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Supervised classification of intertidal macroalgae using georeferenced high-resolution UAV imagery

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Abstract – **Intertidal macroalgae play a pivotal role in marine ecosystems. Therefore, monitoring their distribution is crucial for resource management and ecosystem conservation. However, traditional observation methods are laborious and resource demanding. We aimed to develop an automatic classification methodology of macroalgae using high-resolution Unmanned Aerial Vehicles (UAV) imagery and Haralick Textural Features (HTFs). A supervised classifier was trained with labelled RGB orthoimages acquired in a rocky intertidal area at Galicia, Spain. These images were classified at both species and phylum levels, using a superpixel-based algorithm that was trained with labelled data. Results indicated a validation accuracy of 75% for species and 86% for phylums. However, achieving high accuracy at the species level proved challenging due to species similarity and superpixel complexity. Future work could improve the accuracy by refining the superpixels and expanding the labelled dataset. Our approach offers a useful tool for the quantification of heterogeneous macroalgae cover in rocky intertidal areas, with room for refinement to improve classification precision.**

Keywords – *UAV, High resolution RGB imagery, Supervised classification, Machine learning*

I. INTRODUCTION

Macroalgae assemblages play a vital role in intertidal ecosystems as they provide food and shelter and act as a nursery area for several faunal populations [1,2,3]. They are also an important source of marine primary production and could act as a sink of anthropogenic CO_2. Due to their ecological importance, monitoring their coverage and diversity is imperative. However, conventional monitoring of an intertidal area requires assessing multiple transects by experts on the field, which is a costly and laborious process. Our primary objective was to develop an alternative process, based on machine learning methods, for the automatic classification of complex, multi-specific, intertidal macroalgae assemblages. To achieve this, we monitored intertidal exploitable resources using UAV imagery. The resulting georeferenced orthoimages were processed using HTFs and classified using supervised classification methods.

II. METHODOLOGY

A set of HTFs (Haralick Textural Features) was used as input for a Random Forest classifier (RF) [4]. The classifier was trained with manually labelled georeferenced Red-Green-Blue (RGB) orthoimages of two areas of study in Galicia (NW Spain): Baiona, with an area of 2.3 ha, and Illa de Arousa, with an area of 2.5 ha (Figure 1A).

Eight flights were performed at 12 m of altitude using a DJI Mavic 3E between May and September 2023. Another flight at 15 m of altitude was performed using a DJI Mavic 300RTK over Baiona in July 2023. After each flight, the coordinates of several pre-deployed targets were used to create orthoimages of the study areas with a Ground Sampling Distance (GSD) between 0.37 cm and 0.51 cm.

The orthoimages were manually segmented and labelled by experts, cataloguing 24 different classes. The labelled orthoimages were divided into train and test datasets. The classes without enough representation (less than 100 instances) were eliminated, resulting in 5,446 and 1,978 labels for train and test datasets, respectively, and 15 final classes. For each label, the mean RGB colour and the HTFs (contrast, standard deviation, inverse difference moment, average sum, and entropy) over the green band were calculated and then used to train the RF classifier. To classify the validation orthoimages using the HTFs, macroalgae were grouped in ensembles with similar colour characteristics (superpixels) using an unsupervised SLIC algorithm. For each superpixel, HTFs were calculated and used as input for the trained RF model. Two types of classification were performed: at the species level (11 macroalgae species, rock, sand, unclassified) and at the phylum level (Rhodophyta, Ochrophyta, Chlorophyta, rock, sand, unclassified).

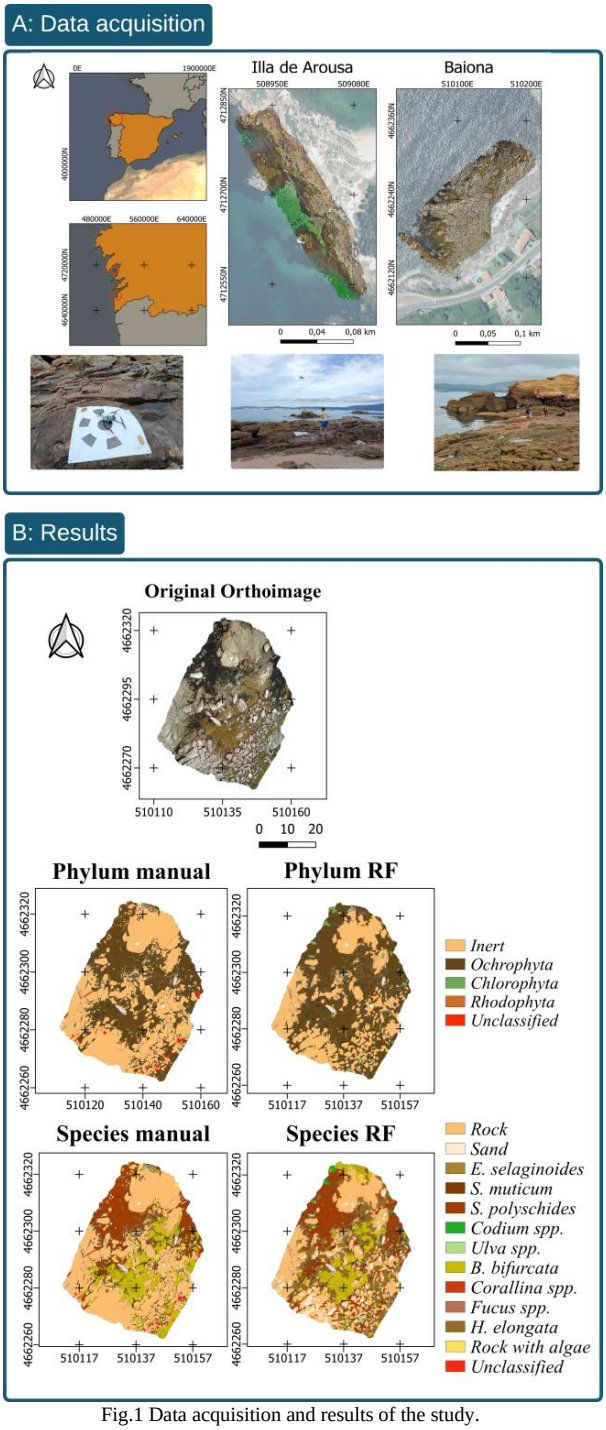

Fig.1 Data acquisition and results of the study.

III. RESULTS

The classification of the validation dataset showed an accuracy of 75% at the species level and 86% at the phylum level. We used the mean Jacquard Index and Cohen's Kappa to evaluate the classification of the orthoimages using superpixels. The Phylum classification obtained higher Jacquard and Kappa indexes (0.80 and 0.81, respectively) than the species classification (0.74 and 0.69). Because of the heterogeneity of both rocks and macroalgae ensembles, the RF misclassified grainy rock surfaces as both green and brown macroalgae, and dry rock patches were classified as sand (Figure 1B).

IV. CONCLUSIONS

We developed a workflow for automatically classifying intertidal macroalgae from high resolution UAV imagery. The method proposed in this study has proven to be a good tool for the rapid assessment of heterogeneous macroalgae coverage in intertidal areas. The RF classifier showed a good performance at the phylum level, while the validation accuracy was lower at the species level due to the similarity between macroalgal species and the complex diversity of each superpixel. Improving the accuracy at both classification tasks would require refine superpixel creation and delimitation and, adding more labelled orthoimages of macroalgae to increase the number of elements in the training dataset.

V. ACKNOWLEDGEMENTS

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