Automatic classification of plankton images through Deep Learning

The Laboratoire d'Océanographie de Villefranche (LOV) studies plankton (the broad group of biological organisms that drift in the world’s oceans) because of its important roles in the regulation of climate through the trapping of greenhouse gases, the renewal of breathable oxygen, the sustainability of oceanic food chains, etc.

To standardise and speed up the acquisition of data in the laboratory or allow precise in situ measurements, the LOV and other labs developed instruments that take images of plankton (such as the ones used in the illustration above). Those instruments currently record billions of pixels every year, hence yielding several million images of organisms, that need to be identified and classified taxonomically to be useful for ecological studies. The current classification scheme consists in the deterministic extraction of ~50 features for each object (grey level, size, aspect ratio, etc.) followed by the training and application of a RandomForest model for classification. This process yields success rates around 70% for a classification in ~20 groups, which is not enough to most ecological studies and therefore requires human operators to check, correct, and refine the classification before data can be used. Better classification schemes are dearly needed because (i) the rate of acquisition of images accelerates and checking all automated classifications is no longer sustainable, (ii) new remote, autonomous instruments are being developed, which will need to perform the classification in situ because they cannot send the images back, hence preventing any check.

The Laboratoire d’Informatique, Signaux et Systèmes de Sophia-Antipolis (I3S) uses computer vision to solve applied biology problems. They are experts in machine learning and deed learning in particular. In a working partnership with LOV, they tackle the problem of plankton images classification presented above.

The goal of this internship would be to develop new classification approaches for plankton images.

The operational steps envisioned are:
- Collation of sets of labelled images, assembled per instrument (~5 different instruments, with different imaging characteristics) from the internal databases of LOV. Several million labelled images are available and labels will be refined by another intern. The work of the intern will only be to set up a pipeline between the image databases and the classification tools.
- Baseline tests of the current algorithm (working implementation available).

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1 http://lov.obs-vlfr.fr
2 http://www.i3s.unice.fr
- Baseline tests of a few Convoluted Neural Networks (CNNS) extracted from a kaggle competition on plankton images (working implementations available).
- Marginal improvements of the most promising CNN architecture.

This application is currently in production and used by about a dozen operators daily, from various teams around the world. The implementation will be subcontracted and the intern will just need to provide settings based on the tests performed above.

These steps should be relatively quick because most of the work is already done or prepared. They are essential, however, to pave the way for new developments. The potential avenues envisioned for this internship are:

- Exploration of mixed models including a CNN for feature extraction and classic machine learning for classification, hence allowing the inclusion of ancillary data (such as location, date, depth, etc.).
- Test of the generality of CNN-based models by training models across several instruments. Exploration of input images modification that can help generalise the problem across various sensors with different resolutions, dynamic ranges, etc.
- Exploration of the representation of images along the layers of the neural network, to determine which features are relevant for classification, with the aim of pre-processing the images and simplifying the network for its future implementation on embedded platforms.
- Exploration of hierarchical classification (rather than classifying all classes simultaneously) to improve classification reliability and accuracy.

All these research questions would be of interest for the task at hand. It is unlikely that all can be tackle within the internship but the most interesting/promising will be identified through a discussion between the partners and the intern and then pursued.

The intern will be supervised by Marc Picheral (Ingénieur de Recherche) and Jean-Olivier Irisson (Maître de Conférence) at LOV and will collaborate with researchers at I3S. He/she will work in the framework of an existing convention between the two labs and a common project funded by CNRS (DL-PIC: Deep Learning for Plankton Images Classification). The DL-PIC project also involves international partners: ecologists at the Hatfield Marine Science Center of Oregon State University (OSU) and a deep learning expert at Facebook Artificial Intelligence Research lab (FAIR).

Practically, housing facilities may be available in the lab directly (depending on dates). The student will need to travel between Villefranche and Sophia-Antipolis to meet with all team members and a car would be useful (but not required). The student will be compensated for such travels in addition to the usual internship stipend. The student will be provided with a Linux computer but would be able to use his/her own. All actual work will be done on a remote Linux server equipped with a Tesla GPU entirely dedicated to the project.