

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

Making **computers** see the world as humans

Computer Vision

GI

Deep Learning

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

Why Earth Observation (EO) ?

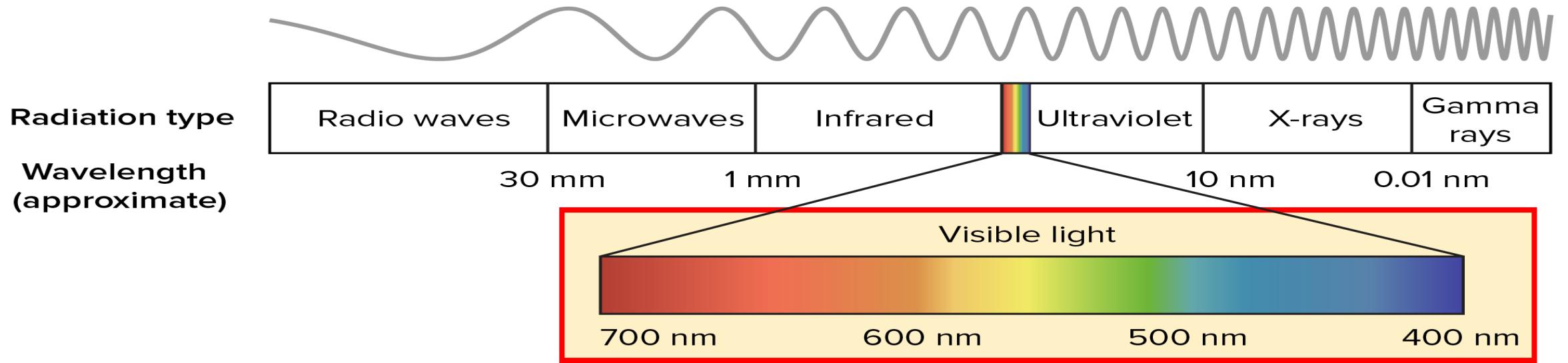
- Currently **only 25%** of the Earth's surface can be seen by ground sensors
- Limits our capability to monitor the entire Earth

Satellite Earth Observation is 'Eye from the Sky'!



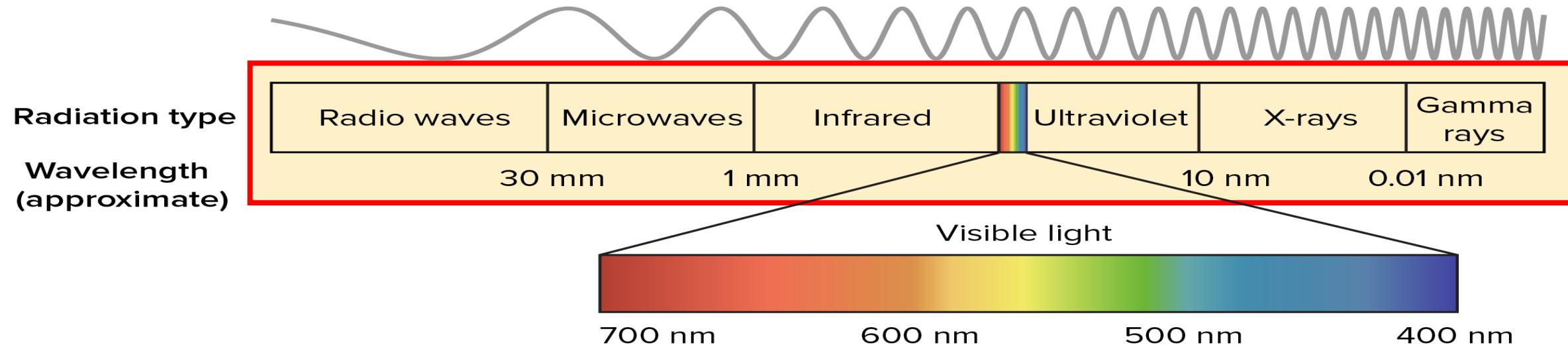
How we see Earth?

Electromagnetic Spectrum



How satellite sees Earth?

Electromagnetic Spectrum

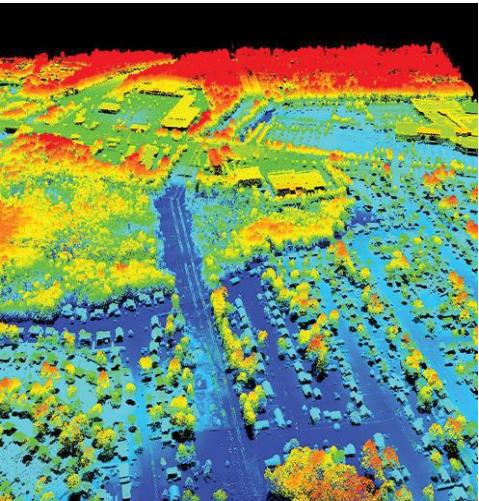


Microwave



©RISAT

LIDAR



Infrared



©NASA

Visible



Panchromatic

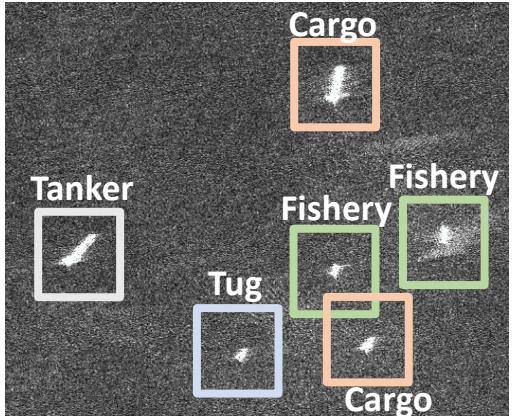


DIGITAL GLOBE | World Cup 2010 - Nelson Mandela Stadium | Port Elizabeth, South Africa | March 1, 2010 | 30 cm

Applications

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

Ship Classification



Change Detection



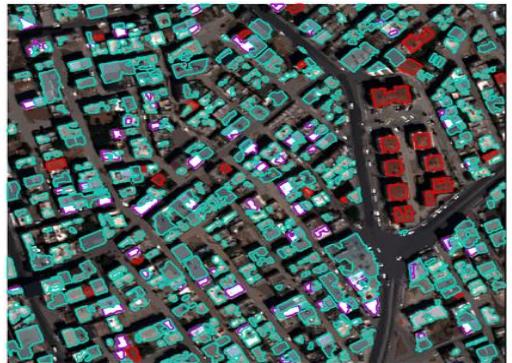
Road Extraction



Tree Counting



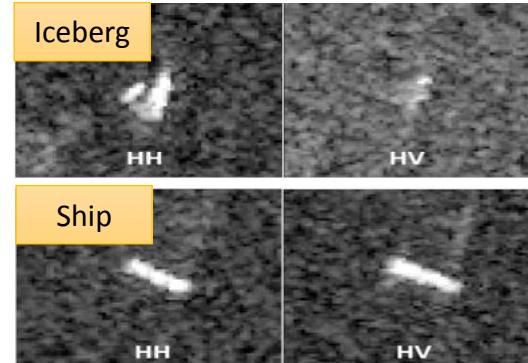
Building Extraction



Land Classification



Iceberg-ship Detection



Disaster Response

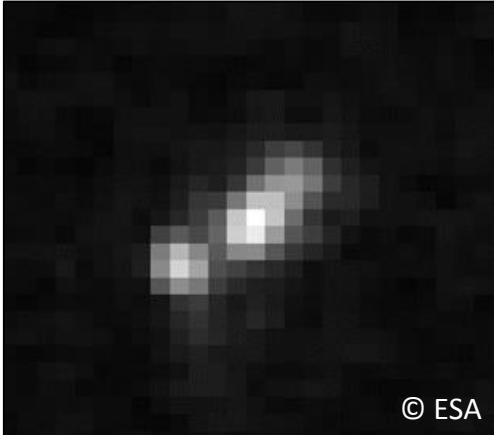


Diverse applications across industries

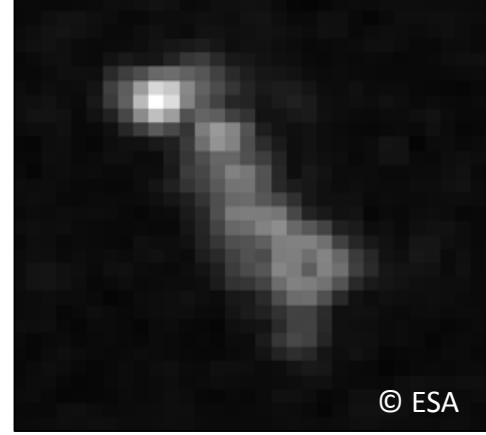
My Research Work : Microwave Images + Deep Learning

■ Ship Classification

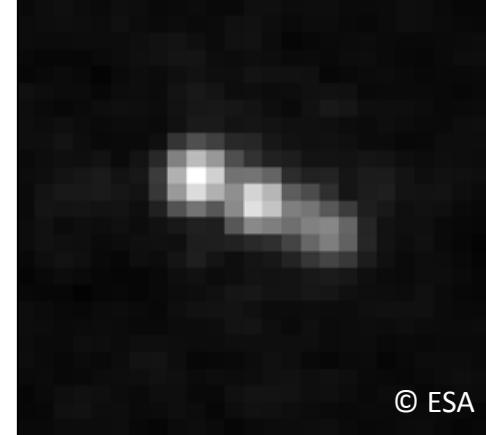
Container



Bulk-carrier

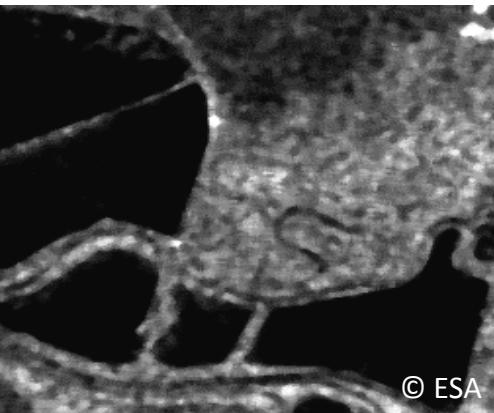


Tanker

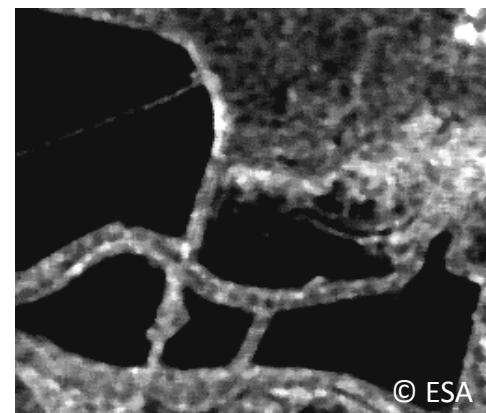


■ Change Detection

Before Image



After Image



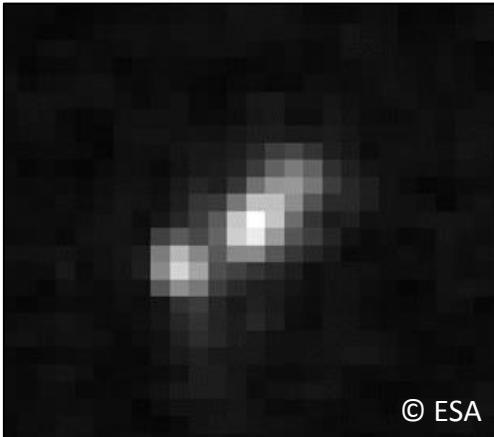
Change Map



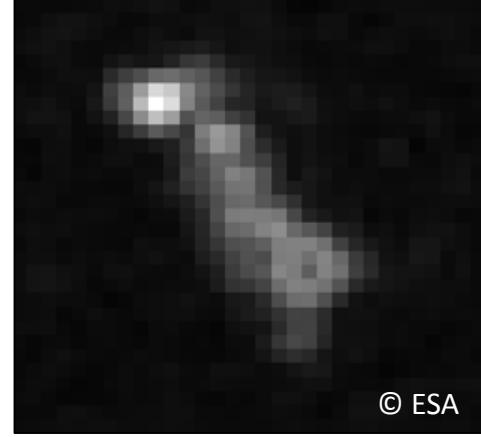
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■ Ship Classification

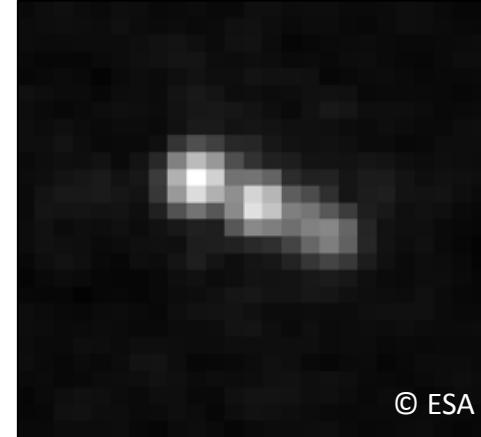
Container



Bulk-carrier

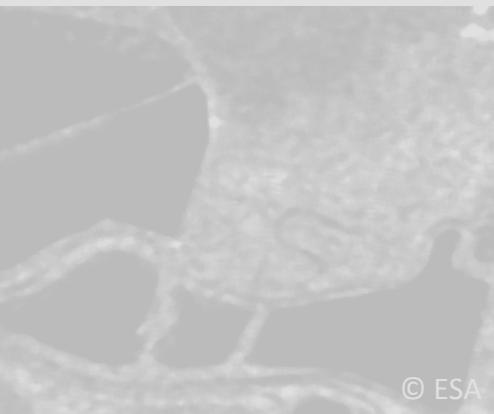


Tanker

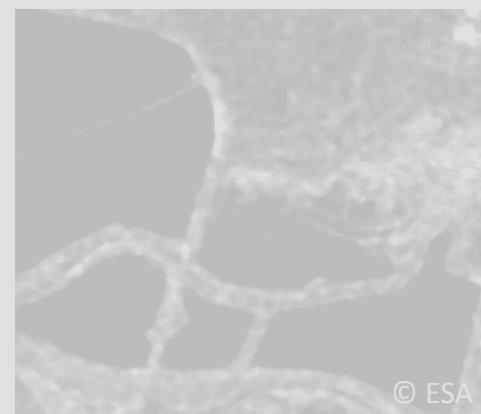


■ Change Detection

Before Image



After Image



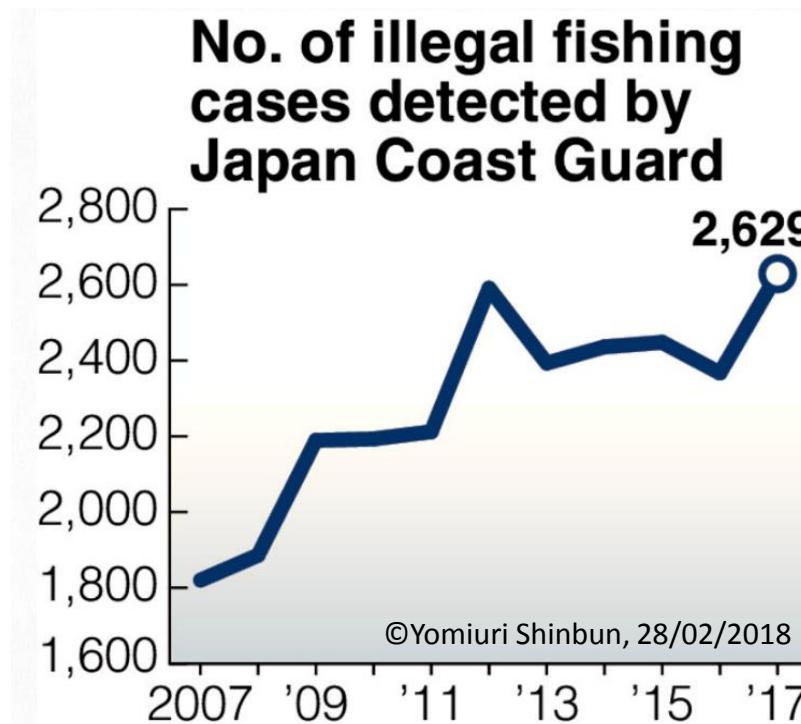
Change Map



Motivation

Ship Classification is a key application in maritime surveillance

Helps in quick identification of ships involved in illegal activities



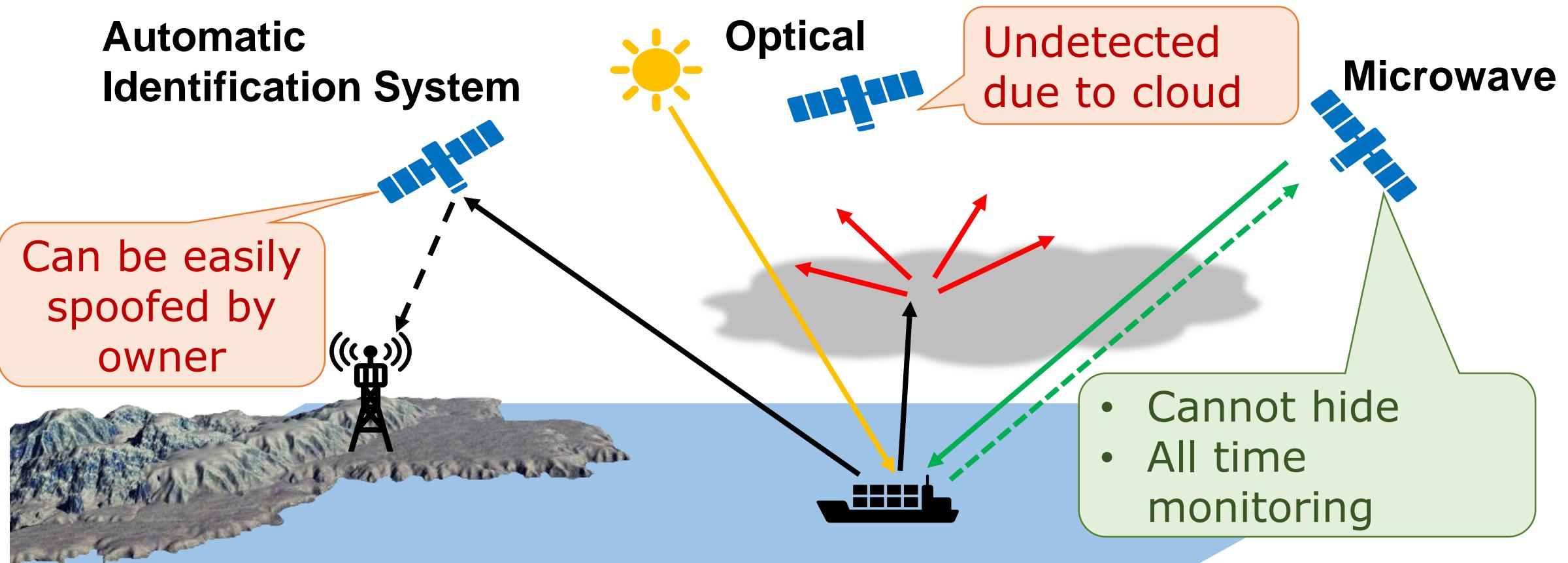
**\$US23 billion loss
worldwide per year!**



Microwaves for Ship Classification

Ship owners indulge in illegal activities to earn high profits

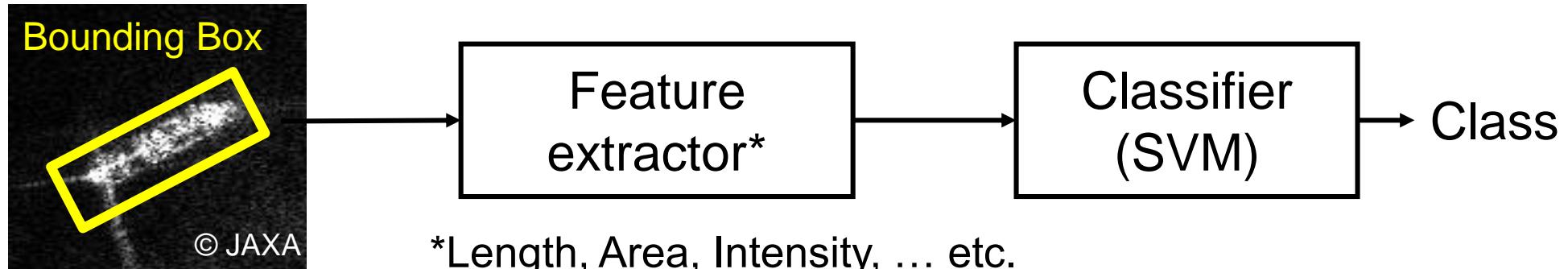
Microwaves can see ships undetected/spoofed by traditional sensing



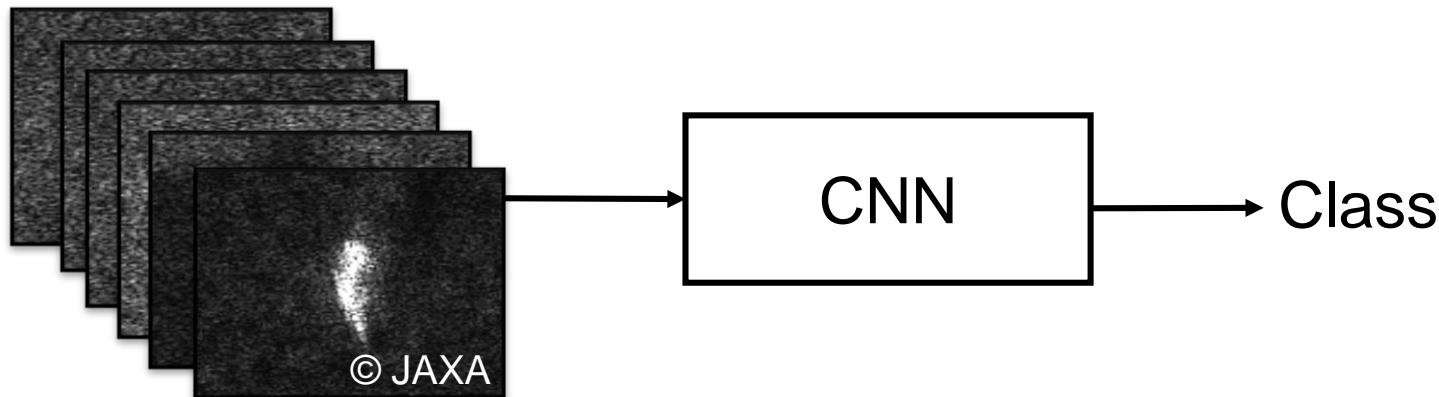
Microwave images are highly reliable for ship classification

Conventional Methods

1. Hand-crafted feature (HCF)-based



2. Convolutional Neural Network (CNN)-based



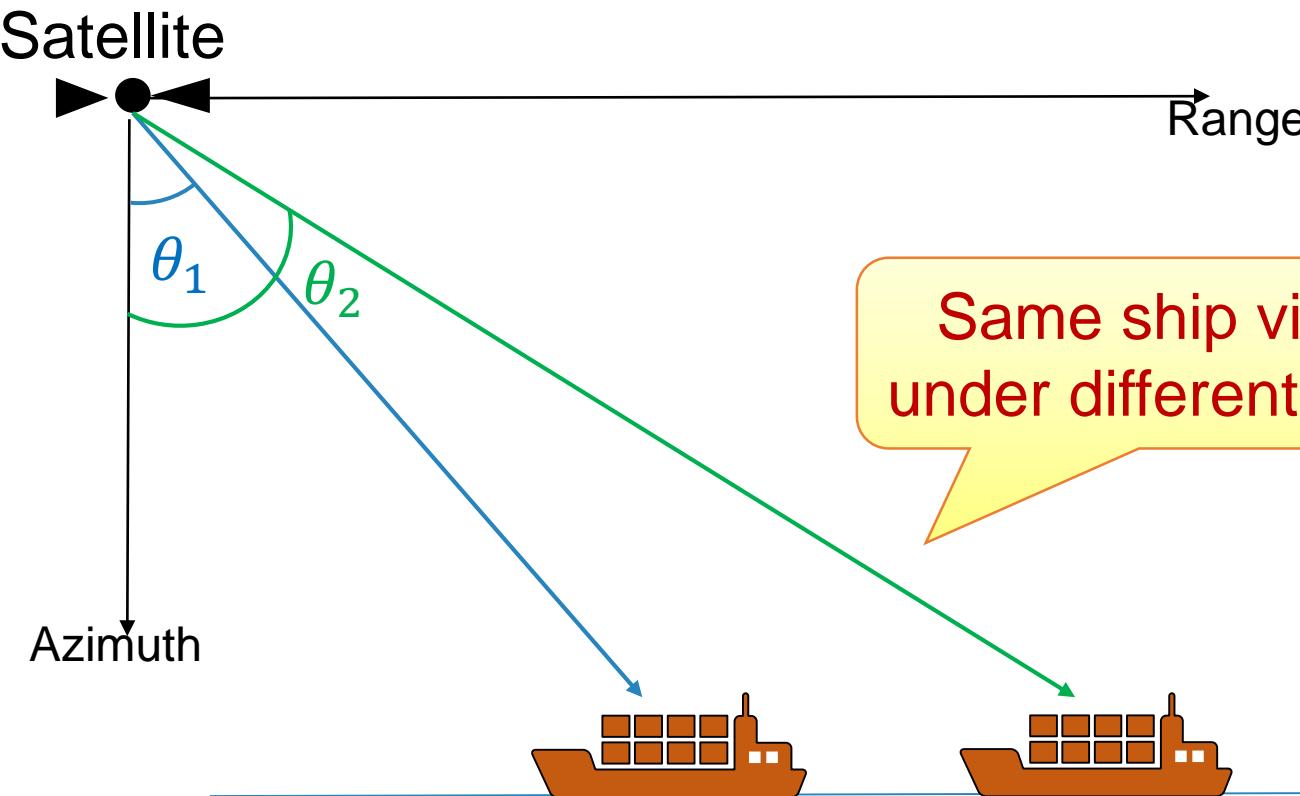
These methods classify a ship based on its appearance in image

Problem

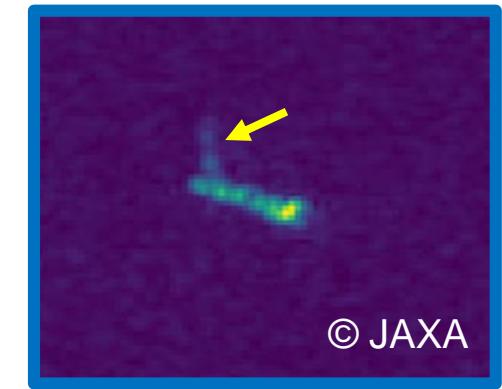
Appearance of a ship varies with satellite viewing angle

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

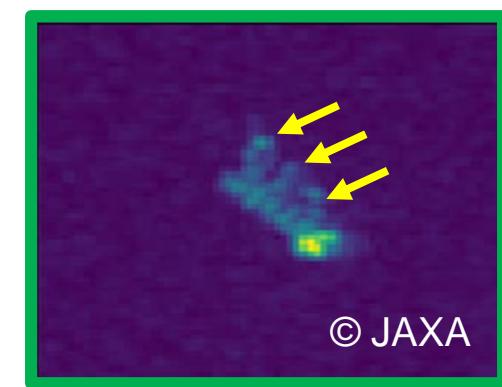
Example:



$$\theta_1 = 30^\circ$$



$$\theta_2 = 40^\circ$$

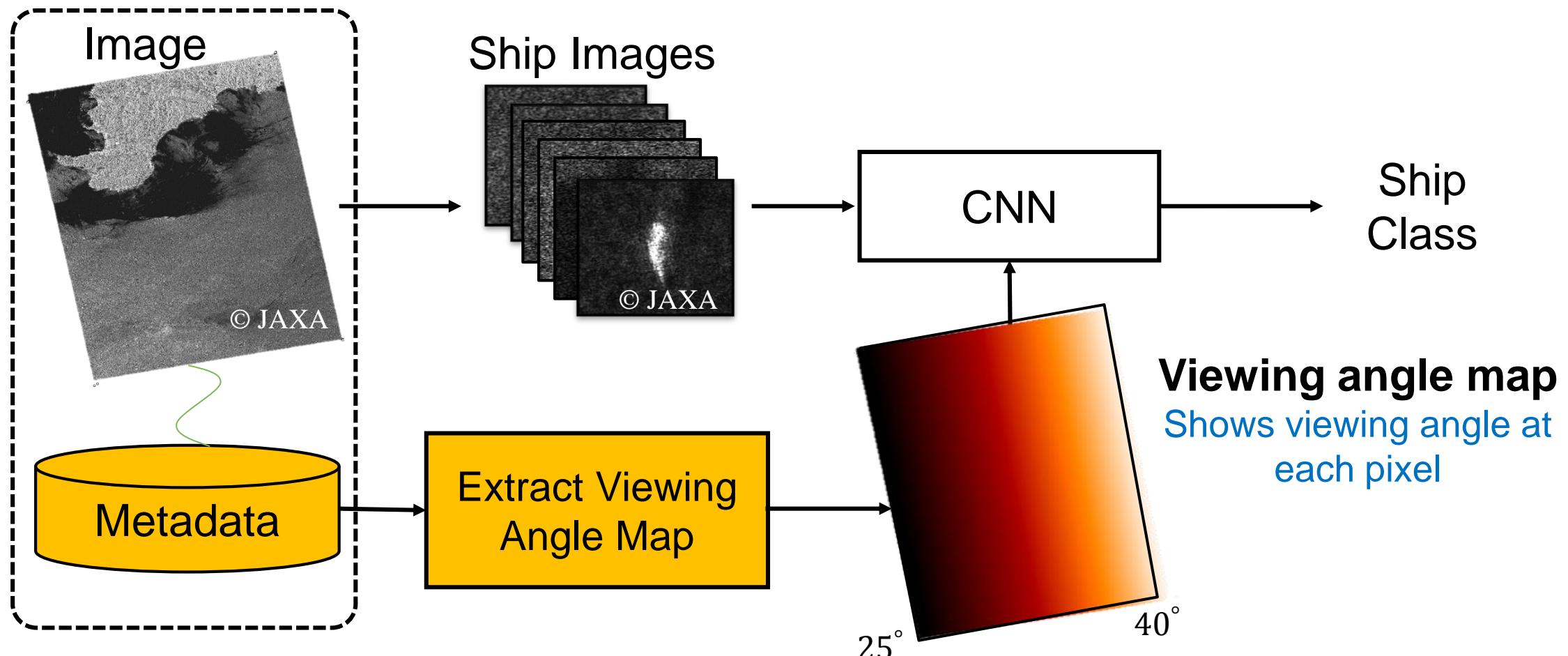


Only image information is insufficient for robust classification

Proposed Method

Use viewing angle as an additional information in a NN

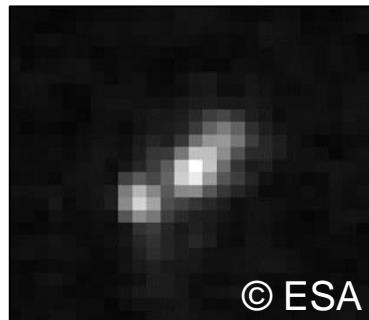
Helps the CNN to follow the appearance changes by learning a relationship



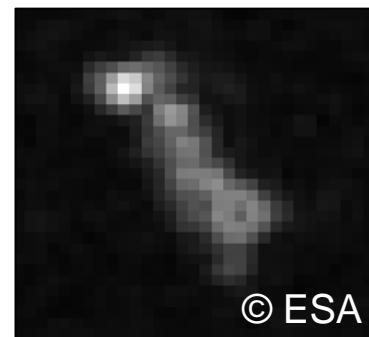
Experiments

Dataset: OpenSARShip*

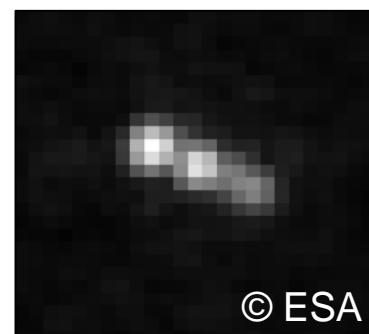
Container



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

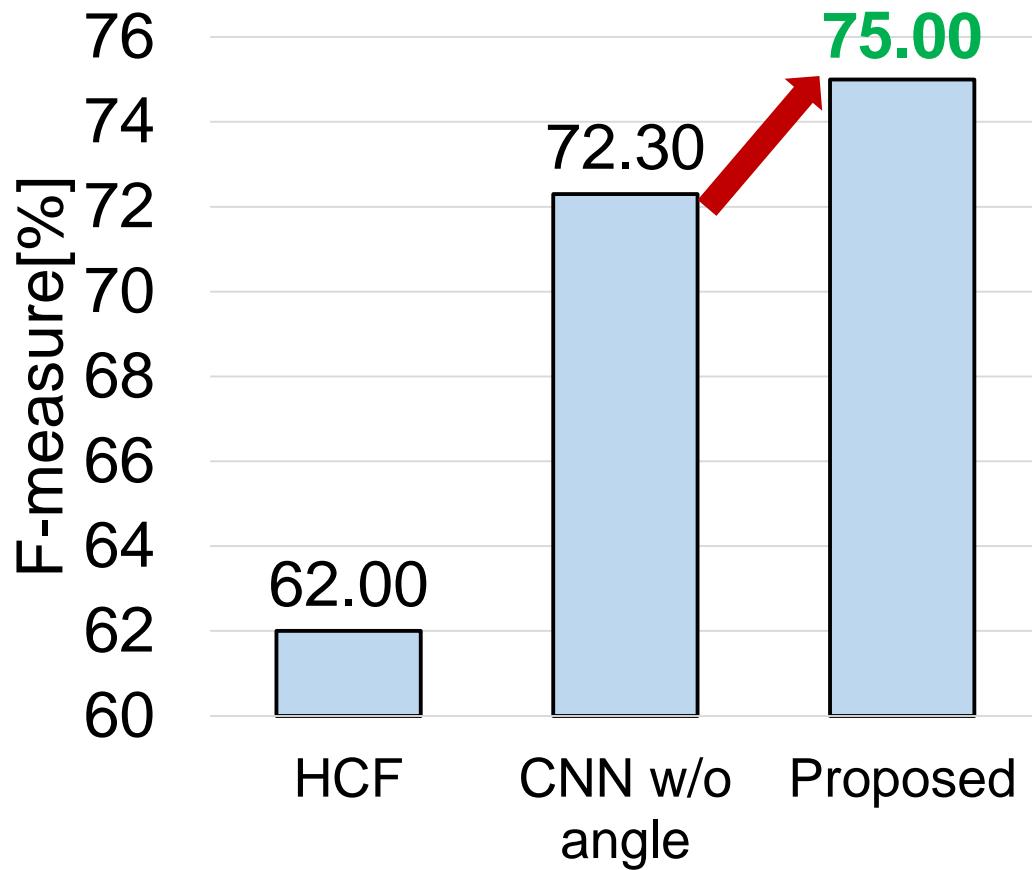
Metrics

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

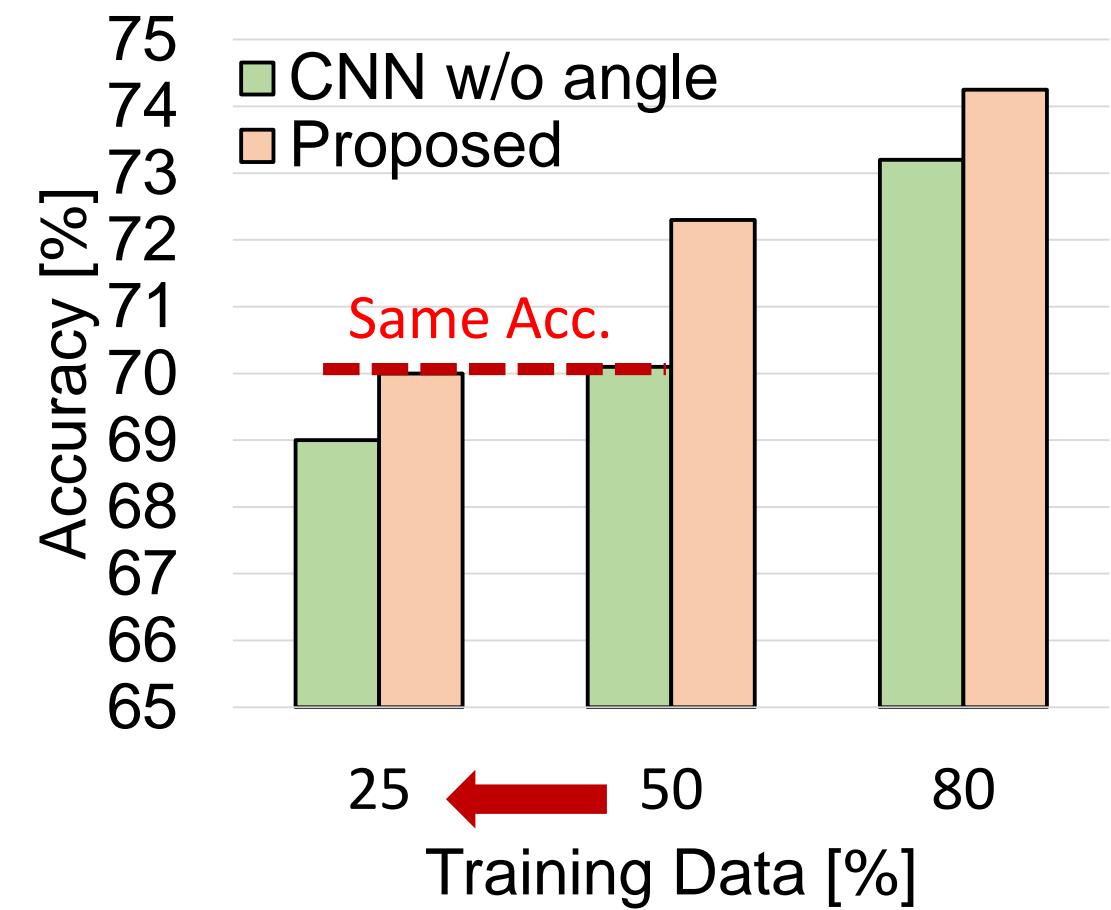
*Huang, L et al., "OpenSARShip: A dataset dedicated to Sentinel-1 ship interpretation," IEEE Journal of Sel. Top. in App. Earth Obs. and Rem. Sen. 11(1), 195-208 (2018).

Results

4.2% improvement in f-measure



25% reduction in training data requirement



Demo

Please select SAR image.

--Image list-- ▾

[exec detection](#) [show detail](#) [show not linked](#)

Input Image

Result Image



\Orchestrating a brighter world

NEC

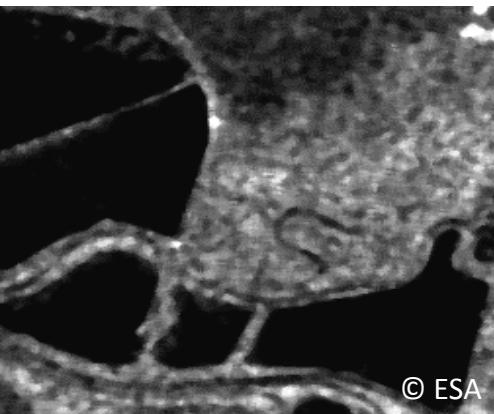
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■ Ship Classification

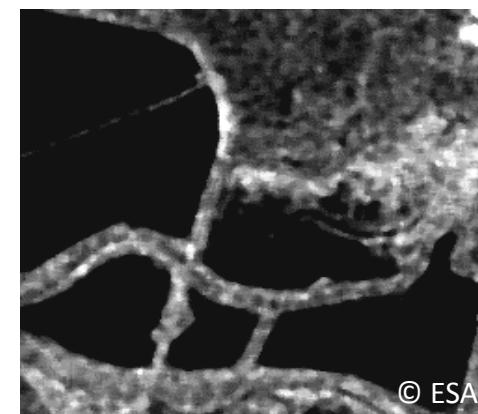


■ Change Detection

Before Image



After Image



Change Map



Motivation

Change detection enables us to understand dynamics of Earth

Dubai Coastal Expansion



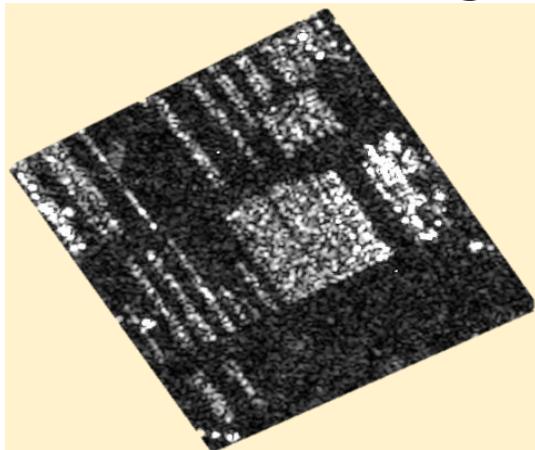
Saudi Arabia Irrigation



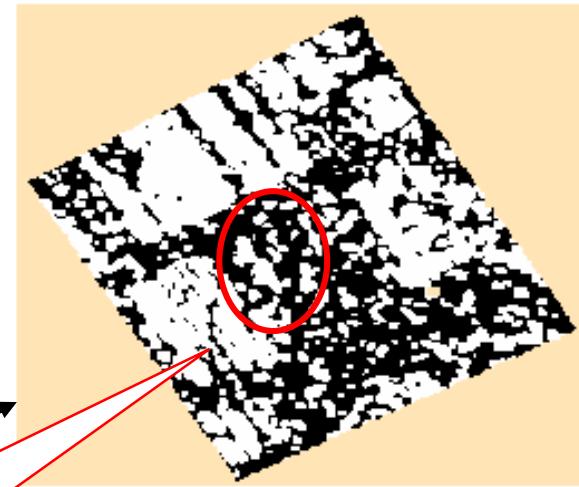
Conventional Method

Based on pixel-to-pixel difference followed by classification

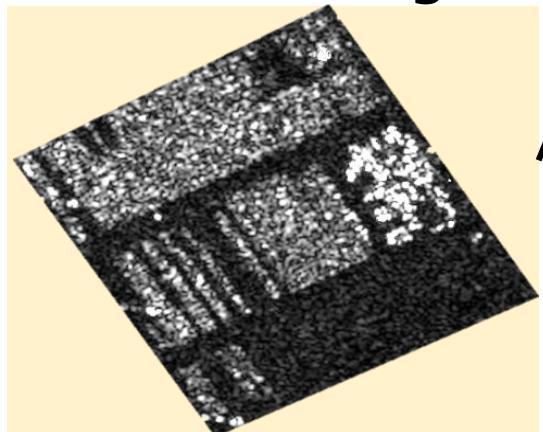
Before Image



Change Map



After Image



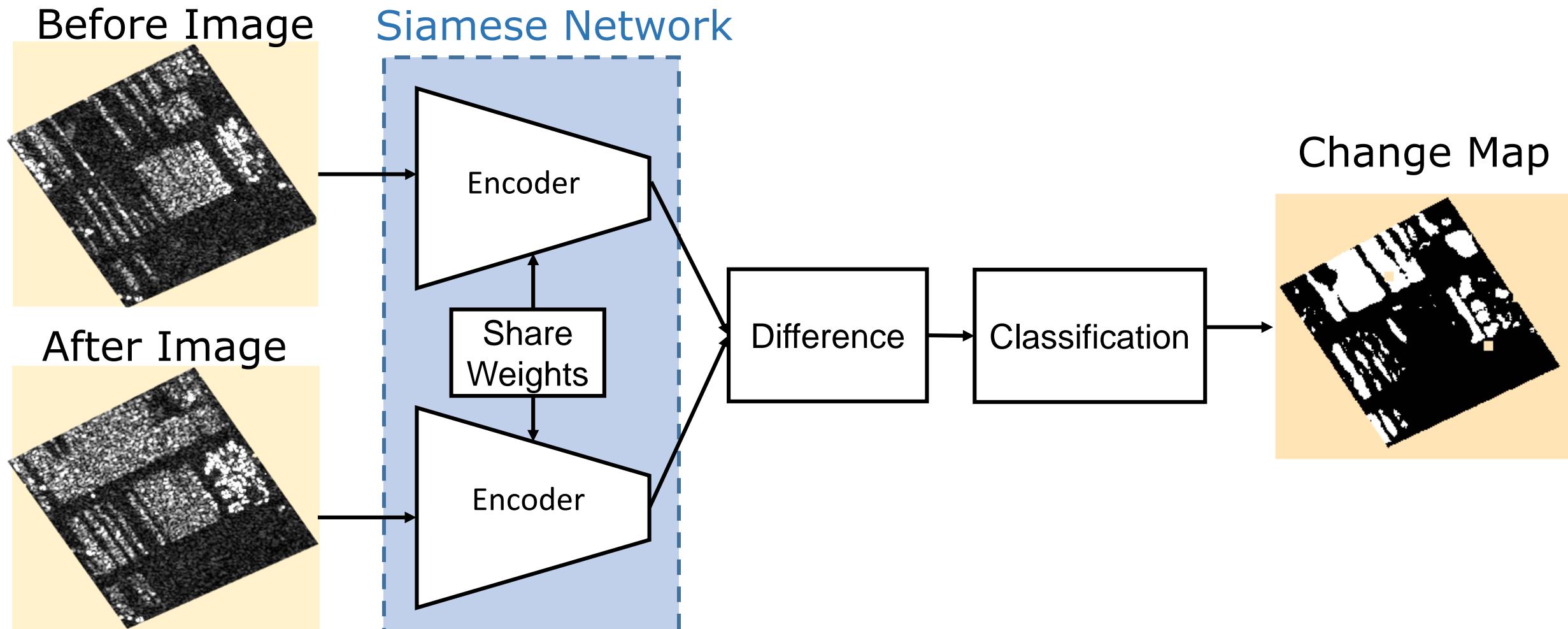
Pixel-to-pixel
difference

Classification

**Problem:
Many False Alarms!**

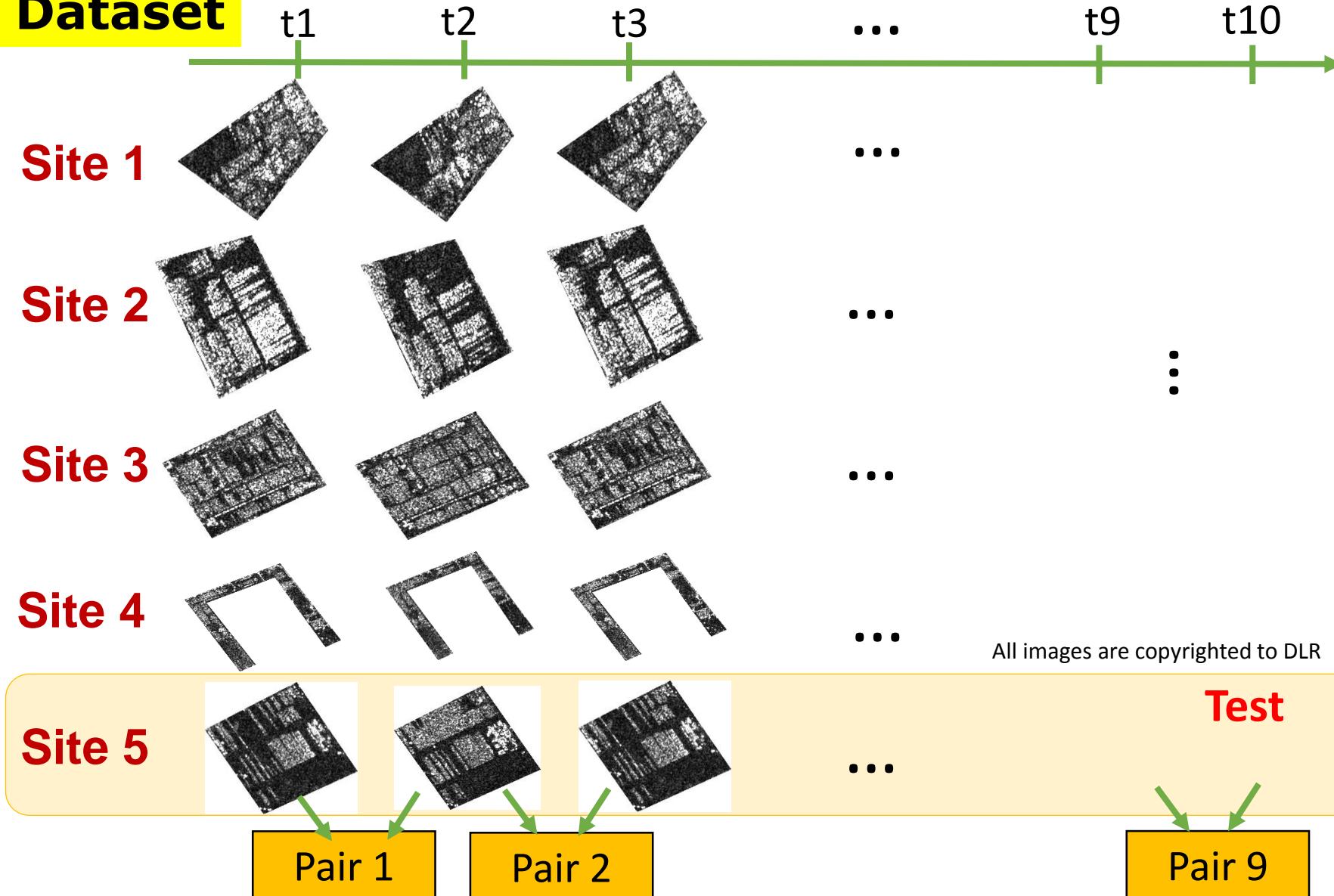
Proposed Method

Transform the images into features and compute difference between features



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

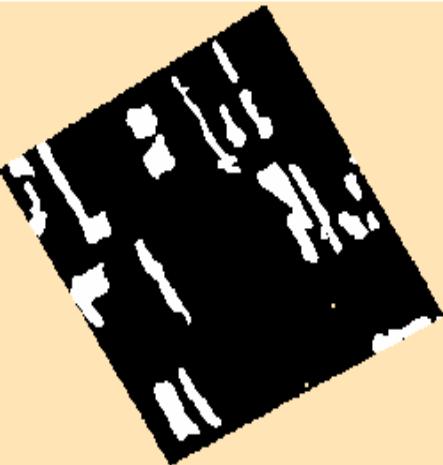
Proposed method improves f-measure by 15% over baselines



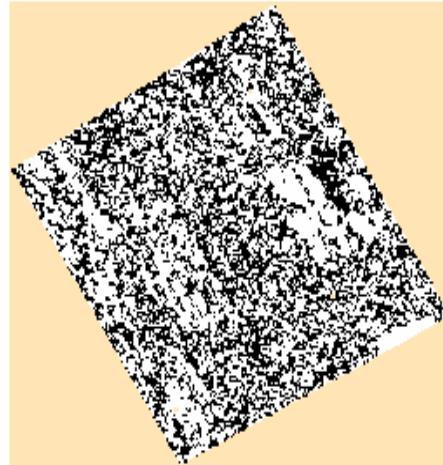
Result [2/2] : Change Maps

Proposed method produces visually better change maps

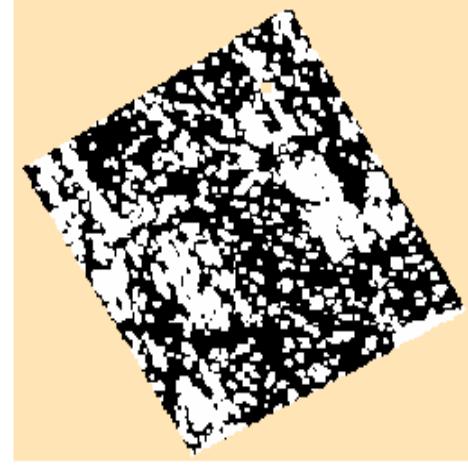
Ground Truth



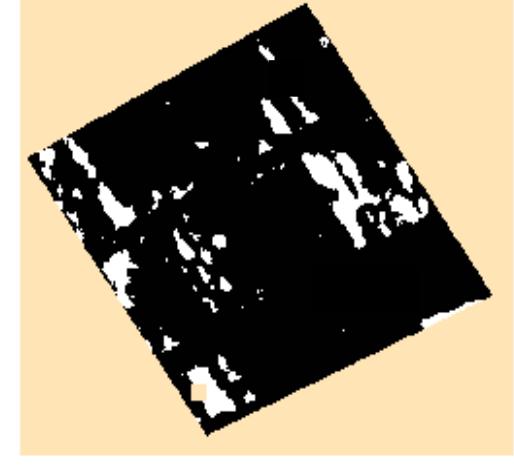
PCA-K



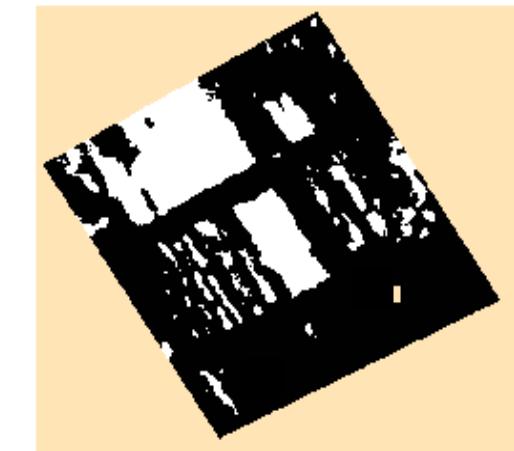
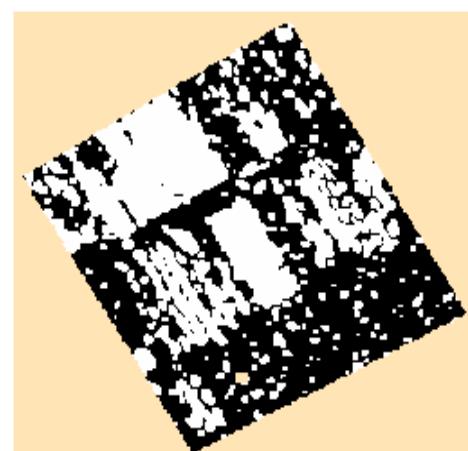
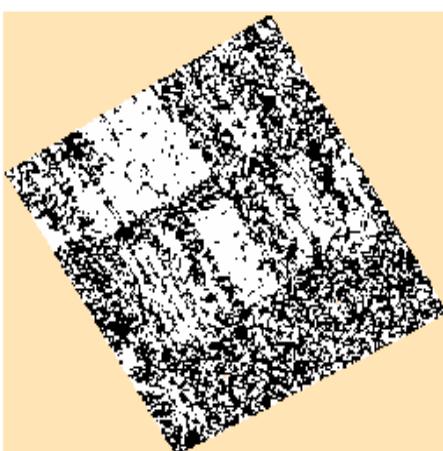
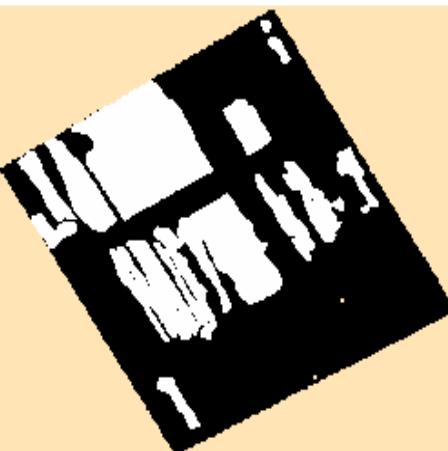
SAE-K



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 of Life**'
- Presented **my research work** on
 - Ship classification
 - Change detection

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