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Uncertainty estimation methods for the detection of marine litter from Sentinel-2

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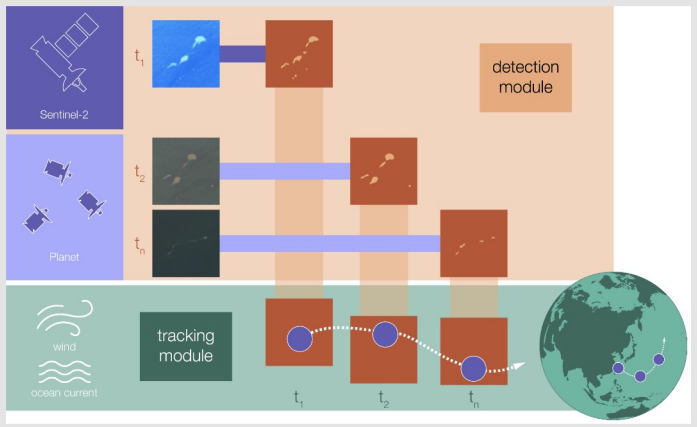
Broader context and Objectives

The ADOPT project (AI for Detecting Ocean Plastic pollution with Tracking) proposes approaches for marine litter detection and tracking.

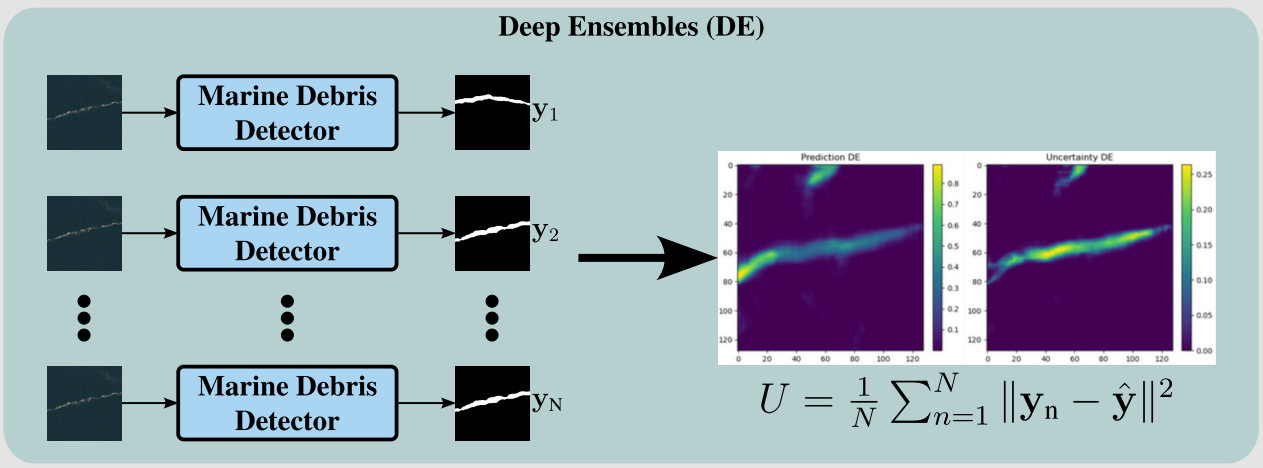
Within this context, we explore ways to to assess the uncertainty of a prediction model [1]. We considered two objectives:

- Comparison of sampling-free approaches: Deep Ensembles [2] and ZigZag [3].
- Assessment in terms of performance, computational cost, uncertainty quality.

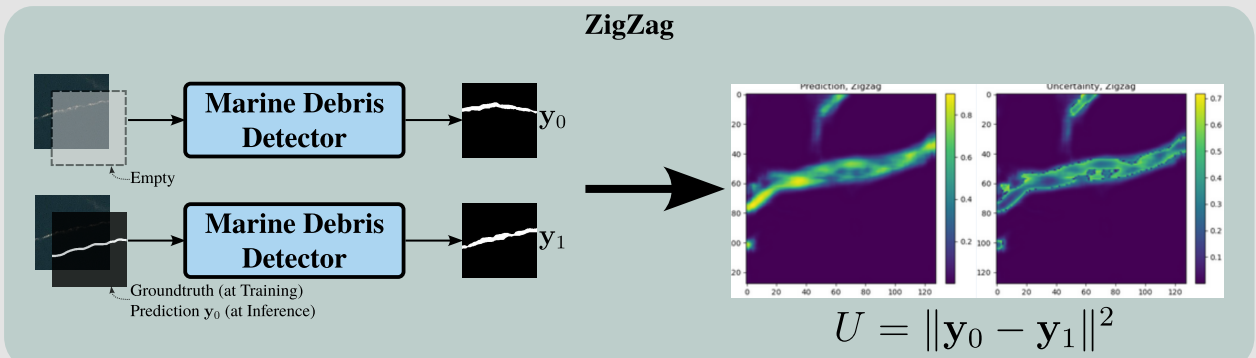


Sampling-free uncertainty estimation: Deep Ensembles [2] and ZigZag [3]

- Deep Ensembles [2] consists in training several independent networks with different initializations, where each model of the ensemble provides its prediction: variations on models' predictions on the same input indicate low confidence.



- With ZigZag [3] a model is trained to produce the same prediction, whether the true label is provided as additional input. At inference, a model which is confident will produce an output close to the true label which, if provided as additional input to the same model, will lead to a similar prediction: their distance represents the uncertainty.

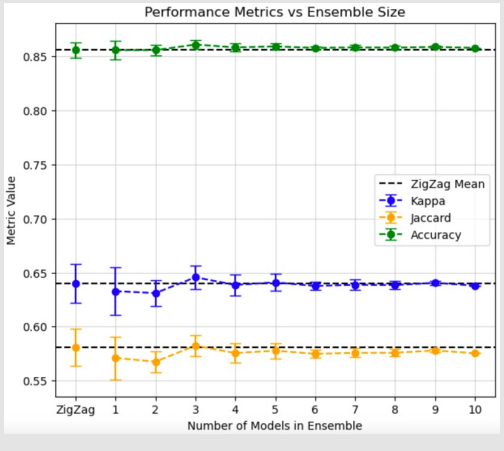


Results and conclusions

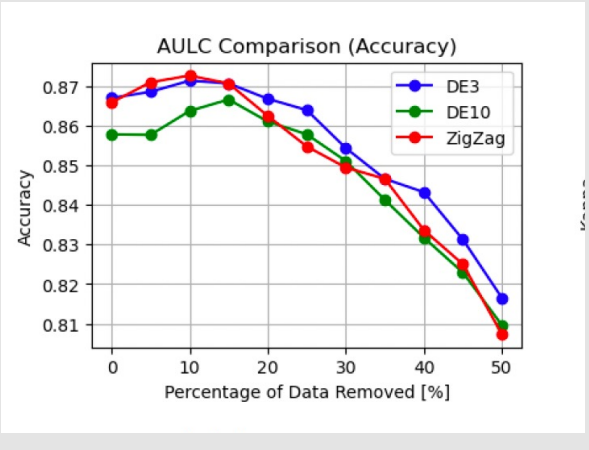
Similar performance between the two uncertainty estimation methods: both better than the UNet reference, corresponding to the Marine Debris Detector [1]

	UNet (ref.)	Deep Ensembles (best)	Zigzag (best)
Accuracy	0.865	0.867 (+0.2%)	0.866 (+0.1%)
Jaccard	0.589	0.597 (+1.3%)	0.599 (+1.7%)
Kappa	0.654	0.661 (+1.1%)	0.661 (+1.1%)

Comparable computational cost: DE with 3 models gives as good estimates as ZigZag (2 forward passes by definition).



Uncertainty quality: removing examples with low confidence increases the performance.



[1]Rußwurm et al., "Large-scale detection of marine debris in coastal areas with Sentinel-2", in iScience 2023
[2]Lakshminarayanan et al., "Simple and scalable predictive uncertainty estimation using deep ensembles", in NIPS 2017
[3]Durasov et al., "Universal Sampling-free Uncertainty Estimation Through Two-Step Infrence", in TMLR 2024

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