西安電子科技大學
XIDIAN UNIVERSITY

MSSDet: A Multi-scale Ship Detection Framework in Optical Remote Sensing Images

Speaker: Weiming Chen

2021-10-28

Visual Information in Processing Lab(VIP Lab)

Outline

- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

The significance of ship detection

Fishery management

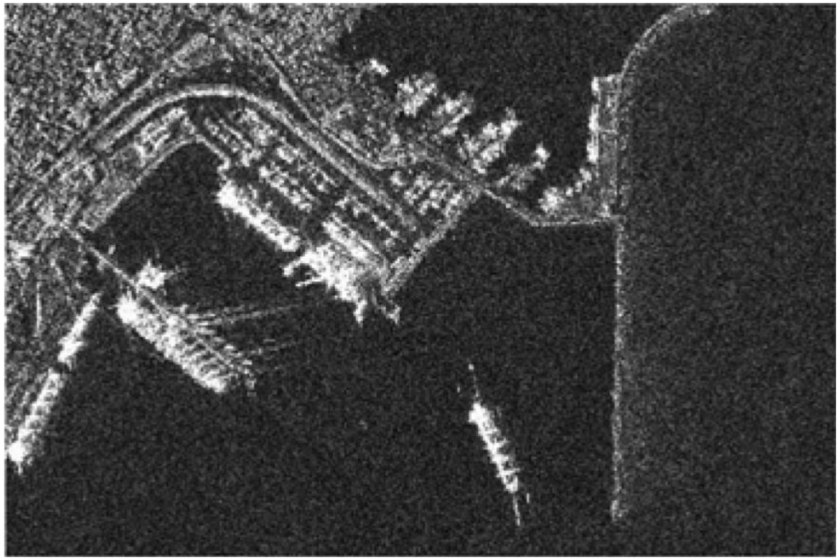
Suppress smuggling

Maritime transportation

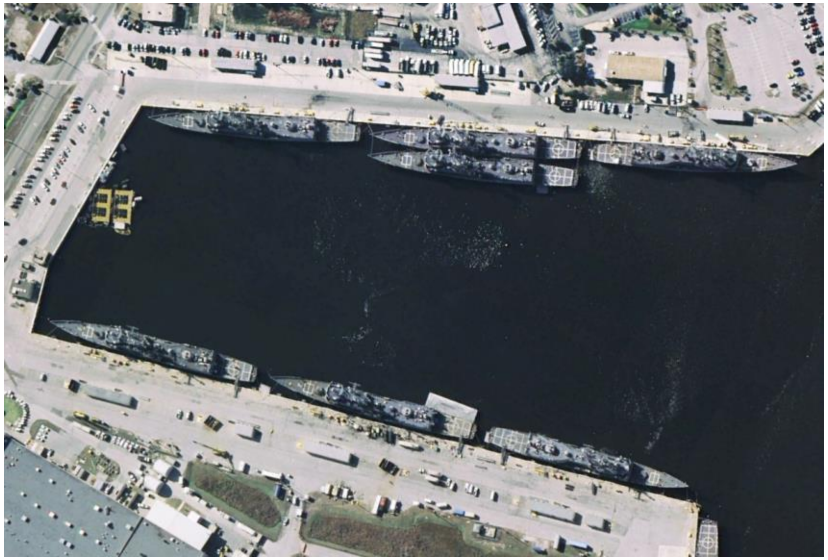
Naval warfare

https://image.baidu.com/

Why is optical remote sensing images?



Synthetic Aperture Radar (SAR)



Optical Remote Sensing (ORS)

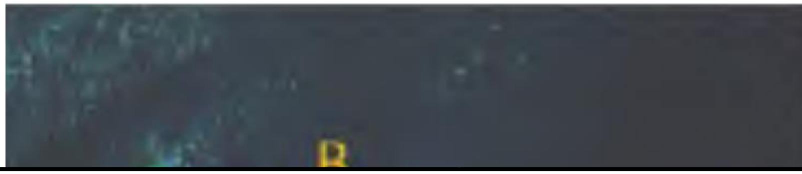
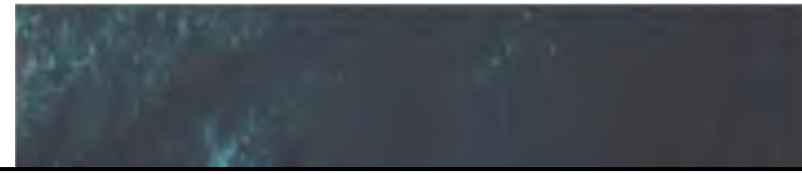
J. Li, et al. Ship Detection in SAR Images based on an improved faster R-CNN. SAR in Big Data Era: Models, Methods, and Applications,, 2017.
Z. Liu, et al. A High Resolution Optical Satellite Image Dataset for Ship Recognition and Some New Baselines. ICPRAM, 2017.

Public optical remote sensing datasets

Dataset	Categories	Images	Instances	Year
TAS	1	30	1319	2008
SZTAKIINRIA	1	9	665	2012
*NWPU VHR10	10	800	3775	2014
VEDAI	9	1210	3640	2015
UCASAOD	2	910	6029	2015
DLR 3K Vehicle	2	20	14235	2015
*HRSC2016	1	1070	2976	2016
RSOD	4	976	6950	2017
*DOTA	15	2806	188282	2018
*DIOR	20	23463	192472	2019
*HRRSD	13	26722	55740	2019

*: the dataset contains the category of ship.

Ship Detection in ORS Images

Method	Advantages	Disadvantages
Non-oriented Ship Detection	High accuracy; Strong robustness	Cannot predict orientation; Weak detection performance for dense objects
Oriented Ship Detection	Can predict orientation; Good detection performance for dense objects	Hard to annotate; Low efficiency


Non-oriented Ship Detection **Oriented Ship Detection**

C. Zhang, et al. A survey of ship detection in optical satellite remote sensing images. Chinese journal of radio science, 35(5): 637-647, 2020.

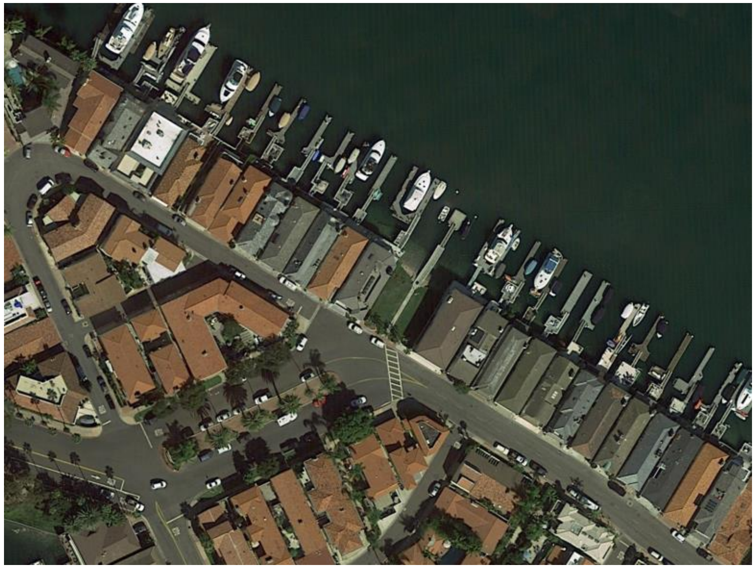
Difficulties

Natural Image

Moderate size

Pure scenario

Optical Remote Sensing Image

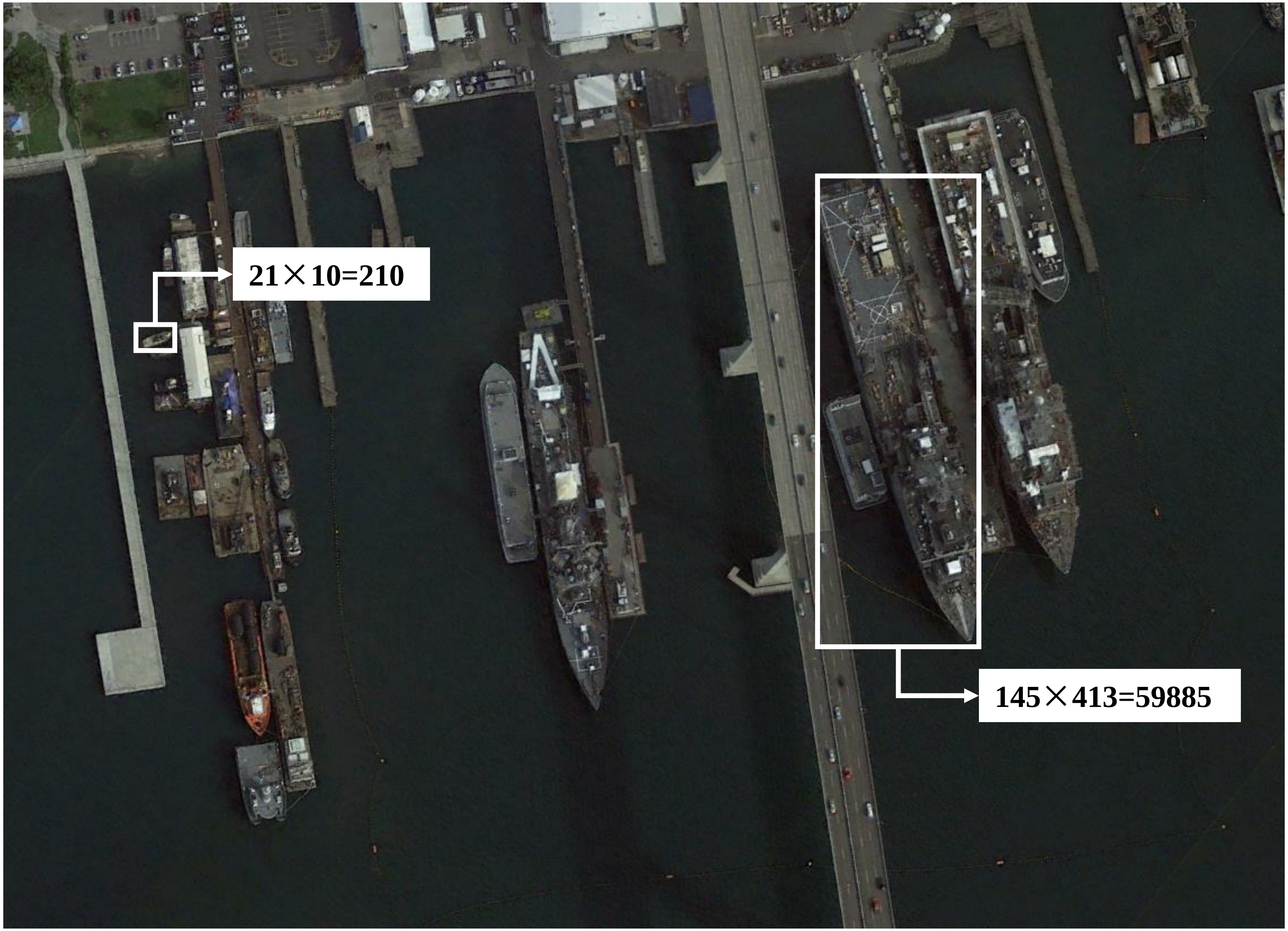


Large size

Complex scenario

T. Lin, et al. Microsoft COCO: Common Objects in Context. ECCV, 2014.
G. Xia, et al. DOTA: A largescale dataset for object detection in aerial images. CVPR, 2018.

Difficulties

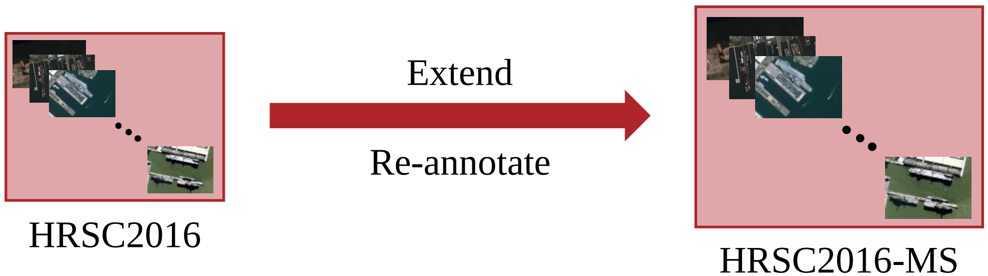


Z. Liu, et al. A High Resolution Optical Satellite Image Dataset for Ship Recognition and Some New Baselines. ICPRAM, 2017.

Contributions

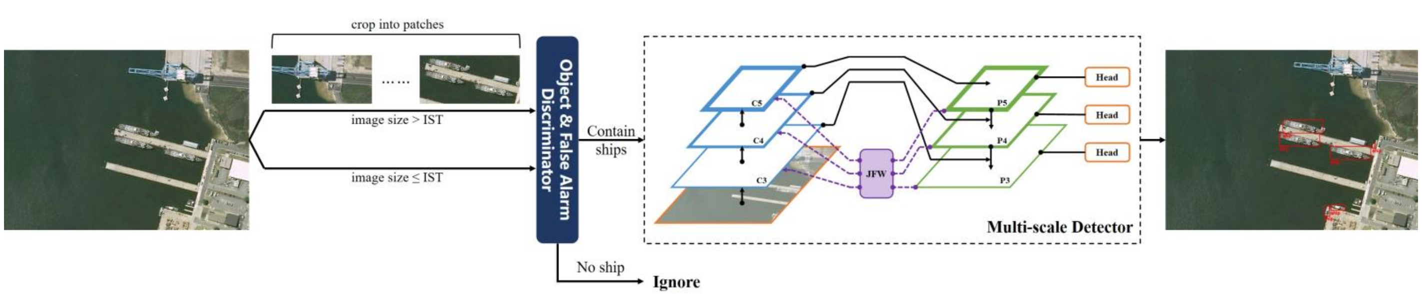
DATASET

- We build a new dataset with rich multi-scale ship instances based on HRSC2016.



ALGORITHM

- We propose **Adaptive Cropping Strategy** and **Objects and False Alarms Discriminator** to deal with the difficulty of size.
- We propose **Joint Recursive Feature Pyramid** to deal with the difficulty of scenario and multi-scale instances.

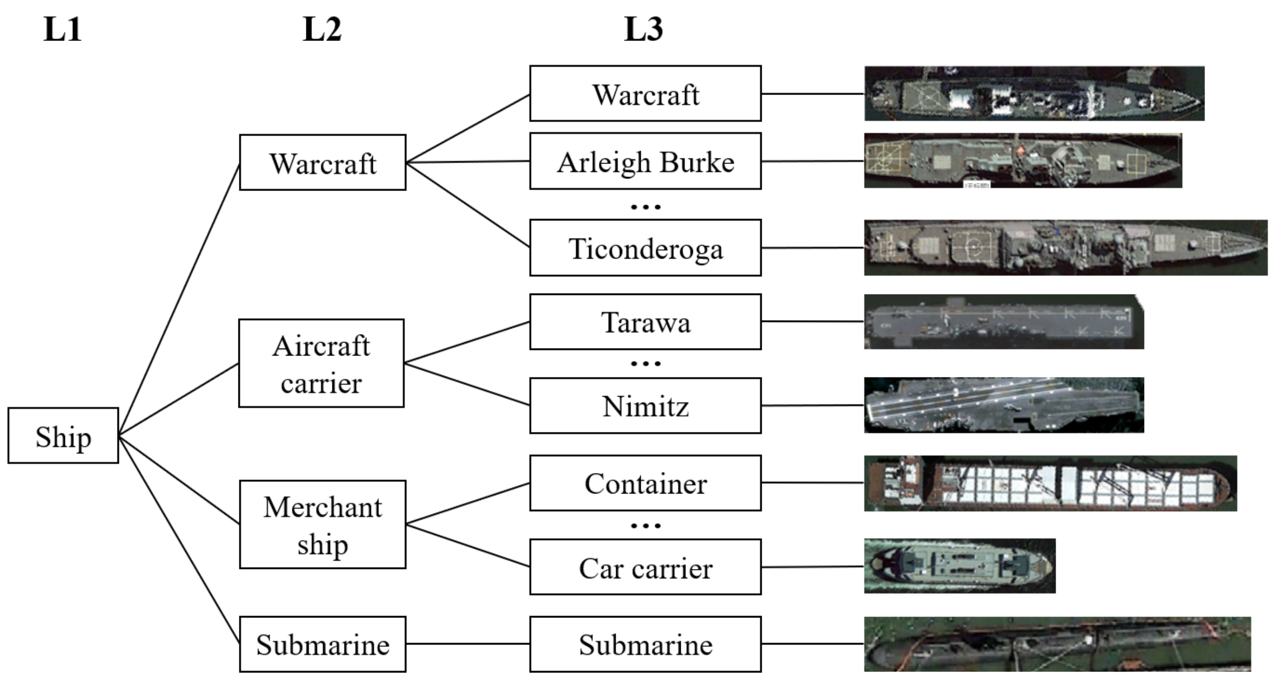


Outline

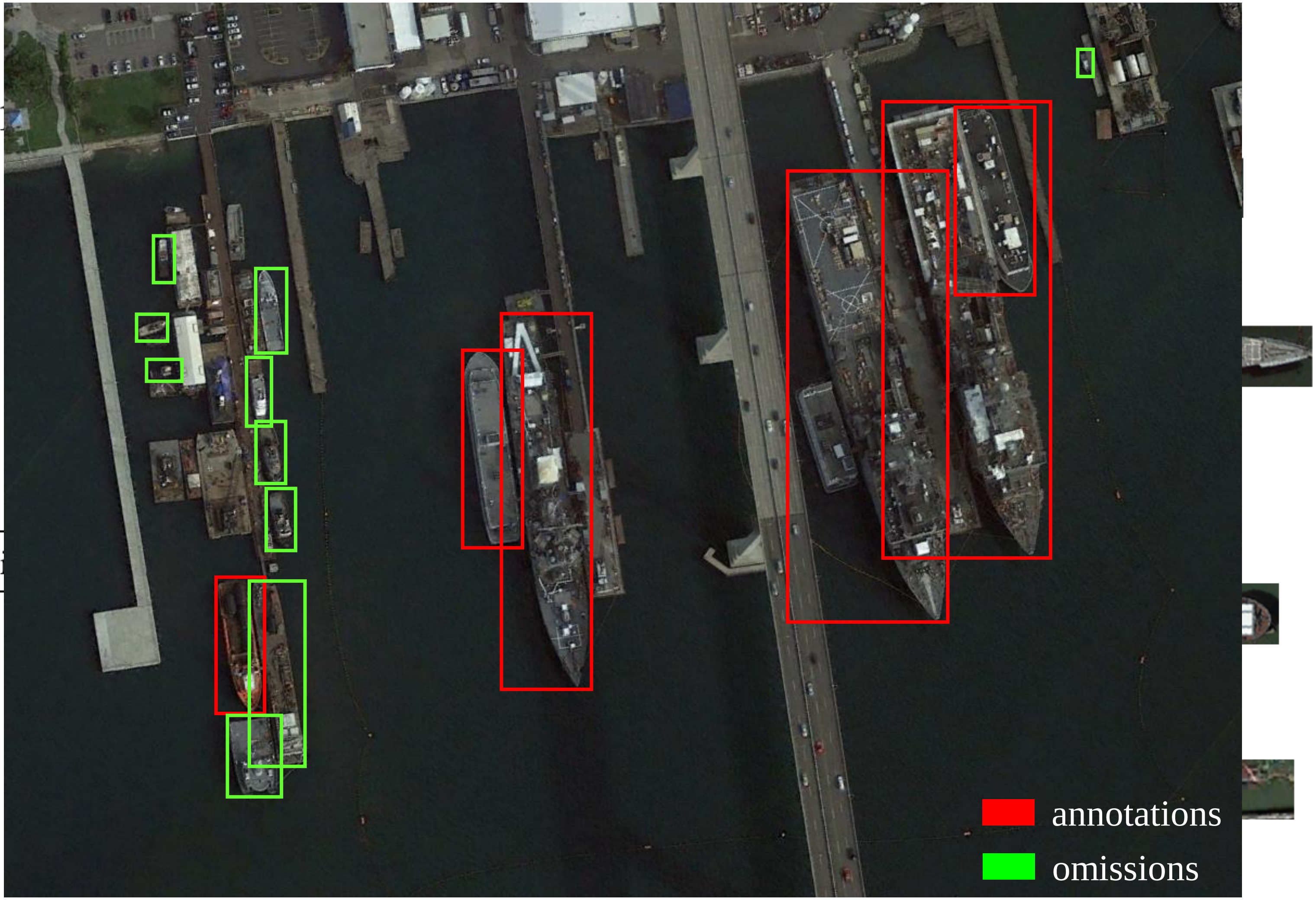
- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

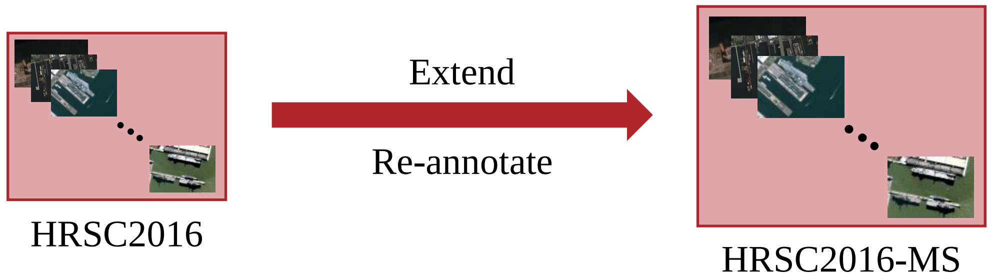
HRSC2016 Dataset

- **Data source**: Google Earth
- **Data volume**: 1070 images with 2976 ship instances
- **Image size**: 300×300 to 1500×900 (most of them are larger than 1000×600)
- **Spatial resolution**: between 2m and 0.4m
- **Scenario**: sea and sea-land
- **Annotation**: HBB and OBB
- **Label set**: cover 1, 4, 27 classes respectively.



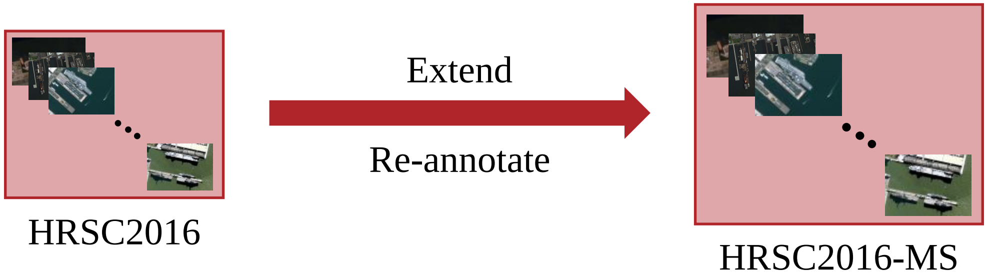
- **Defect 1**: the insufficiency of data
- **Defect 2**: annotation omission





Extend

- **Data source**: Google Earth
- **Data volume**: 610 images
- **Image size**: 300×300 to 1500×900 (most of them are larger than 1000×600)
- **Spatial resolution**: between 2m and 0.4m
- **Scenario**: sea and sea-land



Re-annotate

HRSC2016-MS Dataset

Annotation Method

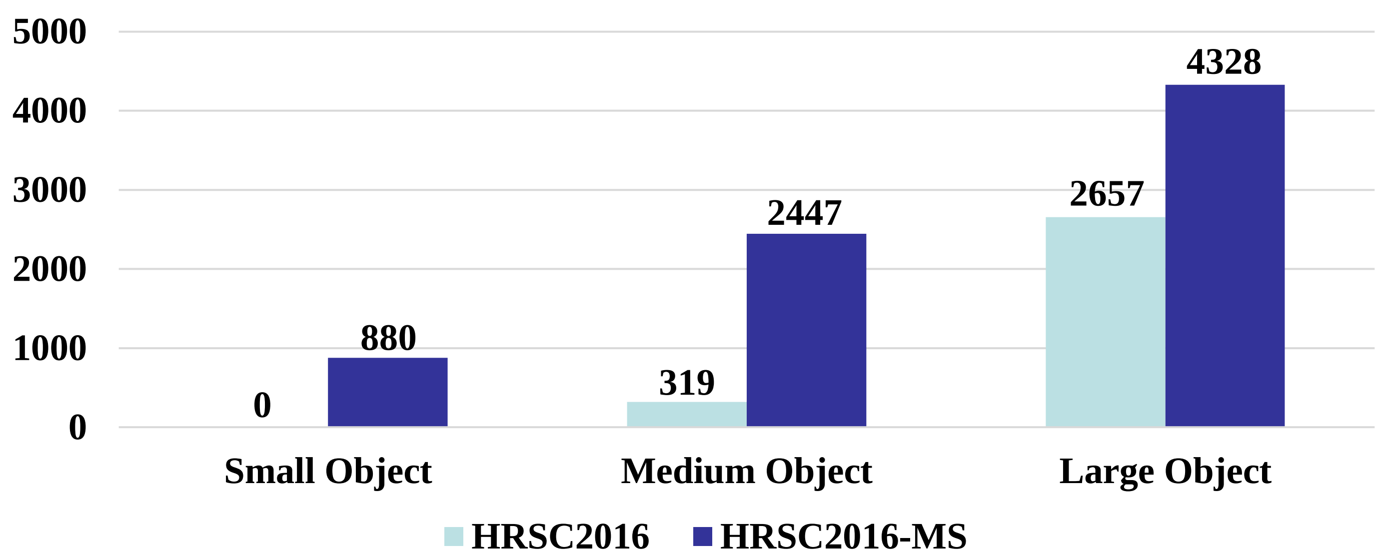
Comparison

HRSC2016

- **Data source**: Google Earth
- **Data volume**: 1070 images with 2976 instances
- **Image size**: 300×300 to 1500×900
- **Spatial resolution**: between 2m and 0.4m
- **Scenario**: sea and sea-land
- **Annotation**: HBB and OBB
- **Label set**: cover 1, 4, 27 classes respectively

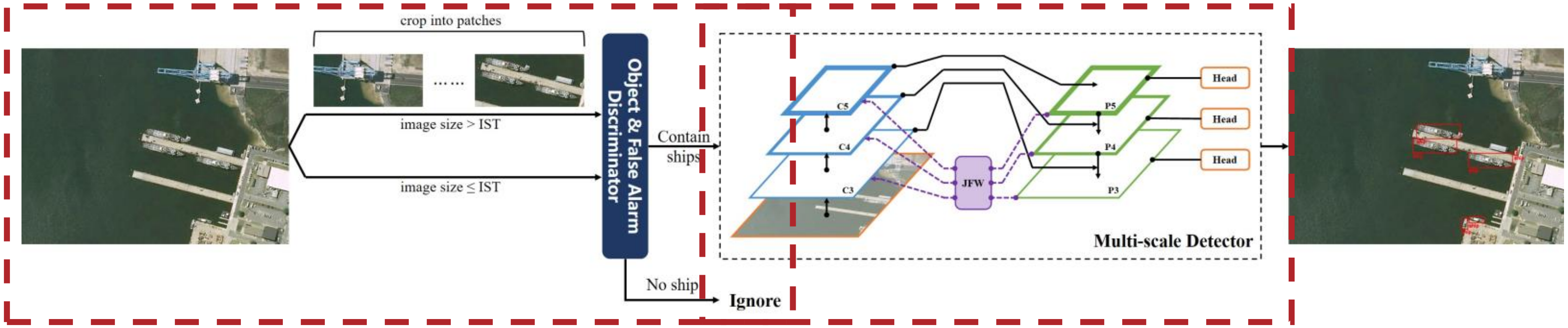
HRSC2016-MS

- **Data source**: Google Earth
- **Data volume**: 1680 images with 7655 instances
- **Image size**: 300×300 to 1500×900
- **Spatial resolution**: between 2m and 0.4m
- **Scenario**: sea and sea-land
- **Annotation**: HBB and OBB
- **Label set**: cover 1 class

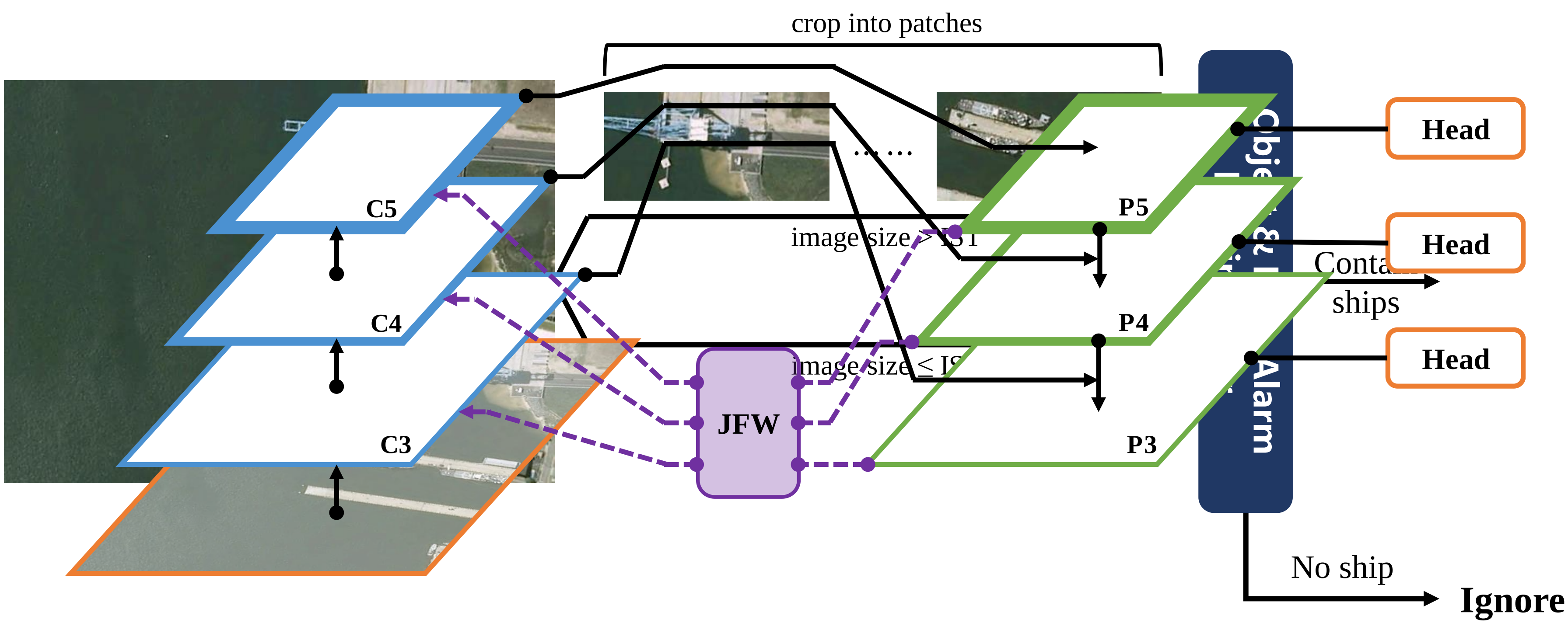


Outline

- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

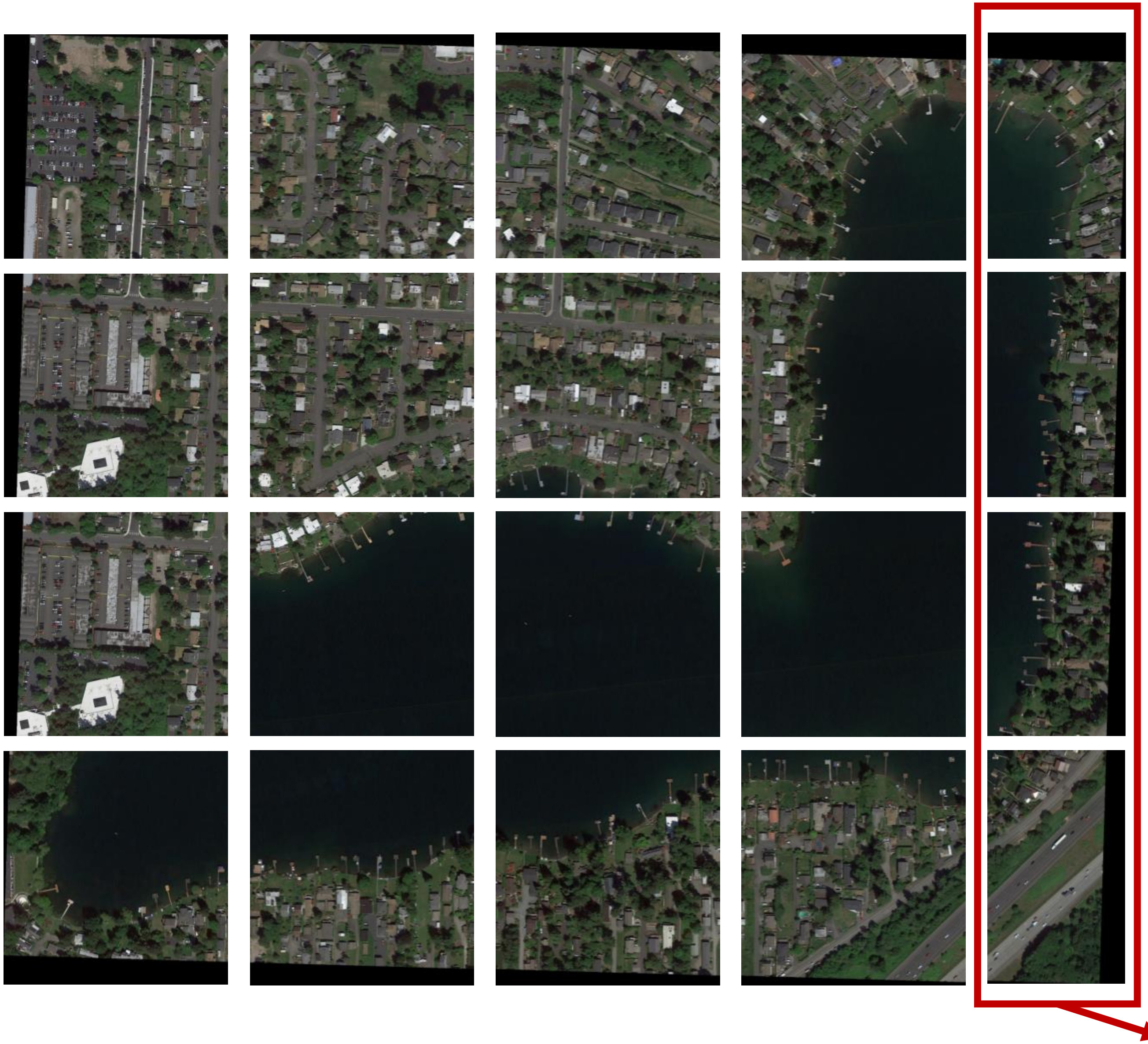


Data preprocessing / Multi-scale detector



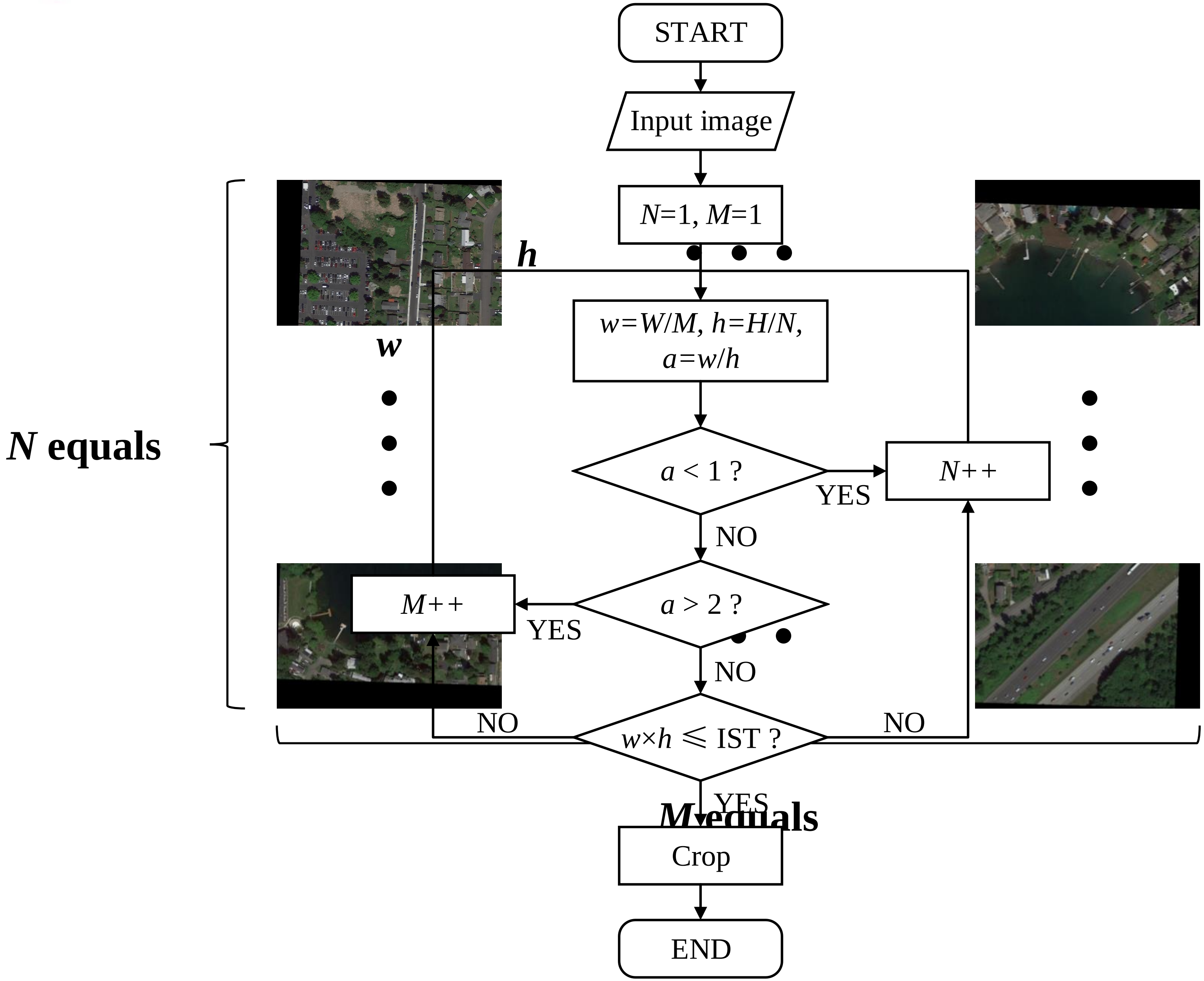
Data preprocessing

Data preprocessing



Unsuitable aspect ratio

Adaptive Cropping Strategy (ACS)



Objects and False Alarms Discriminator

Blank Patch

- It is **waste of computing resources** when the detector is processing blank patches.
- It may **increase the risk of detecting false alarms** when input blank patches into the detector.

Objects and False Alarms Discriminator

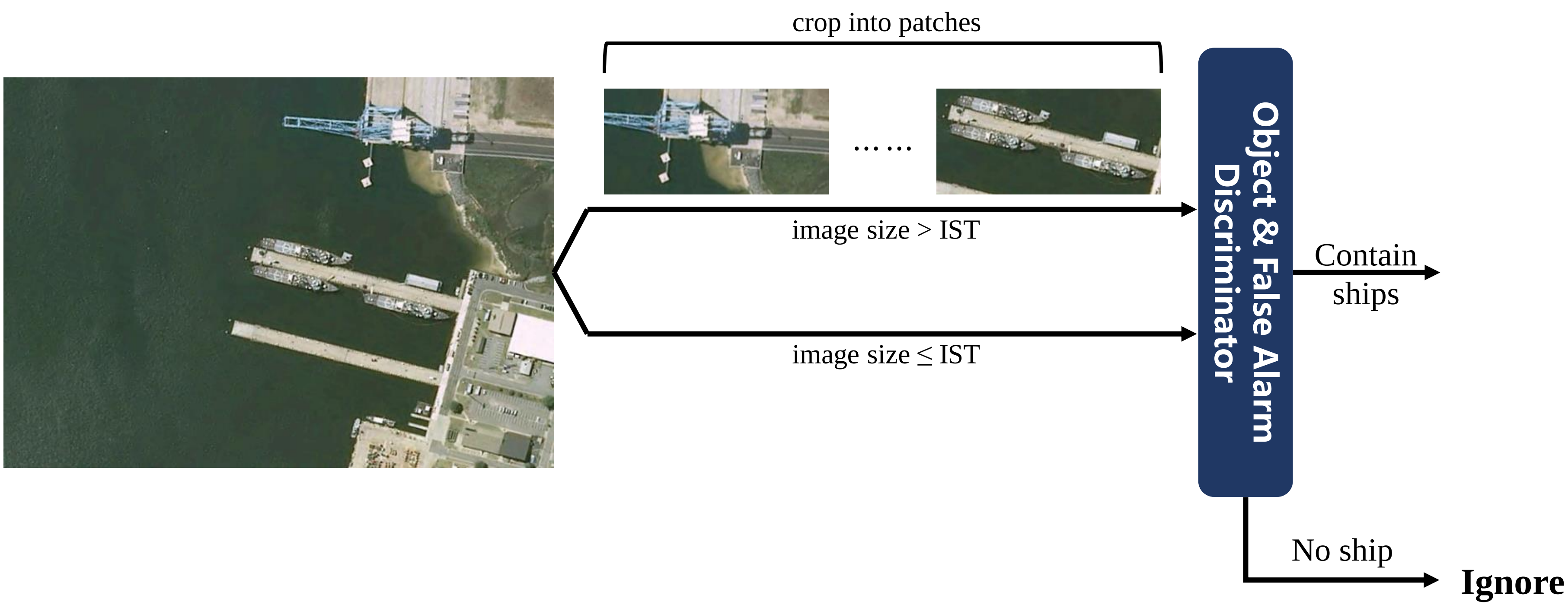
ResNet34

layer name	architecture
conv1	conv, 7×7, 64, stride 2 max pooling, 3×3, stride 2
conv2	$\begin{bmatrix} 3\times3, 64 \\ 3\times3, 64 \end{bmatrix} \times 3$
conv3	$\begin{bmatrix} 3\times3, 128 \\ 3\times3, 128 \end{bmatrix} \times 4$
conv4	$\begin{bmatrix} 3\times3, 256 \\ 3\times3, 256 \end{bmatrix} \times 6$
conv5	$\begin{bmatrix} 3\times3, 512 \\ 3\times3, 512 \end{bmatrix} \times 3$
	global average pooling fc, 2-d softmax

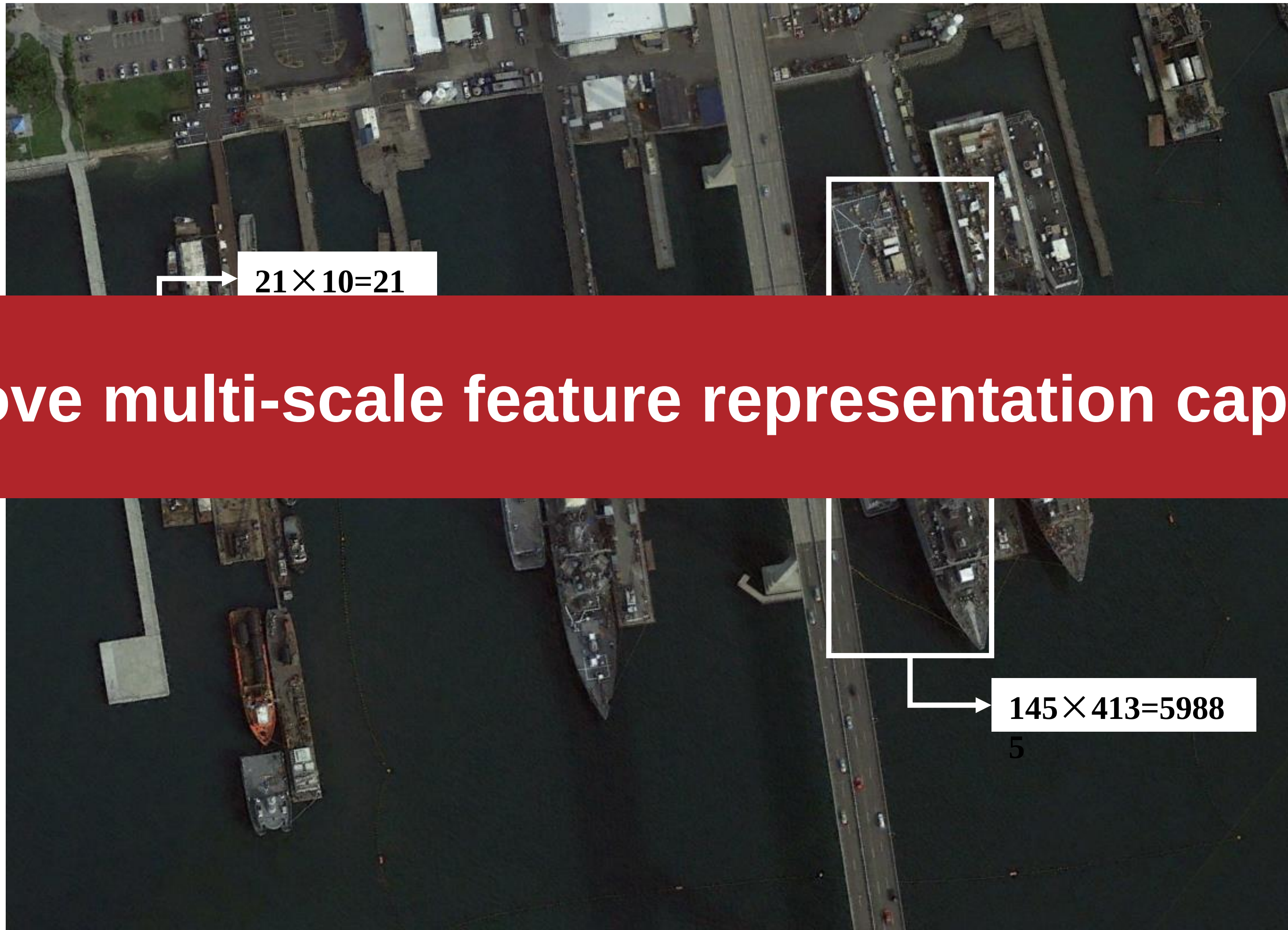
- OFAD act as a filter t
- A good OFAD shoulc , **fast inference speed** and **strong generaliz**

K. He, et al. Deep Residual Learning for Image Recognition. CVPR, 2016.

Data preprocessing



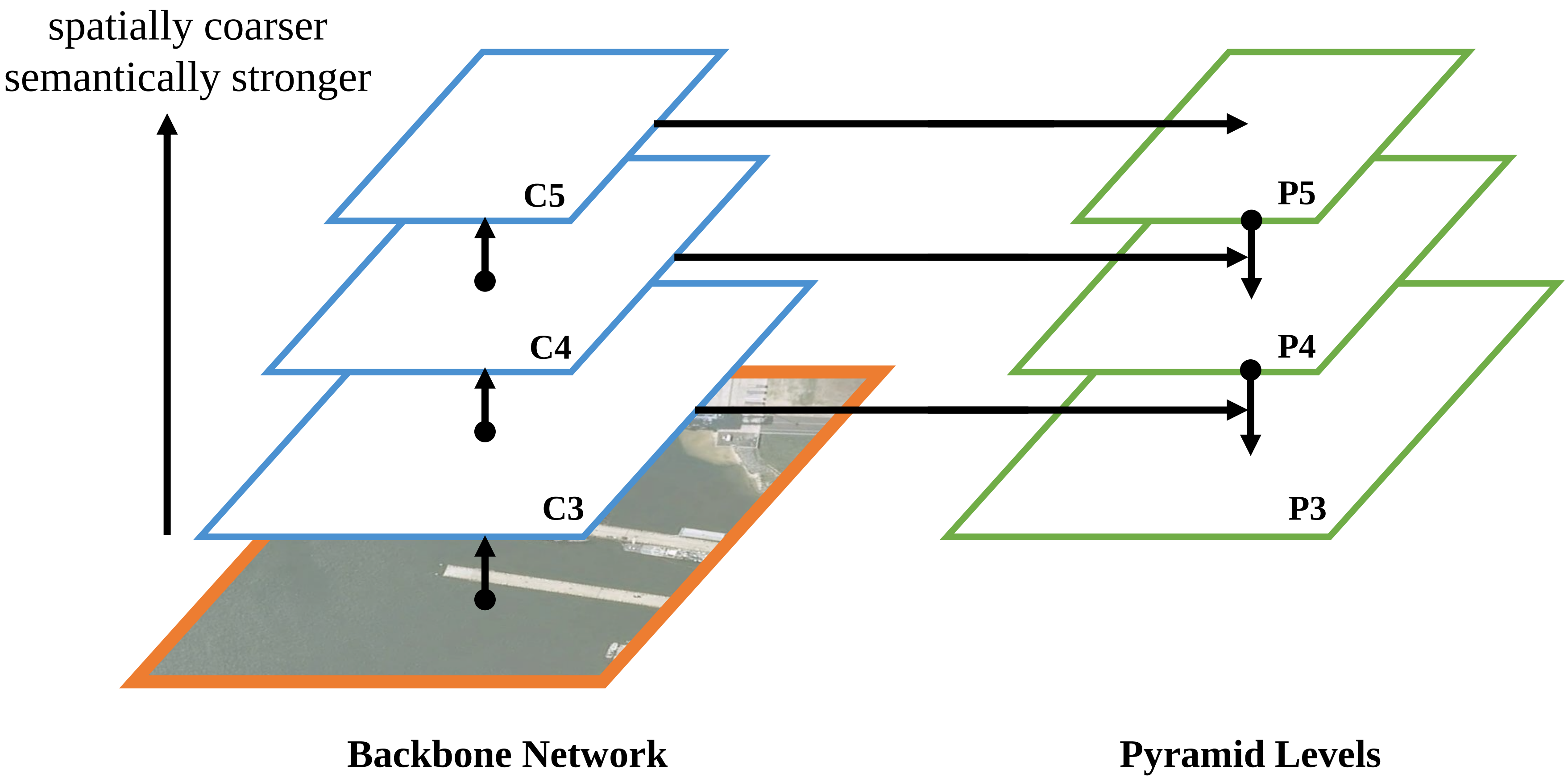
Learning the pattern of multi-scale objects is huge challenge



Improve multi-scale feature representation capability

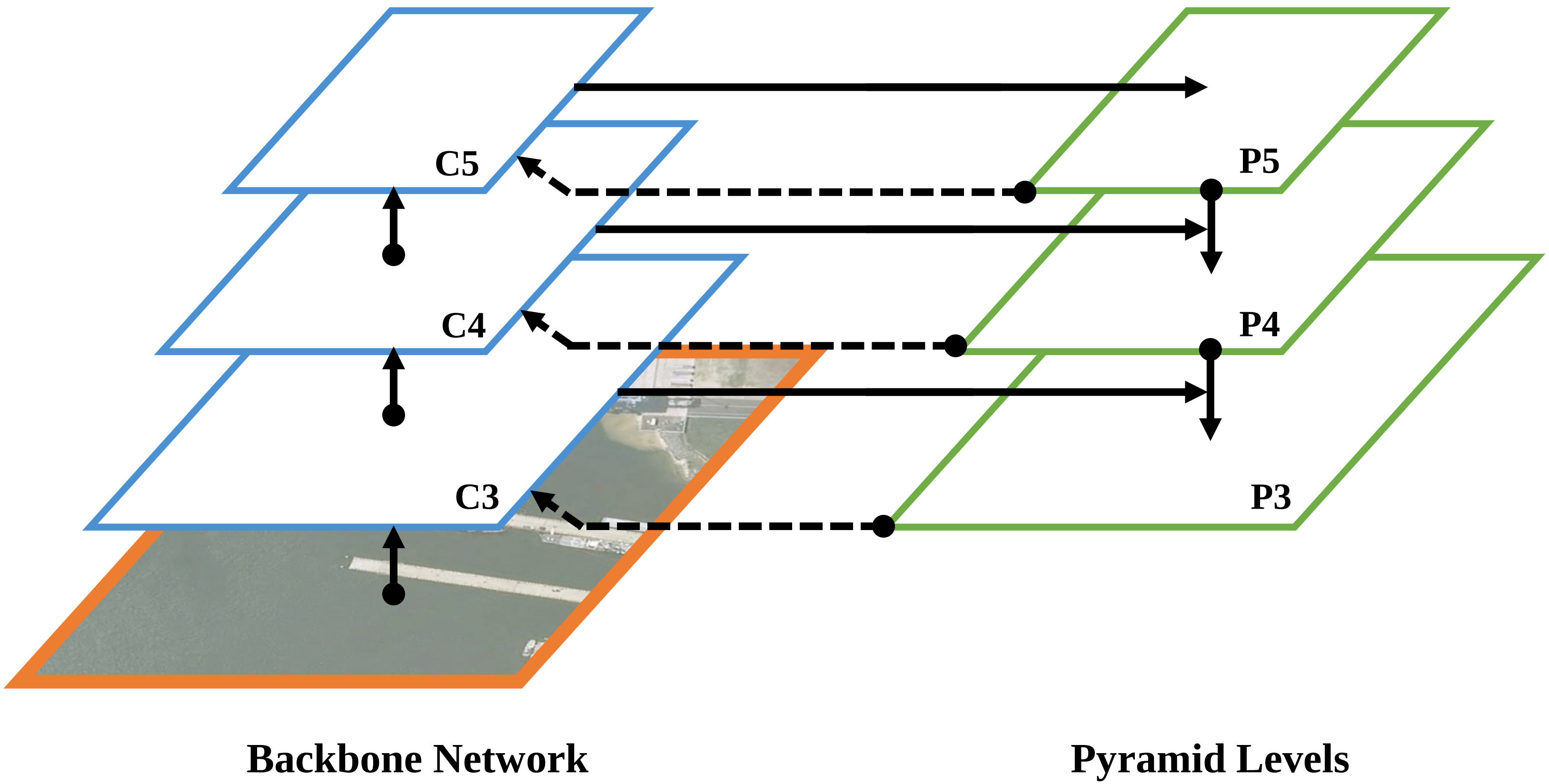
Z. Liu, et al. A High Resolution Optical Satellite Image Dataset for Ship Recognition and Some New Baselines. ICPRAM, 2017.

Feature Pyramid Network (FPN)



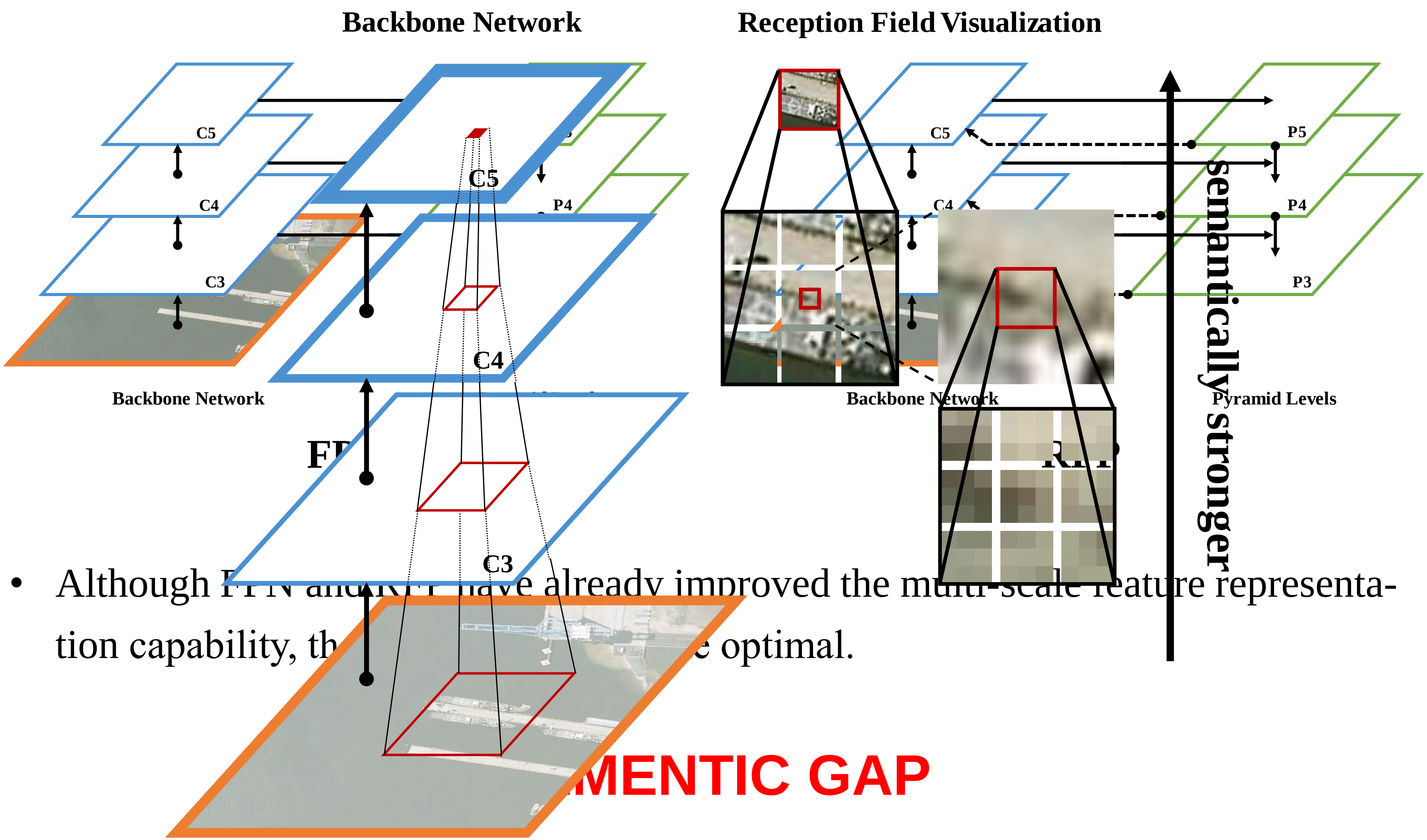
T. Lin, et al. Feature pyramid networks for object detection. CVPR, 2017.

Recursive Feature Pyramid (RFP)



S. Qiao, et al. DetectoRS: Detecting Objects with Recursive Feature Pyramid and Switchable Atrous Convolution. arXiv:2006.02334, 2020

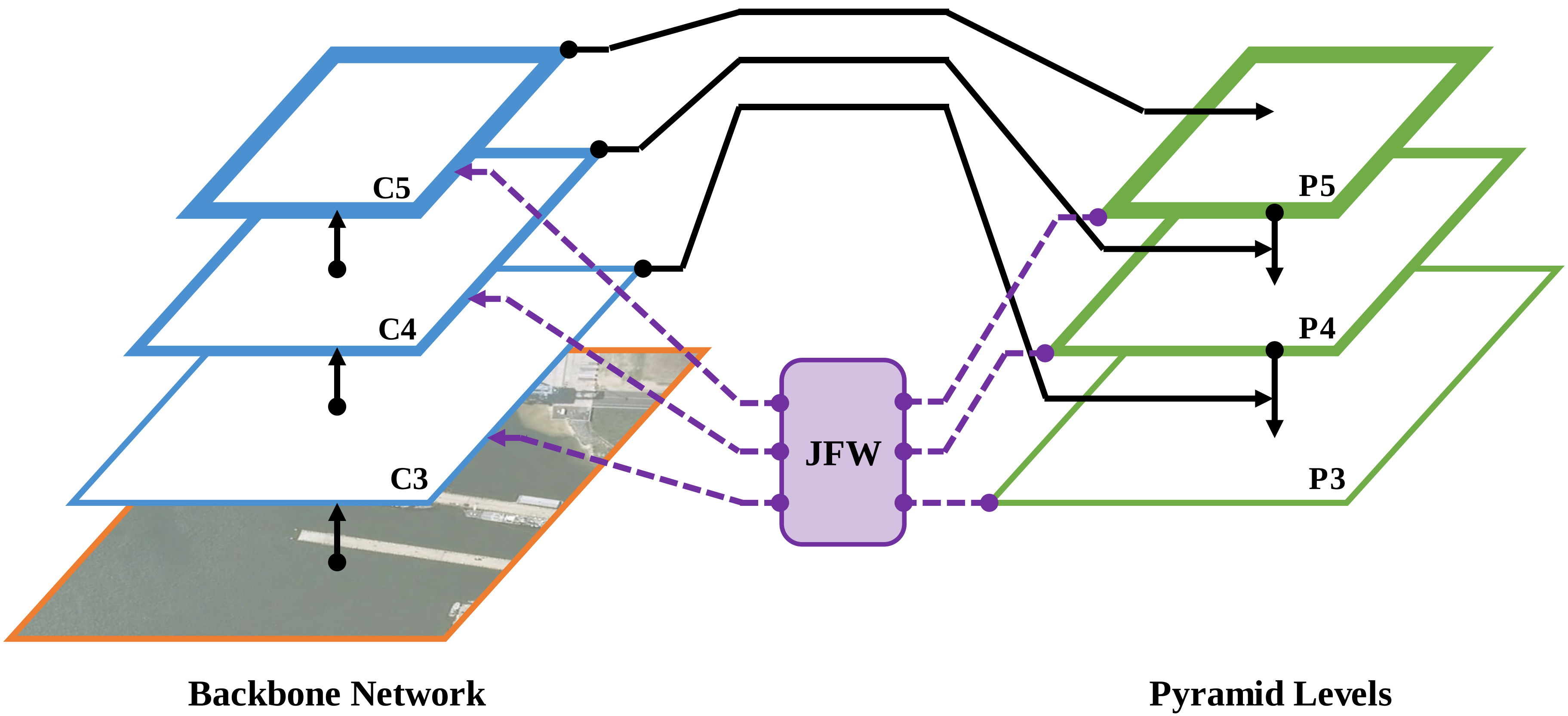
Semantic gap



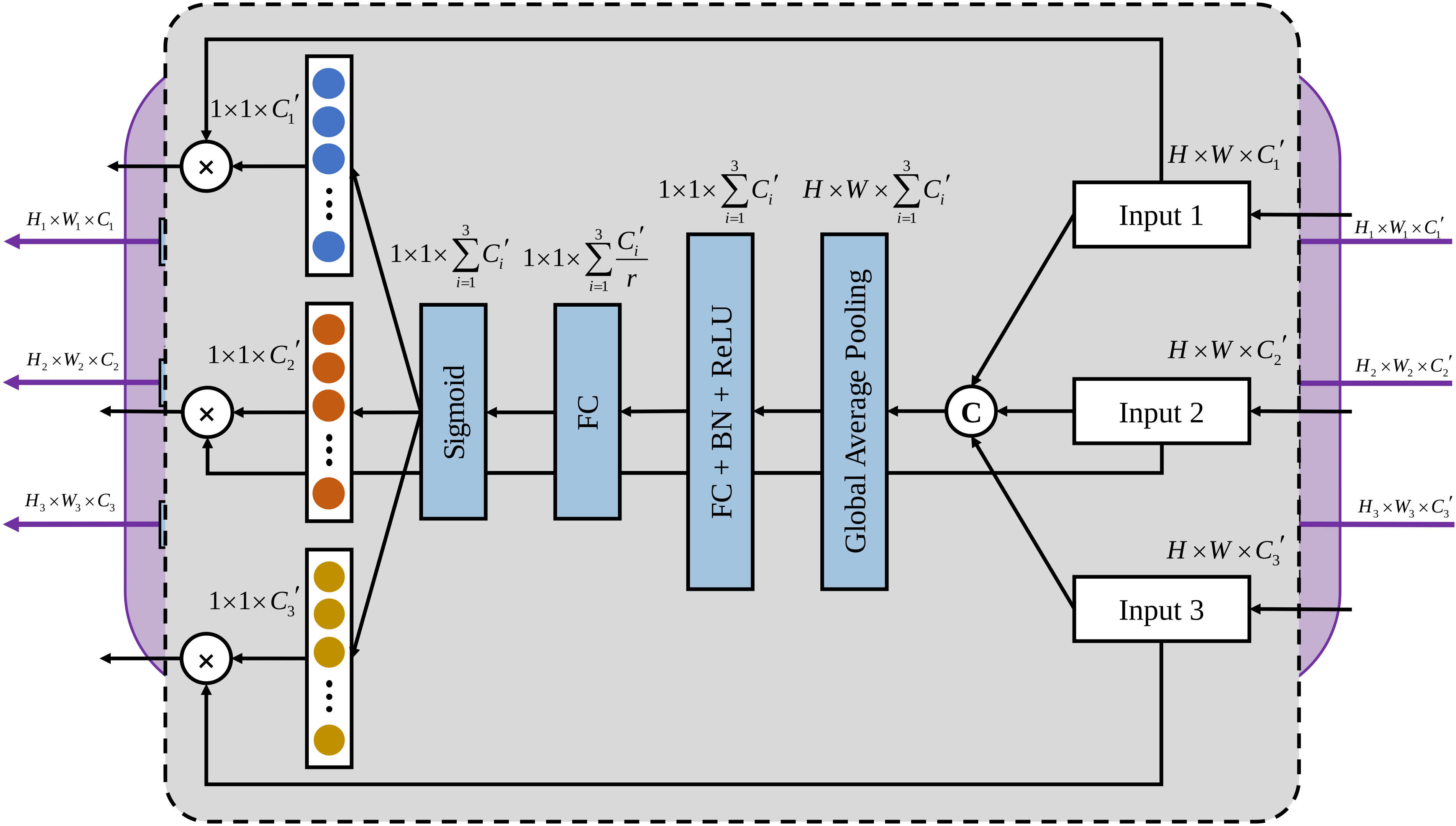
- Although FPN and RFP have already improved the multi-scale feature representa-tion capability, th … e optimal.

MENTIC GAP

Joint Recursive Feature Pyramid (JRFP)



Joint Feedback Worker (JFW)



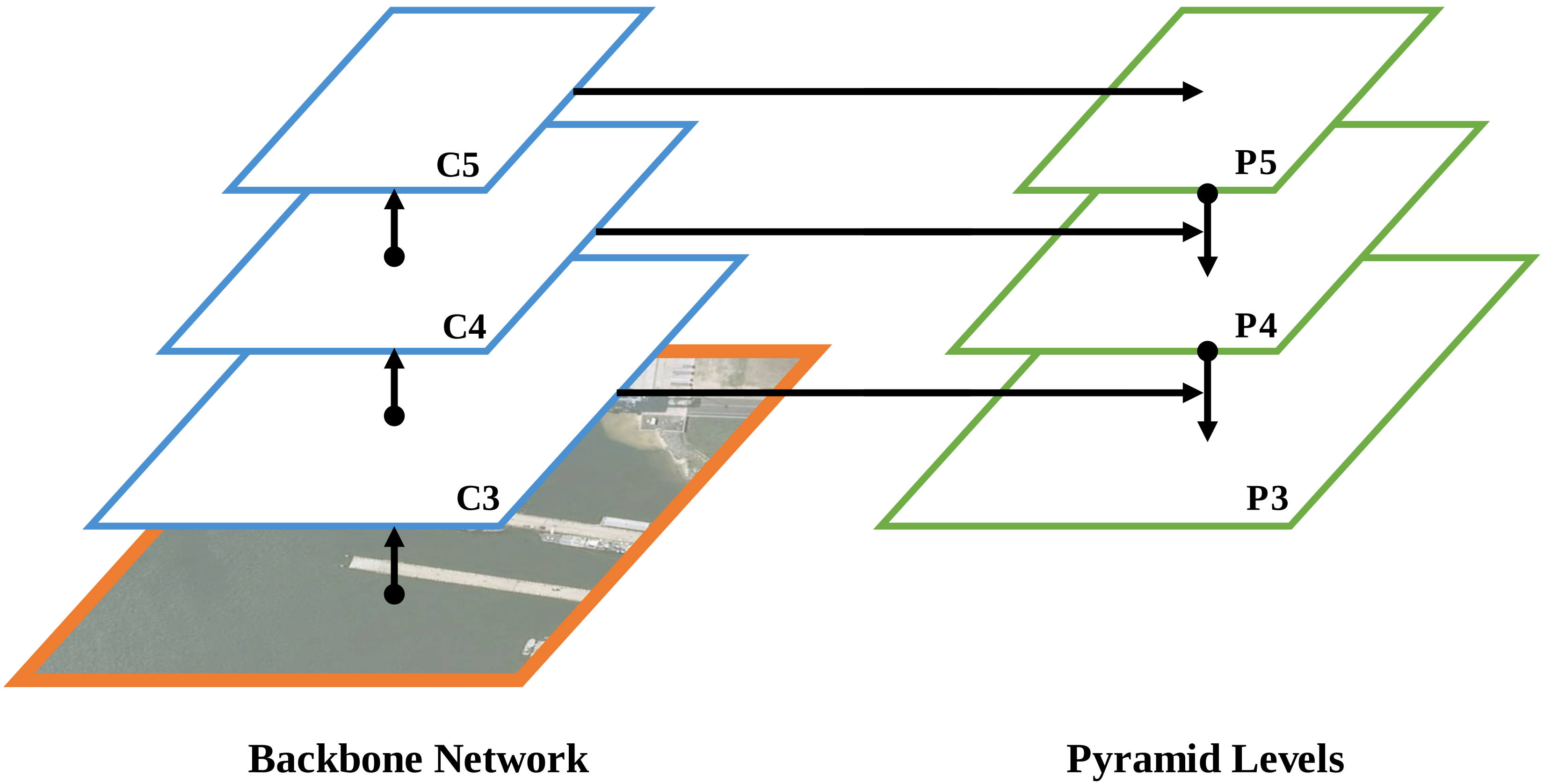
BALANCE

Specificity ⟷ Uniformity

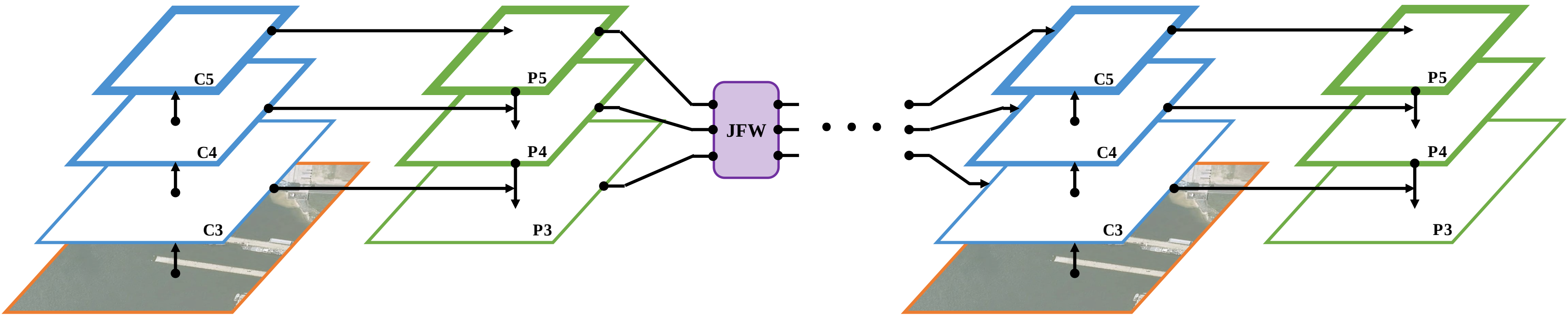
↓

Recursive Index (RI)

Unrolled JRFP (RI=0)



Unrolled JRFP (RI>0)



- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

Results on HRSC2016-MS dataset

Method	mAP (VOC2012 fashion)
Faster R-CNN [1]	0.246
Cascade R-CNN [2]	0.617
DetectoRS [3]	0.637
MSSDet (ours)	**0.721**

[1] S. Ren, et al. Faster R-CNN: Towards real-time object detection with region proposal networks. IEEE TPAMI, 2015.
[2] Z. Cai, et al. Cascade R-CNN: Delving into High Quality Object Detection. CVPR, 2018.
[3] S. Qiao, et al. DetectoRS: Detecting Objects with Recursive Feature Pyramid and Switchable Atrous Convolution. arXiv:2006.02334, 2020

Results on HRSC2016 dataset (L1)

Method	mAP (VOC2012 fashion)
BL1 [1]	0.797
Faster R-CNN (soft NMS) [2]	0.845
Faster R-CNN (dilated conv) [3]	0.709
Cascade R-CNN [4]	0.904
DetectoRS [5]	0.920
MSSDet (ours)	**0.946**

[1] Z. Liu, et al. A High Resolution Optical Satellite Image Dataset for Ship Recognition and Some New Baselines. ICPRAM, 2017.
[2] X. Tan, et al. Inshore ship detection based on improved faster R-CNN. Proc. SPIE 11429, MIPPR 2019.
[3] S. Wei, et al. Ship Detection in Remote Sensing Image based on Faster R-CNN with Dilated Convolution. Proceedings of the 39th Chinese Control Conference, 2020
[4] Z. Cai, et al. Cascade R-CNN: Delving into High Quality Object Detection. CVPR, 2018.
[5] S. Qiao, et al. DetectoRS: Detecting Objects with Recursive Feature Pyramid and Switchable Atrous Convolution. arXiv:2006.02334, 2020

Results on DIOR dataset

Method	mAP (VOC2012 fashion)
R-CNN	0.377
RICNN	0.442
RICAOD	0.509
RIFD-CNN	0.561
Faster R-CNN	0.651
SSD	0.586
YOLOv3	0.571
Mask R-CNN	0.652
RetinaNet	0.661
PANet	0.661
CornerNet	0.649
MSSDet (ours)	**0.778**

K.Li,et al.Object Detection in Optical Remote Sensing Images: A Survey and A New Benchmark.ISPRS Journal of Photogrammetry and Remote Sensing, 2019

Ablation Study on Recursive Index

Method	**mAP (VOC2012 fashion)**
MSSDet (RI=0)	0.660
MSSDet (RI=1)	0.667
MSSDet (RI=2)	**0.721**
MSSDet (RI=3)	0.674

*: The ablation study was done on HRSC2016-MS dataset

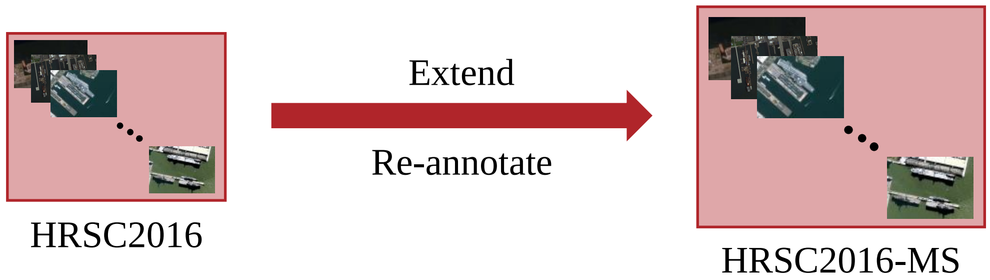
Outline

- Introduction
- HRSC2016-MS Dataset
- MSSDet
- Experimental Result
- Conclusion

Conclusion

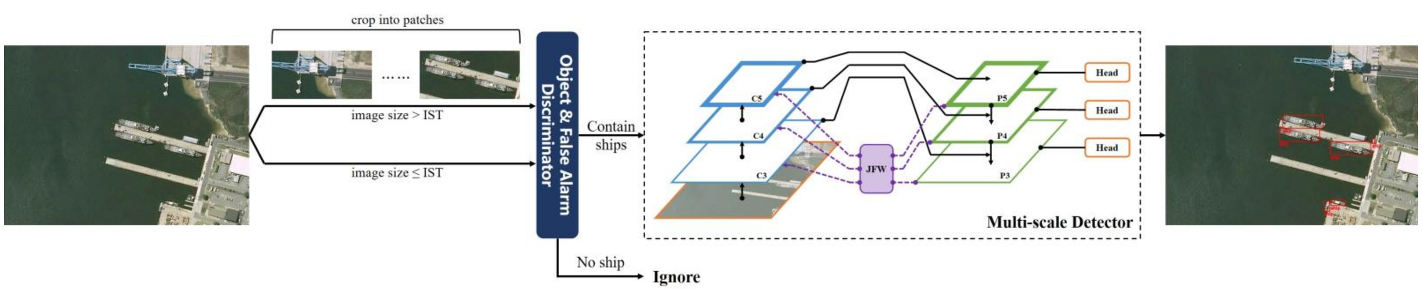
DATASET

- We build a new dataset with rich multi-scale ship instances based on HRSC2016.



ALGORITHM

- We propose **Adaptive Cropping Strategy** and **Objects and False Alarms Discriminator** to deal with the difficulty of size.
- We propose **Joint Recursive Feature Pyramid** to deal with the difficulty of scenario and multi-scale instances.



THANKS FOR LISTENING

Q & A