Predicting forest mortality and recovery from Sentinel-2 time series using deep learning

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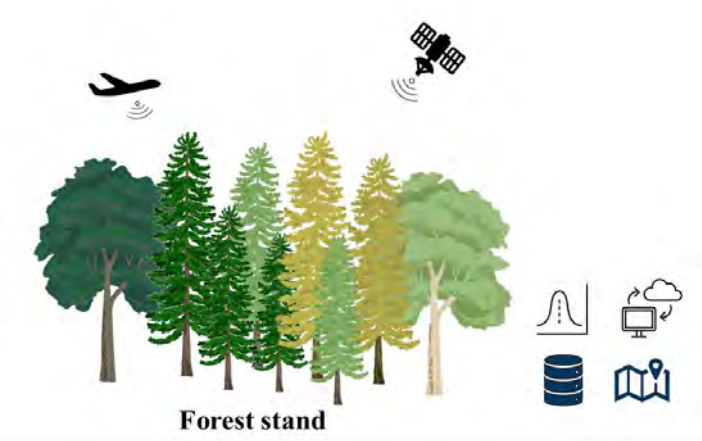

Project description

Context and motivation Global climate change is intensifying disturbance regimes and is negatively impacting the adaptive capacity of forests at an increasing rate. In recent years, there has been evidence of accelerated tree death due to heat and drought. Tree health is an important indicator of forest disturbances, such as droughts, fires, pests and diseases. They can also affect carbon storage, fire risk, wildlife habitat and ecosystem services.

However, detecting and quantifying tree health densely over large spatial and temporal scales remains challenging primarily due to data availability and the use of approaches that have low transferability. Despite an urgent need for forestry professionals to quickly identify tree health, methodical approaches are quite limited and are used mainly on a local scale. The latest developments in remote sensing and Earth observation (EO) data, allow us to tackle this challenge and accurately assess the forest condition at different spatial and temporal scales.

Gaps and challenges This work aims at detecting hotspots of forest vitality decline and tree recovery across scales using machine learning techniques and remotely sensed data. To this end, we aim at making use of most recent machine and deep learning methods, to take full

advantage of the large amounts of EO data in modeling complex spatio-temporal relationships linking visual features from spectral and optical data to complex forest health indicators. We aim at predicting, either as a per-pixel fraction or on an ordinal scale, forest vitality (or damage) and its evolution in time.

Research scope and methods The project will explore different machine-learning approaches to model spatio-temporal relationship in image time series. To this end, the successful student will develop tools based on convolutional and recurrent architectures, and train a loss function encoding a quantitative label for forest vitality and recovery across different forest types and spatial resolutions.

The student will explore different machine learning solutions, and select a baseline method upon which to improve. The main bulk of the research in MSc project will be on developing an architecture that can be trained flexibly, exploiting spatial and temporal information contained in time series of satellite data, and geolocated measurements obtained at different time steps.

Data A database of more than 10,000 tree annotations with various health conditions (alive, slightly damaged, severely damaged, and dead) is already available and will be used for this. Over 2,000 Sentinel-2 tiles are available across Switzerland from 2015 to 2022 (see Table 1). Sentinel-2 imagery is preprocessed and further co-registration of the RGB with the Sentinel-2 data is needed. The co-registration will be done automatically with a provided approach.

Year	2015	2016	2017	2018	2019	2020	2021	2022	Total
Tiles/year	188	206	232	527	310	406	462	589	2920
Tiles/April-October	147	147	170	477	178	276	315	326	2036

Table 1: The number of Sentinel-2 tiles per year and from April to October with $\leq$10% cloud cover for all of Switzerland.

Additional information

- **Difficulty of the project**: Challenging, but experts will be available to support the student
- **You will learn and get your hands dirty** with different deep learning flavors and computer vision tools. You will learn good scientific research practices, literature research, PyTorch.
- **Requirements**: Machine Learning fundamentals, computer vision fundamentals, good Python skills, experience with git, motivation
- **Evaluated and expected deliverables**: Thesis manuscript detailing the research, motivation, approach and original solution; according to d-INFK guidelines. Versioned and commented code, runnable, able to reproduce all the analysis (hosted on SDSC platform renkulab.io).
- **Main supervisors and persons of contact**: Dr. Michele Volpi (michele.volpi@sdsc.ethz.ch), Dr. Mirela Beloiu (mirela.beloiu@usys.ethz.ch)

References

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