High Throughput Phenotyping

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High Throughput Phenotyping

- developing new plants is important to address the ever increasing demand for food resources
  - require superior yield despite marginal conditions
- phenotyping is essential for
  - analysis of specific genes
  - production of new plants with beneficial characteristics
Physiological Characterisation

- must explore a large dimensional space due to
  - plant DNA; and
  - environmental conditions
- characterisation is still time consuming and labour intensive
- advantages of using images to estimate plants’ biomass
  - non-invasive;
  - automated—and therefore high throughput
- growth models predict may yield without growing until maturity
Estimating Biomass from Images

- previous approaches measured the correlation between green pixels and dry weight
- this model is prone to inaccuracy induced by
  - occlusion; and
  - perspective
- dry weight does not necessarily predict yield
The Problem

- given a set of images of a plant during its life, the goal is to estimate the lengths of each leaf over time
- this data can be used to
  - estimate biomass;
  - evaluate growth with greater fidelity; and
  - predict yield
Challenges

- estimating plant growth from images requires
  - identifying leaf correspondences in each image; and
  - estimating the leaf’s 3D length
- 3D reconstruction traditionally requires (dense!) readily identifiable, \textit{rigid} features
- unfortunately, plants are
  - feature poor; and
  - they distort between rotations
Overview of our Approach

▪ our overall approach tackles the problem in two ways:
  ▪ **image**-based
    ▪ recover 3D structure from 2D features
    ▪ relatively easy to initialise
    ▪ susceptible to image-clutter
  ▪ **scene**-based
    ▪ estimate likelihood of predicted 3D models
    ▪ difficult to initialise for complicated plants
    ▪ does not require image correspondence

▪ our approach relies on time-series data
  ▪ use image-based techniques in the beginning, but
  ▪ switch to scene-based when the plant model has been established
Graph Matching

- treat correspondence as a global optimisation problem
- decompose an image into a graph to abstract over pixels
Space Curve Reconstruction

- edge correspondences can be triangulated into 3D
- estimate a 3D curve consistent with the image gradients
- extend curves into generalised cylinders
Generative Plant Model

- generative scene model uses Bayesian inference to find the most likely plant parameters given the images

\[ Pr(\rho|\mathcal{I}) \propto Pr(\mathcal{I}|\rho)Pr(\mathcal{I}) \]
Generative Plant Model
People

**Computer Vision**
- Professor Anton van den Hengel
- Dr John Bastian
- Dr Paul Paisitkriangkrai
- Lachlan Fleming
- Zhenhua Wang

**Phenomics Scientists**
- Professor Mark Tester
- Dr Bettina Berger