Environmental Engineering Institute – IIE
Environmental Computational Science and
Earth Observation Laboratory

Sion, November 6, 2023

Master Thesis Proposal:
Human-in-the-Loop Deep Learning for Land Cover Mapping: An Active Learning Approach

Land cover mapping is a critical task in various fields, including environmental monitoring, urban planning, and disaster management. In Switzerland, the Federal Office for Topography swisstopo is in charge of producing high-precision land cover maps. The high-quality labels are produced via human annotations of aerial images, a process that is particularly time-consuming and costly, but necessary to maintain the high level of quality. Recent machine learning approaches, especially computer vision models, while powerful and versatile, are still far behind humans in such highly specialized and complex tasks. **Active learning** paradigm leverages human expertise to iteratively and intelligently select the most informative samples for labelling, thereby reducing the annotation burden and improving model performance (see Figure 1-2 below). Sample selection is generally based on criteria of uncertainty, diversity, representativeness, or a combination of these.

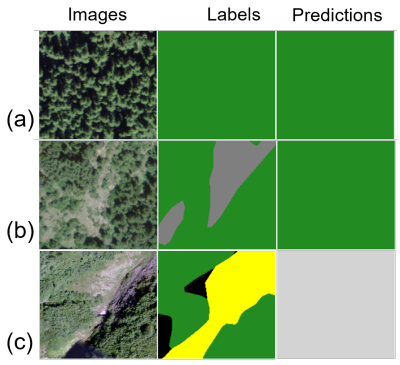
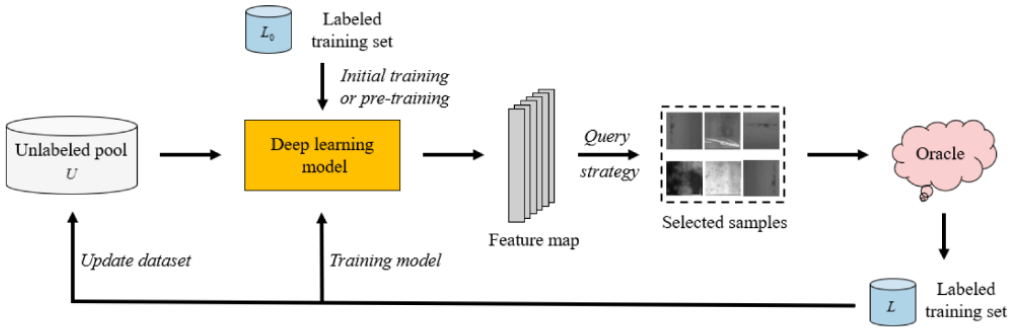


Figure 1. Image (a) is well predicted, whereas predictions for images (b-c) present important differences with the reference labels. The active learning strategy should query these samples as they are probably more informative to update our predictive model. In practice, the reference labels are not available and the query strategy relies on other indicators such as diversity among the samples, uncertainty, etc. to take a decision.



(c) A typical example of deep active learning.

Figure 2. A typical example of deep active learning. A deep learning model is used to annotate unlabelled samples from unlabelled pool U. A query strategy is used to select the most challenging and significant samples and present them to an oracle (or annotator) to obtain better labels. The newly obtained labels are then used to fine-tune and improve the deep-learning model. Figure from Ren et al., 2021.

School of Architecture, Civil and Environmental Engineering (ENAC)

Valerie Zermatten
EPFL VALAIS WALLIS
ENAC-IIE-ECEO
Rue des Ronquos 86
1951 Sion - Switzerland

+41 21 693 82 83
valerie.zermatten@epfl.ch
https://people.epfl.ch/valerie.zermatten

In this master's thesis, we will explore active learning methods in collaboration with swisstopo to enhance their annotation pipeline. By intelligently combining human expertise with active learning strategies, this project aims to speed up the manual annotation process by helping the annotators focus on more challenging land cover and make their work more efficient and effective.

The objectives of this master thesis are as follows:

1. Develop a baseline semantic segmentation network that predicts swisstopo land cover in alpine areas based on high-resolution aerial images.
2. Review active learning literature and test the most relevant query strategies. Implement the feedback loop that selects the most challenging samples and obtains better labels from reference data (annotation work will **not** be involved).
3. If time allows, experiment with different fine-tuning methods to adapt the model to the newly obtained labels and compare your results with existing approaches.

Come and contact us if you are interested in this project!

Valerie Zermatten `valerie.zermatten@epfl.ch`
Gaston Lenczner `gaston.lenczner@epfl.ch`

Bibliography

- P. Ren et al., "A Survey of Deep Active Learning," ACM Comput. Surv., vol. 54, no. 9, p. 180:1-180:40, Oct. 2021, doi: 10.1145/3472291.
- G. Lenczner, A. Chan-Hon-Tong, B. Le Saux, N. Luminari, and G. Le Besnerais, "DIAL: Deep Interactive and Active Learning for Semantic Segmentation in Remote Sensing," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 15, pp. 3376–3389, 2022, doi: 10.1109/JSTARS.2022.3166551.
- S. Desai and D. Ghose, "Active Learning for Improved Semi-Supervised Semantic Segmentation in Satellite Images," presented at the Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision, 2022, pp. 553–563. Accessed: Oct. 31, 2023. [Online]. Available: `https://openaccess.thecvf.com/content/WACV2022/html/Desai_Active_Learning_for_Improved_Semi-Supervised_Semantic_Segmentation_in_Satellite_Images_WACV_2022_paper.html`