

Processing of multispectral image collections by deep learning

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1 Introduction

The selection of high-yielding crops adapted to climate change requires large genotyping and phenotyping datasets. DNA markers are now routinely typed through high-throughput genotyping chips. Plant phenotyping corresponds to the identification of effects resulting from interactions between the genotype and the environmental conditions to which it has been exposed. However, the rapid and precise collection of data on thousands of plants is difficult to achieve on the one hand, and the large volume of associated data difficult to interpret on the other hand.

The speed of observation of phenotypes does not match the speed of genotyping and this creates a bottleneck. It is therefore essential to conduct research to eliminate the "phenotyping bottleneck" and increase the throughput of analyses. Among the fast and non-destructive technologies, multispectral imaging, combining image and spectrum, is revolutionizing the understanding of biology by allowing the measurement and quantification of a significant amount of phenotypic information in a single analysis.

2 Material and methods

A phenotyping robot "Phenotim" has been specially designed and developed, with a multispectral LED imaging system as detector. Its main functions are conveying, cutting and presenting the grains to the detector. From the obtained multispectral images, phenotypic traits are estimated in a second step. 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.

The phenotypic traits were measured on 80 sample lots, constituted by 20 accessions \times 2 locations \times 2 years. The number of grains and therefore images per batch was 500 minimum. The traits were the following ones for each grain and for each batch of samples (average value): dimensions of the cut grain as length and width, the depth of the crease, the thickness of the peripheral layers and the vitreousness.

3 Results and discussion

Two UNet models were created and trained in order to transform a multispectral of cut grain into a segmented image: one corresponding to the whole grain and the second to the grain without the peripheral layers (Figure 1). These models were trained with a random selection of images coming from various lots.

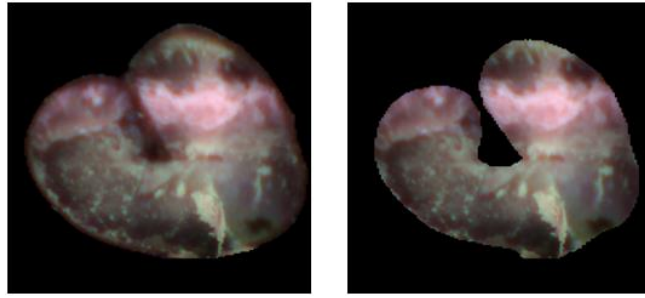


Figure 1 : RGB images obtained by applying segmented images on multispectral ones: whole grain (left) and grain without the peripheral layers (right)

All multispectral images (500×80 lots) were projected onto both models leading to segmented images. Phenotypic traits were then measured and Figure 2 shows the result of the trait “depth of the crease” for several grains.

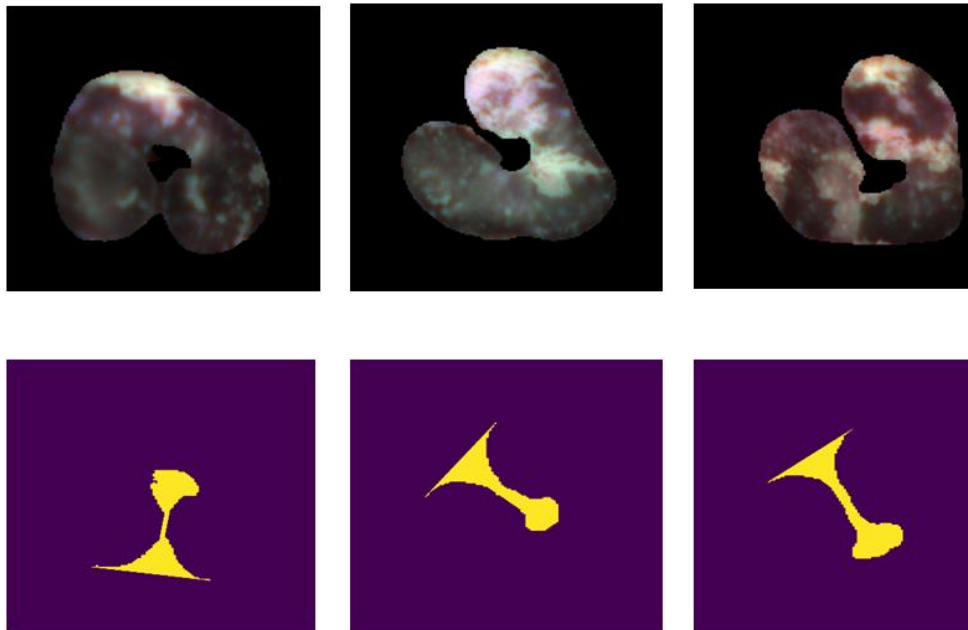


Figure 2 : Segmented images (top) and the corresponding extracted crease (bottom).

To obtain the segmented images, the use of deep learning is required because a manual operation is not feasible. Moreover, by working with a GPU card, it was possible to obtain all the images in two hours, which is an important time saving. Indeed, the work on CPU required 2 days of calculation.

4 Conclusion

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 40,000 multispectral images in short time.

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