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Hyperspectral signal unmixing for the extraction of crop production parameters

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The value of hyperspectral remote sensing in agricultural management has been amply demonstrated. However, the sub-pixel spectral contribution of background soils and shadows hampers the accurate site-specific monitoring of agricultural crop characteristics from aerial or satellite images. Existing unmixing algorithms are able to estimate the ground cover of the crop in a pixel (Area Unmixing). Yet an accurate monitoring of critical cop production parameters demands that undesired spectral background effects (i.e. soils and shadows) are removed from mixed image pixels. To address this problem, the concept of Signal Unmixing (SU) is introduced.

The objective is not the estimation of cover fractions, but the extraction of the pure and complete hyperspectral signature (400-2400nm) of the crop from the mixed pixel signal. The technique is evaluated using images generated from ray tracing simulations of a fully calibrated virtual orchard.

Comparison between the pure vegetation signals (ground truth) and the extracted vegetation signals showed RRMSE values smaller than 0.075 over the whole spectral range. This is further highlighted when comparing the correlation between the water content of the crop and the water-index NDWI derived from the hyperspectral signal. The correlation between the water content of the orchard trees and the NDWI calculated with the reference pure vegetation signal is R^2=0.96, which reduces to R^2=0.4 when using the mixed pixel signal. However, when using the pure vegetation signal extracted from the mixed pixel using SU for the calculation of the NDWI, the R^2 increases again to 0.7, stressing the relevance and feasibility of the SU approach in addressing the mixture problem.