Final Report

December / 2022

Student Project No. [AHDB project number]

Title: Automated 3D traits measurement for strawberries

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Report No: [AHDB Use only]

This is the final report of a PhD project that ran from [Month Year] to [Month Year] . The work was funded by AHDB [,Funder 2 and Funder 3 (etc)]

Notes:

- *Website:*

Please note that this document will be made available through AHDB's website. If you need us to delay publication due a peer review in a publication or journal, please notify us.

The Industry Summary will be used to populate the project webpage and to inform AHDB knowledge exchange and communications; please be mindful of the target audience (famers, levy payers and industry stakeholders).

- *Commercial sensitivity:*

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- *Please try and keep this document to a maximum of 50 pages in length (excluding appendices).*

CONTENTS (right-click and select ‘update field’ and ‘update entire table’ to update table of contents)

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 application 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.

2. Introduction

Start typing here. This part of the report should constitute an abridged scientific record of the research conducted within the project. The introduction should describe why the work was necessary, giving a clear statement of objectives. *The fuller scientific record is the thesis.*

3. Materials and methods

3.1. Heading 2 style (please use the 'Styles' in the panel above so that the automatic table of contents updates correctly)

3.1.1. Heading 3 style

Heading 4 style

Start typing here. Provide sufficient detail to enable another researcher in the subject area to analyse or repeat the experiments described. If methods have been published in detail elsewhere a summary can be provided here with appropriate references.

4. Results

Start typing here. Use tables, graphs and figures, supported by appropriate statistical analysis to present results. All figures should be inserted as close as possible to relevant accompanying text but should have informative titles and axes labels such that they can stand alone and be understood without reference to the accompanying text. Aim to achieve a balance between a summary of the data which does not allow investigation of results and extensive tables of raw data. If necessary, further data can be included as appendices. If you are unsure as to what an appropriate amount of data is, please contact the AHDB Research Manager responsible for the project.

5. Discussion

Start typing here. This should aim to put project results in the context of other relevant research. Pay special attention to recommendations for uptake of results by the industry and suggestions for further R&D.

6. References

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