

Length Phenotyping with Interest Point Detection

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Abstract

Plant phenotyping is the task of measuring plant attributes. We term ‘length phenotyping’ the task of measuring the length of a part of interest of a plant. The recent rise of low cost RGB-D sensors, and accurate deep networks, provides new opportunities for length phenotyping. In this paper we present a general technique for measuring length, based on three stages: object detection, point of interest identification, and a 3D measurement phase. We address object detection and interest point identification by training network models for each task, and use robust de-projection for the 3D measurement stage. We apply our method to two real world tasks: measuring the height of a banana tree, and measuring the length, width, and aspect ratio of banana leaves in potted plants. Our results indicate satisfactory measurement accuracy, with less than 10% deviation in all measurements. The two tasks were solved using the same pipeline with minor adaptations, indicating the general potential of the method.

1. Introduction

In plant phenotyping one measures and assesses complex plant traits related to growth, yield, and other significant agricultural properties [5]. As manual phenotyping is extremely costly, there is a need to develop automated analysis algorithms that are accurate and robust, which are able to measure phenotypic traits in field conditions on real crops [21]. Automated algorithms are required for accelerating cycles of genetic engineering [29], and for automating agriculture processes [5]. Field and greenhouse phenotyping is a difficult challenge, as field conditions are notoriously heterogeneous, and the inability to control environmental factors, such as illumination and occlusion, makes results difficult to interpret [2]. Image analysis algorithms are crucial for advancing large scale and accurate plant phenotyping [18]. A second recent advancement is the abundance of low-cost sensors, from RGB to depth and thermal sensors, useful for capturing plant traits. For example, depth sensors

Figure 1. **Length based phenotyping.** **Left:** A banana tree with two interest points: basal (red) and upper (blue). The distance between them is the tree height. **Right:** A banana leaf with 4 interest points: basal (red), apex (blue), left (purple) and right (yellow). Only measurable objects are annotated. The line between the two former points is the leaf center line, and its length is the leaf length. The distance between the latter points is the width. Note that the position of the latter points (left and right) is somewhat ambiguous in the direction of the leaf center line.

can capture the plant shape in three dimensions, containing useful information about its developmental stage[24].

This paper focuses on the problem of measuring 3D physical lengths of plant parts in field conditions, using a low cost RGBD sensor and a deep network architecture. Measuring the size of plant’s parts can provide important cues about the plant state[32] and expected utility. For example, measuring the aspect ratio (the ratio between the length and the width) of young banana leaves in a potted plant prior to planting in the plantation, can determine whether the plant has undergone a mutation that results in undesirable fruits. Specifically, such mutations are characterized by a ratio smaller than 1.8, while normal plant typically have a ratio approaching 2.2 [8]. Another example is estimating the height of a banana tree. It is important since one goal of variety developers is to lower the banana tree height, enabling easier tree treatment for farmers. An example from a different crop is cucumber length measurement. The histogram of cucumber fruit lengths in a given plot provides strong indication regarding the cucumber growth

