

Image Processing in the National Plant Phenomics Centre

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1 Project Description

The National Plant Phenomics Centre (NPPC) is a newly developed research facility belonging to the Institute of Biological, Environmental, and Rural Sciences (IBERS), Aberystwyth University. Described by the University as the "most advanced research greenhouse" in the UK [1], the facility is designed to achieve non-destructive phenotyping of plants through the use of automated processes; with every plant in the system being individually identifiable and able to be analysed using the equipment available including a battery of imaging devices that image the plants across different spectrums to allow for gene identification based on physical characteristics such as leaf density, water usage, and chlorophyll production.

In this course of this project, I shall seek to develop software that utilises camera technology to image each plant, and then process and analyse the resulting images. In doing so, seeking to answer questions about the properties of the plant populations such as flowering time and other points of interest to biologists.

2 Work to be tackled

In attempting the development of a plant imaging, processing, and analysis system, there are several issues to be addressed.

2.1 Imaging

The project relies on the provision of sequential images over time, and must be able to match corresponding image features to those seen throughout the image set. This introduces uncertainty that must be addressed, as the world state being imaged changes each time - for example, lighting may be inconsistent, and trays may rattle, move, or rotate.

As a result of these difficulties, the hardware needs to be configured in such a way as to mitigate uncertainty by controlling variables such as lighting and camera positioning. Whilst the actual NPPC technology is designed to help facilitate this, any testing set-ups may contain uncontrollable variables that present additional challenges, the tackling of which should make the final product more robust if adequately addressed. In undertaking the work, I shall investigate hardware configurations that allow for the minimisation of impact of external factors.

2.2 Processing

The system must be capable of delineating not only what is and isn't a plant, but the boundary between individual plants, and the features of each individual plant (e.g each leaf, flowers, stems, etc.). This is impeded by the

variable nature that is the growth of the plants - the shape of plants and their features will inherently change over time, and also results in occlusion - both of a plants own features, and of surrounding plants. This presents additional challenges to identifying structures and may require the use of multiple algorithms to do so adequately. To do this, I shall investigate image processing techniques such as skeletonisation and occlusion culling, as well as building on existing knowledge of edge and feature detection. I shall also look at processing toolkits and APIs such as openCV.

2.3 Analysis

Ultimately, the project needs to be able to use processed imagery to answer questions regarding the phenomics and physical characteristics of the plant populations. To achieve this it must be able to identify key differences in plants to look for statistically significant differentiation.

3 Project Deliverables

- Software that images the plant populations and produces processing images from these, and performs analysis of the features of the processed image sets to answer posited questions about the plant populations.
- Raw and processed image sets used by the above software.
- Documentation including design, experimentation, testing and software comparison and analysis.
- Review of project outcomes including the results of the analysis.
- Meta-Documents about the project including progress report and final report.

4 Initial Bibliography

In addition to references included in this document, I shall in the course of my research look at work including that produced by LemnaTec, who provide the hardware for the NPPC; software libraries; and previous academic research and journals on the subjects of image processing and analysis, as well as phenomics.

References

- [1] BBC News, "Aberystwyth university phenomics centre to develop new plants and crops." <http://www.bbc.co.uk/news/uk-wales-mid-wales-18045351>, May 2012.