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Seafloor classification with optimized texture convolutional neural network: application to complex benthic habitats on seamount and volcanic island slopes



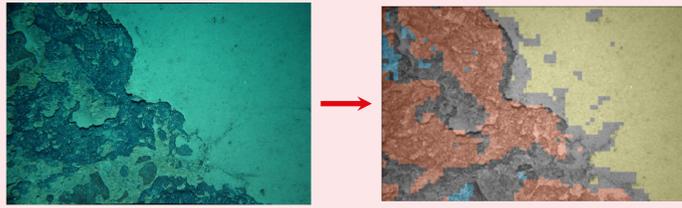
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Motivation

- Objectives:**
- Automatic seafloor annotation
 - Substrate types quantification
⇒ four classes: soft, gravel, volcanic and carbonate
 - Automatic supervised machine learning algorithm



Original image (left) and automatic segmented image (right)

- Challenges:**
- Small annotation set (< 1000)
 - Texture images with no structures
⇒ hard to extract features
 - No pixel based annotation

Dataset

Original annotations are non-oriented parallelograms. They are normalized to 224x224 using diagonal crop technique and aligned to image coordinate system.

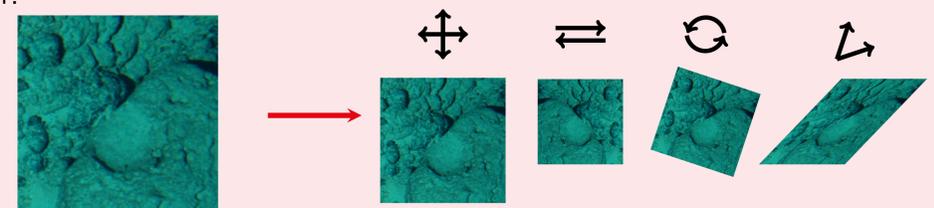
The initial biogenic class was removed due to its too small size.



Type	Number
Soft	199
Gravel	200
Volcanic	199
Carbonate	174
Biogenic	49

Data augmentation

Due to the small number of annotations, the dataset is artificially increased by randomly applying a data augmentation technique: zoom, flip, rotation and shear.



Data augmentation technique

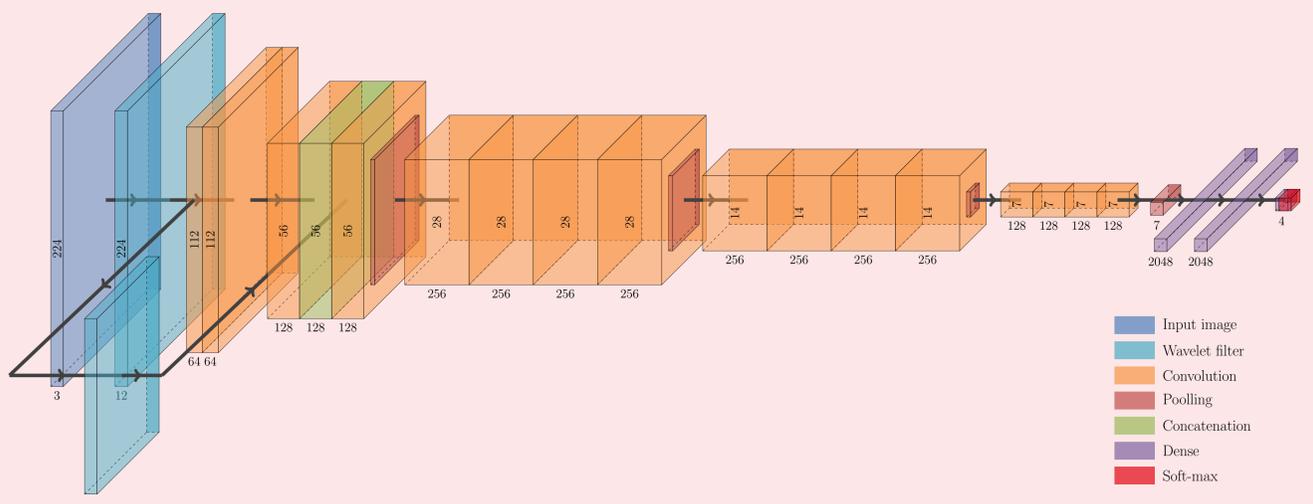
Proposed deep neural network architecture

To extract seafloor features we choose to use the well known VGG19 neural network[1]. However, substrates are more textures than objects. Thus, we added wavelets layers in association to VGG19 in the same way as proposed by Fujieda et al[2] in their Wavelet CNN neural network.

In order to improve our results, we adapted these networks to fit our problem by adding two wavelet stages.

Finally, we modified the last dense layer for our four classes classification task and we added a soft-max output.

(the learning parameters are: Adam optimizer, categorical cross entropy loss, 50 epoch)



Proposed deep neural network architecture based on VGG19[1] and Wavelet CNN[2]

Experiments

The dataset was randomly splitted into two parts: 90% for training, 10% for validation (with multiple splits).

To improve the deep neural network performances, several architectures have been evaluated with and without transfer learning (feature extractor and fine tuning). Thus the original Wavelet CNN performance has increased by 9 points (see next table).

Also, different annotation normalization have been tested and diagonal crop give the best results. For image patch based segmentation, 224x224 patch size without overlap seems to be a good time / precision compromise (10 seconds).

Type	Mean score (%)
Wavelet CNN (original)	74.44
VGG19 - with transfer learning	80.77
Wavelet CNN (original) - with transfer learning	82.05
Optimized Wavelet CNN - with transfer learning	83.59

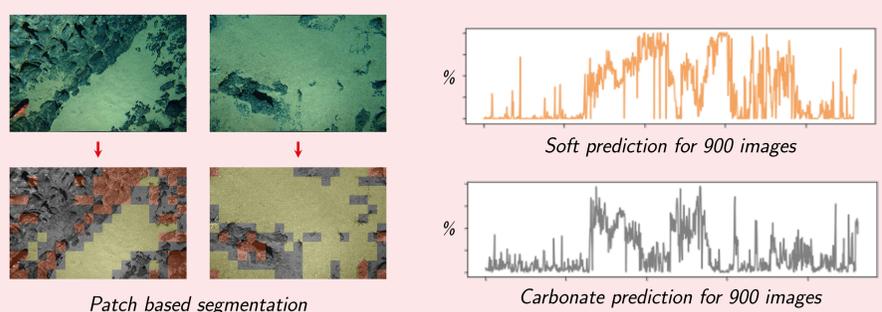
Classification performance for tested networks on test dataset

	Soft	Gravel	Volcanic	Carbonate
Soft	85	7	0	8
Gravel	10	90	0	0
Volcanic	0	0	95	5
Carbonate	22	13	4	61

Per class performances (confusion matrix)

This method was used to assess percent cover on 9000 images taken on seven seamounts and volcanic island slopes along the Mozambique Channel. Thereby, the variability of substrate composition along and among these seamounts was tested as structuring factors of benthic megafaunal assemblages (Mélissa Hanafi-Portier, ongoing PhD).

Results



Perspectives

- For results:**
- Use semantic segmentation (Unet, Segnet)
 - Improve results using a better texture based deep neural network
- For usage:**
- Learn more substrates and megafauna
 - Integrate the tool to Biigle[3]

Bibliography

- [1] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," 2015.
- [2] S. Fujieda, K. Takayama, and T. Hachisuka, "Wavelet convolutional neural networks for texture classification," 2017.
- [3] D. Langenkämper, M. Zurowicz, T. Schoening, and T. W. Nattkemper, "Biigle 2.0 - browsing and annotating large marine image collections," *Frontiers in Marine Science*, vol. 4, p. 83, 2017.