Final Industry Report (more detail can be found in the thesis)

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Title: Automated 3D traits measurement for strawberries

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1. Industry Summary

Automation and robotisation of the agricultural sector are seen as viable solutions to the socio-economic challenges faced by this industry. One of its direct applications is automated phenotyping, where breeders analyse plants and fruits' external traits (fruit shape, leaves areas, branch length etc.) to inform the gene selection process and fulfil consumers' and growers' needs. Cultivated strawberries (*Fragaria x ananassa*) are a perfect example of a plant with a recent significant increase in demand but affected by labour shortages.

To improve the gathering of strawberry traits, we propose to focus on 3D information and how we can use it for non-destructive crop analysis and understanding. The first main contribution of this project is introducing a novel 3D segmentation method and evaluating modern 3D sensors through shape analysis.

Following the findings on 3D sensing challenges in an agricultural context, we identified a need to extract meaningful 3D information from images and visual cues. Therefore, the second main contribution is a novel method for extracting 3D orientation, shape and maturity traits from single images of strawberries.

We then investigate the potential of using very high-resolution 3D scans of strawberries to extract precise 3D traits over the surface of the fruits. In particular, we propose a novel method to predict the 3D location and count of achenes, the seeds found on the surface of strawberries.

Lastly, capturing and annotating datasets in an agricultural context is challenging due to the complexity of the environment and the amount of data needed. Thus, for our last contribution, we present several annotated datasets captured in the Riseholme strawberry farm and a simulated farm, together with a high-quality dataset comprised of 3D strawberry scans with high-resolution textures.

This project was the first to investigate the use of 3D information and the creation of 3D vision algorithms for extracting strawberries' traits. With new techniques and datasets, this project enables the automation of some phenotyping traits and understanding of these characteristics from a computer vision perspective. Furthermore, such automation opens the way to breeding programs on a larger scale, removing the phenotyping bottleneck due to the limited amount of domain experts. In the long run, with these techniques applied to breeding programs, breeders should save significant time and funds and obtain higher-quality phenotyping reports at a larger scale.