

Zero- to Few-Shot Learning for Real-Time Pollen Monitoring

Ausgangslage

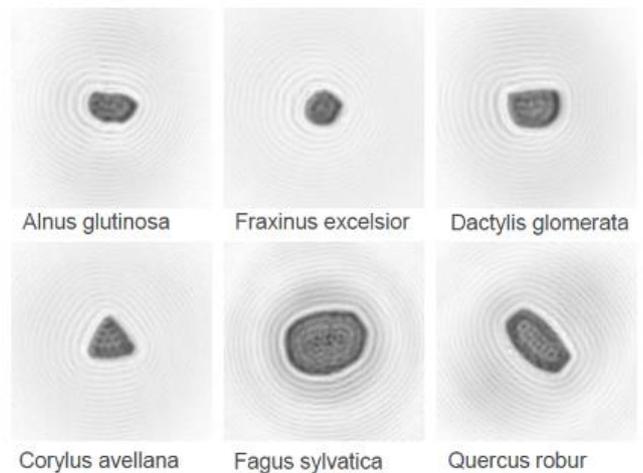
Pollen forecasts – such as those provided by MeteoSwiss – are essential for millions of allergy sufferers. Today, these forecasts rely on precise measurements from only a small number of monitoring stations (17 in Switzerland). The quality of the forecast therefore depends heavily on how well we can measure pollen concentrations at these locations.

Swisens AG has developed an innovative instrument that continuously samples the air and records **holographic images** of individual particles using laser-based imaging. These images (examples shown in the figure) can be used to identify pollen species using deep learning models trained on large collections of labelled images.

However, there is a major bottleneck:

- Creating high-quality labels for new pollen species is **expensive and slow**, and
- Every time the device is deployed in a **new region with new species**, the models must be updated or retrained.

This is where **zero-shot and few-shot learning** come in. With modern multimodal models such as CLIP, it is possible to classify images based on **textual descriptions** of classes, even if no or only very few labelled examples are available. This master project explores what kind of zero-shot learning approaches are suited in the context of real-time pollen monitoring.



Zielsetzung

The overarching goal of this master project is to **design, implement and evaluate zero- to few-shot learning methods** for automatic identification of pollen species from holographic images.

Required Skills

Basic skills in machine learning, deep learning, and image processing; interest in data analysis (data wrangling, data exploration, statistical analysis, visualization), expertise in programming (Python).

Teilaufgabe für den Masterstudierenden

We envision the following project phases (can be adapted to your interests and schedule):

- **P7 – Ramp-up & State of the Art**
Familiarise yourself with the pollen use case, the holographic image data and available semantic information. Work through and summarise state-of-the-art techniques in unsupervised representation learning, zero-shot and few-shot learning, focusing on approaches that could work with pollen images.
- **P8 – Zero-Shot & Representation Learning Experiments**
Implement selected representation learning techniques and evaluate their suitability for **zero-shot pollen classification**. Compare different ways of defining textual class descriptions and analyse how they affect performance.
- **P9 – From Zero-Shot to Few-Shot & Active Learning**
Extend the best zero-shot approaches with **few-shot learning** techniques using a limited number of labelled images. Develop and test strategies for **transitioning from zero- to few-shot** (e.g. by selecting informative samples via active learning). Provide recommendations for a practical deployment workflow.

Studienart: [x] Full time study
[x] Part time study (50%)

Arbeitsort: Windisch

Advisor: Prof. Dr. Martin Melchior (I4DS/FHNW)