Environmental Computational Science
and Earth Observation Laboratory

Master thesis subject

Enforcing a hierarchical structure in predicting land cover classes across Europe

Context

With land cover maps, the Earth's surface is classified into different categories, e.g. water, forest, agriculture, urban… This spatial information can be produced at varying scales and in some cases with a varying level of details. In Europe in particular, le CORINE Land Cover inventory (CLC) was defined in the 1980s to provide information on the biophysical characteristics of the Earth's surface and standardise practices throughout the continent. Campaigns were conducted in 1990, 2000, 2006, 2012 and 2018, and each country led their own data collection, producing and submitting their data to the European inventory.

The CLC inventory is organised into 3 levels of classes or labels. The first level, L1, is composed of 5 classes of more general scope; "Artificial areas", "Agricultural areas", "Forest and seminatural areas", "Wetlands" and "Water bodies". The L2 is the second level with a total of 15 classes, each a child of one of the 5 L1 parent class. Finally, the more detailed level is the third one, L3, with 43 labels altogether. The classes are organised using a semantic hierarchical structure, as shown in the figure below.

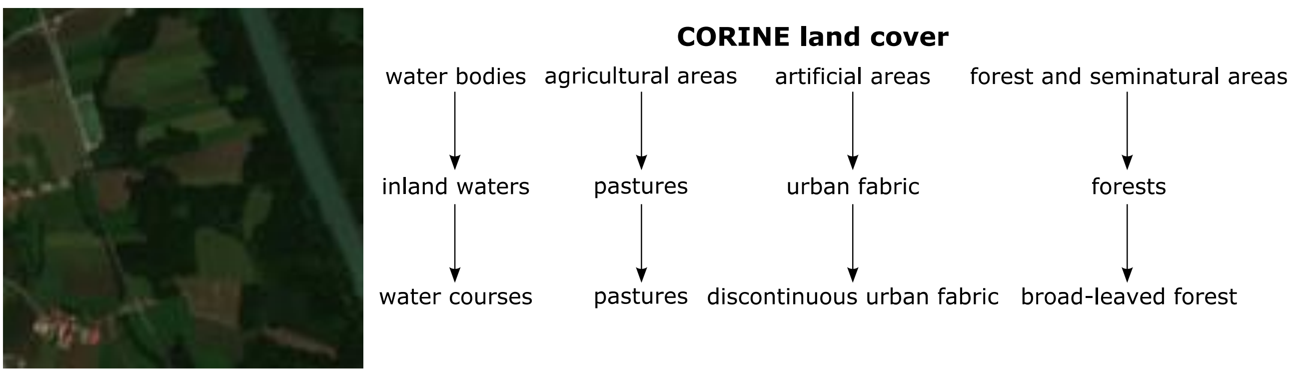

Figure: Example of Sentinel2 image along with the corresponding CORINE land cover labels

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Automatically predicting this hierarchical class structure is primordial for the automatisation of the CLC updates for future releases and new open satellite data from the Sentinel satellites enables such automatisation at large scale.

Leveraging the CLC inventory along with imagery from Sentinel-2, the BigEarthNet dataset (Sumbul et al., 2019) is a large-scale benchmark dataset for multi-label land cover classification. It is composed of 590'326 Sentinel-2 image patches recorded over ten European countries in 2017 and 2018. BigEarthNet associates each image with the L3 CLC labels present in the spatial extent of the patch. The related, parent L2 and L1 CLC labels can be added to the dataset ground truth, and potentially assist or refine predictions, thus opening methodological perspectives to more semantically coherent and accurate predictions.

In this project, we propose to research and improve the classification of land covers by enforcing a hierarchical structure in the model, more specifically in the loss function or in the architecture itself. The student will conduct a literature review on hierarchical multi-label classification (HMC) problems, in the context of remote sensing and beyond, propose a method and conduct experiments on the BigEarthNet dataset to evaluate it.

Objectives

- Get familiar and train a land cover classification architecture
- Investigate strategies to enforce the coherent prediction of land cover classes across different precision levels throughout Europe

Requirements and practical info

- Background in machine/deep learning is welcome.
- Programming skills in Python.
- The thesis will be supervised from the Sion campus.
- Access to parallel computing resources is provided.

Literature

- G. Sumbul, M. Charfuelan, B. Demir, and V. Markl. BigEarthNet: A Large-Scale Benchmark Archive for Remote Sensing Image Understanding. *In IGARSS 2019 – 2019 IEEE International Geoscience and Remote Sensing Symposium*, pages 5901-5904. Yogohama, Japan, July 2019.
- D. Tuia, M. Kanevski, J. Munoz-Mari, and G. Camps-Valls, "Structured output SVM for remote sensing image classification," in *2009 IEEE International Workshop on Machine Learning for Signal Processing,* Grenoble, France, Sep. 2009, pp. 1–6.
- R. Cerri, R. C. Barros, and A. C. P. L. F. de Carvalho, "Hierarchical multi-label classification using local neural networks," *Journal of Computer and System Sciences*, vol. 80, no. 1, pp. 39–56, Feb. 2014.
- R. La Grassa, I. Gallo, and N. Landro, "Learn class hierarchy using convolutional neural networks," *Applied Intelligence,* vol. 51, no. 10, pp. 6622–6632, Oct. 2021.

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