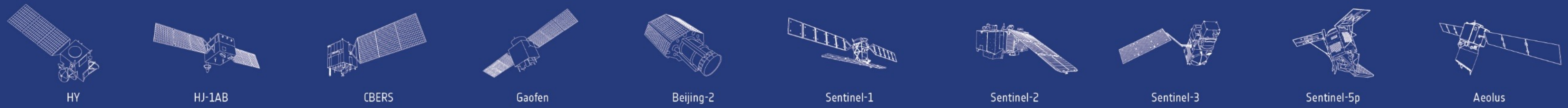


2023 DRAGON 5 SYMPOSIUM

3rd YEAR RESULTS REPORTING

11-15 SEPTEMBER 2023

[PROJECT ID.57971]

[AUTOMATED IDENTIFYING OF ENVIRONMENTAL CHANGES USING SATELLITE TIME-SERIES]

<13/SEPT/2023: 2:00PM - 3:30PM>

ID. 57971

PROJECT TITLE: MULTI-SOURCE AND MULTI-TEMPORAL REMOTE SENSING IMAGES FOR SHIPBUILDING PRODUCTION STATE MONITORING

PRINCIPAL INVESTIGATORS: [YAN SONG, YUNSHENG WANG]

CO-AUTHORS: [YAN SONG, YUHONG TU, ZEKAI LIU, WANROU QIN]

PRESENTED BY: [ZEKAI LIU]

EO Data Delivery

Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since July 2020) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert "ftp"

ESA /Copernicus Missions	No. Scenes
1. Sentinel-1	700
2.	
3.	
4.	
5.	
6.	
Total:	700
Issues:	

ESA Third Party Missions	No. Scenes
1. Google Earth	
2. Map world	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Chinese EO data	No. Scenes
1. ZY-3	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Project's objectives

- Use deep learning methods to observe shipyards based on multi-source and multi-temporal remote sensing image
- Explore the deep learning methods to analyse time-series Sentinel-1 datasets
- Develop deep learning architecture to fuse multi-source and multi-temporal RS images' features

Research background and meaning

The **shipbuilding industry** is important in national defense security, transportation, and marine development. Monitoring shipyard helps to master the profitability in time.

Satellite remote sensing data can monitor shipyard production state accurately from the perspective of space and time series efficiently, which makes up for the shortcomings of traditional methods of collecting order data.

Research background and meaning

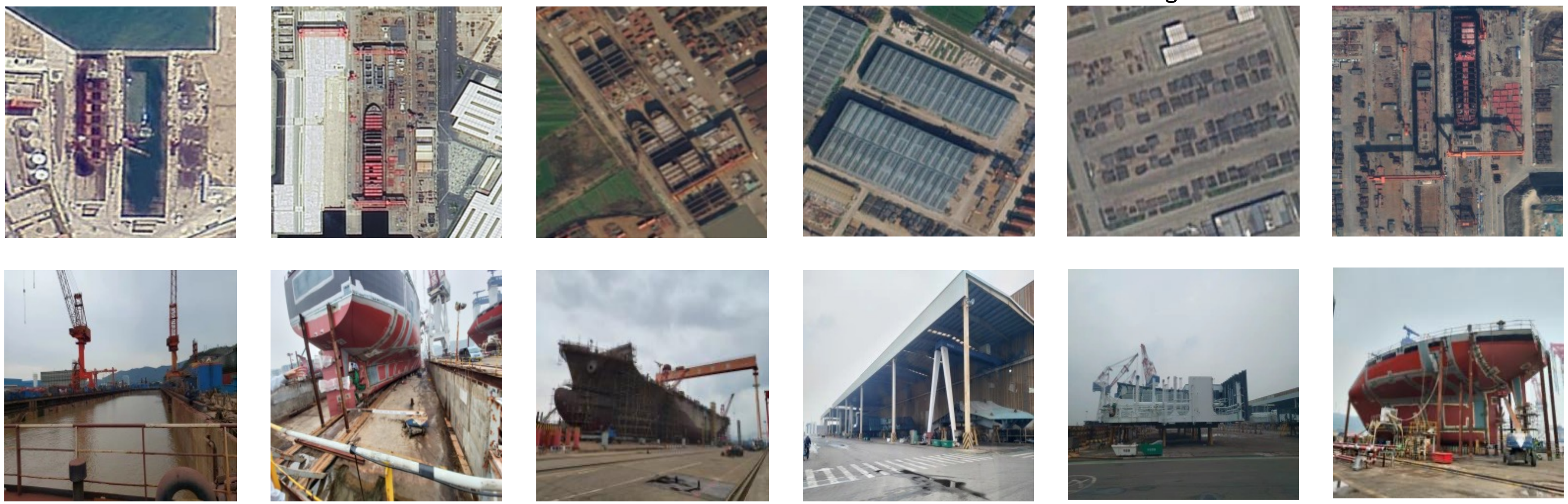
Shipyards are located near the seashore or water shore, utilized to construct new ships and repair old ones, exerting a crucial effect in the shipbuilding industry.

Photos of shipyards taken in Zhoushan, Hangzhou

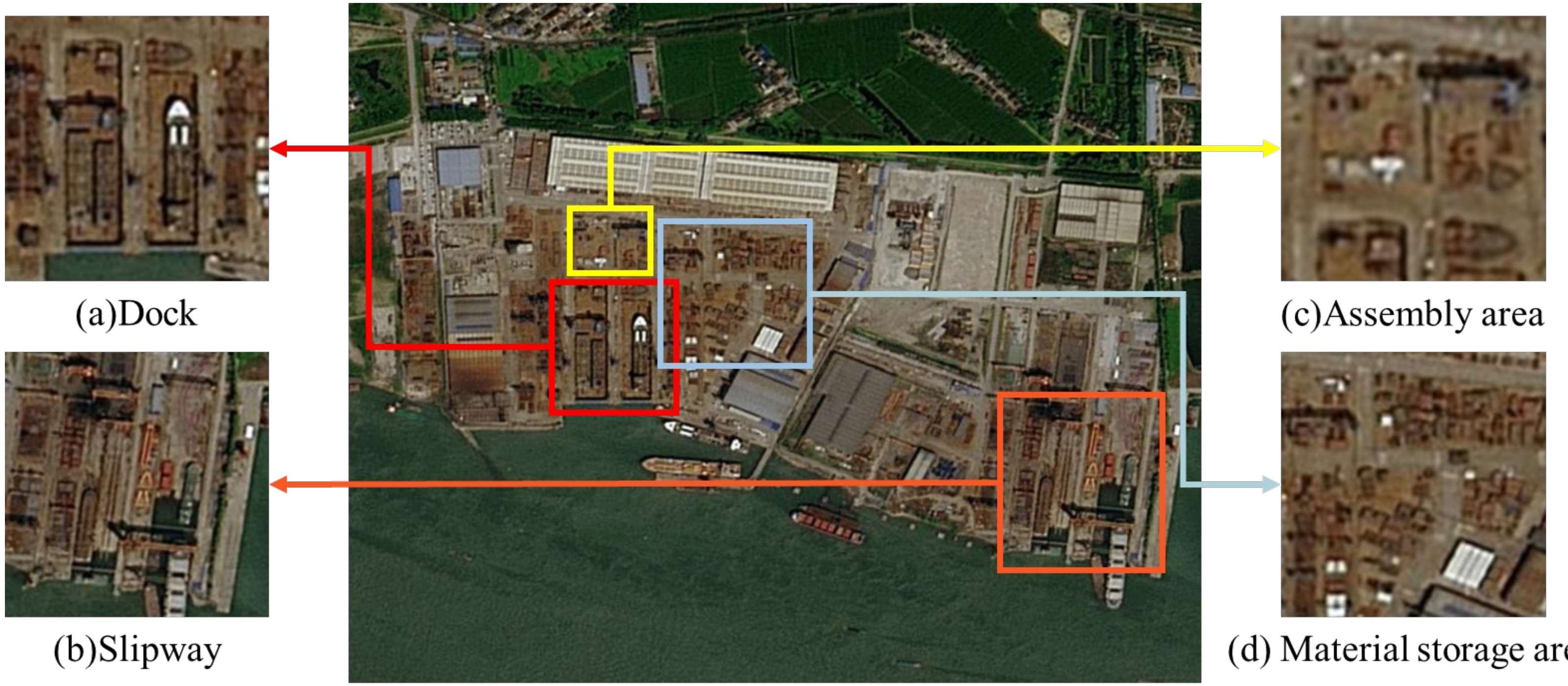
Dock | Slipway | Ship under construction | Workshop | Material storage areas | Assembly areas

RS images

Fieldwork photos



The shipyard scene includes the **docks**, **slipways**, **assembly areas** and **material storage areas** which are closely related to production.



Shipbuilding core places

Material utilization core places

Research background and meaning

This study performs **object detection network and status recognition network for docks** based on high-resolution remote sensing images and **deep learning methods**. Meanwhile, according to the imaging characteristics of optical remote sensing images and SAR images of shipbuilding places, we used satellite remote sensing data to dynamically monitor the **shipyard production state** from spatial and time series perspective.

Dock dataset

In order to train the networks, a dock status dataset is proposed, which contains more than **1400 images** and **4600 docks**. The dataset is collected from **Google Earth**, **map world (MW)**, and **ZY-3**. And the resolutions of the images are 2m, 0.5m, 0.5m, respectively

Dock dataset

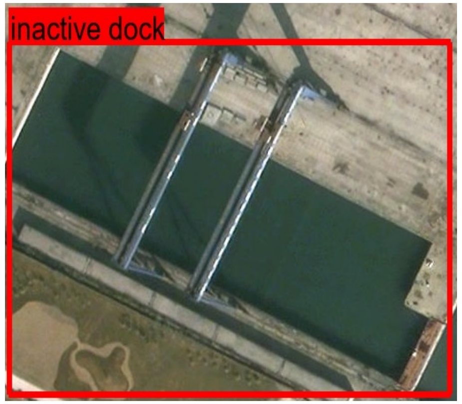
GE

MW

ZY-3

Status dataset

active

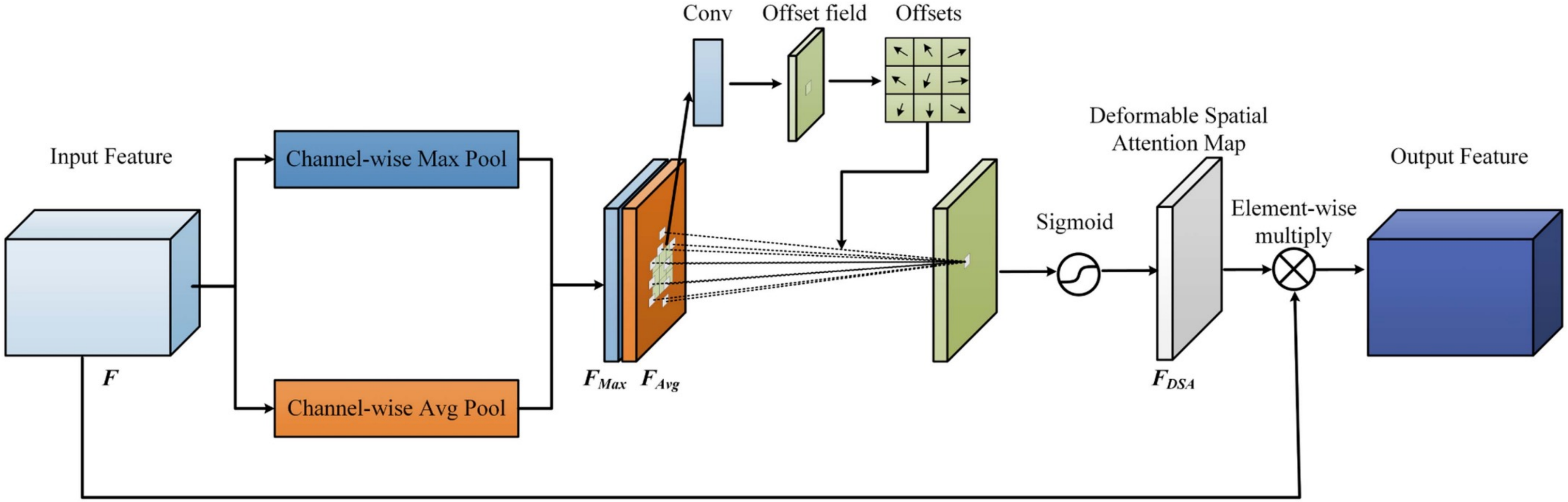


inactive

Method for Dock Detection

DSAM

We use an object detection network based on the **deformable spatial attention module (DSAM)**, which can be used to detect the docks on high spatial resolution remote sensing image.

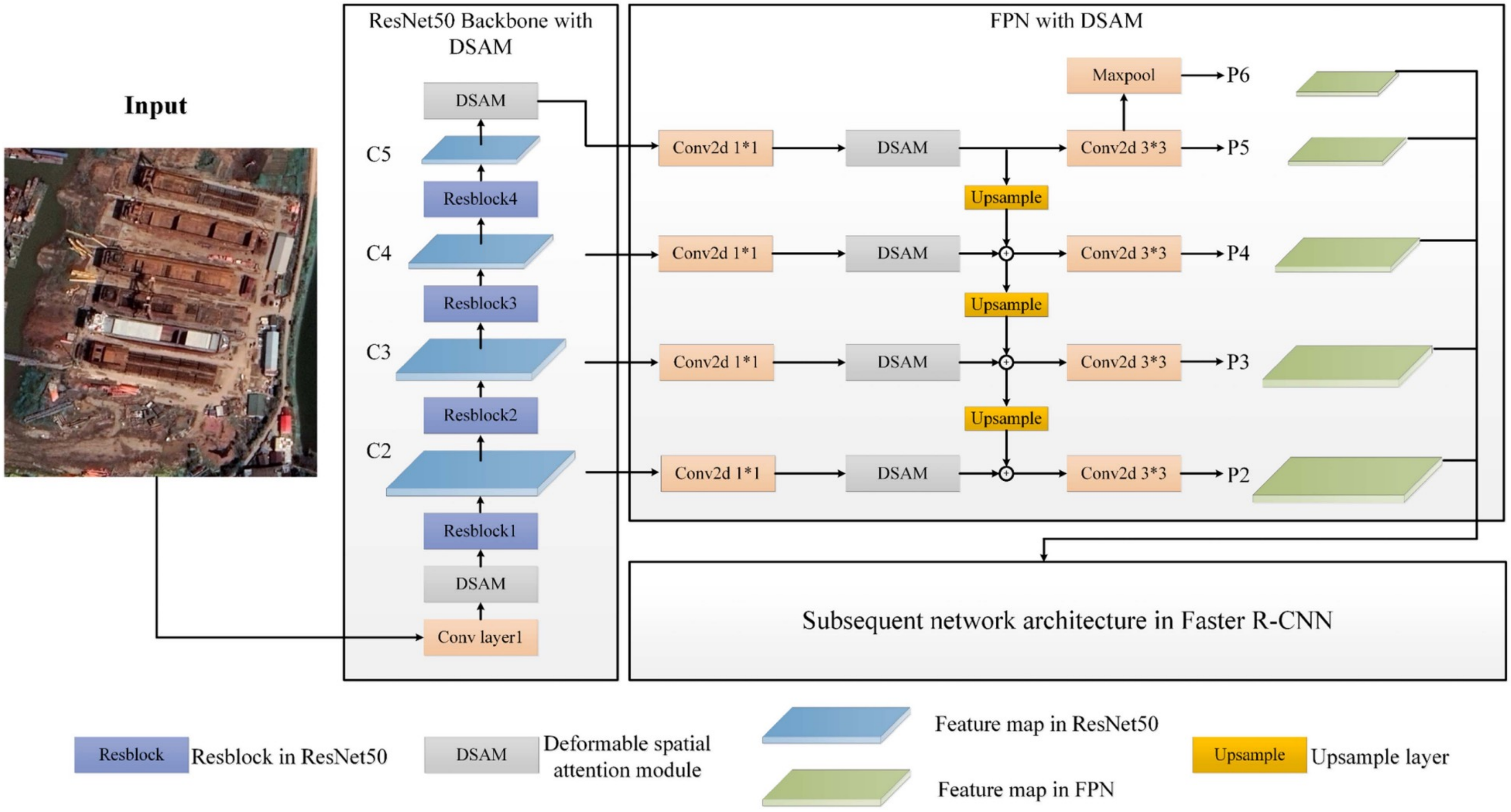


$$\begin{cases} \boldsymbol{F}_{\boldsymbol{Avg}} = AvgPool(\boldsymbol{F}) \\ \boldsymbol{F}_{\boldsymbol{Max}} = MaxPool(\boldsymbol{F}) \end{cases}$$

$$\boldsymbol{F}_{\boldsymbol{DSA}} = \sigma\left(f_{DC}^{N\times N}([\boldsymbol{F}_{\boldsymbol{Avg}}; \boldsymbol{F}_{\boldsymbol{Max}}])\right)$$

$$\boldsymbol{F}_{\boldsymbol{Out}} = \boldsymbol{F} \otimes \boldsymbol{F}_{\boldsymbol{DSA}}$$

Method for Dock Detection

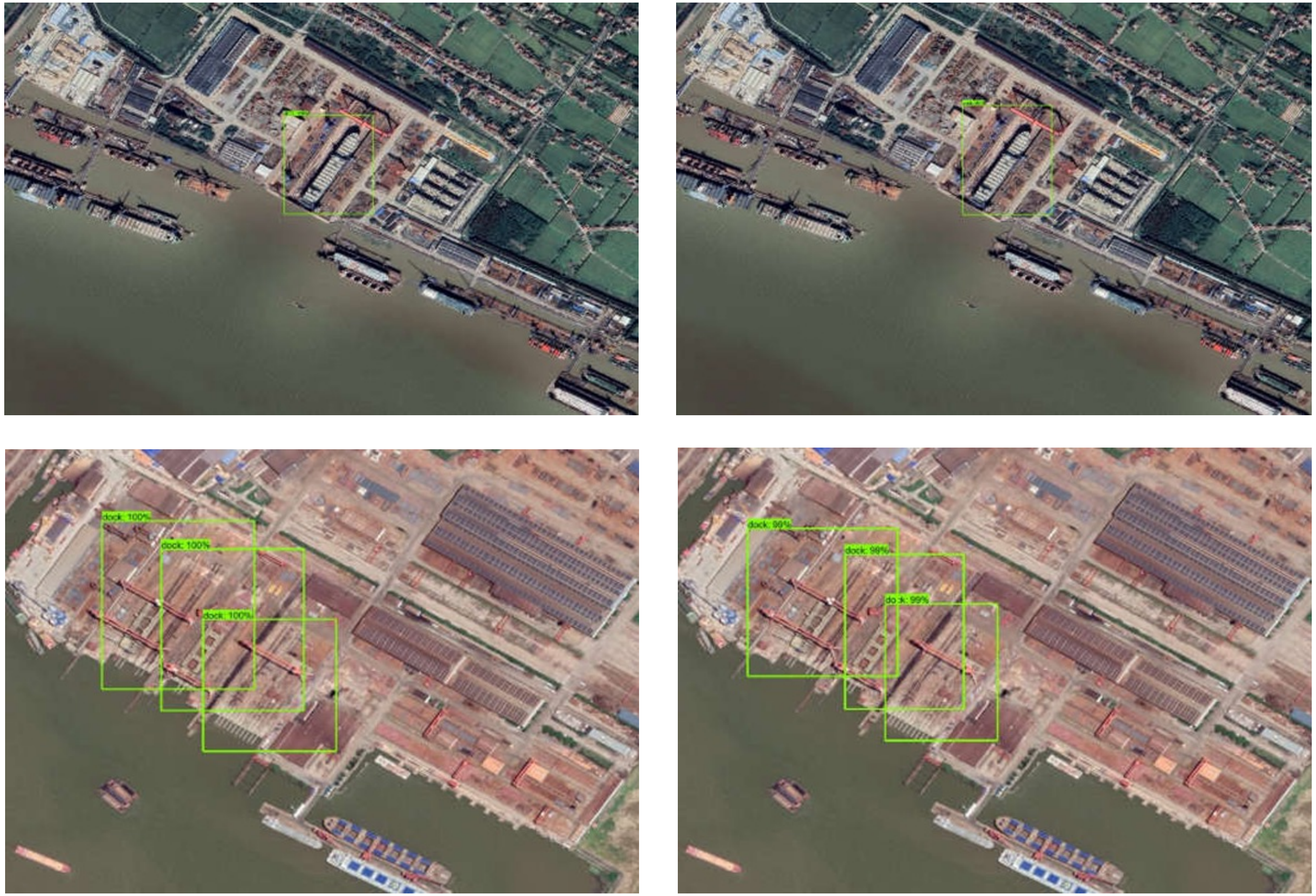


Method for Dock Detection

Results of different kernel size in DSAM

Kernel size	Param.	mAP
9*9	41.50M	67.43%
7*7	**41.41M**	**71.02%**
5*5	41.37M	68.61%
3*3	41.36M	66.88%

Ground truth Prediction



Results of different network architecture

Network	Backbone	mAP
Faster R-CNN	**Proposed architecture**	**71.02%**
	ResNet50+FPN(Without intermediate DSAM)	68.23%
	ResNet50+FPN(Baseline)	66.03%
	ResNet101+FPN	65.89%
	Xception	60.26%
	MobileNet	59.72%
R-FCN	ResNet50	63.47%
Sparse R-CNN	ResNet50	65.30%

Method for Dock Detection

Ground truth

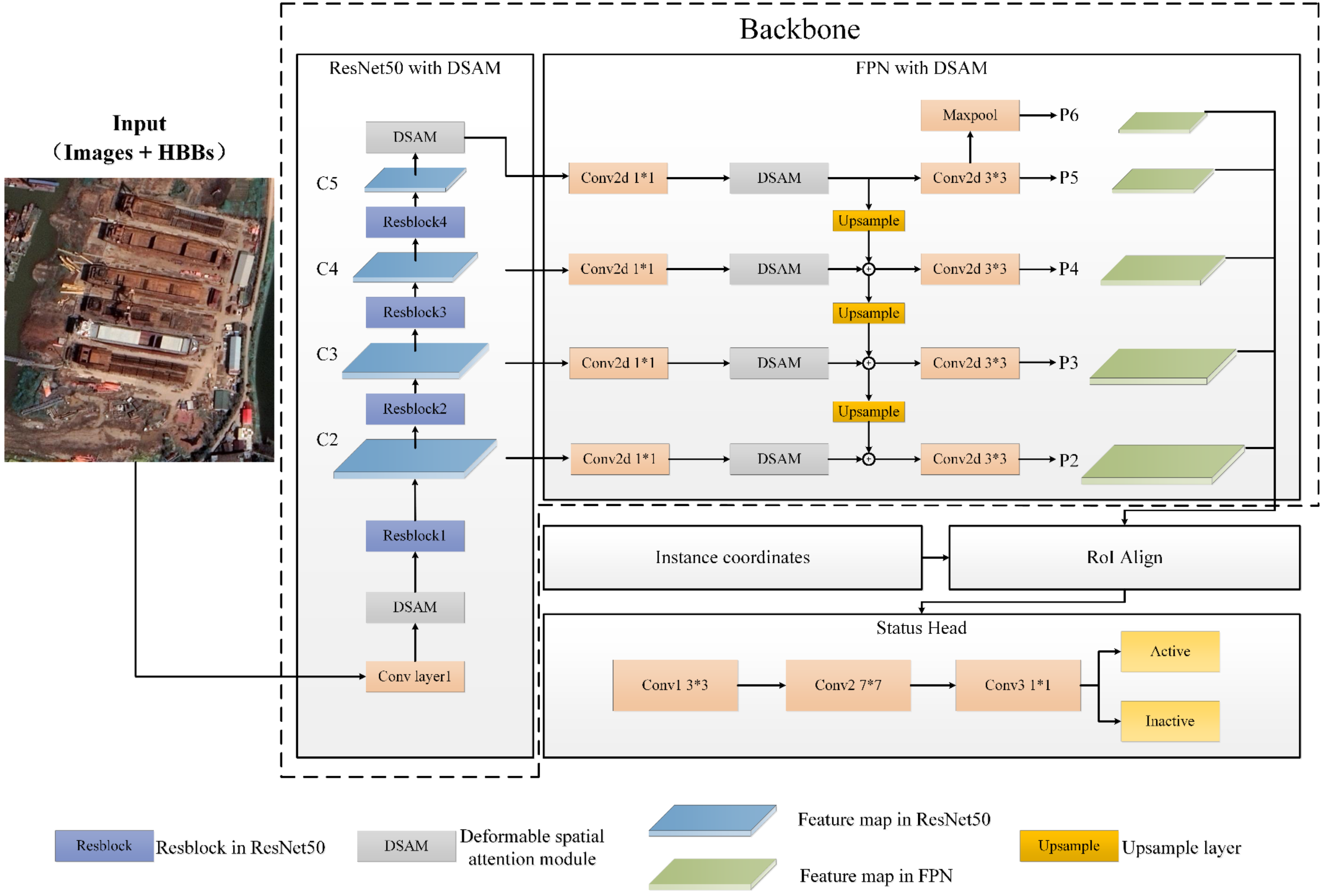
Proposed

Baseline

Results of Ablation Experiments

	Baseline	Baseline + Different settings				
DSAM	Faster R-CNN	**√**				√
CAM			√		√	√
SAM				√	√	
mAP	66.03	**71.02**	67.11	68.45	69.13	66.78
FPS	10	8	8	8	7	6
Param.	41.35M	41.41M	41.38M	41.36M	41.39M	41.45M

Production status recognition for docks

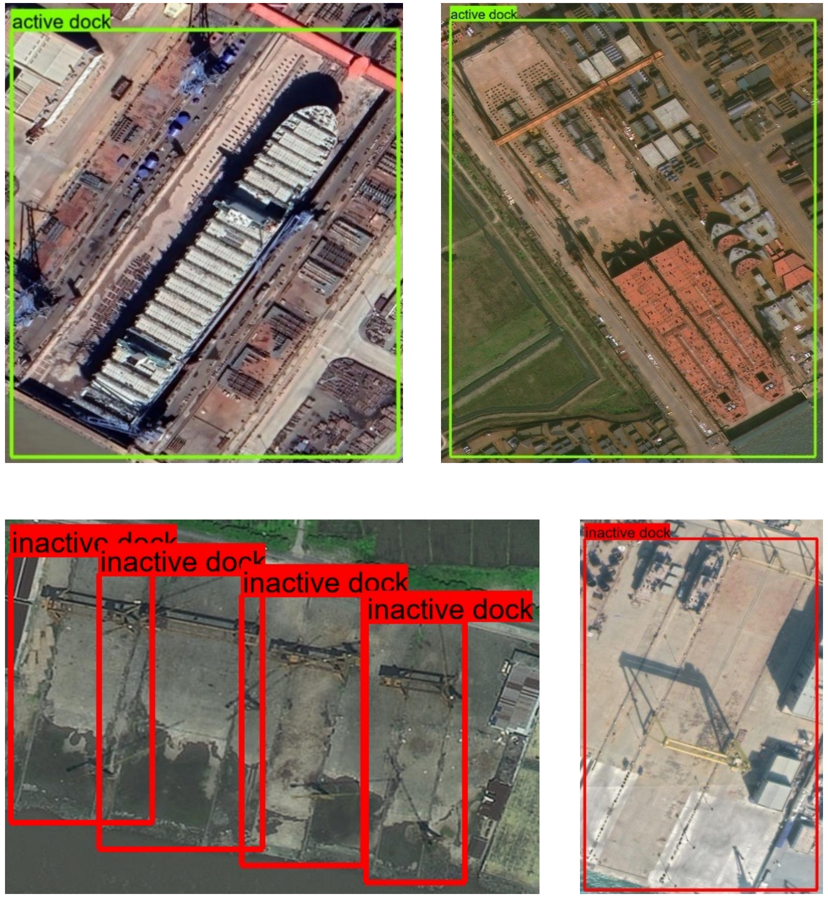


Since the backbone of the dock object detection network is with the excellent feature extraction capability for docks, this study connects the backbone with a lightweight status recognition network (Status Head) to determine the dock production status information based on the features extracted from the backbone.

The recognition results of different methods

Methods	R	P	A	AP	F1 score
Proposed method	**94.36%**	**88.11%**	**85.48%**	**87.68%**	**91.12%**
ResNet50	86.53%	87.97%	80.01%	83.27%	87.25%
GoogleNet	83.26%	86.65%	76.64%	81.23%	84.92%
Xception	80.71%	84.72%	73.26%	77.14%	82.67%
VGG	80.07%	87.39%	75.13%	77.26%	83.57%

Production status recognition for docks



(1) As shipbuilding period takes long, single phase observation data cannot fully reflect the production state in different shipbuilding stages.

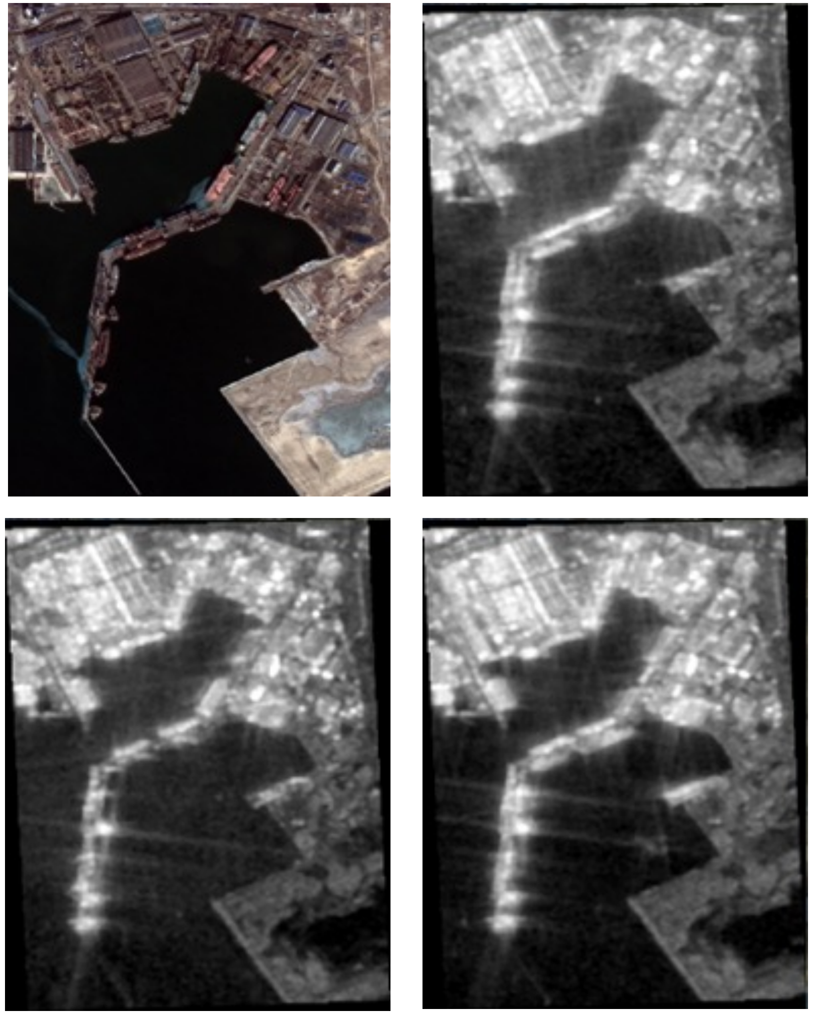
(2)Shipyards located in coastal areas or along rivers, so that cloudy or rainy day is common.

(3)Assembly areas and material storage areas are also closely related to production.

Multi-temporal SAR images for production status recognition

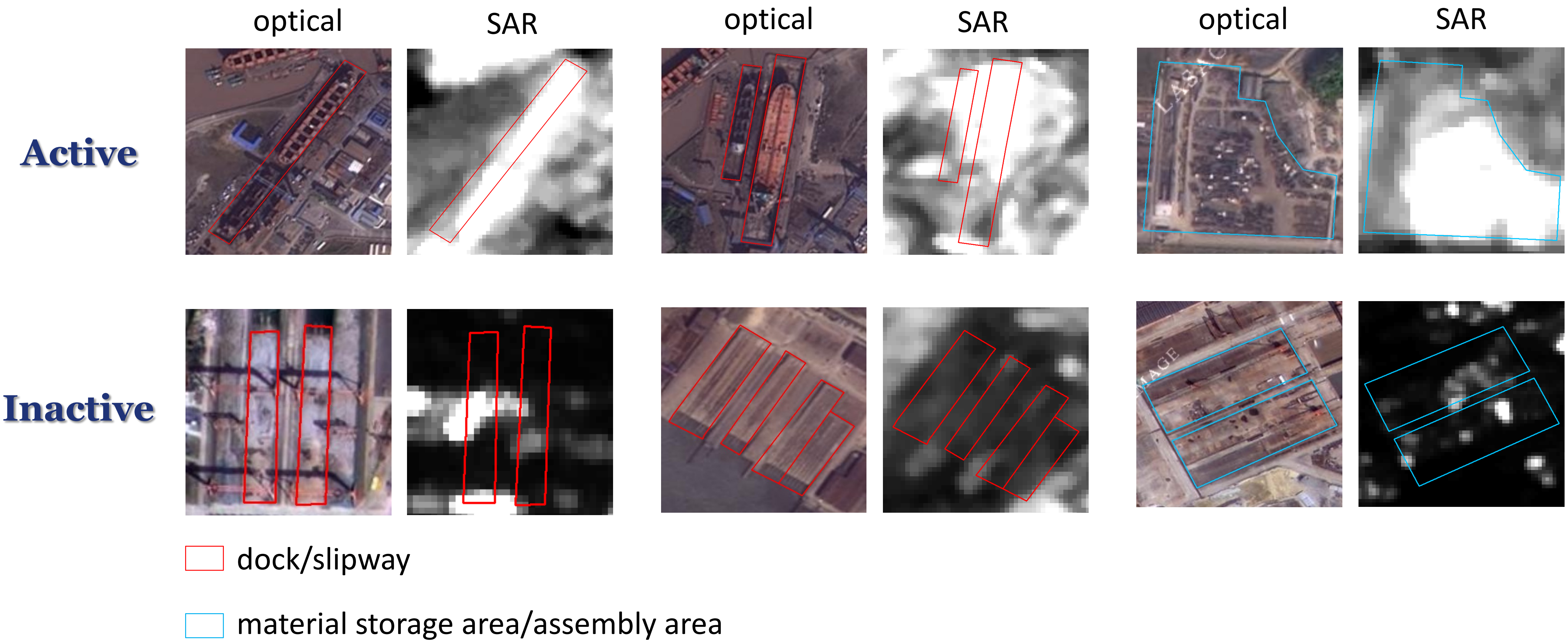
Synthetic Aperture Radar (SAR) with the merits of unaffected by weather can complement the optical satellite imagery for monitoring the shipyard production state fully.

As the shipbuilding procedure is long, the application of multi-temporal RS data to monitor shipyard production state is proposed to increase the amount of observation data avoiding errors caused by single phase data.

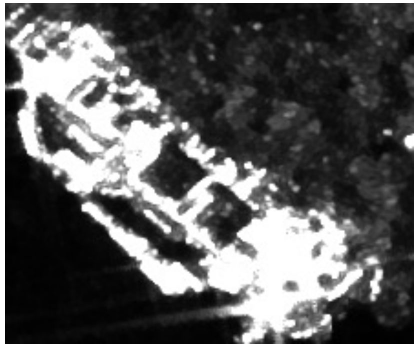


Production status recognition for shipyards

In order to found the connection between SAR images and shipbuilding production status, we statistics more than **150** shipyards and **1700** areas.

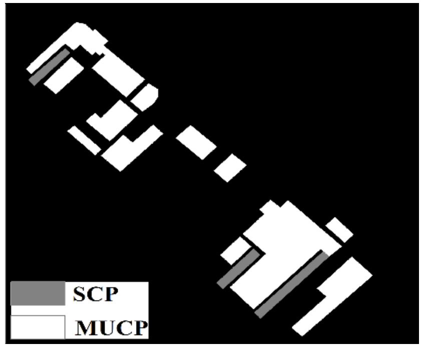


Production status recognition for shipyards

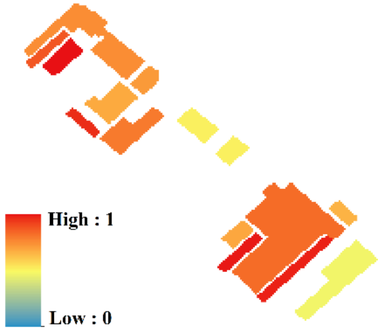


(a) SAR image

(b) Binary result



(c) Core places map



(d) Percentage of strong backscattered pixels

Pearson correlation coefficients between backscattered intensity features and production states for the SCP and the MUCP are **0.796** and **0.764**.

Outlook

SAR images are very sensitive to metal materials， as a result, it is difficult to distinguish between the production core places and other places from SAR.

We are going to develop deep learning architecture to fuse optical remote sensing images and SAR images' features.