

Towards Geospatial Intelligence with AI



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What is Geospatial Intelligence (GI) ?

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

Remote Sensing

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

Making **computers** see the world as humans

Computer Vision

GI

Deep Learning

Why Earth Observation (EO) ?

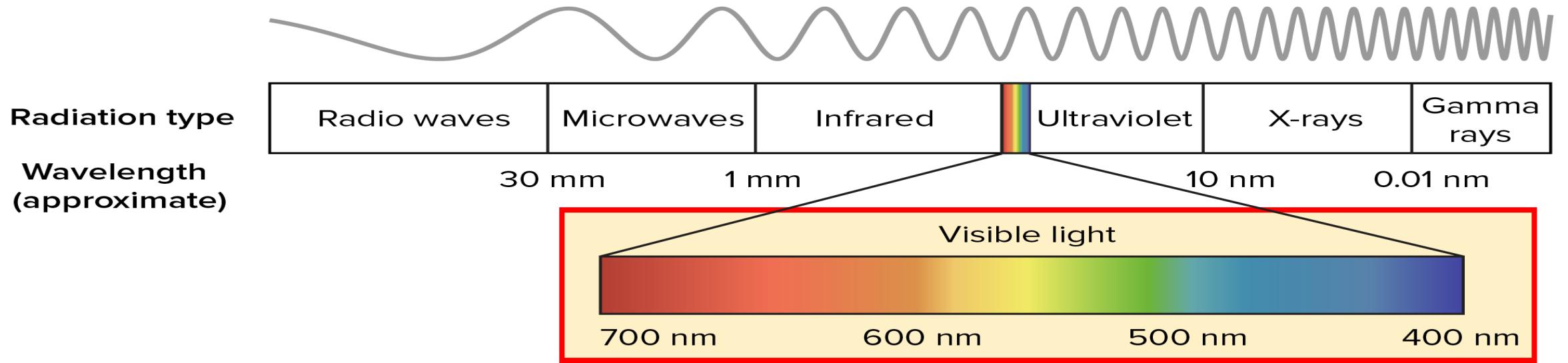
- Currently **only 25%** of the Earth's surface can be seen by ground sensors
- Limits our capability to monitor the entire Earth

Satellite Earth Observation is 'Eye from the Sky'!



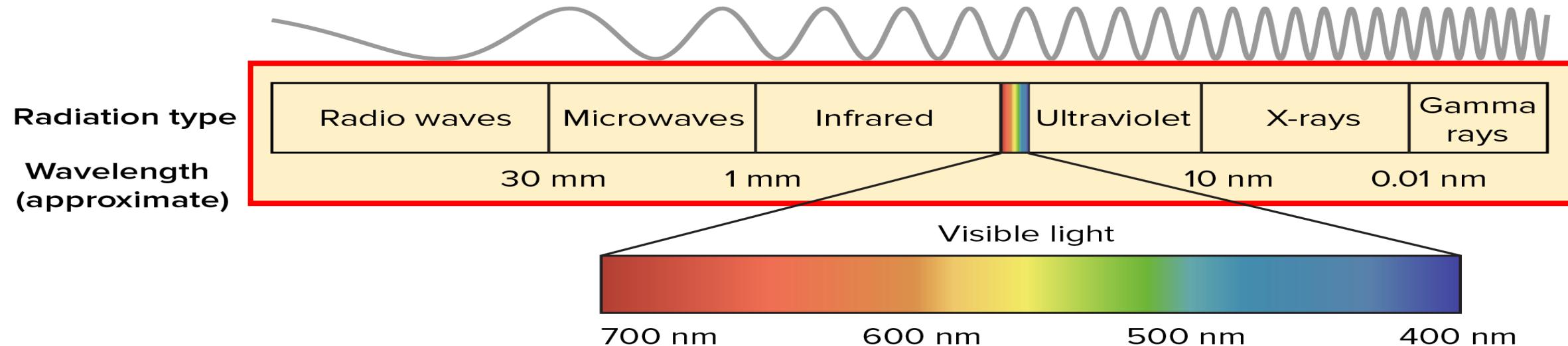
How we see Earth?

Electromagnetic Spectrum



How satellite sees Earth?

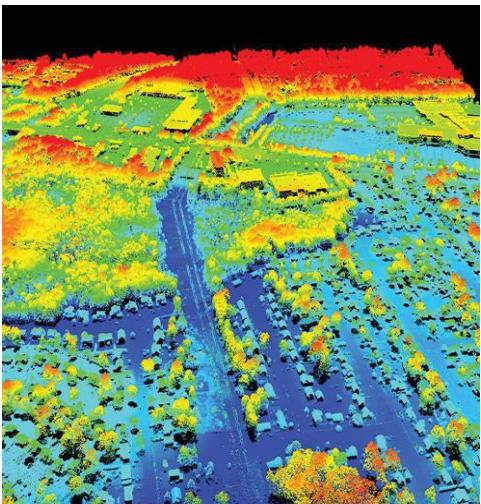
Electromagnetic Spectrum



Microwave



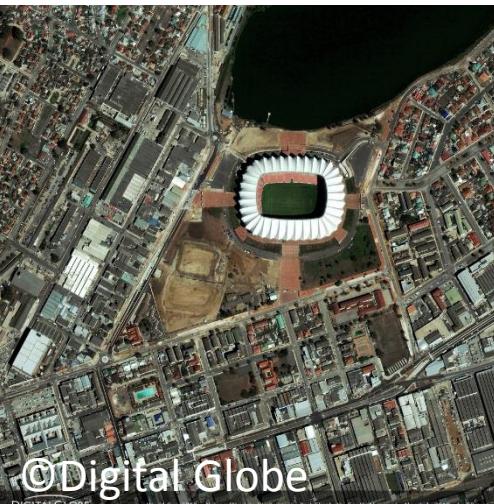
LIDAR



Infrared



Visible



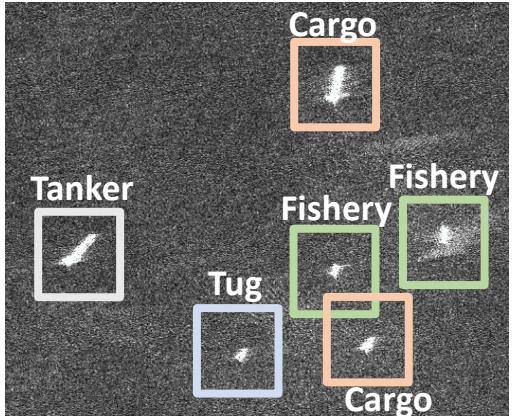
Panchromatic



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



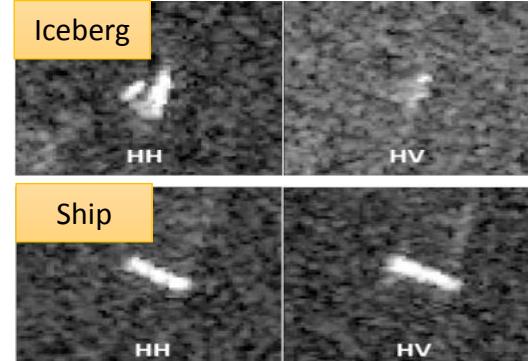
Building Extraction



Land Classification



Iceberg-ship Detection



Disaster Response

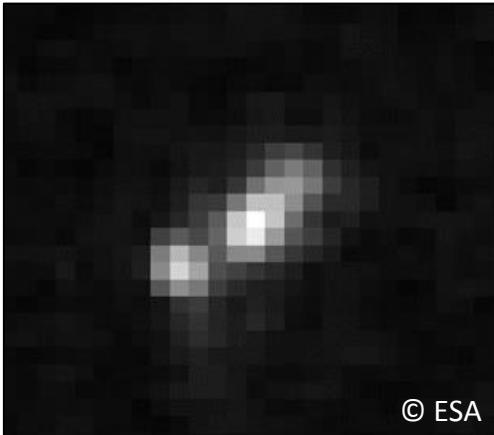


Diverse applications across industries

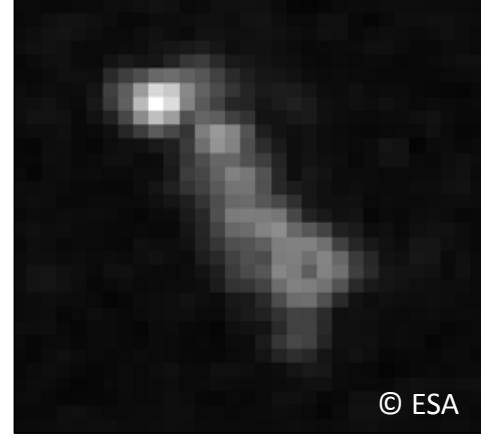
My Research Work : Microwave Images + Deep Learning

■ Ship Classification

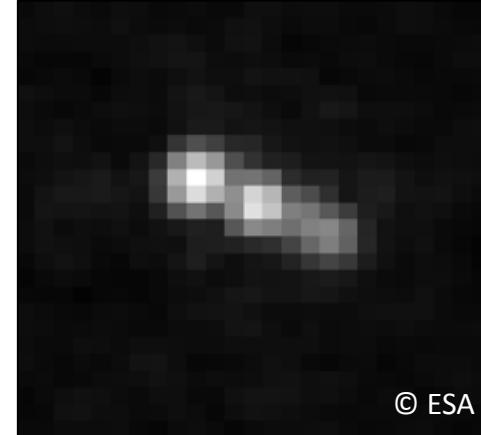
Container



Bulk-carrier



Tanker



■ Change Detection

Image at
time 1

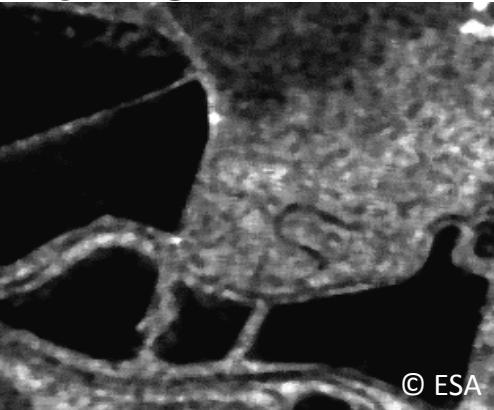
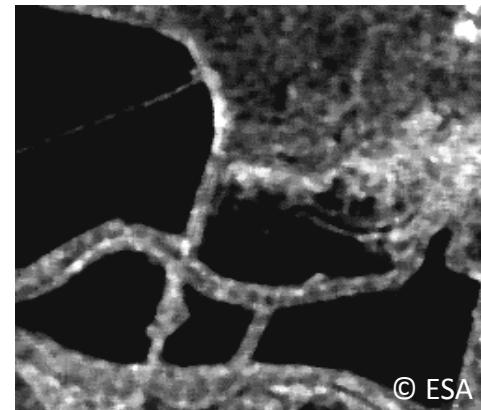
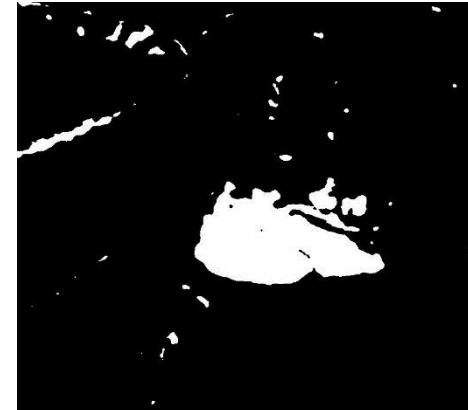


Image at
time 2



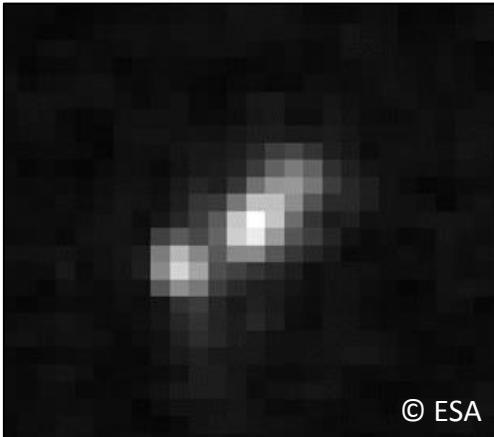
Change Map



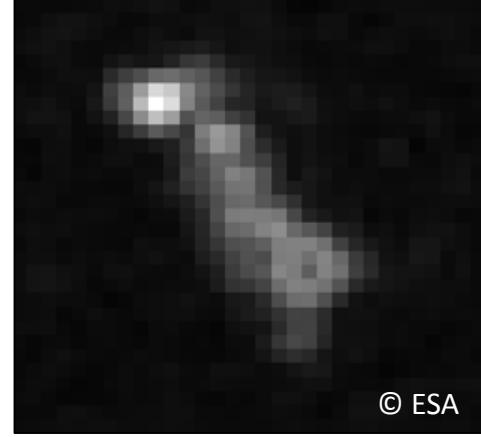
My Research Work : Microwave Images + Deep Learning

■ Ship Classification

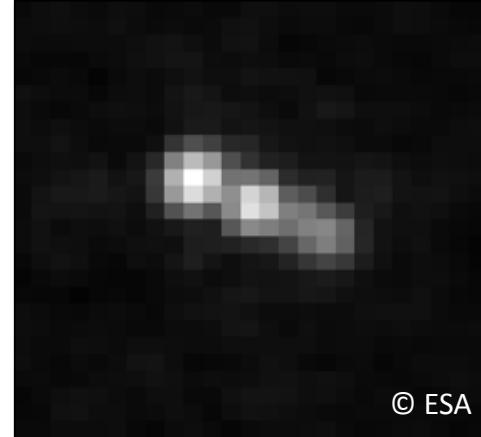
Container



Bulk-carrier



Tanker



■ Change Detection

Image at
time 1

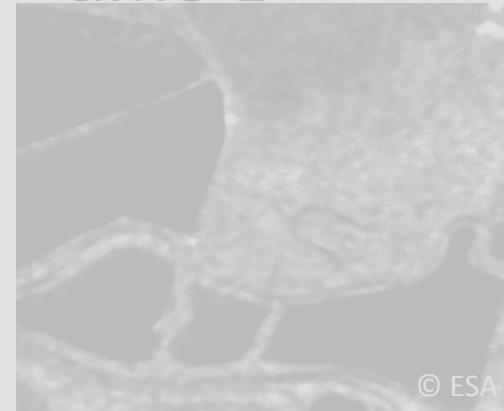
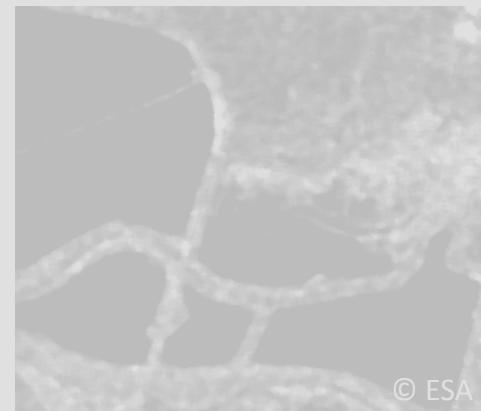


Image at
time 2



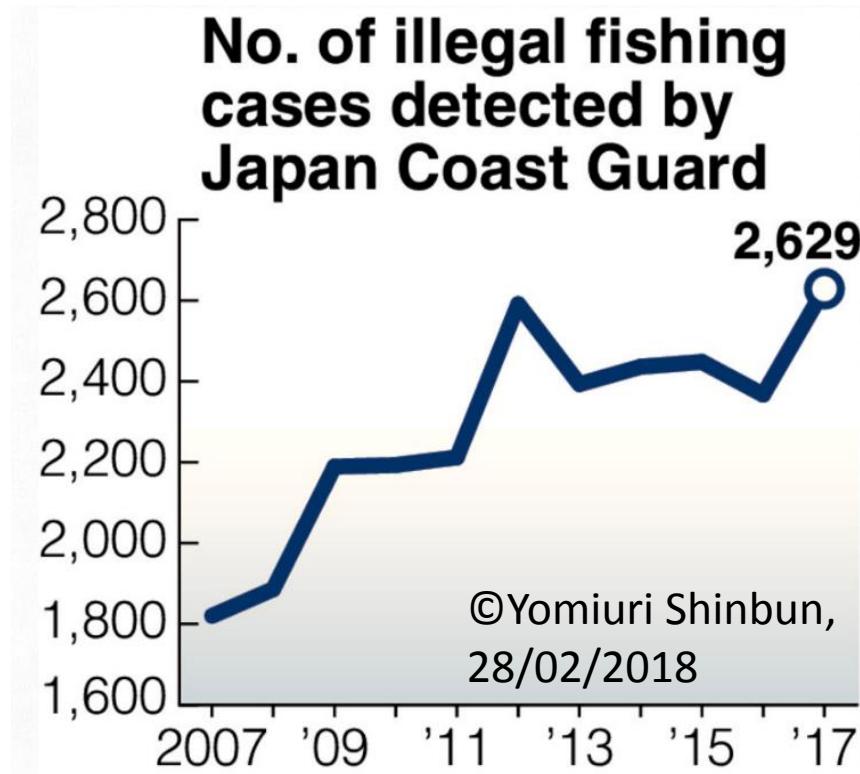
Change Map



Motivation

Ship Classification is a key application in maritime surveillance

Helps in quick identification of ships involved in illegal activities



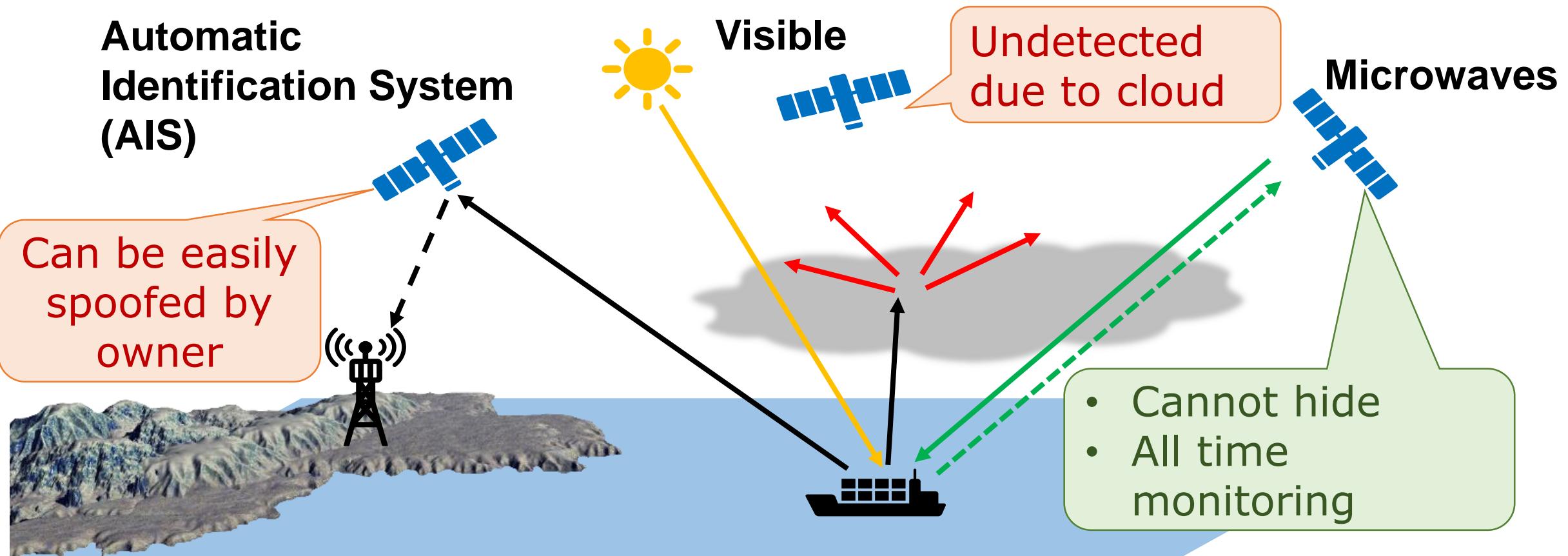
**\$US23 billion loss
worldwide per year!**



Ship Classification from Space

3 major sources of information : AIS, Visible and Microwaves

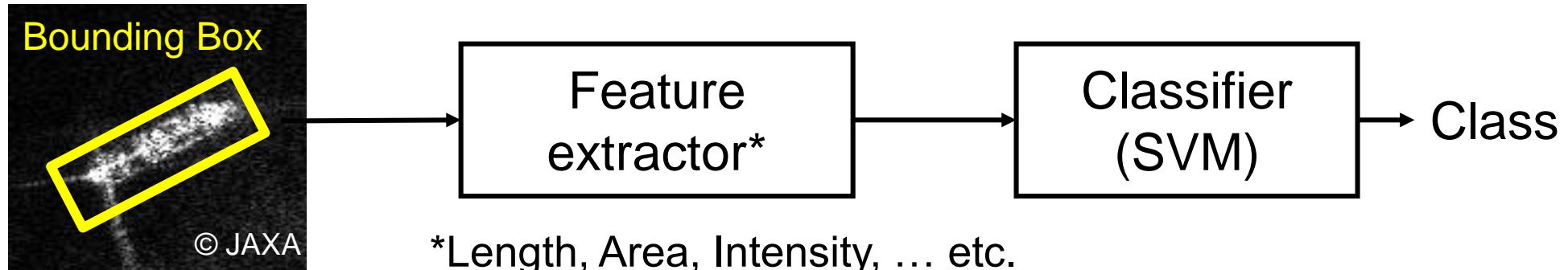
Microwaves can see ships undetected/spoofed by AIS and Visible



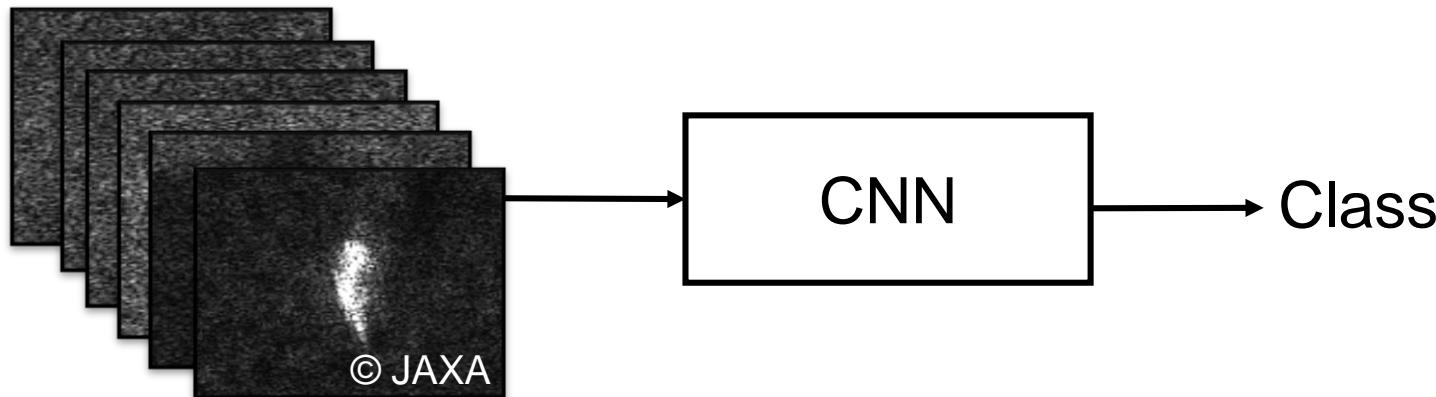
Microwave images are highly reliable for ship classification

Conventional Methods

1. Hand-crafted feature (HCF)-based



2. Convolutional Neural Network (CNN)-based



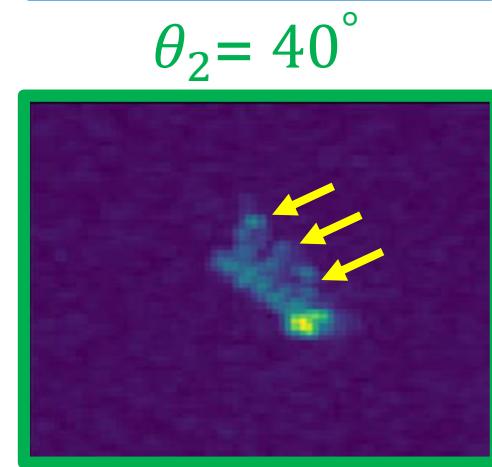
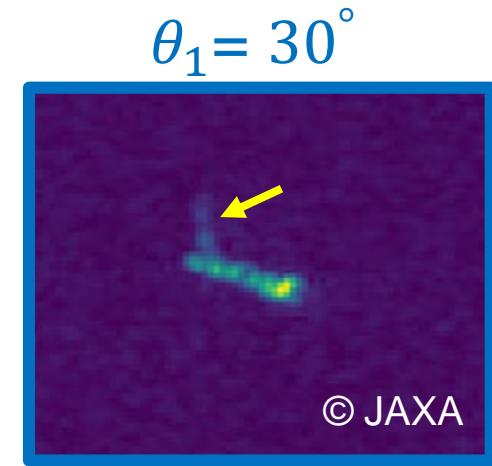
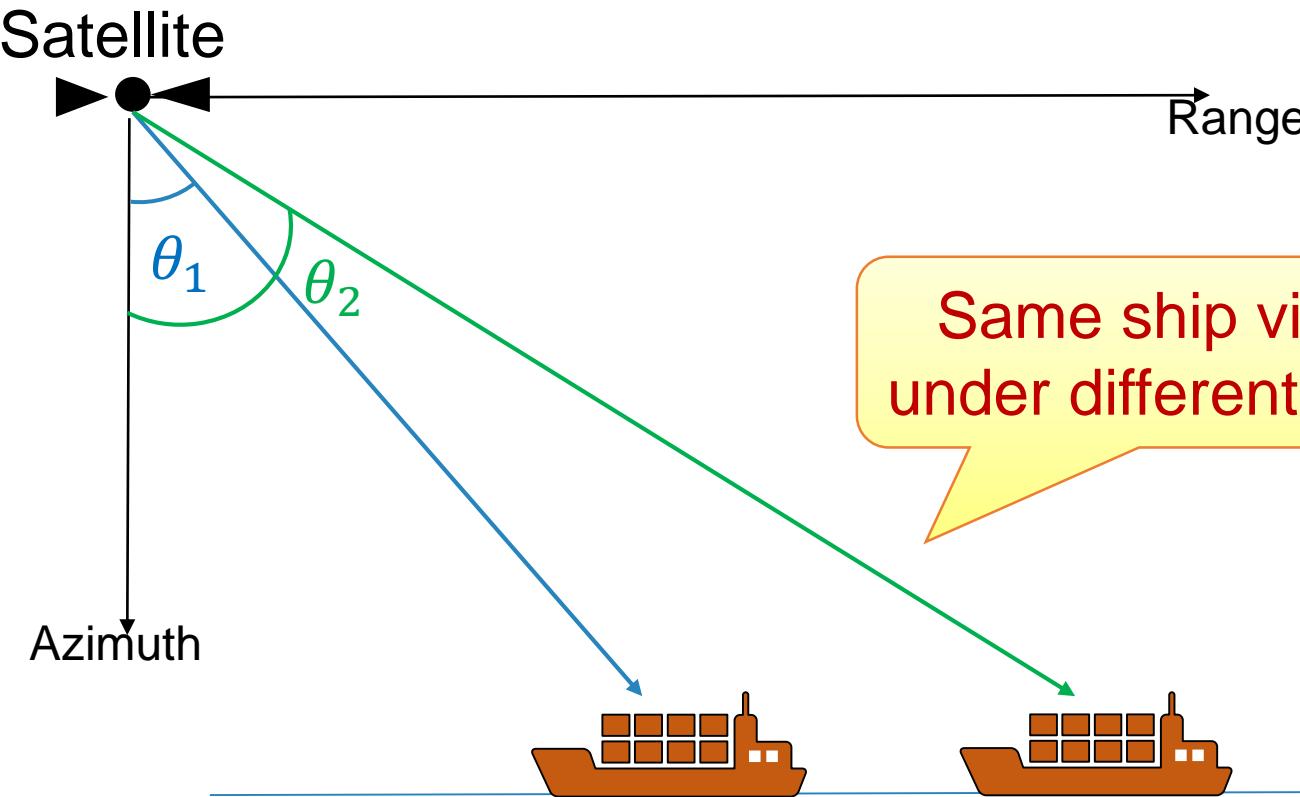
These methods classify a ship based on its appearance in image

Problem

Appearance of a ship varies with satellite viewing angle

Labelled microwave images are **very few** to learn all possible variations

Example:

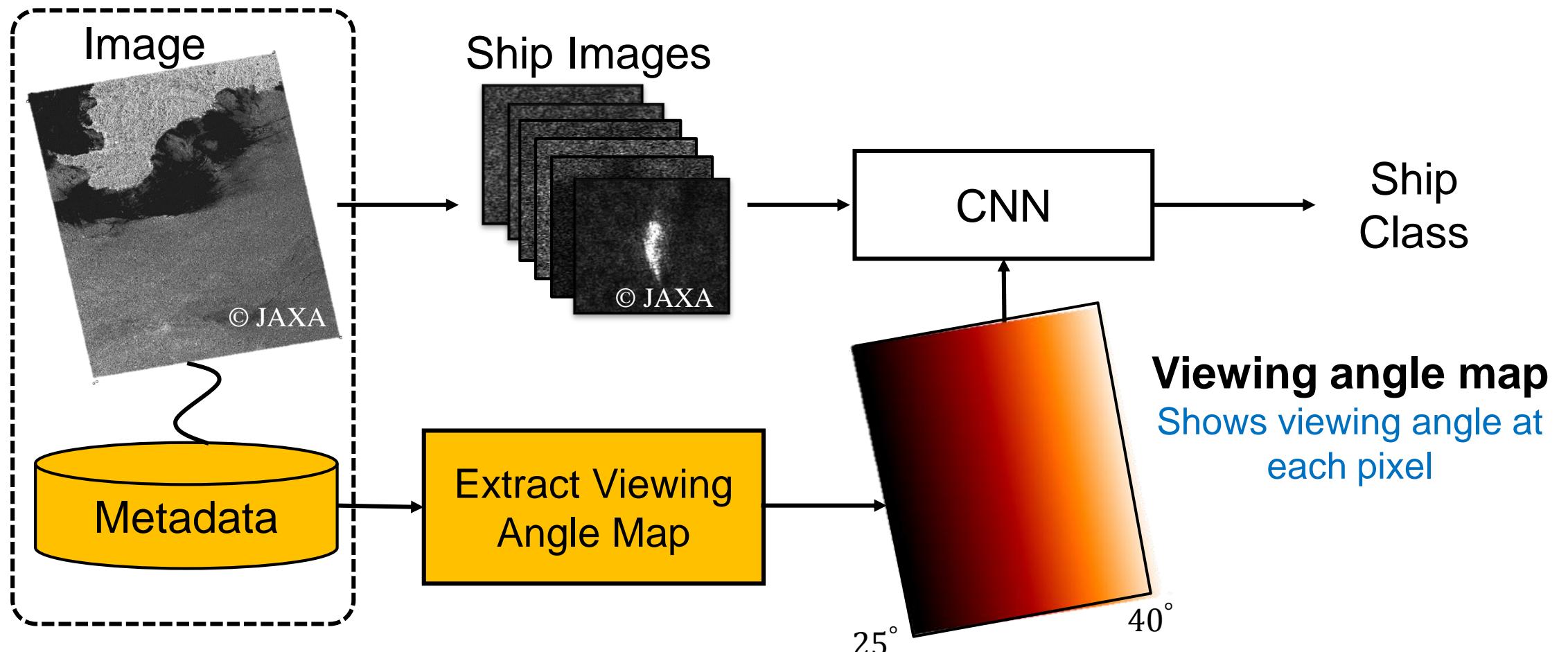


Only image information is insufficient for robust classification

Proposed Method

Use viewing angle as an additional information in a CNN

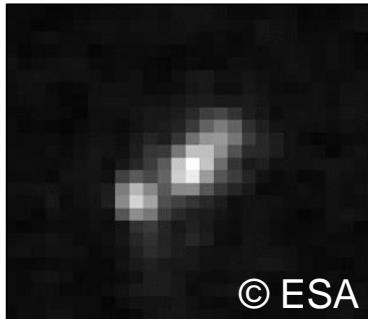
Helps the CNN to follow the appearance changes by learning a relationship



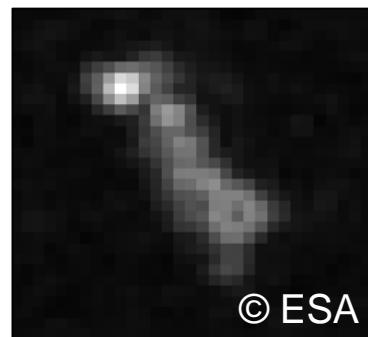
Experiments

Dataset: OpenSARShip*

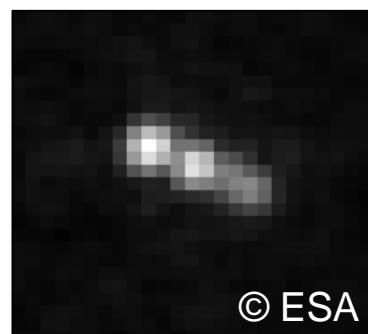
Container



Bulk-carrier



Tanker



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

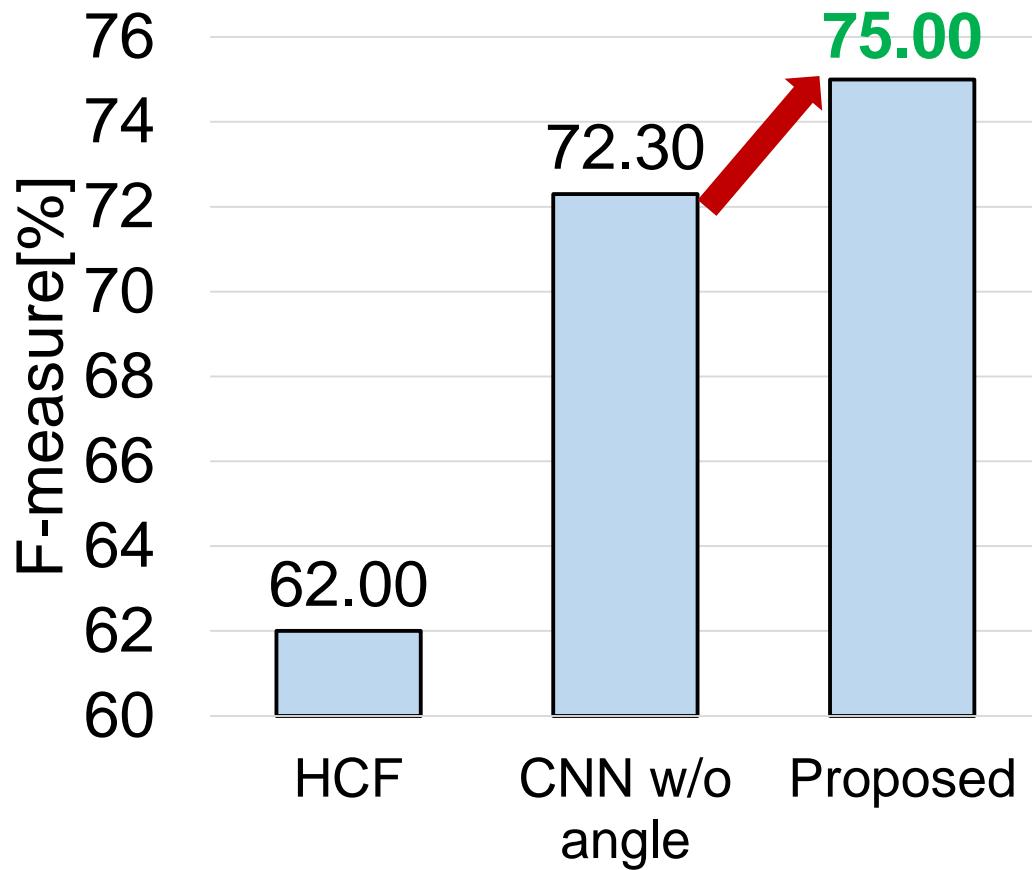
Metrics

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

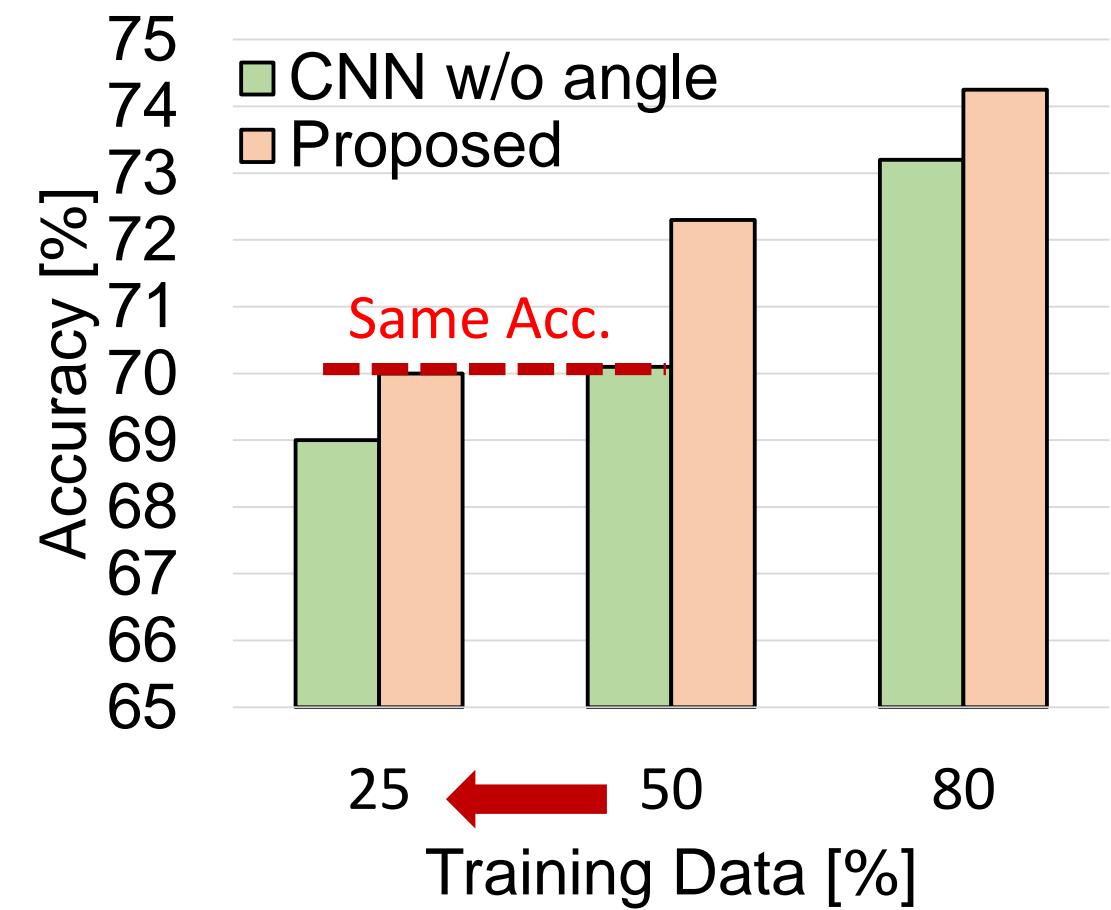
*Huang, L et al., "OpenSARShip: A dataset dedicated to Sentinel-1 ship interpretation," IEEE Journal of Sel. Top. in App. Earth Obs. and Rem. Sen. 11(1), 195-208 (2018).

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

The screenshot shows a web application interface for ship detection. The top navigation bar includes a back button, forward button, refresh button, and a search bar with the URL 'localhost:8000/demo/'. Below the navigation is a message 'Please select SAR image.' followed by a dropdown menu with the placeholder '-Image list--'. At the bottom of the header are three buttons: 'exec detection' (highlighted in red), 'show detail', and 'show not linked'. The main content area is split into two sections: 'Input Image' on the left and 'Result Image' on the right, both of which are currently blank blue screens. A cursor is visible near the top center of the page.



\Orchestrating a brighter world

NEC

My Research Work : Microwave Images + Deep Learning

■ Ship Classification



■ Change Detection

Image at
time 1

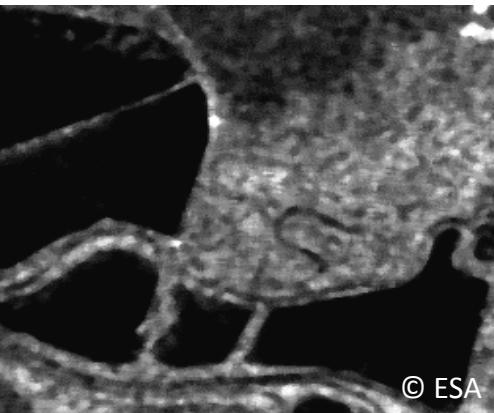
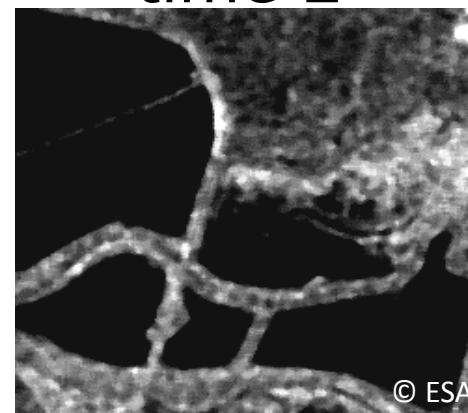


Image at
time 2



Change Map



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

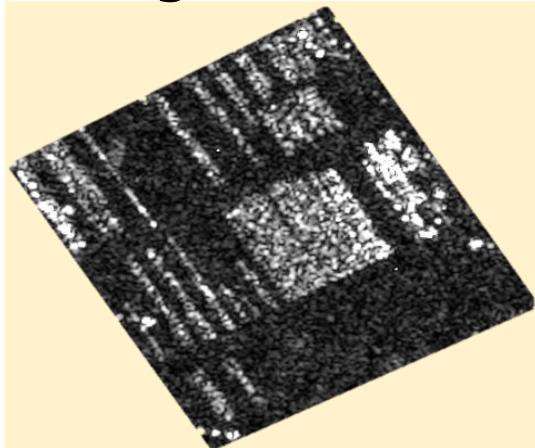
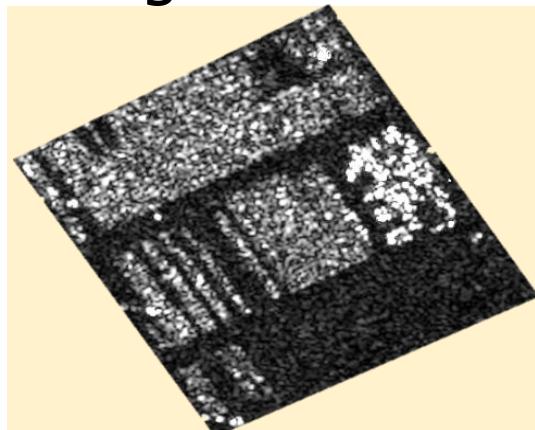
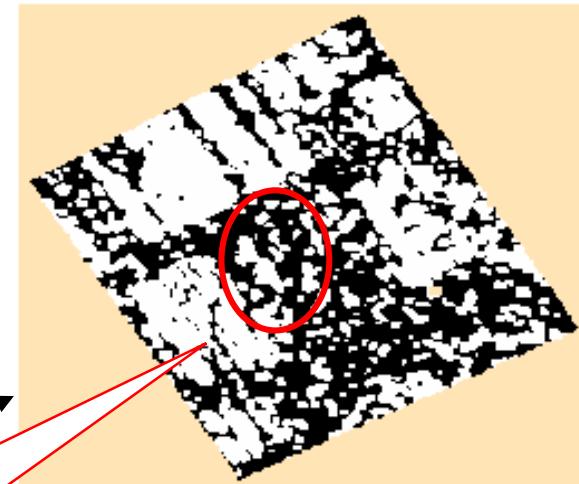


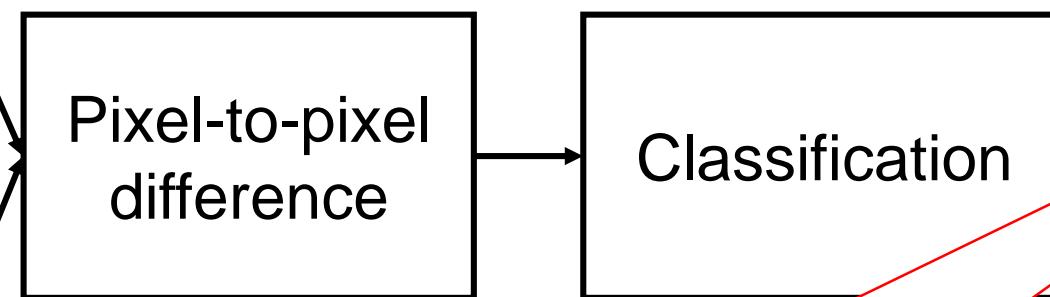
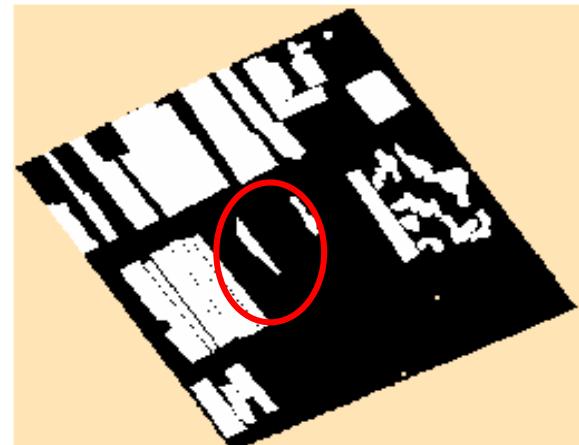
Image at time 2



Change Map



Ground Truth

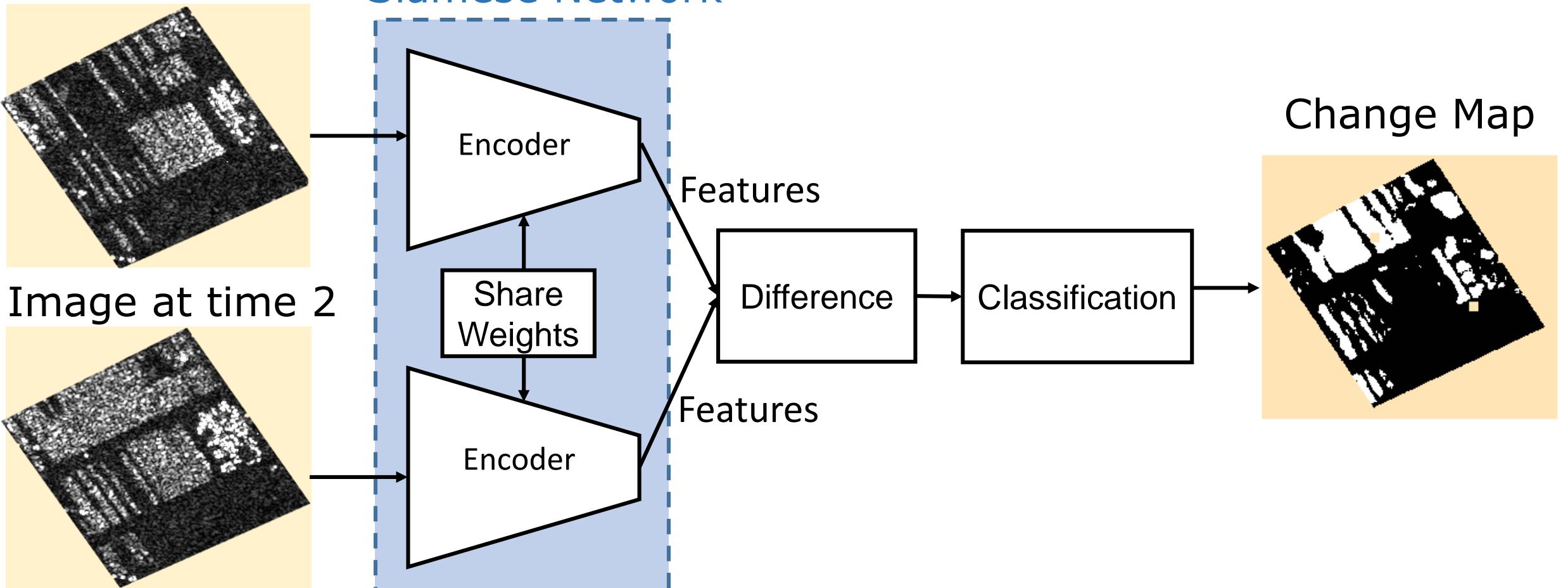


**Problem:
Many False Alarms!**

Proposed Method

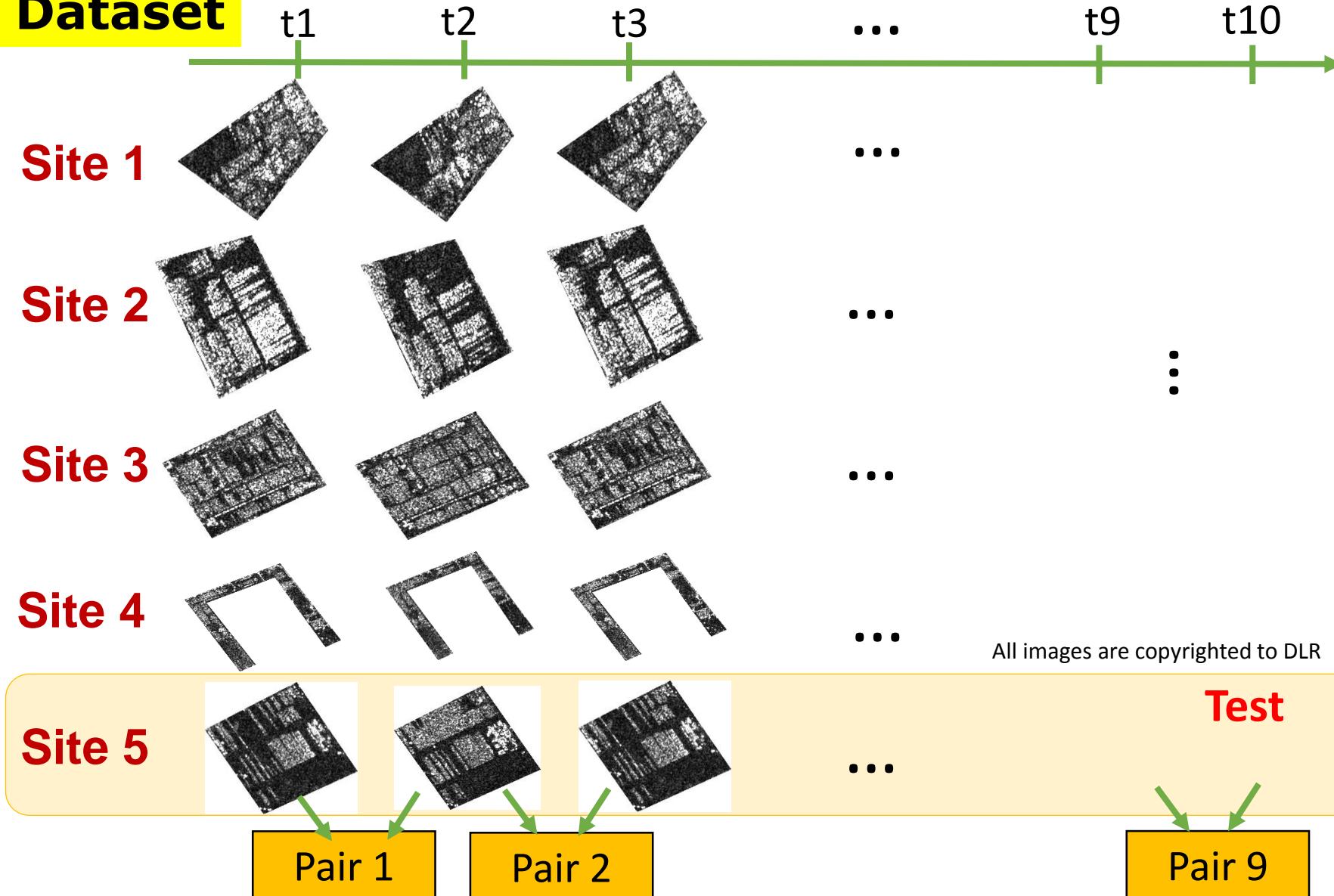
Transform the images into features and compute difference between features

Image at time 1 **Siamese Network**



Experiments : Parking Lot Monitoring

Dataset



Specifications

- TerraSAR-X satellite
- 1m resolution

Baselines:

- PCA-K [1]
- SAE-K [2]

Evaluation Metrics

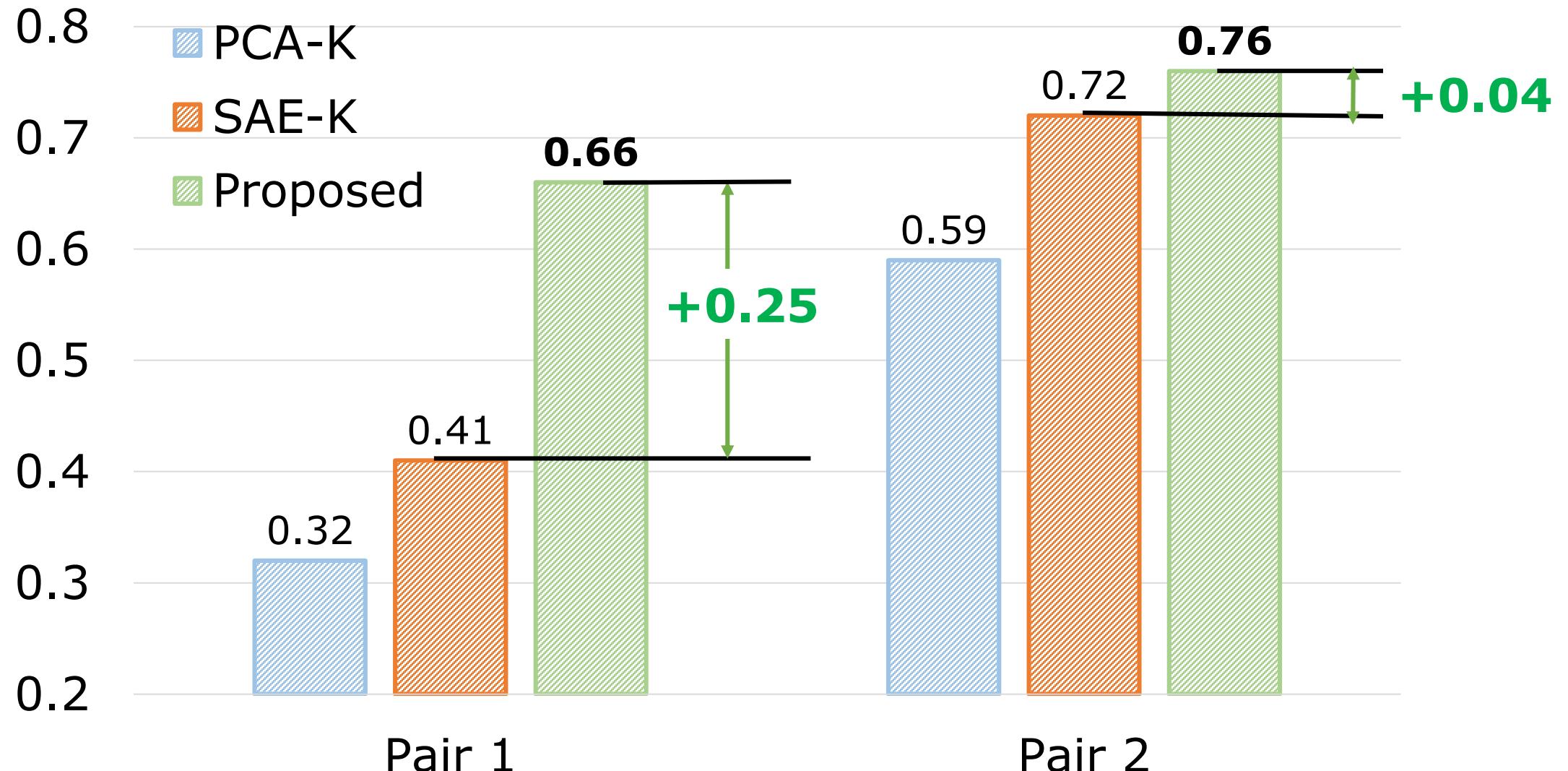
- f-measure
- Change Maps

[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

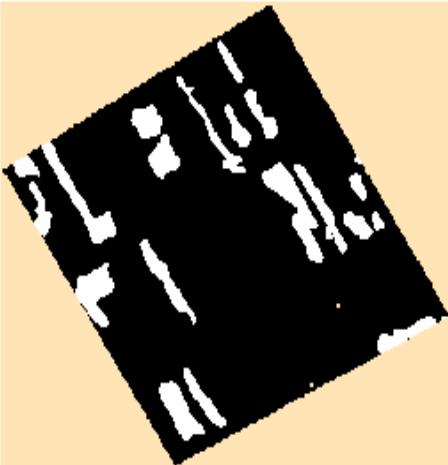
Proposed method improves f-measure by 15% over baselines



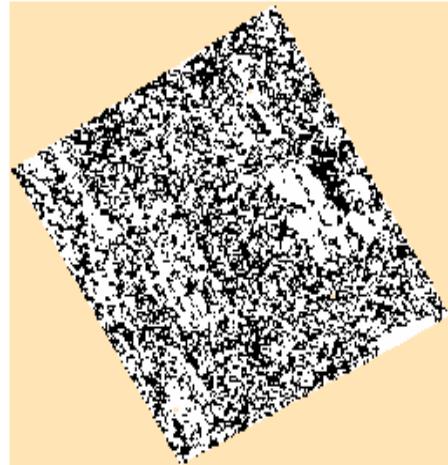
Result [2/2] : Change Maps

Proposed method produces visually better change maps

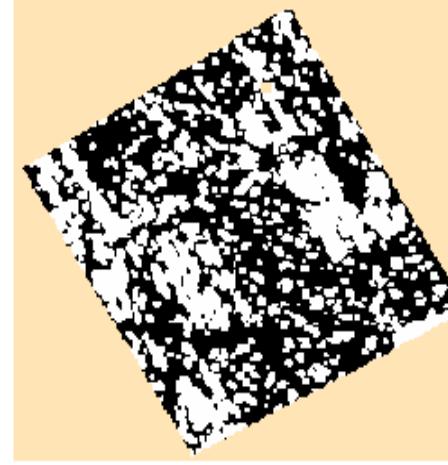
Ground Truth



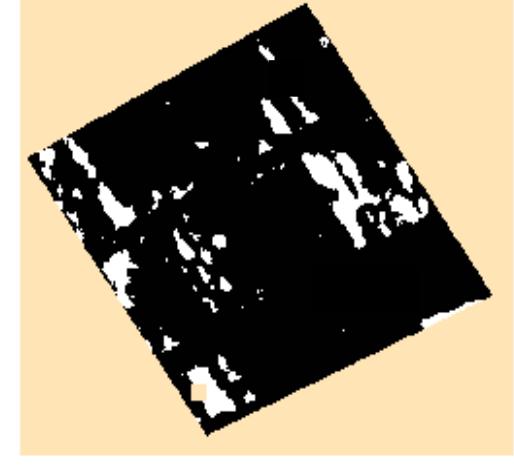
PCA-K



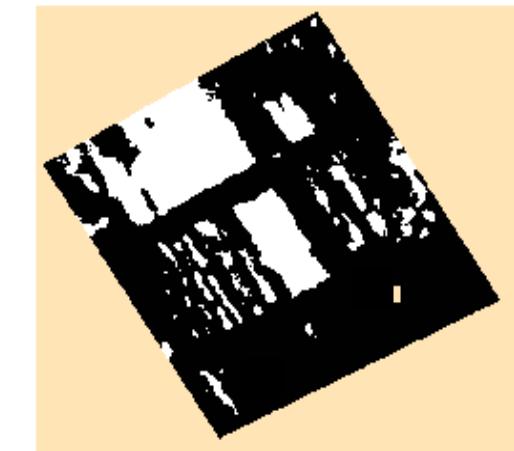
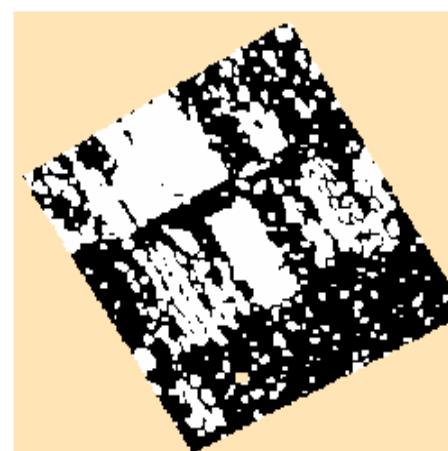
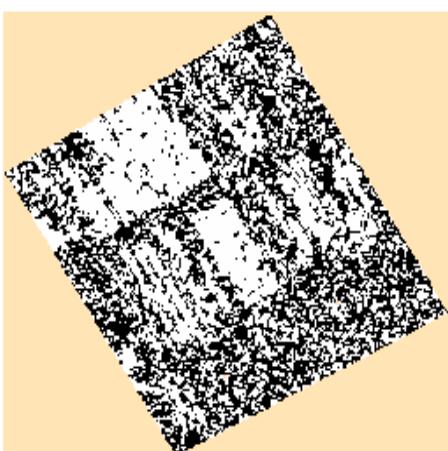
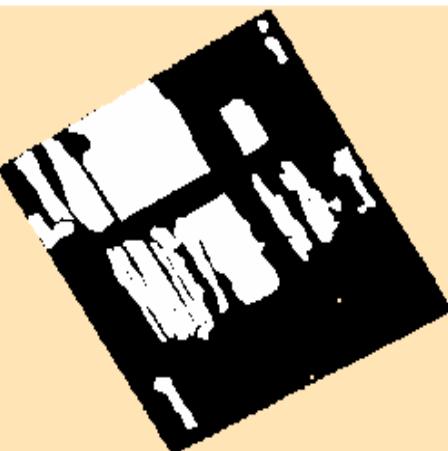
SAE-K



Proposed



Pair 1



Pair 2

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!