

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) ?

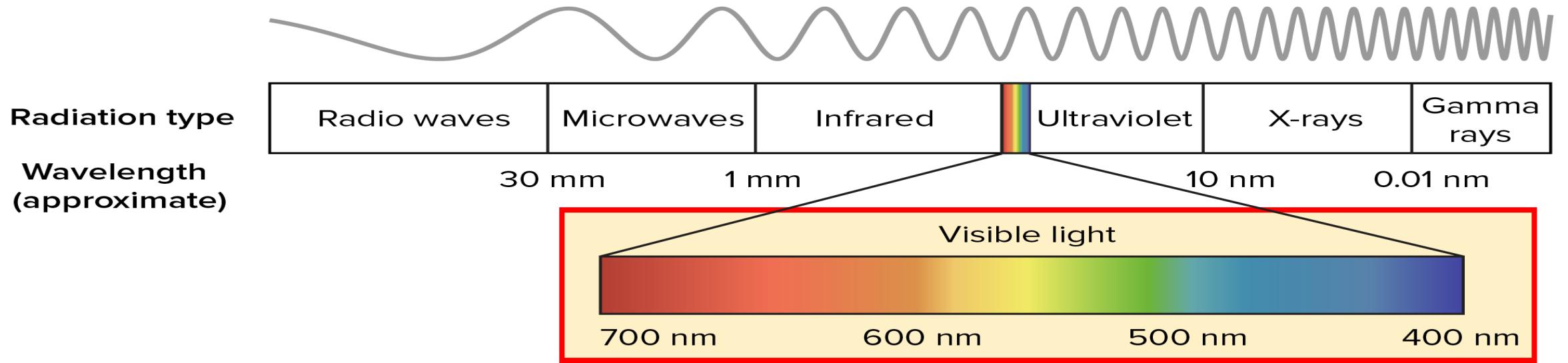
- Currently **only 25%** of the Earth's surface can be seen by ground sensors
- Limits our capability to monitor the entire Earth



Satellite Earth Observation is 'Eye from the Sky'!

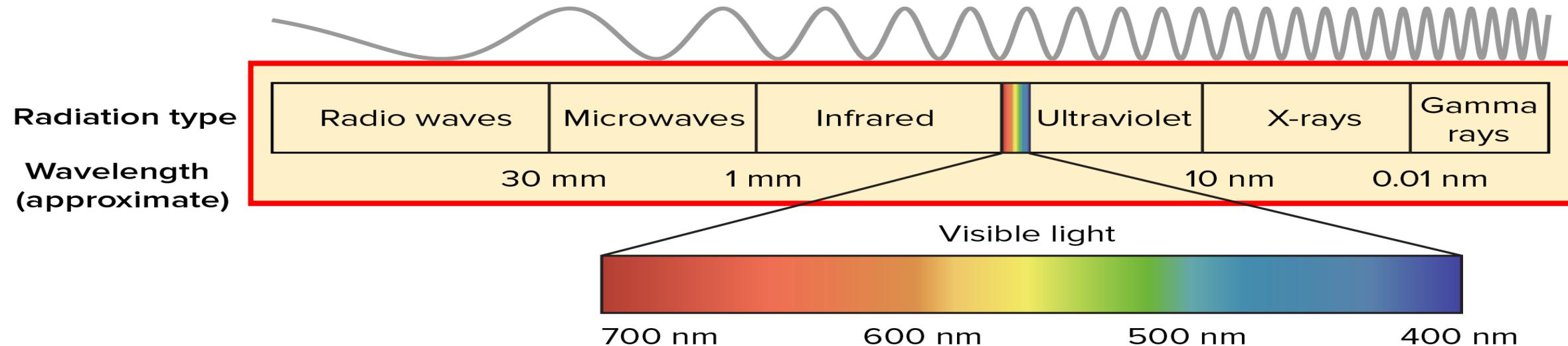
How we see Earth?

Electromagnetic Spectrum



How satellite sees Earth?

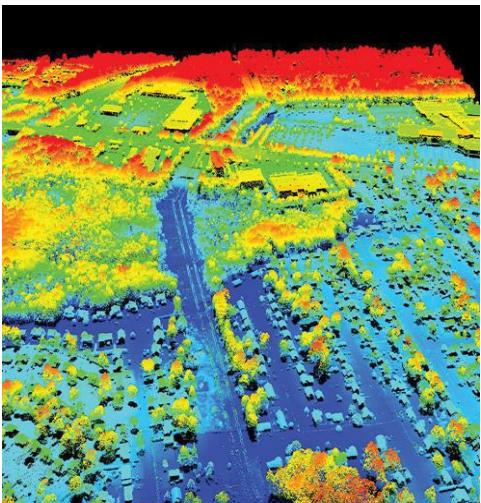
Electromagnetic Spectrum



Microwave



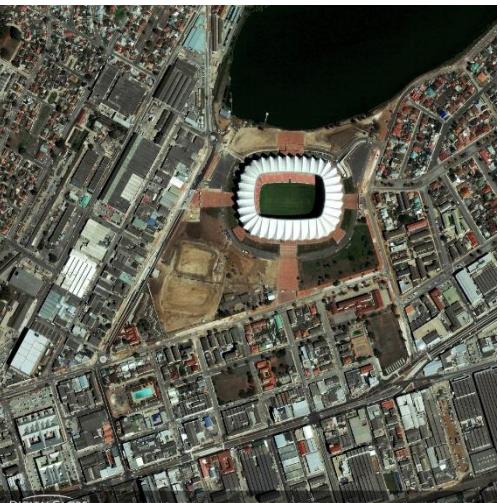
LIDAR



Infrared



Visible



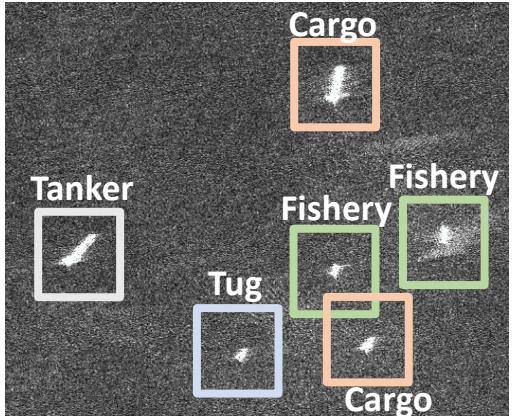
Panchromatic



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



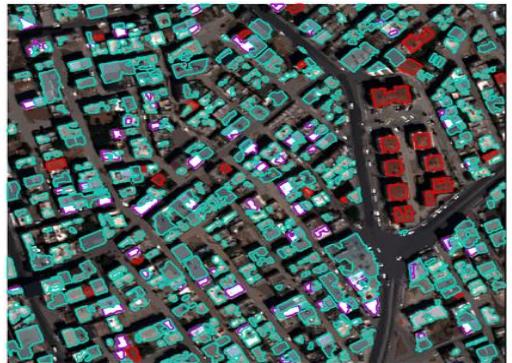
Road Extraction



Tree Counting



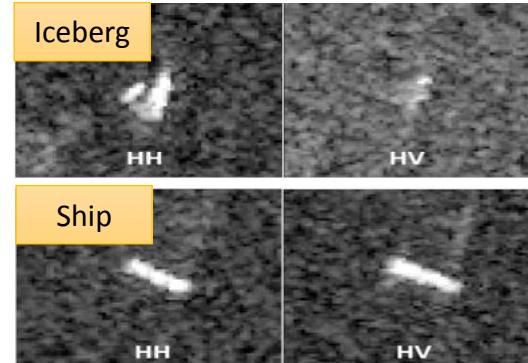
Building Extraction



Land Classification



Iceberg-ship Detection



Disaster Response

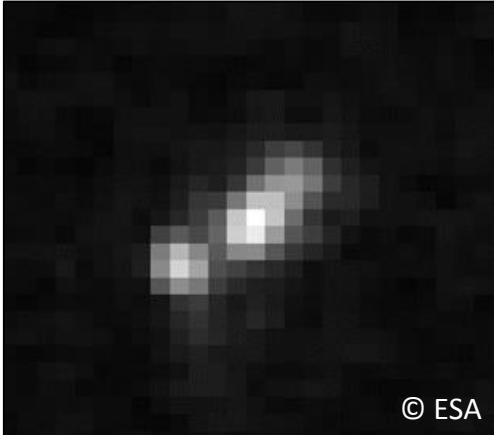


Diverse applications across industries

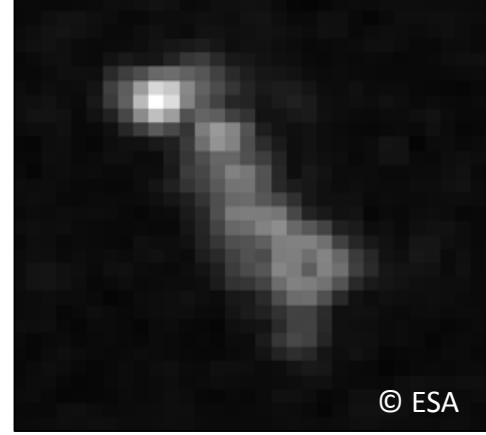
My Research Work : Microwave Images + Deep Learning

■ Ship Classification

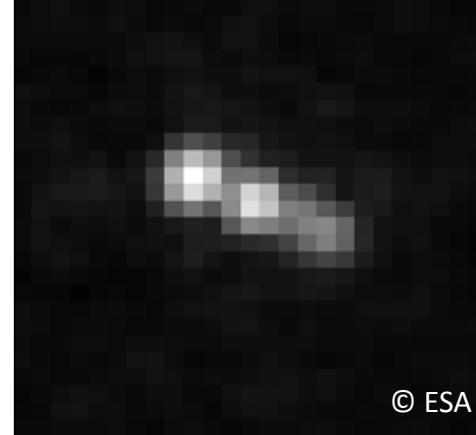
Container



Bulk-carrier

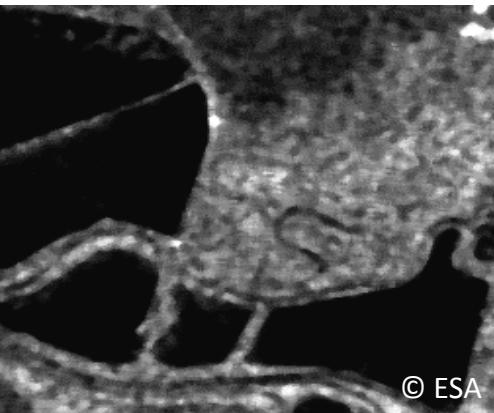


Tanker

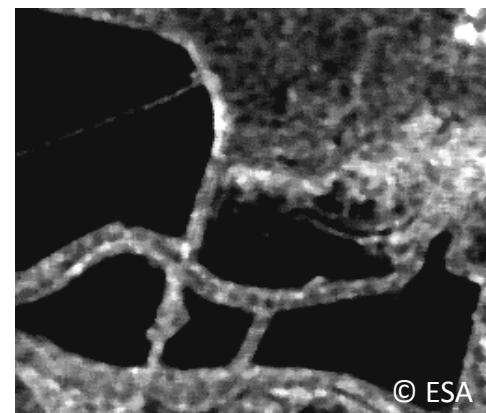


■ Change Detection

Before Image



After Image



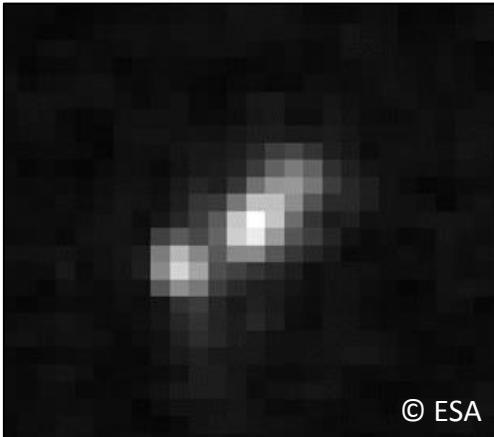
Change Map



My Research Work : Microwave Images + Deep Learning

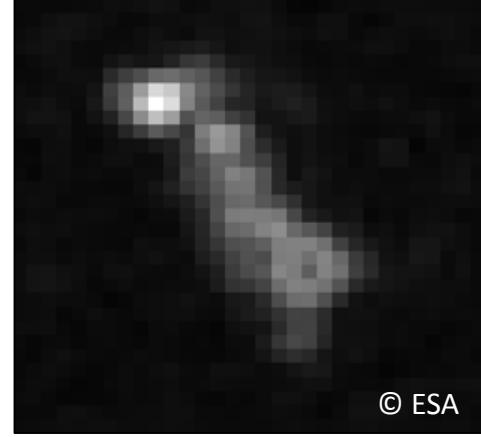
■ Ship Classification

Container



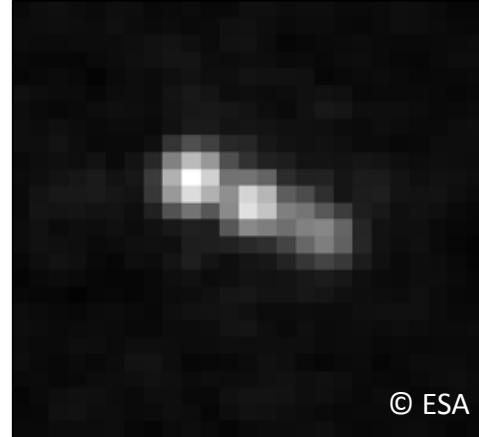
© ESA

Bulk-carrier



© ESA

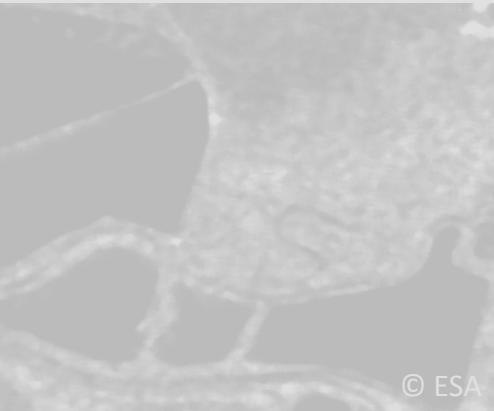
Tanker



© ESA

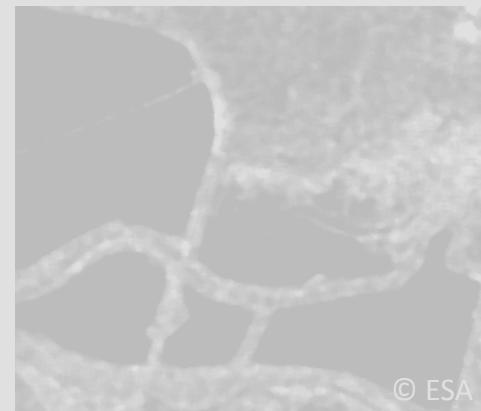
■ Change Detection

Before Image



© ESA

After Image



© ESA

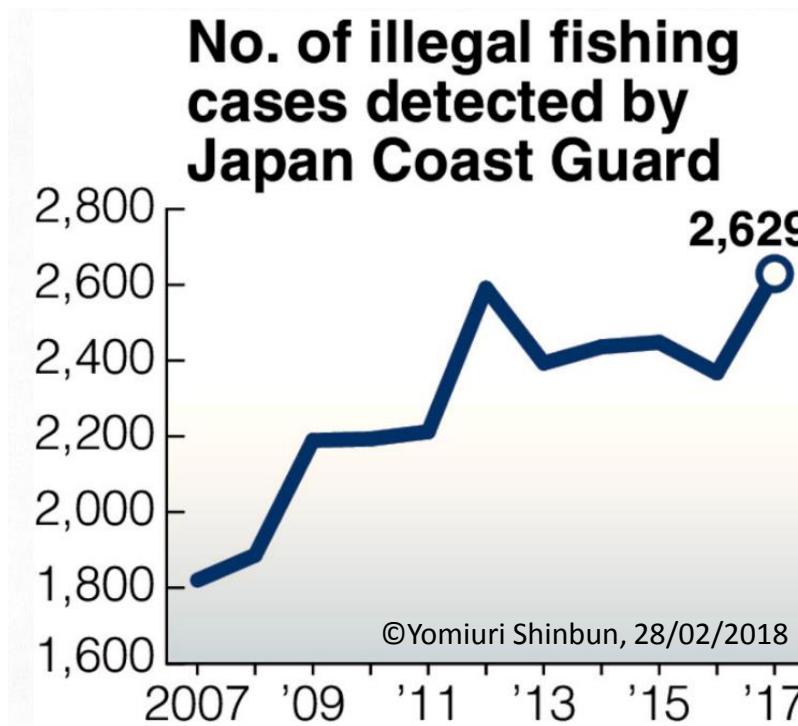
Change Map



Motivation

Ship Classification is a key application in maritime surveillance

Helps in quick identification of ships involved in illegal activities

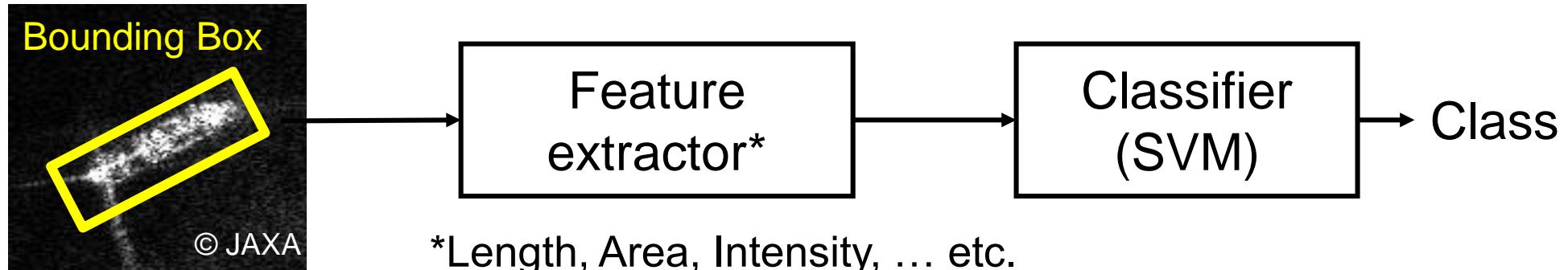


\$US23 billion loss worldwide per year!

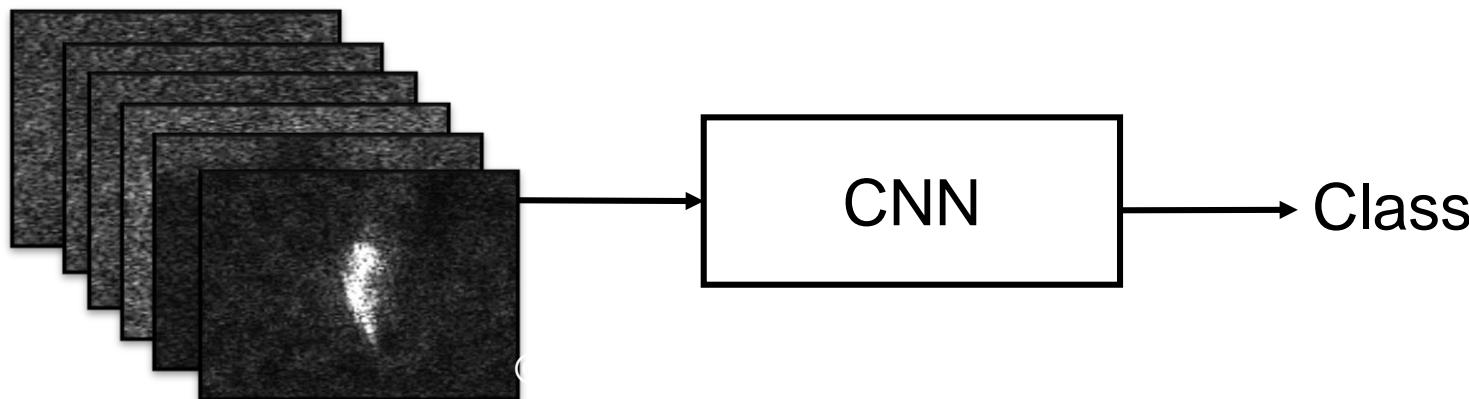


Conventional Ship Classification Methods

1. Hand-crafted feature-based



2. Convolutional Neural Network (CNN)-based



These methods classify a ship based on its appearance in image

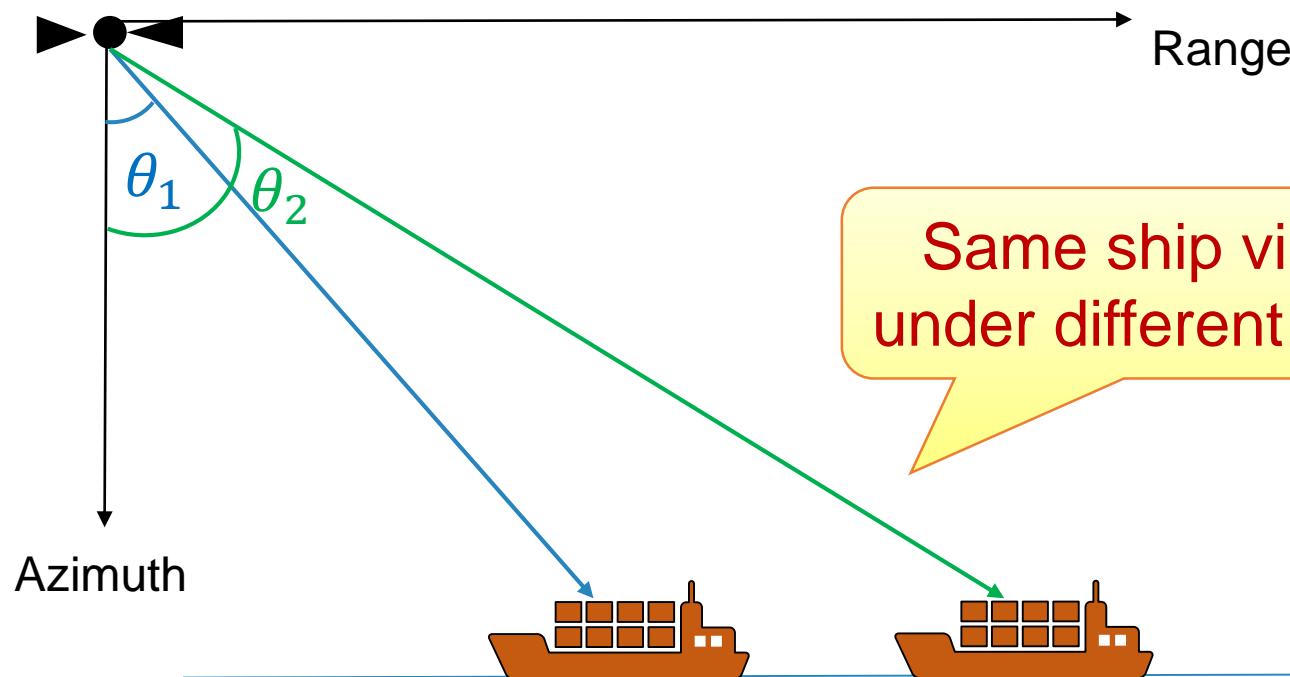
Problem

Appearance of a ship varies with satellite viewing angle

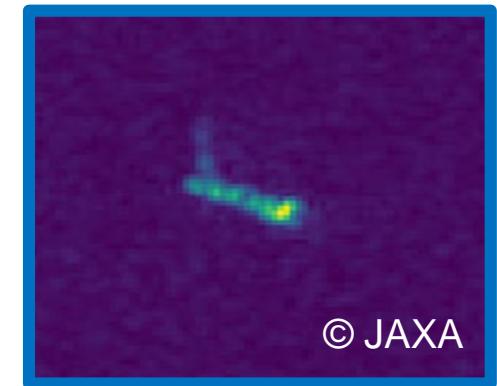
Labelled images are **very few** to learn all possible variations

Example:

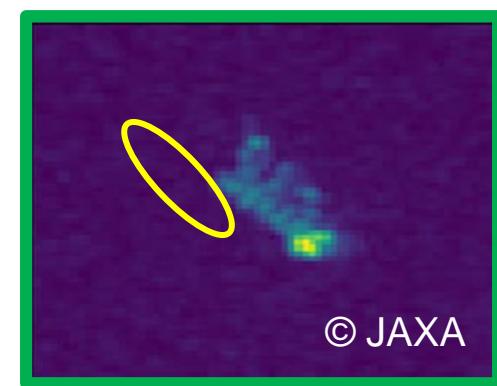
Satellite



$$\theta_1 = 30^\circ$$



$$\theta_2 = 40^\circ$$

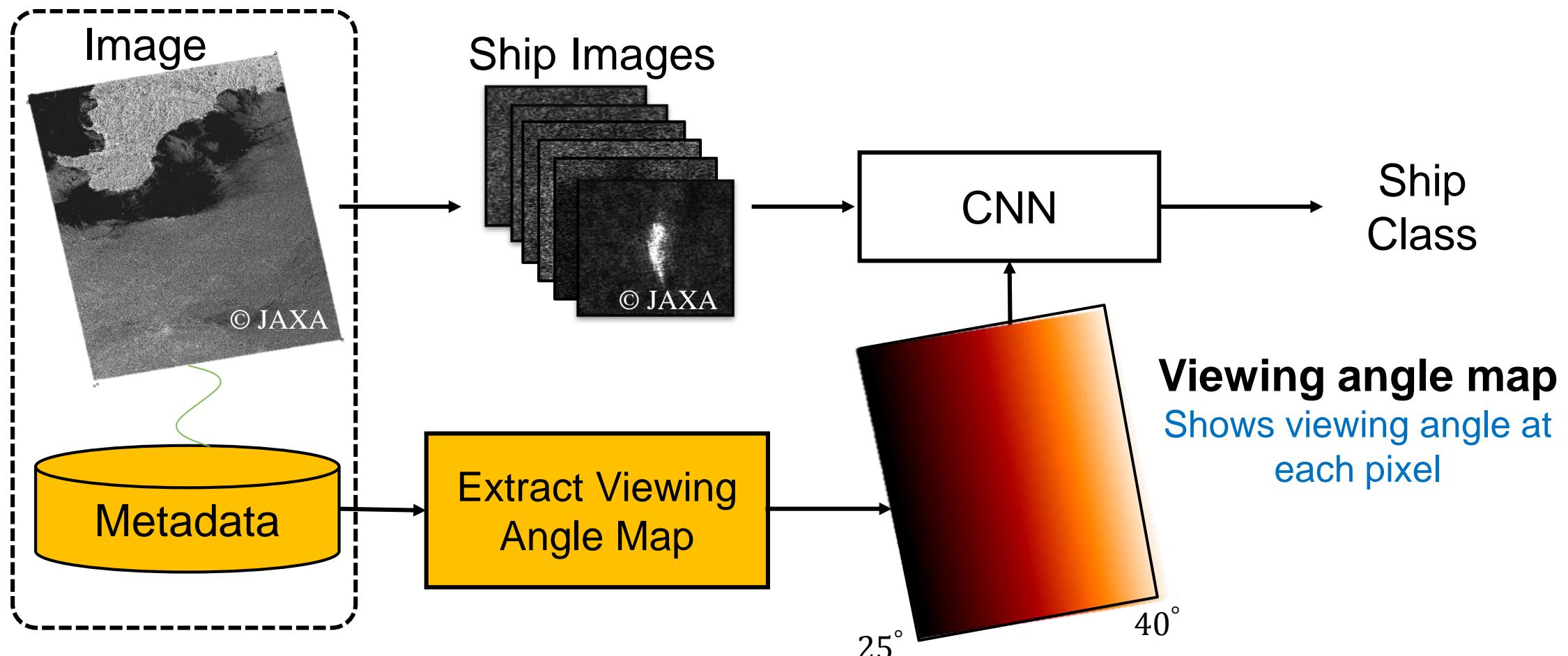


Only image information is insufficient for robust classification

Proposed Method

Use viewing angle as an additional information in a NN

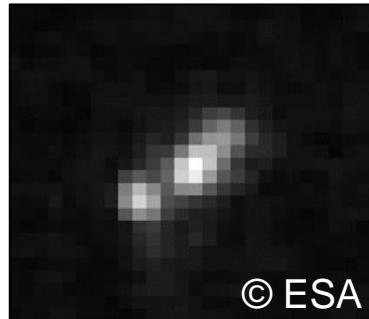
Helps the CNN to follow the appearance changes by learning a relationship



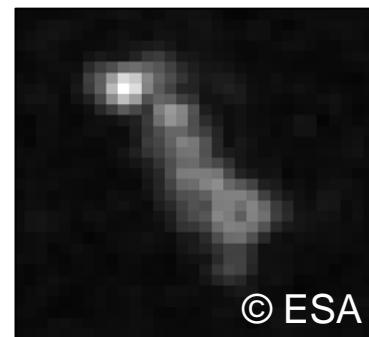
Experiments

Dataset: OpenSARShip*

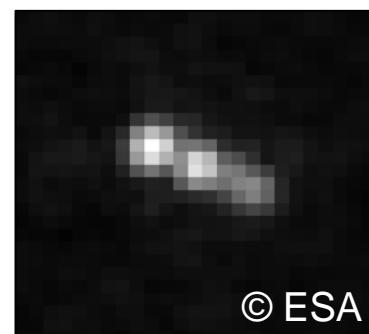
Container



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

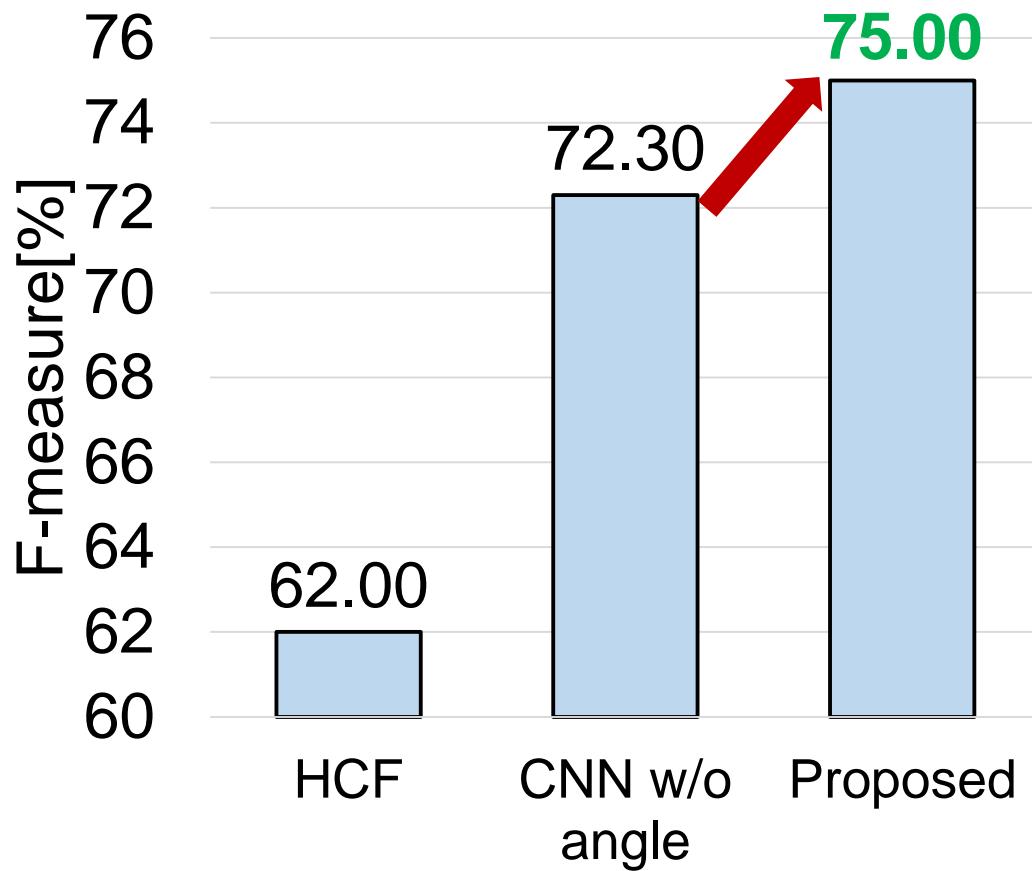
Metrics

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

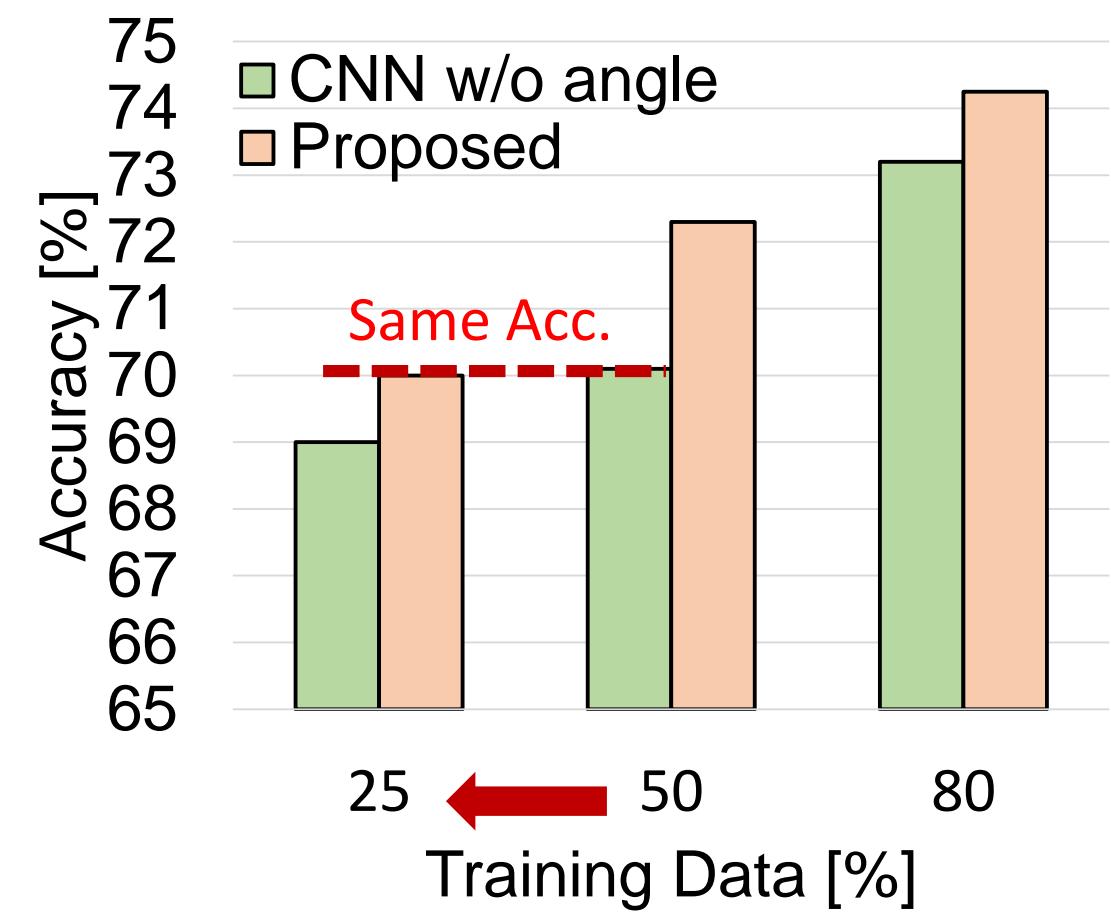
*Huang, L et al., "OpenSARShip: A dataset dedicated to Sentinel-1 ship interpretation," IEEE Journal of Sel. Top. in App. Earth Obs. and Rem. Sen. 11(1), 195-208 (2018).

Results

4.2% improvement in f-measure



25% reduction in training data requirement



Demo

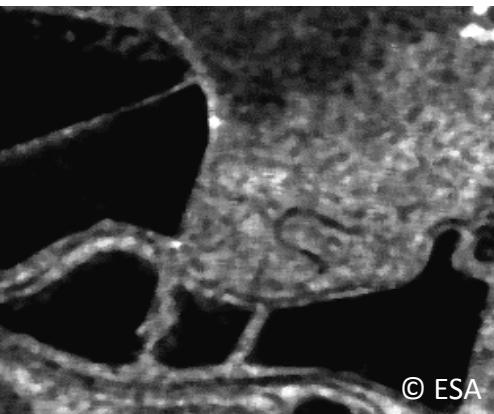
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■ Ship Classification

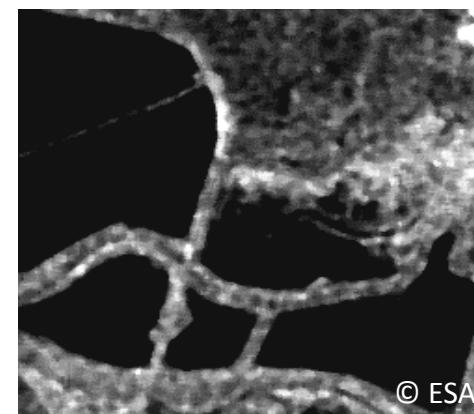


■ Change Detection

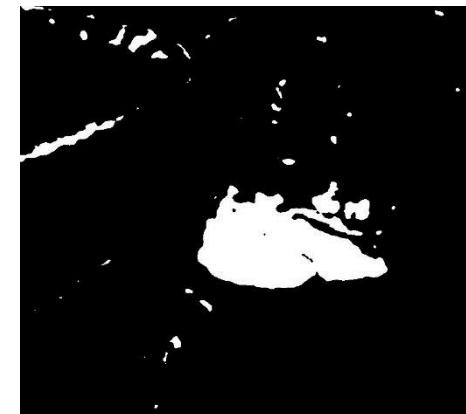
Before Image



After Image



Change Map



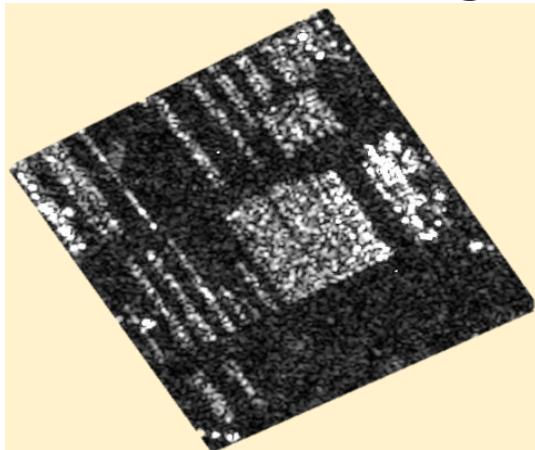
Motivation

Change detection enables us to understand dynamics of Earth

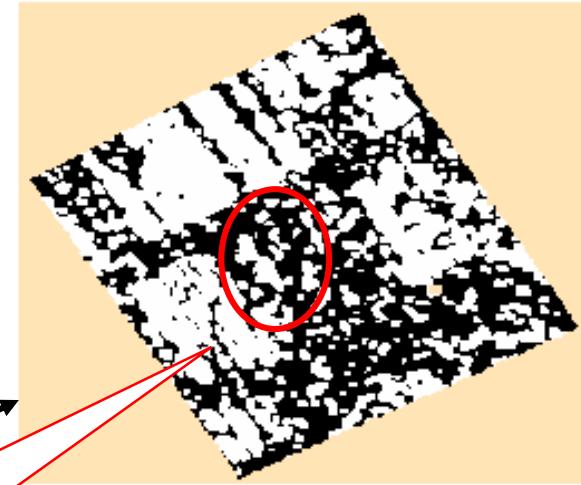
Conventional Method

Based on pixel-to-pixel difference followed by classification

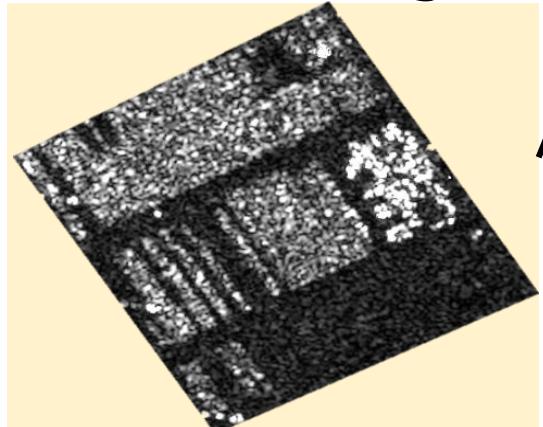
Before Image



Change Map



After Image



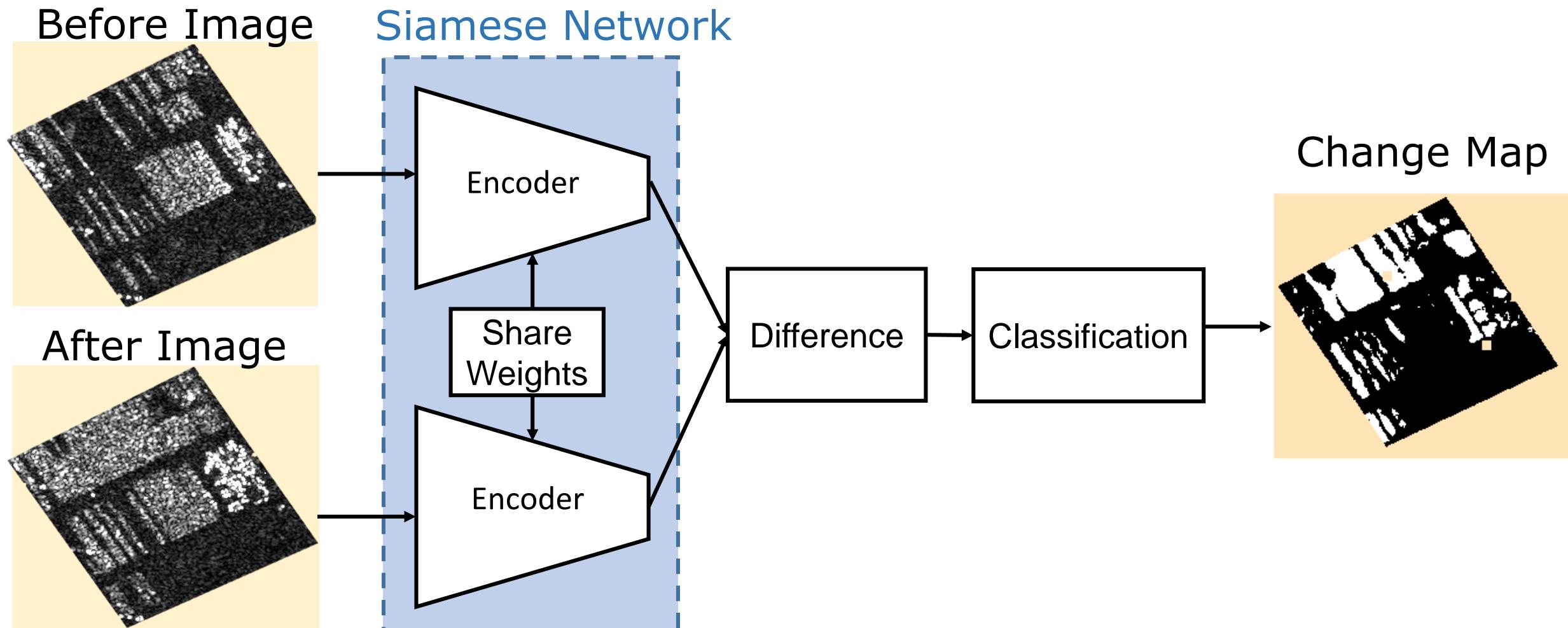
Pixel-to-pixel
difference

Classification

**Problem:
Many False Alarms!**

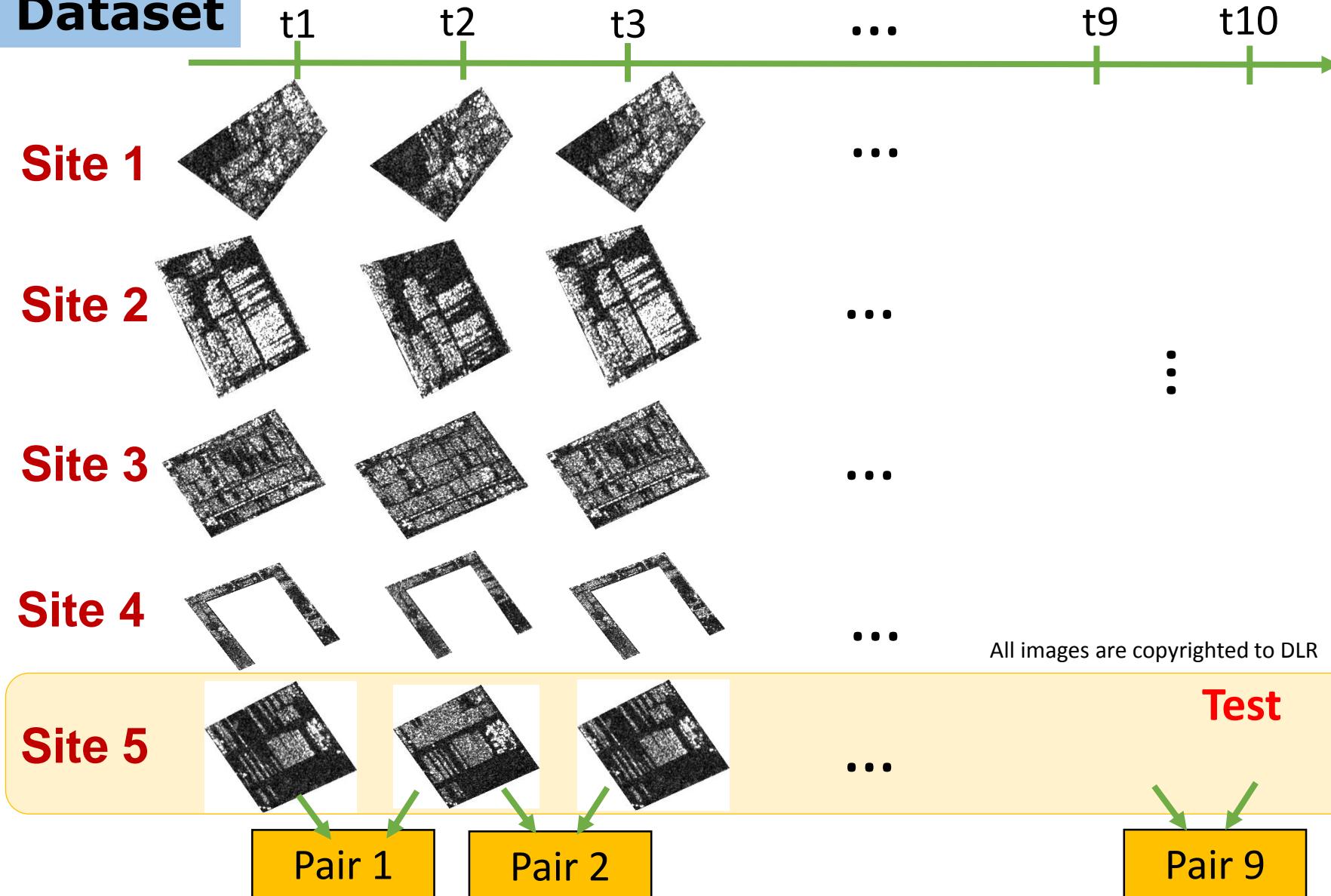
Proposed Method

Transform the images into features and compute difference between features



Experiments for Parking Lot Monitoring

Dataset



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

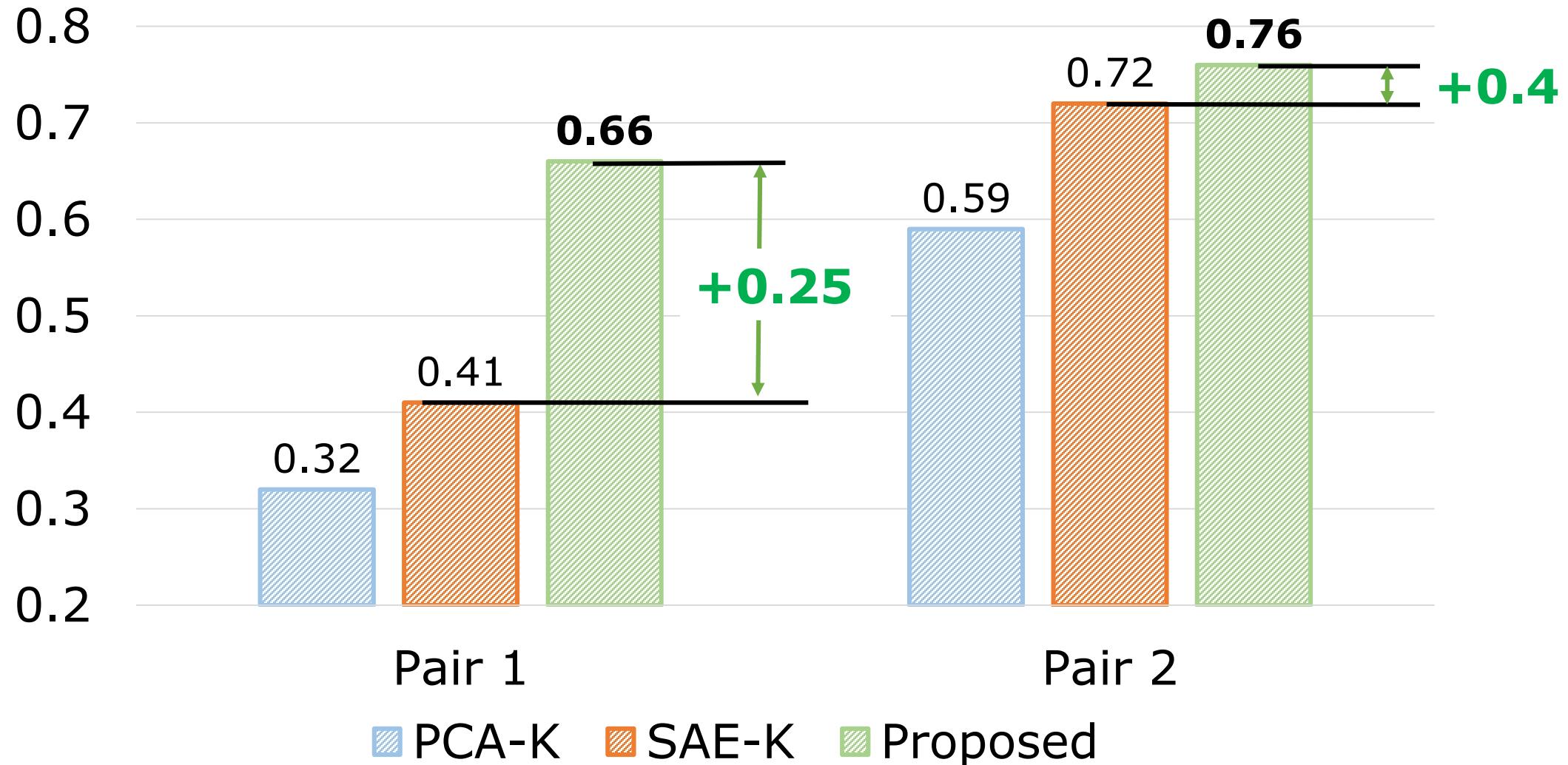
[1] T. Celik: Unsupervised change detection in satellite images using principal component analysis and k-means clustering, IEEE Geoscience and Remote Sensing Letters, vol. 6, no. 4, pp. 772-776, 2009.

[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 methods improves f-measure by xx% over baselines

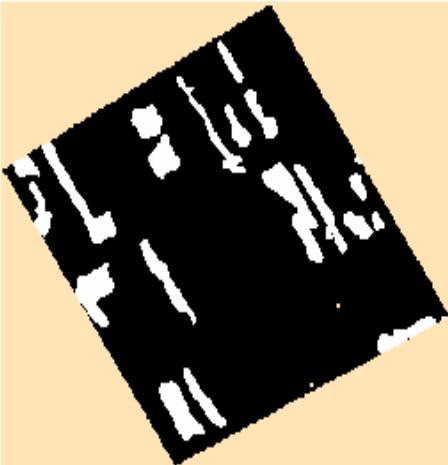
Comparison of f-measure for 2 test pairs



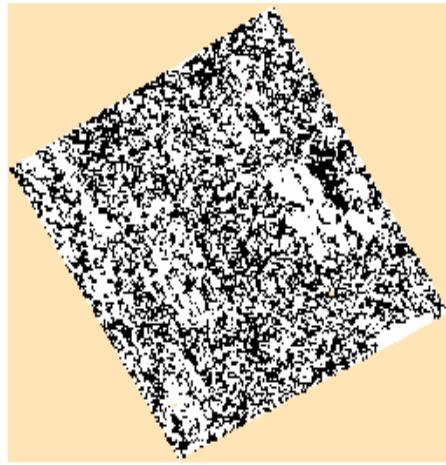
Result [2/2] : Change Maps

Proposed method produces visually better change maps

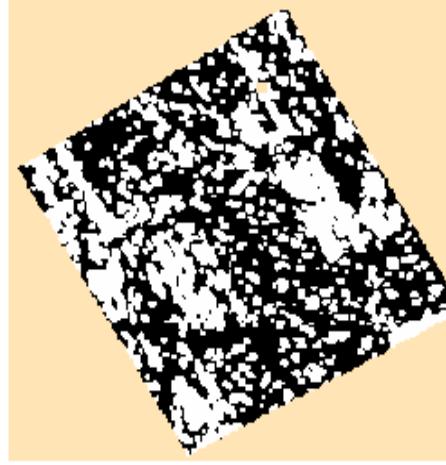
Ground Truth



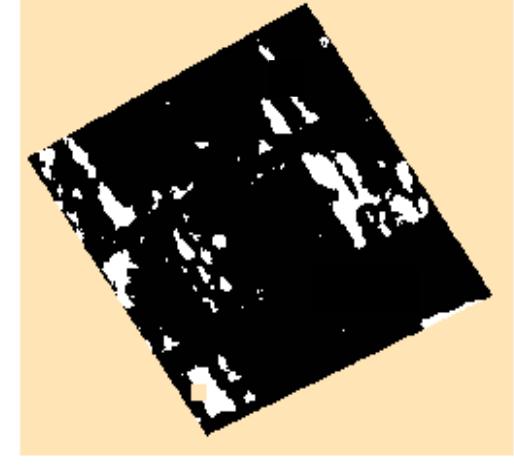
PCA-K



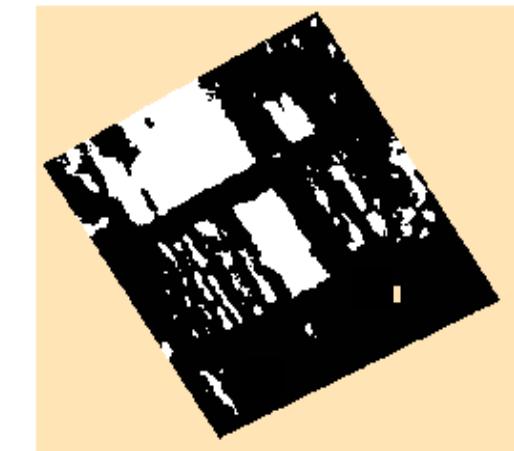
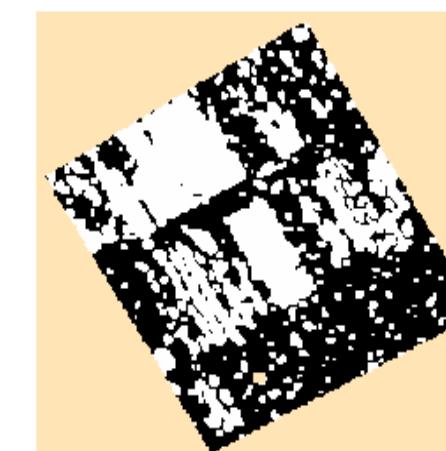
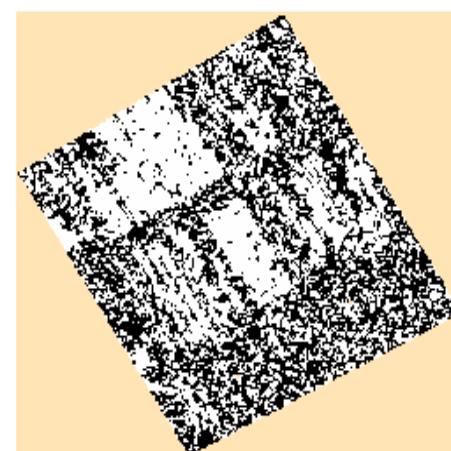
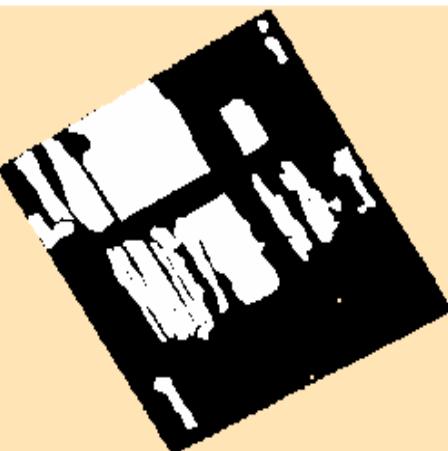
SAE-K



Proposed



Pair 1



Pair 2

Conclusion