SUMMER RESEARCH 2024/25
PROJECT ABSTRACT

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

PROJECT # 43

SUPERVISOR/S: Prof Margaret Barbour & Ben McGuinness

PROJECT TITLE: 3D reconstruction and measurement of woody plant features

FIELD: Engineering / Plant Science / Multidisciplinary

DIVISION/SCHOOL: HECS - Te Kura Mata Ao School of Engineering

PROJECT LOCATION: Hamilton

PROJECT ABSTRACT:

Three-dimensional imaging of plants has recently emerged as a powerful technique to quantify the spatial arrangements, volumes and shapes of key structures such as leaves, stems, branches and fruits. These measurements have applications in horticulture and forestry, allowing automation of labour-intensive manual processes and removing the need for destructive measurements. A low-cost, semi-automated system developed at Sydney University provided 3D reconstructions of canopy architecture and leaf area for chickpea, allowing assessment of differences between a number of cultivars in terms of canopy development (Salter, Shrestha and Barbour 2021). However, the system has several shortcomings that limit its applicability beyond the single species tested in the published paper.

This project will develop and test a 3D imaging system to overcome the limitations of the previous system including improving the hardware to handle larger payloads (up to 30 kg), addressing canopy volume restrictions (currently ~30,000 cm3), and (most importantly) distinguishing between leaf and stem biomass. The previous system used a stepper motor to spin a turntable which held the plant, and three DSLR cameras to capture the images. VisualSFM software was used to generate a point cloud from Structure from Motion (SFM) and processed using Meshlab, however significant advances in AI since 2020 (e.g. Instant NeRF) could greatly reduce the computing power and time required for processing. Alternatively, accurate control and positioning of the turntable and cameras could allow for rapid stitching of point cloud data from stereo cameras directly without the need for computationally expensive Structure from Motion (SFM).

Distinguishing key plant components, such as woody structures, leaves and fruit, would be extremely valuable for all applications of plant 3D imaging. This project will take the novel approach of using small trees in pots (bonsai) to develop and validate photogrammetry methods that could be applied to plants in the field in horticultural and forestry settings.

STUDENT SKILLS:

- Mechatronic engineering design
- Solidworks CAD
- Hardware control (turn table control, trigger cameras etc)
- Programming – Arduino, python, etc
- Interest in photogrammetry and applied AI
- Accuracy and attention to detail with scientific measurements, recording and calculations

PROJECT TASKS:

1. Develop hardware for an improved low-cost 3D imaging system for potted plants based on the design described in Salter, Shrestha and Barbour (2021).
2. Generate 3D point clouds of plants and investigate methods to segment into leaves and woody structure (e.g. using convolutional neural networks).
3. Process the point cloud and quantify woody biomass volume and leaf area.
4. Validate estimates of woody volume and leaf area with measurements of plant biomass.
5. Create and present a final research poster describing the project.

EXPECTED OUTCOMES:

- Student's Research Poster (as per clause 6 of the Scholarship regulations)
- Functional hardware and control system for capturing point clouds of objects on a turntable.
- Semi-automated wood volume and leaf surface area measurement from 3D point clouds.