Detection of vine diseases in multispectral (UAVs and satellite) and hyperspectral (airborned) images: Preliminary results using a non-linear unmixing tool (SAGA+)

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1. Context and purpose of the study

Vine diseases have a strong impact on vineyards sustainability, which in turns leads to strong economic consequences. Among those diseases, ***Flavescence dorée*** spreads quickly and is incurable, which led in France to the setup of a **mandatory pest control** implying the systematic use of pesticides and the **prospection and uprooting of every infected plants**.

Remote sensing could be a very powerful tool to optimize prospection as it allows to produce quickly accurate maps over large areas. Recent studies have shown that high spatial resolution (10cm/pixel) multispectral images acquired from UAVs allow to map *Flavescence dorée* in vineyards using leaves discolorations [e.g. 1,2,3]. Nevertheless, **confusion and misdetections** still exist, especially with other diseases showing similar leaves discolorations and with **mixtures of different materials occurring within one pixel**. Mixture effects are also crucial when dealing with satellite images where spatial resolution is much lower (≥10m/pixel).

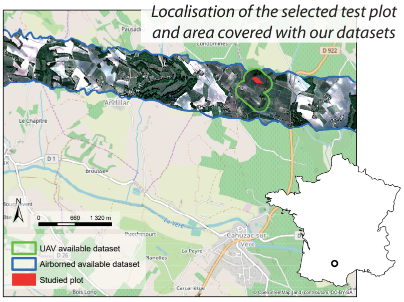
This study aims at **improving the detection of vine diseases** in UAVs, airborned and satellite images using an innovative tool that **identifies the spectral signatures** of every elementary materials (e.g. healthy and sick leaves) and their relative contribution at a **subpixel level**.

2. Material: available datasets

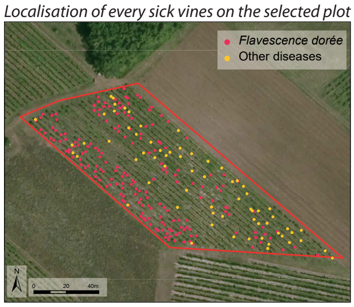
→ 2 datasets acquired in 2016 over the same vineyard located in the Southwest of France (AOC Gaillac)
- **multispectral image** acquired with MicaSense sensor onboard an **UAV** (5 bands, 10cm/pixel)
- Visible to Short-Wave infrared **airborned hyperspectral** image (256 bands, 1m/pixel)

→ Ground truth for validation is available through exhaustive **centimetric locations of every sick vines** for several plots in the studied area.

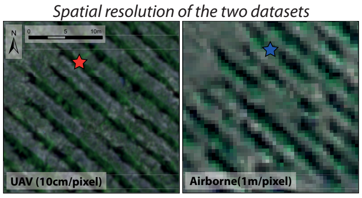
Localisation of the selected test plot and area covered with our datasets



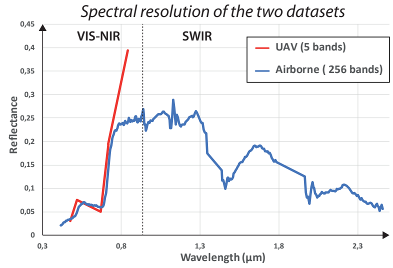
Localisation of every sick vines on the selected plot



Spatial resolution of the two datasets



Spectral resolution of the two datasets



In this work we focus on the processing of:
- the UAV image
- the airborne image in the VIS-NIR range
- the airborne image over the whole VIS-SWIR range (noisy in the SWIR range)

3. Method: unmixing

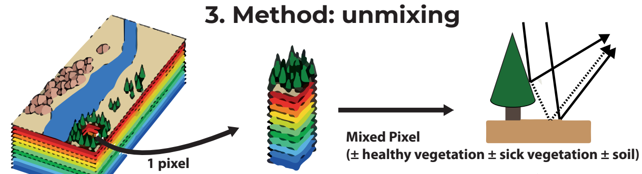
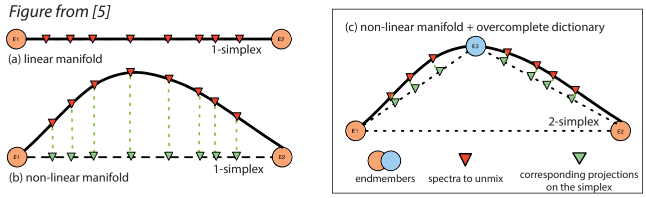


Figure adapted from N. Yokoya

→ innovative method successfully applied for other purposes [4,5]:
- **unsupervised unmixing** with anomaly-detection capacities
- global linear complexity and **nonlinearities** handled by decomposing the data on an **overcomplete set of spectra,** combined with a specific sparse projection (guarantees the interpretability of the analysis)

Figure from [5]



4. Preliminary results

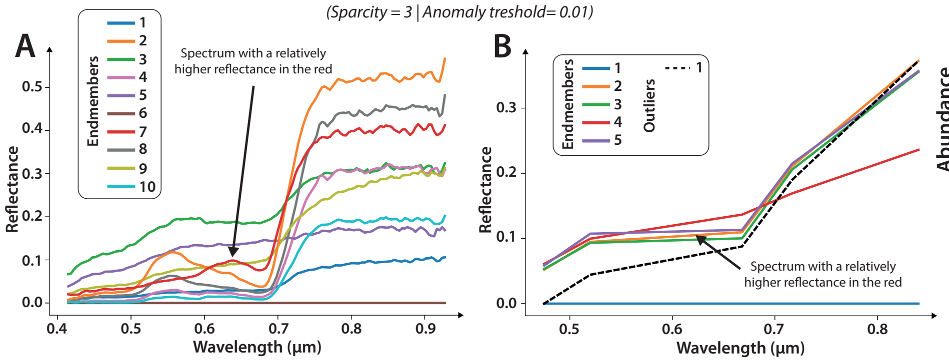
→ The unmixing algorithm is tested with several values for each key parameters. Additional configurations still need to be explored.

Number of endmembers	5	10	15		
Sparcity	1	2	3	5	10
Anomaly treshold	0,1	0,01	0,001		

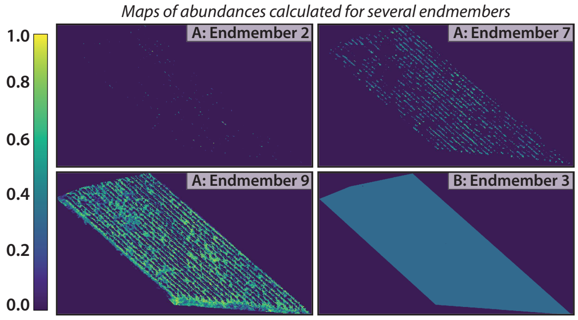
Table of parameters' space explored so far

- How many pure materials are needed to describe the scene?
- How different are the spectral signatures of those materials?
- Is there something unusual in the image? (low spatial representativeness)

Extracted endmembers for the VIS-NIR airborne and UAV images (Sparcity = 3 | Anomaly treshold= 0.01)



Maps of abundances calculated for several endmembers



→ Some extracted endmembers show **interesting spectral signatures**, that could be interpreted in relation with **leaves discoloration**

→ **No direct correlation** is observed yet between the produced **maps and groundtruth**. Errors occur in the unmixing process of the UAV image.

5. Conclusions

This paper reports **preliminary results** obtained with the **SAGA+ unmixing algorithm** ran over one selected plot located in the Gaillac region (France). We test two available datasets: a UAV multispectral image and a VIS-SWIR airborned hyperspectral image.

Initial results show the **algorithm can detect and separate multiple sources within the plot**. Analysis of retrieved endmembers shows a good correlation with the components that can be found in the field, especially with the **evidence of healthy and sick leaves' signatures**. Nevertheless, initial mapping shows some **discrepancies with ground truth** and further work needs to be done to test different model parameters. Additional work has also to be done to **include a Sentinel-2 multispectral image** (12 bands, 10m/pixel) in the process.

6. References

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[2] H. Al-Saddik et al., 2019, Assessment of the optimal spectral bands for designing a sensor for vineyard disease detection: the case of 'Flavescence dorée', *Precision Agriculture 20*, 10.1007/s11119-018-9594-1
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[5] S. Nakhostin et al., 2016, Joint Anomaly Detection and Spectral Unmixing for Planetary Hyperspectral Images, *IEEE Transactions on Geoscience and Remote Sensing 54*, 10.1109/TGRS.2016.2586188.

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