Estimation of ear density in winter wheat crop by stereoscopic imaging for crop yield prediction

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Objective

Robust automated ear counting in the field represents a valuable tool for crop yield estimates in phenotyping and breeding studies. Associated with plant density, it indicates the number of ears per plant, an important component of cereal crops yield.

New deep learning methods [1,2] enable accurate counting at the cost of an immense load of images labelling.

This presentation aims at exploring the performance of regular image analysis methods **complemented with 3D information from a stereoscopic device**, demanding less development time and potentially adressing specific issues in 2D ear counting.

Data acquisition

JAI-5000C-USB RGB cameras

5 MP sensor

Exposure time based on saturation ratio

Microcontroller triggering simultaneous acquisition

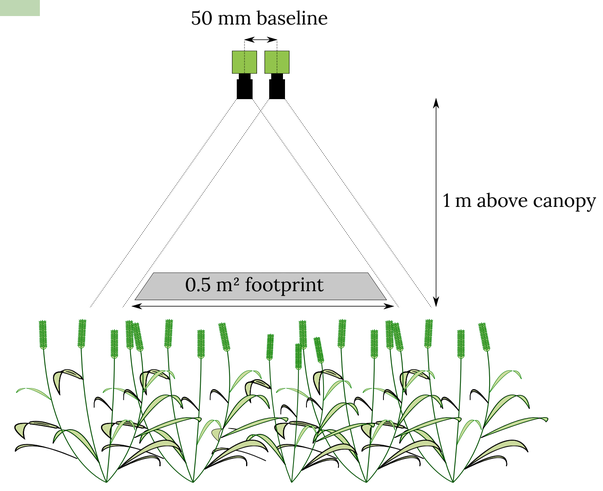
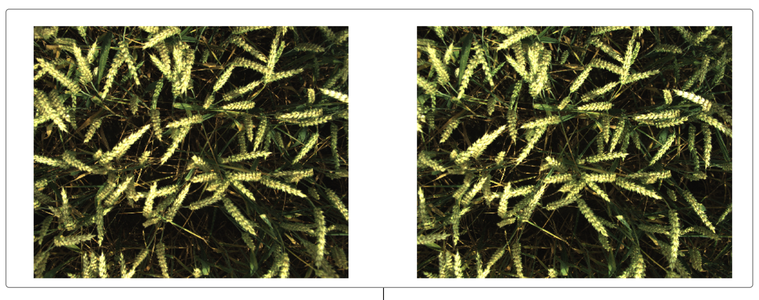


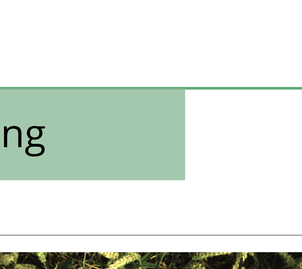
Image processing

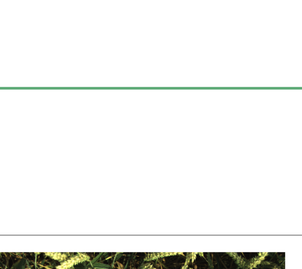


Stereo rectification — Correction to make sure corresponding pixels are aligned

Keep only the area common to left and right stereo frames — Crop to common area

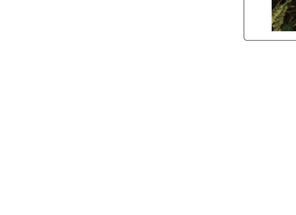
Stereo matching — Computation of a height map based on the calibration parameters of the stereo device



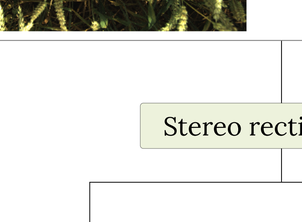


Height map

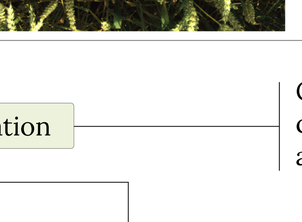
Computation of local textural features [3] — Haralick textural features



Variance



Contrast

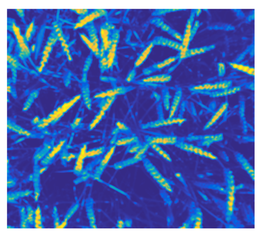


Entropy

Ear segmentation

The vast majority of ears are detected with a simple threshold on the variance map

Some leaves are also segmented with this simplified approach



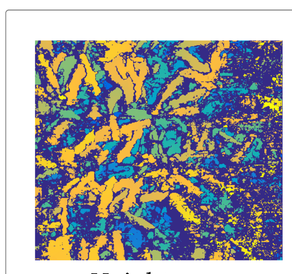
Variance

Threshold segmentation

Segmented image

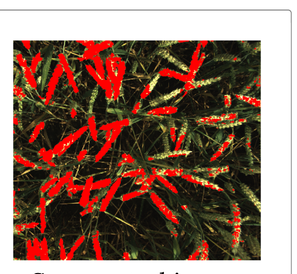
3D refining

3D information from the height map can be used to eliminate leaves from lower layers of the canopy



Height map

Height threshold



Segmented image

Future work

Increase robustness of the method

Basic machine learning algorithms will be explored to better discriminate between "border-line" organs and could perform a better segmentation

Reprocessing of height maps for smoother result

The OpenCV library provides more advanced tools for stereovision processing

Untangling of overlapping ears based on height maps

The 3D information will be exploited to adress the recurring issue of overlapping ears in ear counting algorithms

Literature cited

[1] Pound, Michael P., Jonathan A. Atkinson, Alexandra J. Townsend, Michael H. Wilson, Marcus Griffiths, Aaron S. Jackson, Adrian Bulat, et al. 2017. “Deep Machine Learning Provides State-of-the-Art Performance in Image-Based Plant Phenotyping.” GigaScience 6 (10). Oxford University Press:1–10.

[2] Madec, S. et al. (2019) ‘Ear density estimation from high resolution RGB imagery using deep learning technique’, Agricultural and Forest Meteorology. Elsevier, 264(October 2018), pp. 225–234. doi: 10.1016/j.agrformet.2018.10.013.

[3] Haralick, R. M., Shanmugam, K. and Dinstein, I. (1973) "Textural Features for Image Classification", IEEE Transactions on Systems, Man, and Cybernetics, SMC-3(6), pp. 610–621. doi: 10.1109/TSMC.1973.4309314.

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