COMPUTER VISION CHALLENGES FOR PLANT PHENOTYPING

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Abstract

The observable traits of a plant (*phenome*) originate from the interaction between *genome* and environment. An affordable and high-throughput solution to collect and analyse phenotypes is highly desirable. In previous work, we proposed a framework for the automated segmentation of plants in time-lapse images from phenotyping experiments. Currently, our focus is on computer vision challenges (e.g, leaf counting, detection, segmentation), that are key for studying structural properties of plants.

Motivation

Plants have always been a crucial source of food, feed, fibre, and fuel. Striving for a more efficient and sustainable agriculture researchers try to:

- identify and improve key traits to satisfy growing demand;
- increase resistance to parasites and diseases;
- minimize environmental impact (less water, less fertilizer).

Plants are a complex and variable system. Measuring relevant properties of the plants with an image-based approach gives rise to several exciting computer vision problems (e.g., multi-object detection and multi-label segmentation), that prove easily understandable also by non specialists.

References

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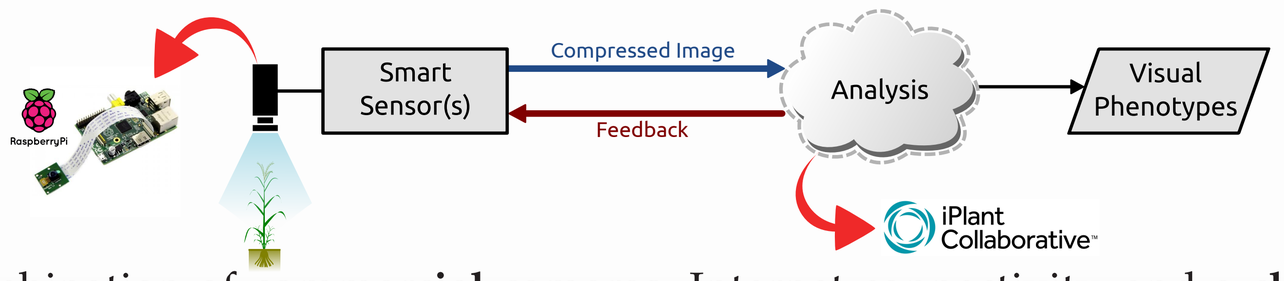
PHIDIAS Project

Affordable, high-throughput, distributed, knowledge-sharing platform for phenotype collection and analysis [1]:

- **simple-to-use** for acquiring (non-destructively and continuously) and analysing phenotypes from plant experiments;
- combines distributed **affordable** cameras to collect images and transmit them over the Internet to a centralized location for processing;
- application-aware **image compression** strategies to minimize loss in accuracy, while meeting limited channel bandwidth constraints [2].



The combination of **commercial cameras**, Internet connectivity, and a **cloud infrastructure** allows to:

1. keep the cost low and carry out sophisticated image analysis tasks [3];
2. bring automated phenotyping to a large number of laboratories and to developing countries.

The images will be stored in repositories and the user will be able to navigate and explore the data through a modern **web-based GUI**, the Bisque Image Analysis Environment, made available by the iPlant Collaborative project [4].

Challenges and Leaf Segmentation

- Sophisticated computer vision approaches are necessary to extract visual phenotypes related to plant shape, growth, colour, and leaf/root structure.
- Segmenting individual leaves may prove particularly challenging, due to severe **overlapping** and **high shape variability**.
- However, this difficult task may be bypassed for certain phenotyping problems (e.g., time of flowering, number of fruits or leaves).
- For example, estimating the **number of leaves** of a plant may be formulated as a **learning problem**, and then cast into a convex quadratic program [5].
- Part of the *Computer Vision Problems in Plant Phenotyping* workshop, ECCV, September 2014, Zurich (http://www.plant-phenotyping.org/CVPPP2014).
- **Benchmark dataset** containing top-view images of rosette plants collected in our laboratories, accompanied by manual labelling of the leaves.

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