

Anchor-free small ship detection from Sentinel-2 images

Master/Ecole d'Ingenieur internship

Expected starting: February/March 2025 (6 months)

Application deadline: 30 November 2024

Keywords

Deep learning, small object detection, anchor-free detection, ship detection, Sentinel-2

Context and objectives

The detection of ships from satellite images is critical for applications ranging from maritime security, illegal fishing detection, and environmental protection to managing shipping traffic. Traditional ship detection methods have relied on high-resolution imagery from SAR (Synthetic Aperture Radar) or other high-cost optical systems. However, the recent availability of freely accessible optical data from the Sentinel-2 satellites offers a promising alternative, especially with its high revisit frequency, wide swath, and 10-meter resolution.

Despite these advantages, the detection of small ships remains a challenging task. Sentinel-2's moderate spatial resolution makes it difficult to identify small vessels due to their small pixel footprint and visual similarity to background features (e.g., waves, coastal structures). Recent advances in deep learning, particularly in anchor-free object detection, present a promising path forward. Anchor-free methods are particularly suited for detecting small objects in cluttered backgrounds by eliminating the need for anchor box generation, which is critical in dealing with limited resolution scenarios.

This proposal aims to investigate and improve deep learning-based anchor-free detection models for small ships in Sentinel-2 images. Here are some expected (not exclusive) objectives:

- Explore and develop deep learning models capable of detecting small ships in Sentinel-2 images using anchor-free approaches (e.g., FCOS, CenterNet, ConnerNet, etc.), including but not limited to
 - (1) Address the unique challenges posed by Sentinel-2 data, such as small object sizes, low contrast, and noise, through tailored pre-processing, model architecture refinement, and/or post-processing techniques;
 - (2) Benchmark the developed solution on publicly available datasets for ship detection using Sentinel-2 images.
- The architecture will be expanded for further developments upon discussing with the student, which include but is not limited to multi-modalities input, (partial) multi-task learning (super-resolution and object detection), domain adaptation, and representative learning with contrastive loss, etc.

Required background and skills

- Student Master 2, Ecole d'Ingénieur or equivalent with excellent academic track;
- Ability to communicate in English;
- Background in computer science and/or machine/statistical learning and/or applied mathematics for signal and image processing;
- Excellent programming in Python (familiar with one of deep learning packages is a must, preferable PyTorch).

Supervision

The expected intern will join the OBELIX research group (www.irisa.fr/obelix) from IRISA (UMR 6074) is located in the UBS (Université Bretagne Sud) campus in Vannes 56000, France. He/She will be jointly supervised by:

- A/Prof. Minh-Tan Pham¹ (Maître de Conférences) UBS/IRISA
- Dr. Abdelbadie Belmouhcine², Teaching and Research fellow (ATER) UBS/IRISA
- Dr. Hoàng-Ân Lê³, Postdoctoral researcher, CNES/IRISA/UBS

Application

Send your **CV + Motivation letter + Master transcripts** to minh-tan.pham@univ-ubs.fr, abelbadie.belmouhcine@univ-ubs.fr and hoang-an.le@univ-ubs.fr (**BEFORE 30 November 2024**). Potential candidates will be contacted for interview.

References

- [1] Zou, Z., Chen, K., Shi, Z., Guo, Y. and Ye, J., 2023. Object detection in 20 years: A survey. *Proceedings of the IEEE*, 111(3), pp.257-276.
- [2] Tian, Z., Shen, C., Chen, H., He, T. (2020). FCOS: A simple and strong anchor-free object detector. *IEEE transactions on pattern analysis and machine intelligence*, 44(4), 1922-1933.
- [3] Kong, T., Sun, F., Liu, H., Jiang, Y., Li, L., Shi, J. (2020). Foveabox: Beyond anchor-based object detection. *IEEE Transactions on Image Processing*, 29, 7389-7398.
- [4] Cheng, Gong, Jiabao Wang, Ke Li, Xingxing Xie, Chunbo Lang, Yanqing Yao, and Junwei Han. "Anchor-free oriented proposal generator for object detection." *IEEE Transactions on Geoscience and Remote Sensing* 60 (2022): 1-11.
- [5] Fu, J., Sun, X., Wang, Z., Fu, K. (2020). An anchor-free method based on feature balancing and refinement network for multiscale ship detection in SAR images. *IEEE Transactions on Geoscience and Remote Sensing*, 59(2), 1331-1344.
- [6] Zhang, D., Wang, C., Fu, Q. (2023). Ofcos: an oriented anchor-free detector for ship detection in remote sensing images. *IEEE Geoscience and Remote Sensing Letters*, 20, 1-5.
- [7] Ship detection from Sentinel-2 dataset: https://universe.roboflow.com/sentinel2/sentinel-2-ship_detection
- [8] Ship detection from Sentinel-2 dataset: https://github.com/alina2204/contrastive_SSL_ship_detection?tab=readme-ov-file

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