Tree Crown Condition Assessments with UAV Imaging

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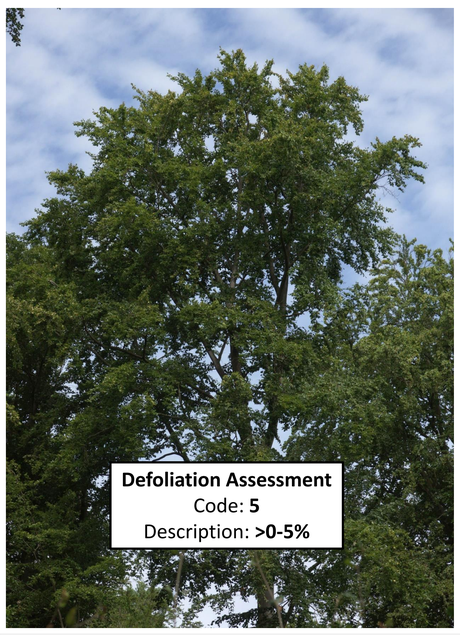
Aims and Motivation

- **Defoliation assessments** (ICP Forests) are highly specialized assessments typically carried out by seasoned experts. A translation of expert ground observations to the aerial perspective, is not necessarily directly compatible in terms of UAV-based **pixel averaging** and **fractional cover.**
- A **harmonization method** to combine intensive monitoring tree condition surveys (i.e. Level II) with UAV-based imaging from the aerial perspective is essential for the acquisition of **reliable** and **standardized** tree crown condition data.
- Utilizing an annotation workflow from a computer workstation can improve data acquisition and enable **consistent** and **verifiable assessments**, while also providing the ability to perform post-checks and reviews among multiple observers.

Visual Assessments

Terrestrial View



Aerial View

A semi-automated **annotation workflow** can help in assessing **defoliation** from terrestrial or even crown images. In particular, terrestrial images with a clear view of the upper tree crown can be used for defoliation estimations. **Annotation experts** use the terrestrial images to assess the target tree crown while creating polygons (WKT) of the **region of interest** (ROI) from the aerial tree crown for **pixel extraction** and re-assessments.

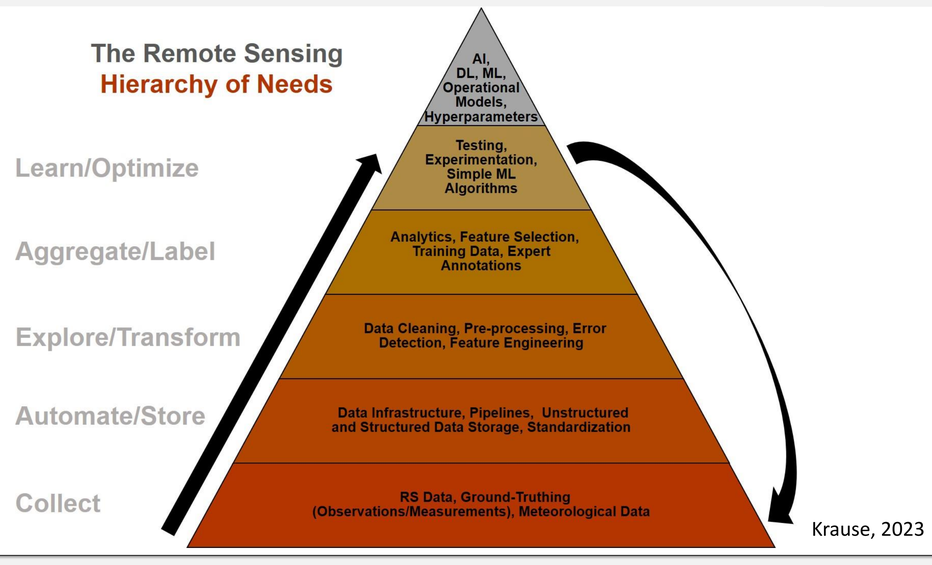
Multiple Instance Learning

class	bag	red	green	blue	poly	...
5	1	162	207	102	wkt1	...
5	1	133	171	120	wkt1	...
5	1	152	205	97	wkt1	...
5	1	210	225	166	wkt1	...
5	1	238	213	183	wkt1	...
55	2	231	229	142	wkt2	...
55	2	140	147	116	wkt2	...
55	2	163	191	104	wkt2	...
55	2	113	121	74	wkt2	...
55	2	65	103	44	wkt2	...

Multiple Instance Learning (MIL) (Carbonneau et al. 2018) offers advantages over taking the mean of all pixels for each tree crown, especially when analyzing high-resolution RGB images where a tree crown can be represented by a **bag** with potentially hundreds of **instances.** By handling detailed instances, MIL provides a more precise analysis of defoliation. MIL also allows pixel information to be stored as **structured data** in **tabular form**, which typically consists of tables with rows and columns, where each column represents a feature and each row represents an instance. This is in contrast to other approaches such as **Convolutional Neural Networks** (CNNs) that extract features automatically from unstructured image data. Tabular data can be stored effectively and can include additional columns containing **metadata** such as the geographical position (WKT) of the tree crown. This metadata can enable retroactive pixel extraction for global masking techniques for the purpose of subsetting particular parts of the crown if required. Utilizing MIL can create **high-quality training data** with bags covering the full defoliation spectrum for each tree species, resulting in potentially more accurate models. Furthermore, the RGB columns in MIL can be used to derive new vegetation features or **indices** for **feature engineering** as well as in-depth analysis and interpretation of the data.

Implementation

- Until a sufficient number of bags of instances are available, the use of **shallow machine learning** (ML) **algorithms** is essential in creating **generalized models** for feature scrutinisation.
- By emphasizing the need to establish a **data infrastructure** before moving to more complex algorithms, the **Remote Sensing Hierarchy of Needs** highlights the importance of testing pixel data-derived features for modelling effectiveness while maintaining **explainability** during the feature selection process.



Krause, 2023

References:

- Carbonneau, M.-A., Cheplygina, V., Granger, E., & Gagnon, G. (2018). Multiple instance learning: A survey of problem characteristics and applications. Pattern Recognition, 77, 329–353.
- Krause, S. (2023). UAV Applications for Intensive Forest Monitoring (Doctoral dissertation, University of Bonn).

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