Marianne Bjorner / Carter Sifferman

CS639 Project Proposal - Image Segmentation for Plant Growth Analysis

Problem Statement

Our goal is to implement an image segmentation algorithm on overhead images of seedlings and young plants. This will involve segmenting the entire plant from the background as well as segmentation of individual leaves. This segmentation could be used in a laboratory setting to monitor plant growth. We also plan to gather and manually annotate a small dataset of our own, containing images of a few young plants as they grow. This dataset will then be used to test how well our image segmentation generalizes.

Current methods used in botany to measure plant growth are manual and destructive. An image segmentation technique can partially replace these manual measurements, resulting in more automated and less resource-intensive data collection.

Goals

Our goals are the following, in order:

- Implement an existing solution for plant-background segmentation on the CVPPP 2017 dataset
- Collect our own small dataset of plants growing over time
- Test our plant-background segmentation algorithm on our own dataset
- Implement an algorithm for segmenting the plant's individual leaves and test on existing datasets as well as our own
- Stretch goal: Create an algorithm to identify the same leaves over time as they grow between multiple photos, and use our dataset to test the algorithm

Existing Research

The current state-of-the art for leaf image segmentation is to use deep convolutional networks to solve the problem, such as in:

> B. Romera Paredes, P. Torr. *Recurrent Instance Segmentation* ECCV 2016.
> https://arxiv.org/abs/1511.08250

We plan to draw upon simpler and more general solutions for image segmentation. Because the dataset that we plan to use was created for a challenge, a number of papers have resulted from it. Some resources are listed below:

Papers published in response to the ICCV 2017 challenge:

> https://openaccess.thecvf.com/ICCV2017_workshops/ICCV2017_W29

A paper on segmentation on fluorescent images of leaves with accompanying code:

X. Yin, X. Liu, J. Chen, D. M. Kramer. *Joint Multi-Leaf Segmentation, Alignment and Tracking from Fluorescence Plant Videos.* IEEE Transactions on Pattern Analysis and Machine Intelligence 1411-1423 (2018).
https://arxiv.org/abs/1505.00353
Github: https://github.com/xiyinmsu/PlantVision

A method for segmentation of individual leaves without using neural networks:

Cruz, J.A., Yin, X., Liu, X. et al. Multi-modality imagery database for plant phenotyping. Machine Vision and Applications 27, 735–749 (2016).
https://doi.org/10.1007/s00138-015-0734-6

Data

We will utilize the following datasets:

The CVPPP 2017 Leaf Segmentation Challenge Dataset which contains 783 images of Arabidopsis plants as well as ground truth images for individual leaf segmentation.

The dataset we gather will consist of overhead images of a few plants grown indoors in small pots, similar to the CVPPP dataset. To distinguish ours, we will grow a different species of plant in a different type of pot and under different lighting. We will also use a smartphone camera instead of the professional camera used by CVPPP. These differences will help us test how well the algorithm generalizes.

Evaluation

CVPPP provides their own MATLAB-integrated evaluation suite and plant phenotyping datasets as described in

M. Minervini, A. Fischbach, H.Scharr, and S.A. Tsaftaris. *Finely-grained annotated datasets for image-based plant phenotyping.* Pattern Recognition Letters, pages 1-10, 2015, doi:10.1016/j.patrec.2015.10.013

We plan on using CVPPP's evaluation suite to compare our results to the dataset provided for the 2017 Leaf Segmentation Challenge. We will consider this the ground truth data. We will also compare performance of our implementation of the algorithm to algorithms with published results.

As a separate challenge, we will see how the segmentation algorithms perform on our own seedling photos. This will test the performance of the algorithm on plants with leaf structures dissimilar to the dataset provided by CVPPP. To measure success, we will compare the results generated by our method to our photo annotations.

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Timeline

Oct. 1	Proposal completed Begin seedling growth
Oct. 10	Dataset downloaded Github repo / Start project webpage
Nov. 1	Seedling growth completed Own dataset finalized: - Photographs taken and annotated
Nov. 3	Midterm report completed Plant-background segmentation algorithm completed Test plant-background segmentation against 2017 LSC dataset
Nov. 15	Test against self-collected dataset Individual leaf segmentation algorithm completed
Dec. 1	Project presentations begin
Dec. 10	Project webpage and report completed