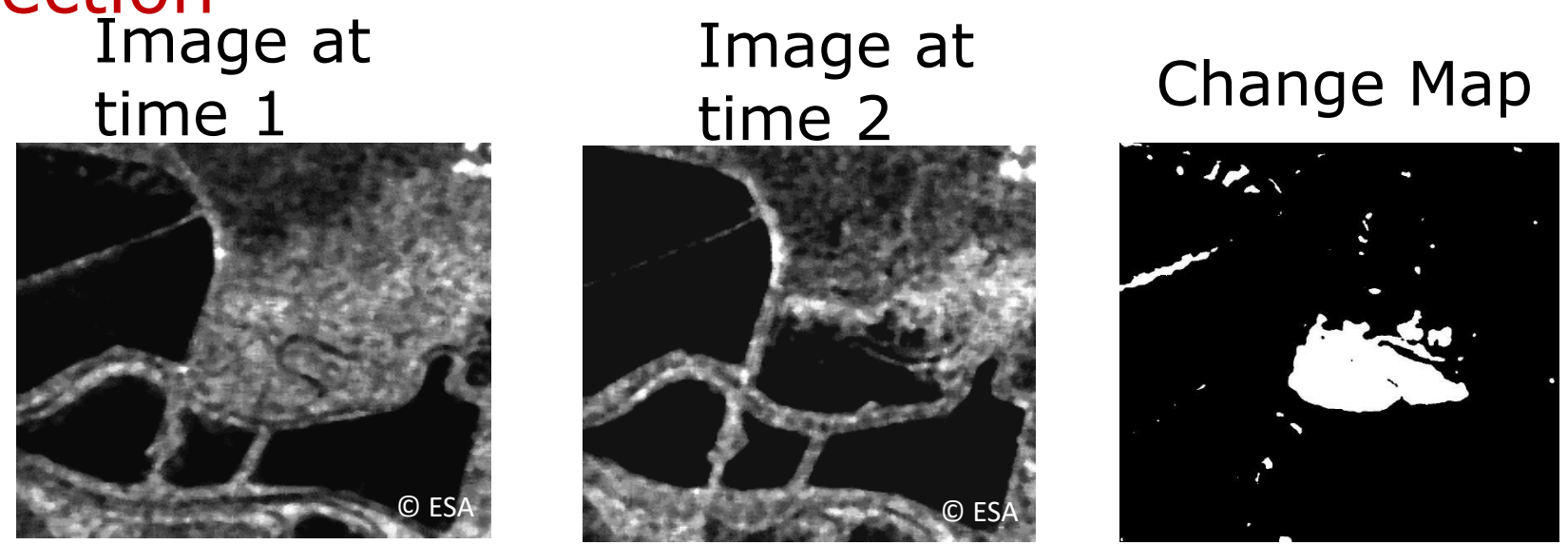
Demo


Ship detection demo
localhost:8000/demo/
Please select SAR image.
--Image list--
exec detection
show detail
show not linked
Input Image
Result Image

My Research Work : Microwave Images + Deep Learning

- Ship Classification

- Change Detection



Motivation

Change detection enables us to understand dynamics of Earth

Dubai Coastal Expansion

Saudi Arabia Irrigation

Conventional Method

Based on pixel-to-pixel difference followed by classification

Image at time 1

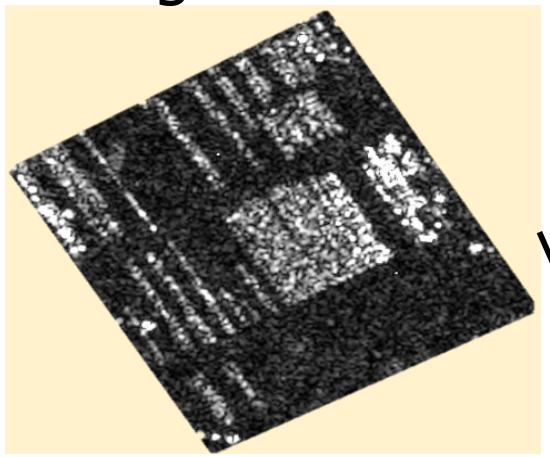
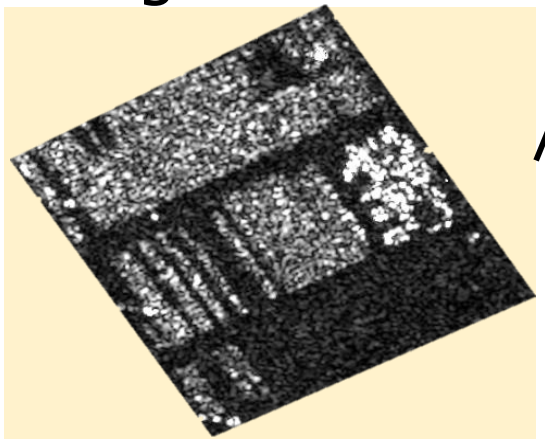


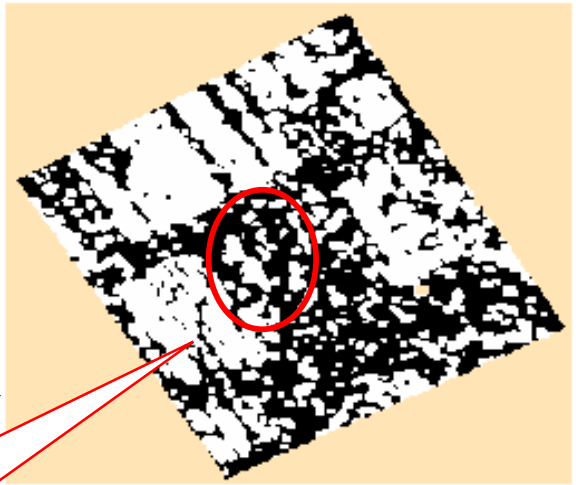
Image at time 2



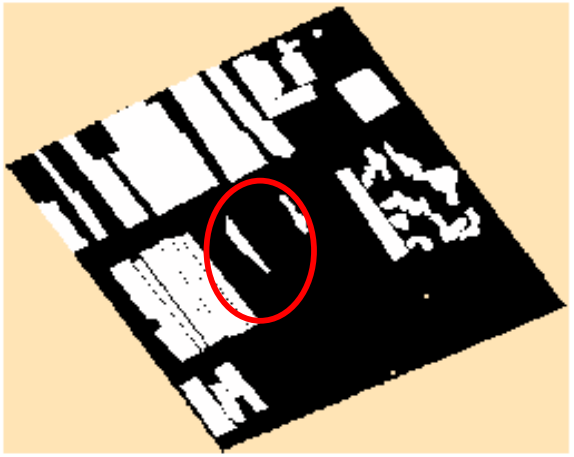
Pixel-to-pixel difference

Classification

Change Map



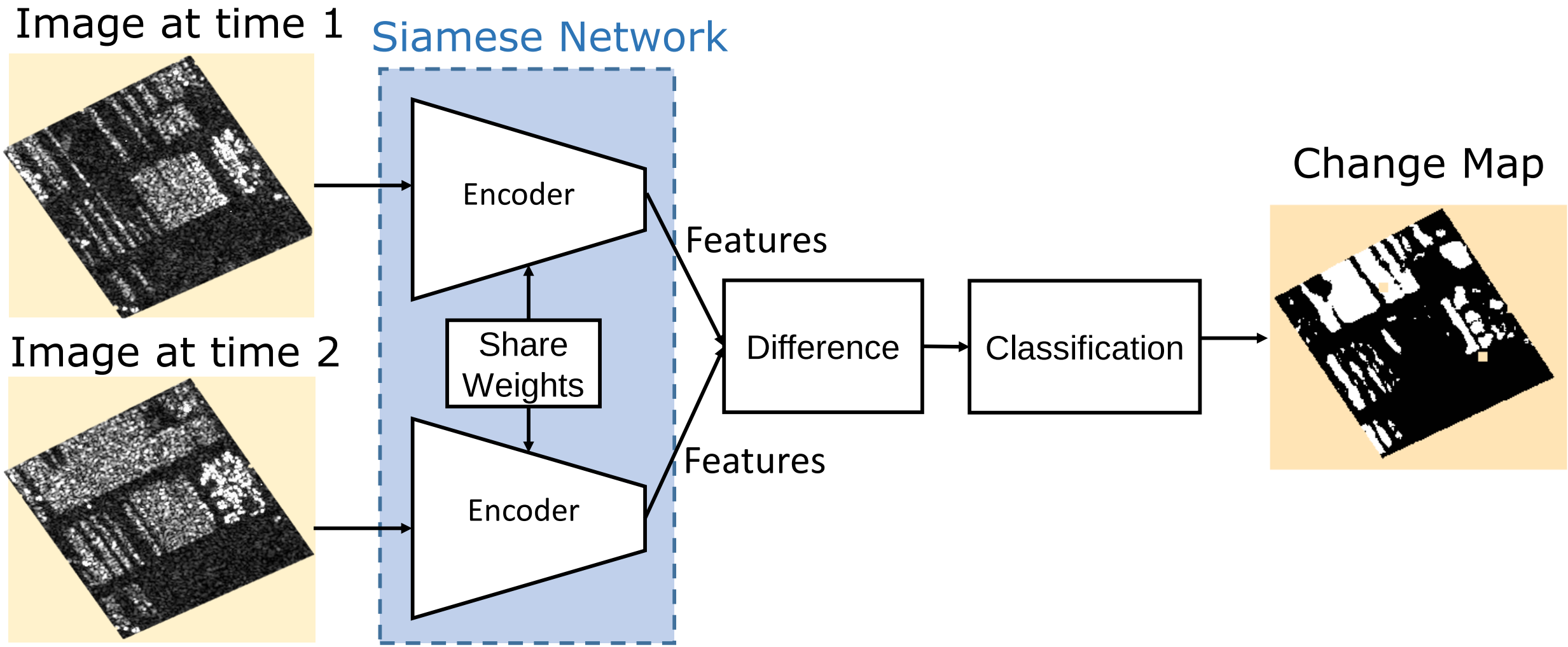
Ground Truth



Problem:
Many False Alarms!

Proposed Method

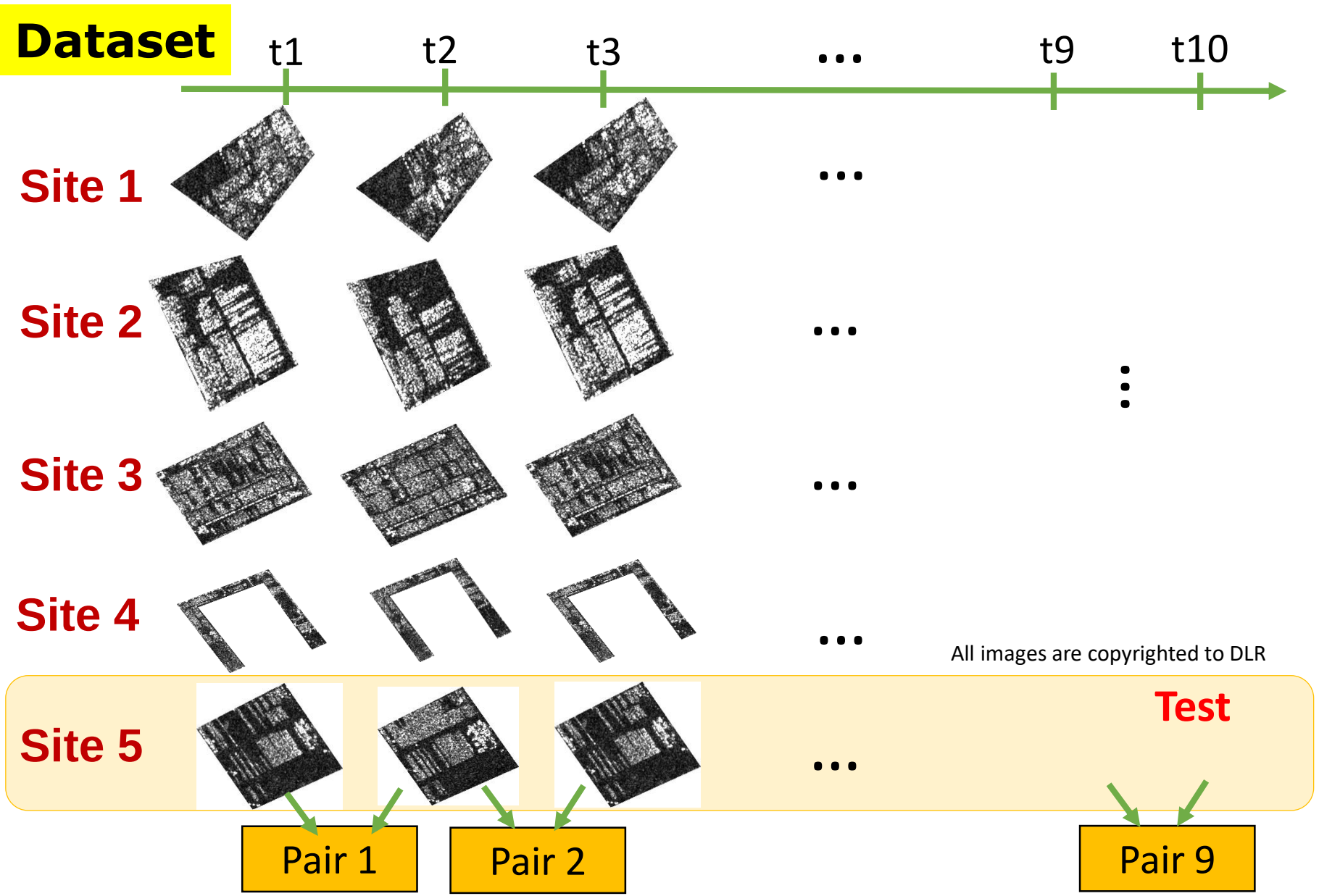
Transform the images into features and compute difference between features



Sharma et al., Very high resolution SAR change detection with Siamese Networks, The 66th Academic Conference of the Remote Sensing Society of Japan, 2019.

Experiments : Parking Lot Monitoring

Dataset



All images are copyrighted to DLR

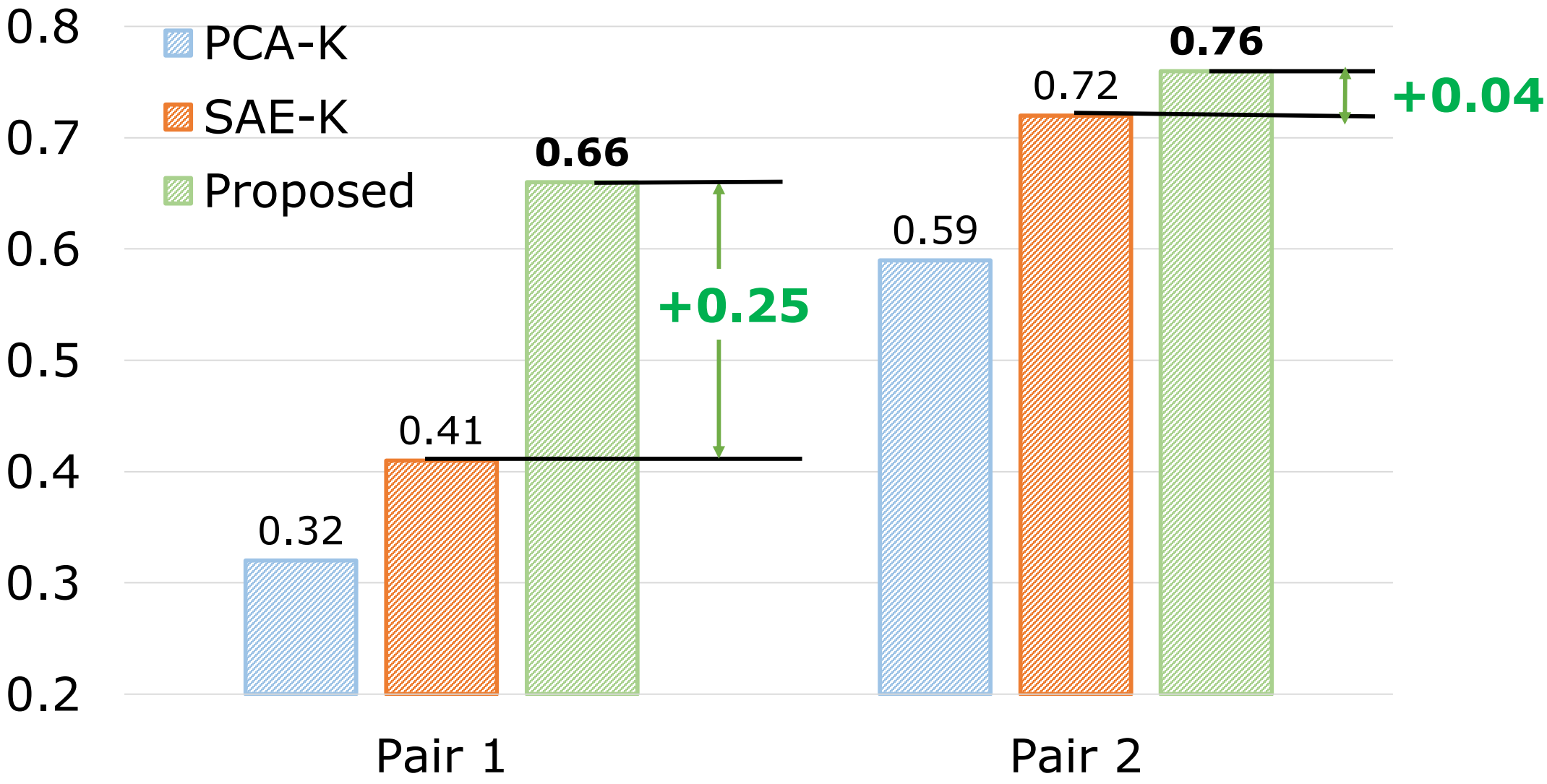
- **Specifications**
  - TerraSAR-X satellite
  - 1m resolution
- **Baselines:**
  - PCA-K [1]
  - SAE-K [2]
- **Evaluation Metrics**
  - f-measure
  - Change Maps

[1] T. Celik: Unsupervised change detection in satellite images using principal component analysis and k-means clustering, IEEE Geoscience and Remote Sensing Letters, vol. 6, no. 4, pp. 772-776, 2009.

[2] M. Gong., H. Yang, and P. Zhang: Feature learning and change feature classification based on deep learning for ternary change detection in SAR images, ISPRS Journal of Photogr. and Remote Sensing, no.129, pp.212-225, 2017.

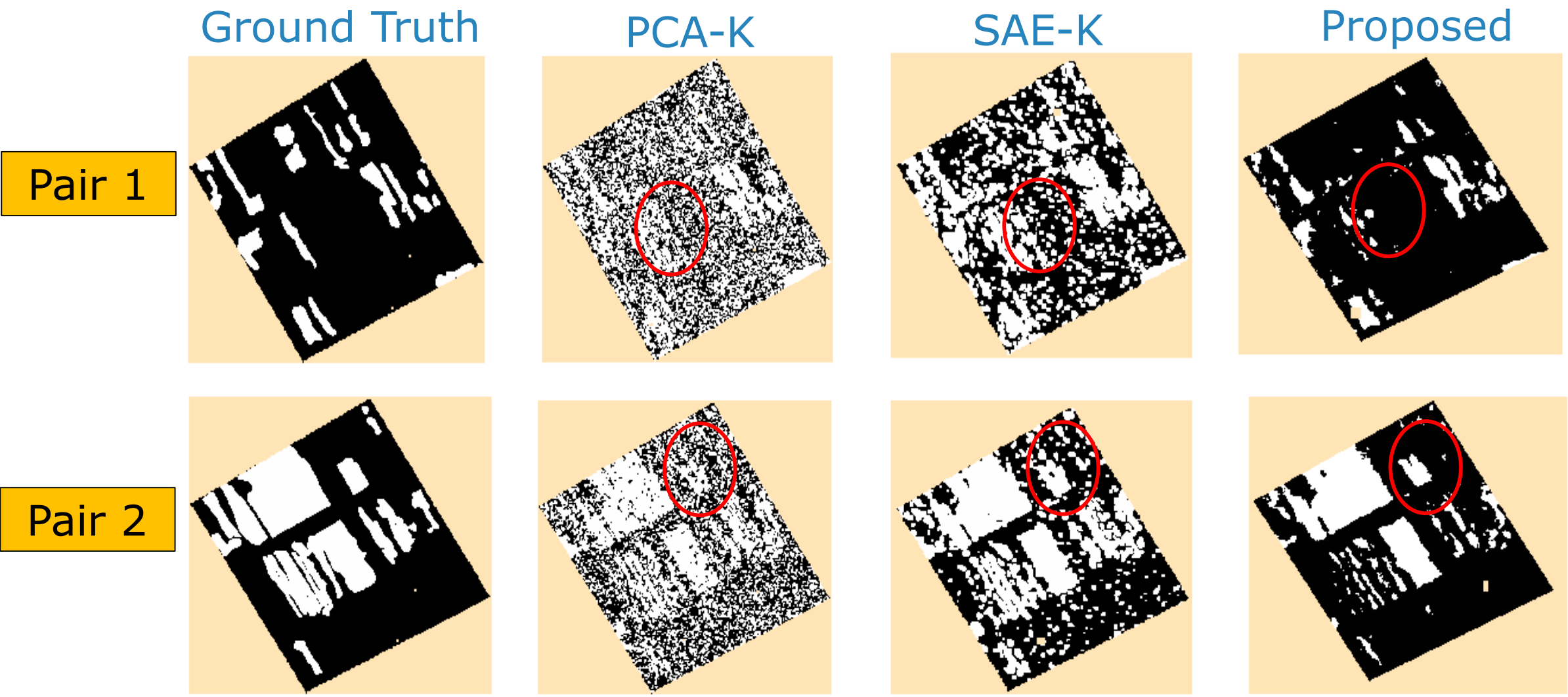
Result [1/2] : f-measure

Proposed method improves f-measure by 15% over baselines



Result [2/2] : Change Maps

Proposed method produces visually better change maps



Conclusion

- Geospatial Intelligence = Remote Sensing + Computer Vision + DL
- Earth Observation data is a highly valuable data source
- Deep learning is a great tool to understand 'Patterns on Earth'
- Presented my research work on
  - Ship classification
  - Change detection

Let's curate the data and make an impactful story!