Extraction of phenotypic traits from multispectral images by Deep Learning

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Plant phenotyping corresponds to the identification of effects resulting from interactions between genotype and environmental conditions. Among fast and non-destructive technologies, multispectral imaging, combining image and spectrum, increases the understanding of biology by allowing the measurement and quantification of a large amount of phenotypic information in a single analysis.

A phenotyping robot "Phenotim" has been specially designed and developed, with a multispectral LED imaging system as detector. The high throughput of the robot (about 500 images per 24-hour period) requires a paradigm shift in data processing to deep learning, based on the use of UNet.

From the obtained multispectral images, phenotypic traits were estimated on 80 sample lots, constituted by 20 accessions × 2 locations × 2 years. The number of grains per lot was 500 minimum. The traits were the following ones for each grain and for each batch of samples: dimensions of the cut grain as length and width, the depth of the crease, the thickness of the peripheral layers and the vitreousness.

Two UNet models were built to transform a multispectral image of cut grain into a segmented image: one corresponding to the whole grain and the second to the grain without the peripheral layers. These models were trained with a random selection of images coming from various lots. All multispectral images were projected onto both models leading to segmented images on which phenotypic traits were estimated.

The design and realization of the robot has thus solved the bottleneck problem of phenotyping. The optimized image processing procedure based on deep learning on the one hand and GPU computing on the other hand allowed to process a collection of 32,000 multispectral images in two hours.

**Keywords:** deep learning, high-throughput phenotyping, multispectral image, wheat.

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