Innovative drone-based remote sensing tools for agricultural management and nature conservation

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Uudsed droonide kaugseire rakendused põllumajanduses ja looduskaitses

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Euroopa Maaelu Arengu Põllumajandusfond: Euroopa investeeringud maapiirkondadesse

Proof-of-Concept

Eesti Teadusagentuur

> Research funding instrument for experimental development in order to test and/or create conditions for the commercialization of research outcomes.

> Enhance technology transfer, application of research outcomes in enterprises and in society.

> 1st Jan 2022 – 31st Dec 2022

Innovative drone-based remote sensing tools for agricultural management and nature conservation

Two main priorities

Nature conservation: Map invasive plant species

Increase the degree of readiness of **Estonian Agriculture sector** to **detect, map and quantify biotic** and **abiotic crop damages:**

> Wind and flood damage

> Weeds (early detection and mapping)

> Pests (early detection and mapping)

Background

The Remote Sensing Lab at EMÜ

Chair of Environmental Protection and Landscape Management

de Lima, R. S., Lang, M., Burnside, N. G., Peciña, M. V., Arumäe, T., Laarmann, D., ... & Sepp, K. (2021). An Evaluation of the Effects of UAS Flight Parameters on Digital Aerial Photogrammetry Processing and Dense-Cloud Production Quality in a Scots Pine Forest. Remote Sensing, 13(6), 1121.

Martínez Prentice, R., Villoslada Peciña, M., Ward, R. D., Bergamo, T. F., Joyce, C. B., & Sepp, K. (2021). Machine learning classification and accuracy assessment from high-resolution images of coastal wetlands. Remote Sensing, 13(18), 3669.

Villoslada, M. V., Bergamo, T. F., Ward, R. D., Joyce, C. B., & Sepp, K. (2021). A novel UAV-based approach for biomass prediction and grassland structure assessment in coastal meadows. Ecological Indicators, 122, 107227.

Villoslada, M., Bergamo, T. F., Ward, R. D., Burnside, N. G., Joyce, C. B., Bunce, R. G. H., & Sepp, K. (2020). Fine scale plant community assessment in coastal meadows using UAV based multispectral data. Ecological Indicators, 111, 105979.

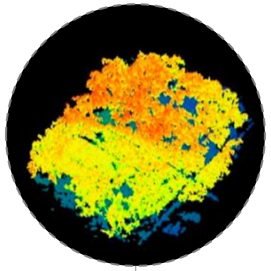
Villoslada, M., Ylänne, H, Juutinen, S., Kumnpula, T (2022). Quantifying the effects of Climate Change in tundra ecosystems using Unmanned Aerial Vehicles. Global Change Biology (in press)

Li, K. Y., Burnside, N. G., de Lima, R. S., Peciña, M. V., Sepp, K., Cabral Pinheiro, V. H., ... & Sepp, K. (2021). An Automated Machine Learning Framework in Unmanned Aircraft Systems: New Insights into Agricultural Management Practices Recognition Approaches. Remote Sensing, 13(16), 3190.

Li, K. Y., Burnside, N. G., Sampaio de Lima, R., Villoslada Peciña, M., Sepp, K., Yang, M. D., ... & Sepp, K. (2021). The Application of an Unmanned Aerial System and Machine Learning Techniques for Red Clover-Grass Mixture Yield Estimation under Variety Performance Trials. Remote Sensing, 13(10), 1994.

Li, K. Y., Sampaio de Lima, R., Burnside, N. G., Vahtmäe, E., Kutser, T., Sepp, K., ... & Sepp, K. (2022). Toward Automated Machine Learning-Based Hyperspectral Image Analysis in Crop Yield and Biomass Estimation. Remote Sensing, 14(5), 1114.

Remote Sensing Lab

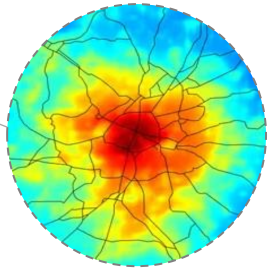


Forestry and forest fires

Raul Sampaio

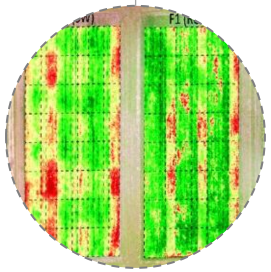
Semi-natural habitats

Miguel Villoslada
Thaísa F. Bergamo
Ricardo Martinez



Urban Environments and Urban Heat Island

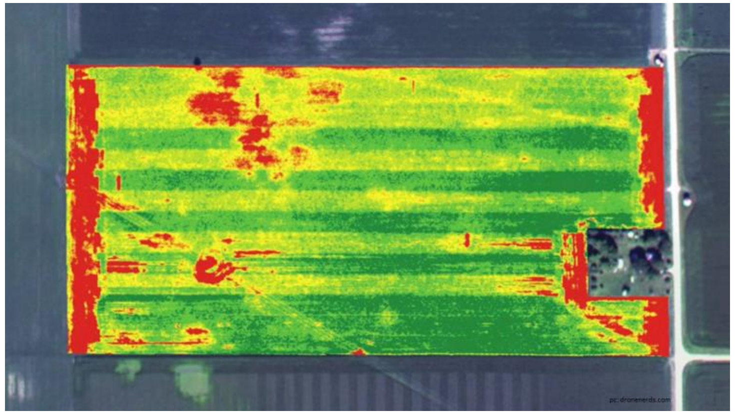
Kaupo Kokamägi



Agricultural applications

Kai Yun Li

Background



> Agriculture drone market has developed quickly (global agri drone market worth US$32.4 billion)

> Most of the applications directed towards precision agriculture in terms of optimizing fertilizer treatment.

> Drones and multispectral cameras have greatly developed in the las few years

BUT

> Still companies offer a one-size-fits-all solution (NDVI)

> Shallow analytical approaches (relative differences in NDVI values)

> Poor reliability of results (or not reported, black box approaches)

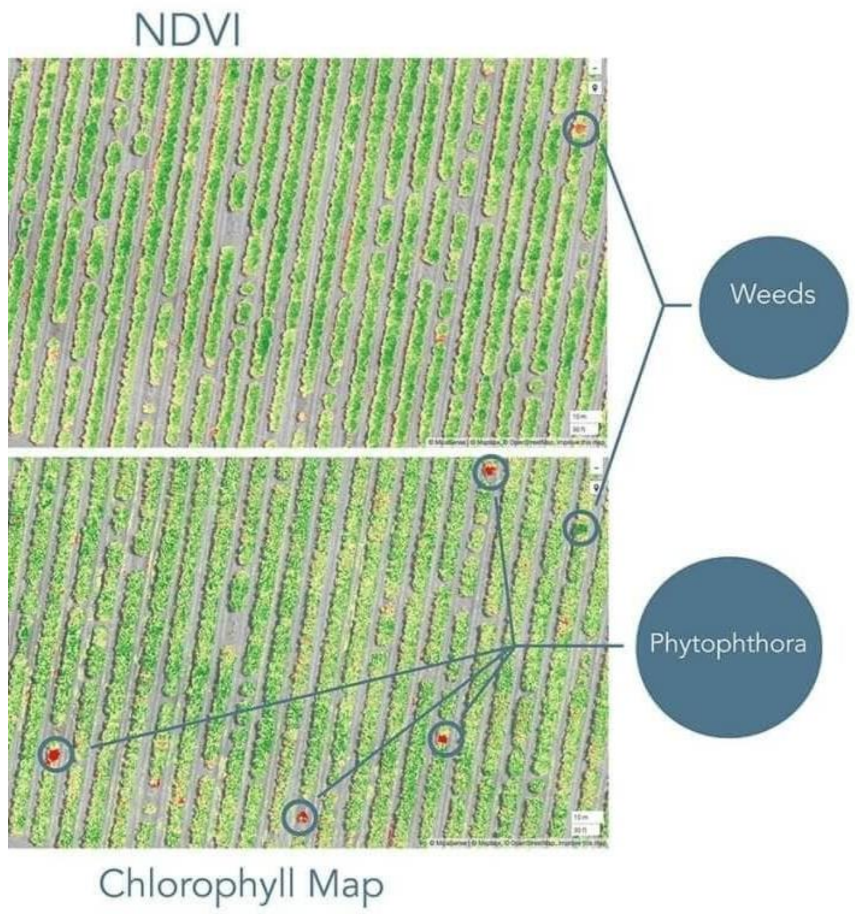
Why move beyond NDVI?

> NDVI loses efficiency to detect crop changes as the season advances (especially mid to late season when crops put on their flowers, tassels and grain heads). NDVI is only moderately sensitive to changes in chlorophyll and pigmentation.

> Alternative spectral indices, textural indices or both combined drastically improve the performance of NDVI in mapping crop health.

> State-of-the-art Machine Learning could greatly benefit the agricultural sector (XGBoost, AutoML), but it is still largely unexplored.

> **There is a vast gap between current scientific knowledge in drone-based remote sensing and the techniques implemented on the field.**



Project aims

Lottes et al. (2016)

We want to improve current practices in drone-based early detection of crop damage by:

1. Developing a set of **targeted machine learning algorithms** and **spectral and chromatic indices** for:

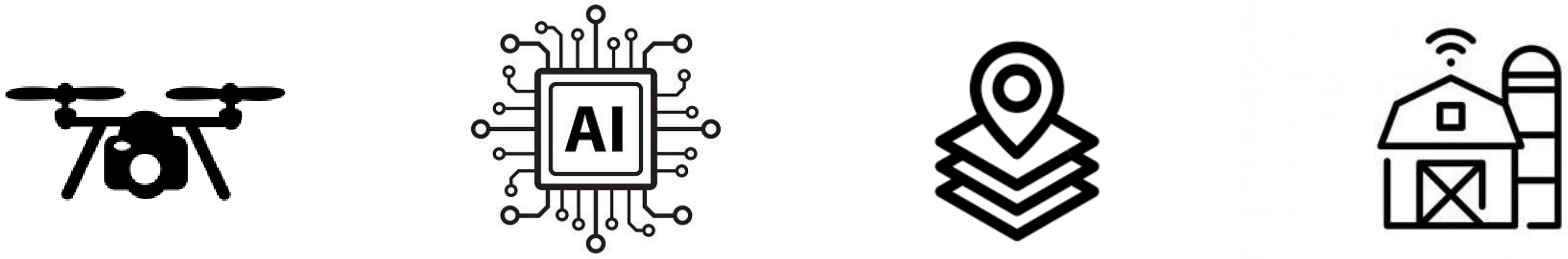
   > Mapping and quantification of wind ,flood or drought damage, pest damage and weeds

   > Tested across a wide range of crops

2. Validating results: Crucial methodological step, as it ensure **quality**, **accuracy** and **replicability**.

3. Ultimately, make the best possible use of drone-based technologies, ensuring a higher degree of adaptability and mitigation capacity towards Climate Change impacts.

Steps



Data collection
Drone flights

Data processing
Machine Learning

Evaluation of results

Operationalization and transferability

Steps

1. Data collection

Throughout 2022 season, our team will:

> Collect drone images in damaged crops, aiming at maximizing the diversity of crops, types of damage and crop development stages (maximize the robustness of our algorithms in different crop development stages)

> Use a combination of sensors (multispectral, rgb, thermal): Test the best sources of drone imagery

> Collect data at designated pilot areas. Partnership with Jõgeva and Kuusiku agronomy research stations

> **WE NEED YOU!** We are looking for farmers willing to collaborate and contact us, whenever there has been a crop damage of any kind. We are aiming at collecting as much data as possible!

Steps

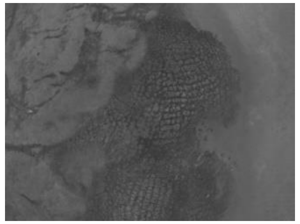
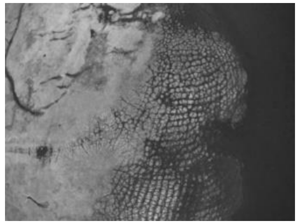
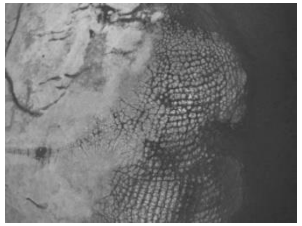
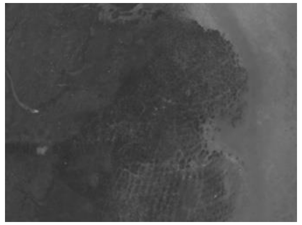
2. Machine learning algorithms

> Processing drone images

> Testing Machine and Deep Learning algorithms, with close attention to latest developments.

> Test vegetation indices and image textural metrics and evaluate sensitivity of data in terms of:

- > Type of crop
- > Type of damage

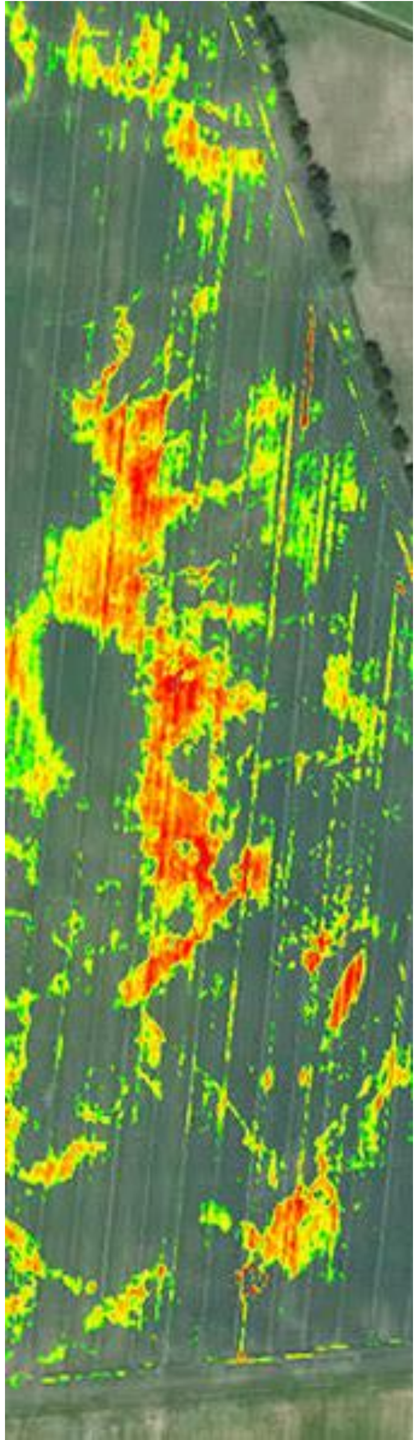
Steps

3. Validation, sensitivity assessment and maps

> Accuracy of crop damage models (how close or far are our models from the situation on the field)

> Sensitivity assessment. Where are the detection thresholds of crop damage with drone data?

- > Across crop types
- > Across crop damage
- > Throughout the season



Our team is looking for collaborators!

> Data is the basis for better models. Quantity and variety.

> We are seeking for farmers who will contact us when crops show signs of damage. Our team will deploy drones on the field and collect data.

> Results will be shared with farmers and public/research institutions interested in the project outcomes

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