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Differentiation of plant species with hyperspectral and deep learning technology

Clément DOUARRE[abc], Gérald GERMAIN[a], Amélie ACHARD[a], Anthony GELIBERT[a], Bastien BILLIOT[d]

a : Carbon Bee, ZA Les Plaines, 26320 Saint Marcel lès Valence, France
b : Université Lyon 2, LIRIS, UMR5205, F-69676, Lyon, France
c : LARIS, UMR INRA IRHS, 62 avenue Notre Dame du Lac, 49000 ANGERS.
d : Agro Innovation International, 18 avenue Franklin Roosevelt, 35401 St Malo, France

Abstract:
Species differentiation has been for a long time only possible for specialized taxonomists and agronomists. Nowadays, applications in computer vision enable a more automatized approach. Differentiation of plant species present on the same surface offers several benefits: highlighting weeds in a crop, determining the floristic composition of plant cover [1]… In the phenotyping context, it permits to tune thoroughly the further analysis depending on the species and their development stage.

Hyperspectral imaging [2] is the process of analyzing an object in a continuous range of wavelengths including outside of the visible range. Such an imaging technique enables much more thorough applications than analysis in visible light. In plant sciences, it is notorious that plants have an interesting behavior when exposed to e.g. infrared light.
This contribution combines hyperspectral acquisition (using a proprietary handheld device) with deep learning processing in a convolutional neural network [3]. This enables to efficiently process an important amount of data while extracting complex features from the images. Detectable features include local structures such as corners, but also more complex ones like texture information which is significant for species identification. Moreover, in difficult fields such as species identification, deep learning's ability to learn and tailor relevant features automatically is paramount.

The hyperspectral and deep learning technology allows us to differentiate three different plant species present on the same surface: thistle, Creeping Cinquefoil and creeping soft grass. Several training sessions have enabled our neural network to discriminate the three species with a success rate of over 85%. An increased resolution and automatic exposure will probably allow us to get even better results.

In the near future, we will work on other species and on the detection of several ones in the same processing.

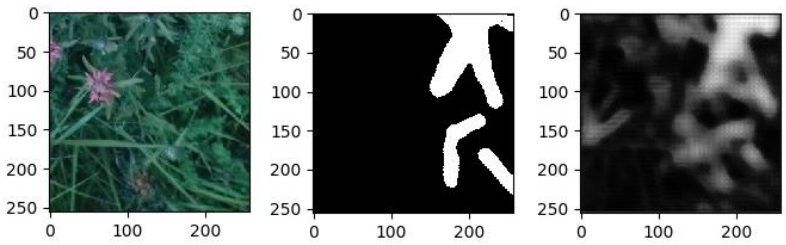

Figure1. Input (left), annotation (middle), output (before thresholding) (right)

References:
[1] Cruz P., Duru M., Therond O., Theau J.P., Ducourtieux C., Jouany C., Al Haj Khaled R., Ansquer P. (2002). Une nouvelle approche pour caractériser les prairies naturelles et leur valeur d'usage. Fourrages. Vol. 172, p. 335-354.
[2] Nathan A. Hagen, Michael W. Kudenov, "Review of snapshot spectral imaging technologies," Optical Engineering 52(9), 090901 (23 September 2013). http://dx.doi.org/10.1117/1.OE.52.9.090901
[3] Lecun Y., Bengio Y., Hinton G. (2015). Deep learning. Nature, Vol. 521, n. 7553, p. 436-444.