Automatic recognition of microfossils using convolutionnal neural networks : applications of a high-throughput workflow for paleoceanographic reconstructions and biostratigraphy

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Recent progresses in image processing, and image recognition have paved the way for automated procedures to classify natural objects such as microfossils, and notably foraminifera. Foraminifera are among the most useful tracers in biostratigraphy and paleoceanography. Yet, the protocol used to extract and recognize the foraminifera did not changed since the mid-18thcentury: manual picking using a brush with a stereomicroscope.
The most recent breakthrough is the development of image identification using convolutionnal neural networks, approach now widely used in biology. Here we present the results we achieve by developing the MiSo -Microfossil Sorter -automaton, to automatically pick microfossils from the sediment coarse fraction. This automated system,built with ATG Technologies, is fully operational and works 24/7 at CEREGE. In this study, we will detail the basic workflow of the automaton, processing ~8000 particles/day, and its ability to cope with the large morphological and structural variability of particles encountered in real, marginal to deep-sea sediments. We use convolutional neural networks adapted and trained on deep sea sediment samples to classify the coarse sediment particles, including planktonic and benthic foraminifera. Ourintegrated software is free of use and available here :https://particle-classification.readthedocs.io/.
We will compare a set of paleoceanographic records generated by a micropaleontologist with the ones generated by our automaton: relative abundance, fragmentation rate, biometrical changes. We have studied a set of deep-sea cores from the equatorial Pacific and the Mediterranean Sea to document past hydrographic changes in the late Quaternary, achieving millennial scale resolution through the last deglaciation. Using the automaton, we processed more than 1,000,000 foraminifera. The accuracy of recognition typically ranges around 85 to 95% depending of the morphoclasses and of the CNN used for the training. Morphoclass size probability density function and assemblages derived from the CNN will be compared to multi-proxy (micropaleontological and geochemical) records. We will discuss the ongoing applications of our workflow, from foraminifera to pteropods or terrigenous particles in deep sea sediments, and the recent updates of our system to different applications.

Mots-Clés : Foraminifera, microfossils, image recognition, neural network, biostratigraphy, paleoclimatology

Merci de ne rien inscrire dans cette zone et ne pas modifier les marges des pieds de page et entêtes.