

A Method for Data Analysis on Pea Nodules



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Context

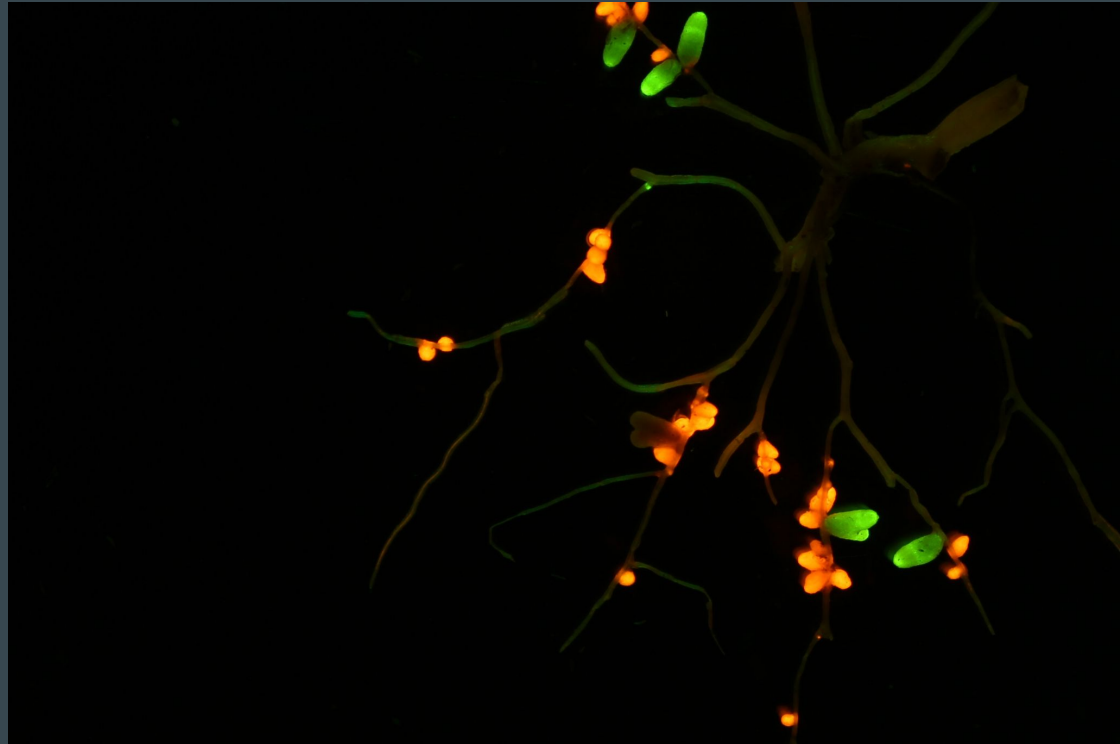
- Can domesticated pea plants perform sanctions as well as wild pea plants?
 - Sanctions are the plants ability to invest in helpful partners and not unhelpful partners
- Are plants facilitating sanctions to specific parts of the plant?

Dataset



Nodule Segmentation

- Nodule classification
- Nodule counts
- Nodule sizes



Nodule Distances

- Distances between nodules
- Various related statistics

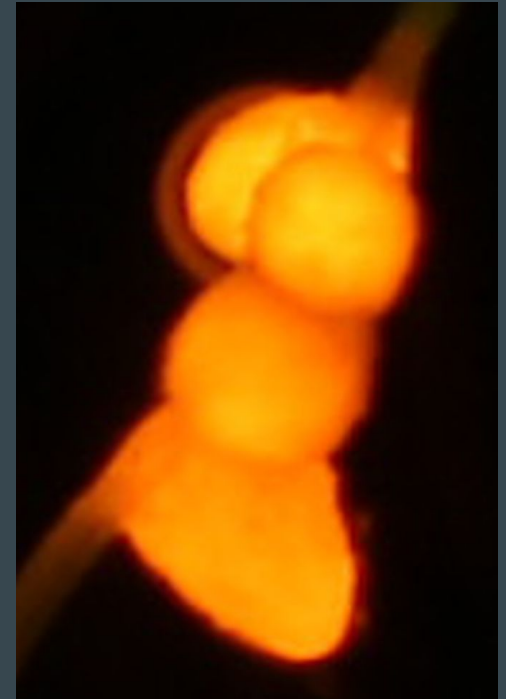


Challenges of Projecting to 2 Dimensions

Roots overlap



Nodules overlap



So... Why not Machine Learning?

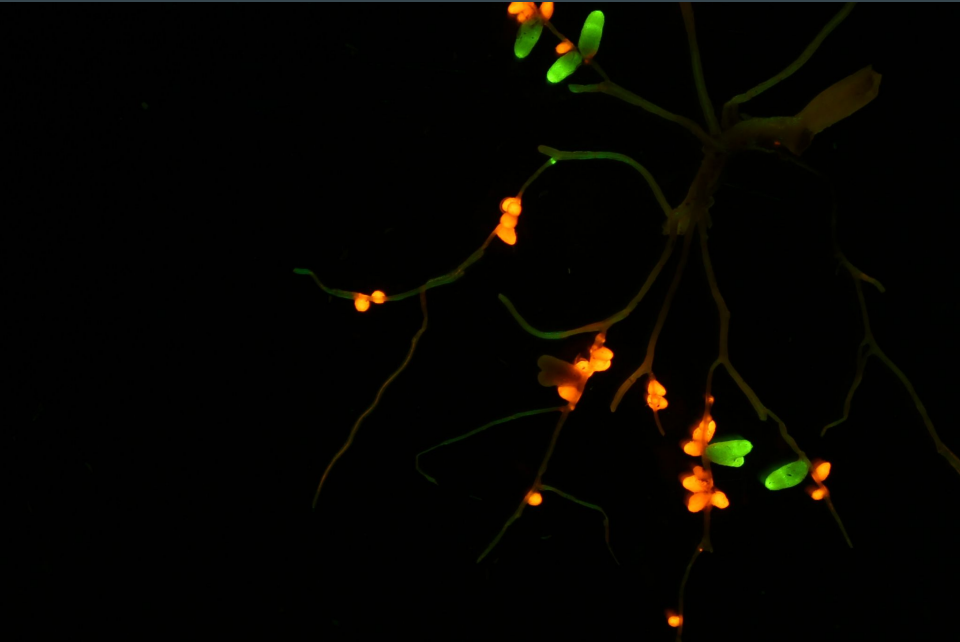
- Machine Learning is often good at segmentation processes
- Machine Learning requires training, and we were hoping to design a more simple system that doesn't require up front work from the scientists.
- Often, unsupervised methods are more consistent.

Dependencies: ImageJ, FIJI, and Weka

- ImageJ(2) is a commonly used program for biological image analysis.
- FIJI is ImageJ2 but with several other plugins pre-installed.
- Weka is one such plugin which my plugin utilizes.

Input for Nodule Segmentation

Root system under blacklight



Weka .model file

Weka is an open source Data analysis software.

My program uses their unsupervised Color Clustering software.

- Segmentation



- Outlining and clump handling



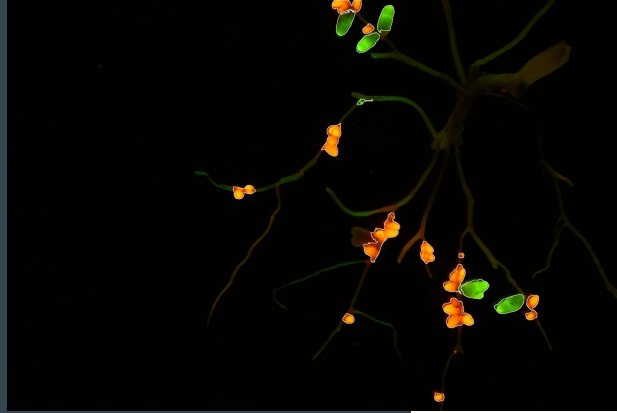
- Manual Correction



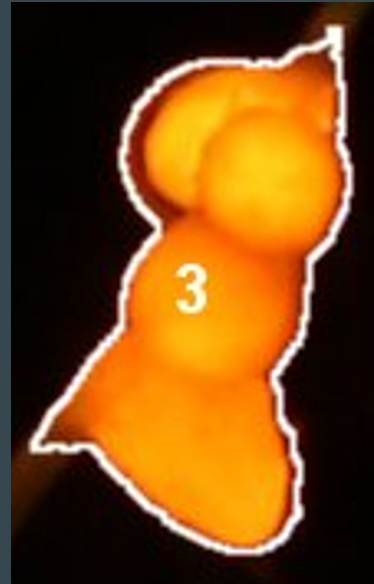
- Measuring



- Save output



- Segmentation
 - ↓
- Outlining and clump handling
 - ↓
- Manual Correction
 - ↓
- Measuring
 - ↓
- Save output

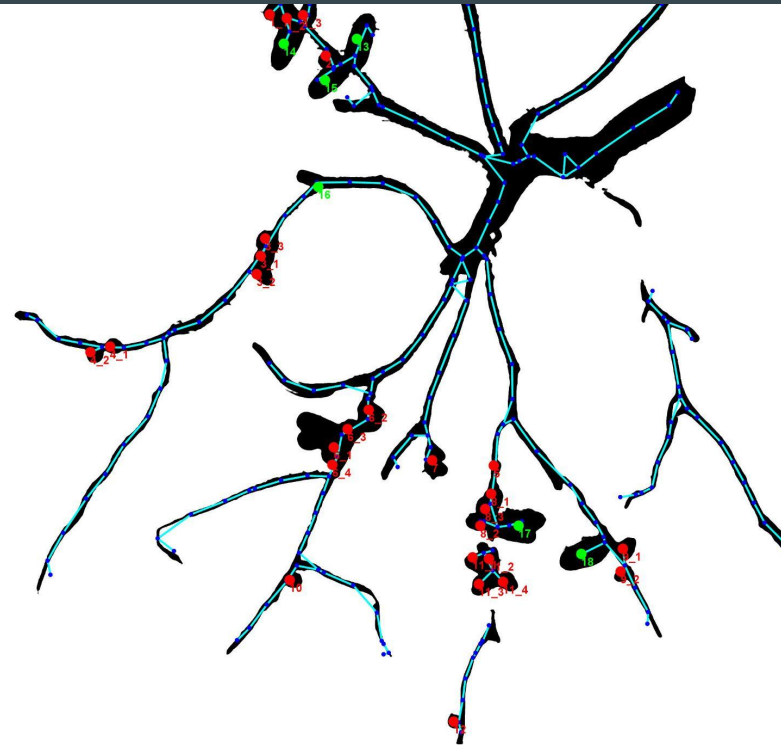


Nodule Distances

- All-pairs distances
- Various derivative statistics
 - Mean distance to all other nodules
 - Mean distances to nodules of same type
 - Number of nodules within x cm
 - etc



Segmenting and Converting to a Graph



Nodule Distances

- Ideally, we have the shortest paths
 - But the roots cross over each other :(
- Using k-shortest paths as an alternative
 - Average over the top k shortest paths



Computing Shortest Paths

- Dijkstra's algorithm computes the shortest path (SP) between a given node to all other nodes.
- Maintain a queue of potential alternative paths, and iteratively add the next alternative path with the shortest distance
 - Alternative paths are found by Identifying the nodes where the previously found K-1 paths differ from each other, and find new paths to those nodes.

Results

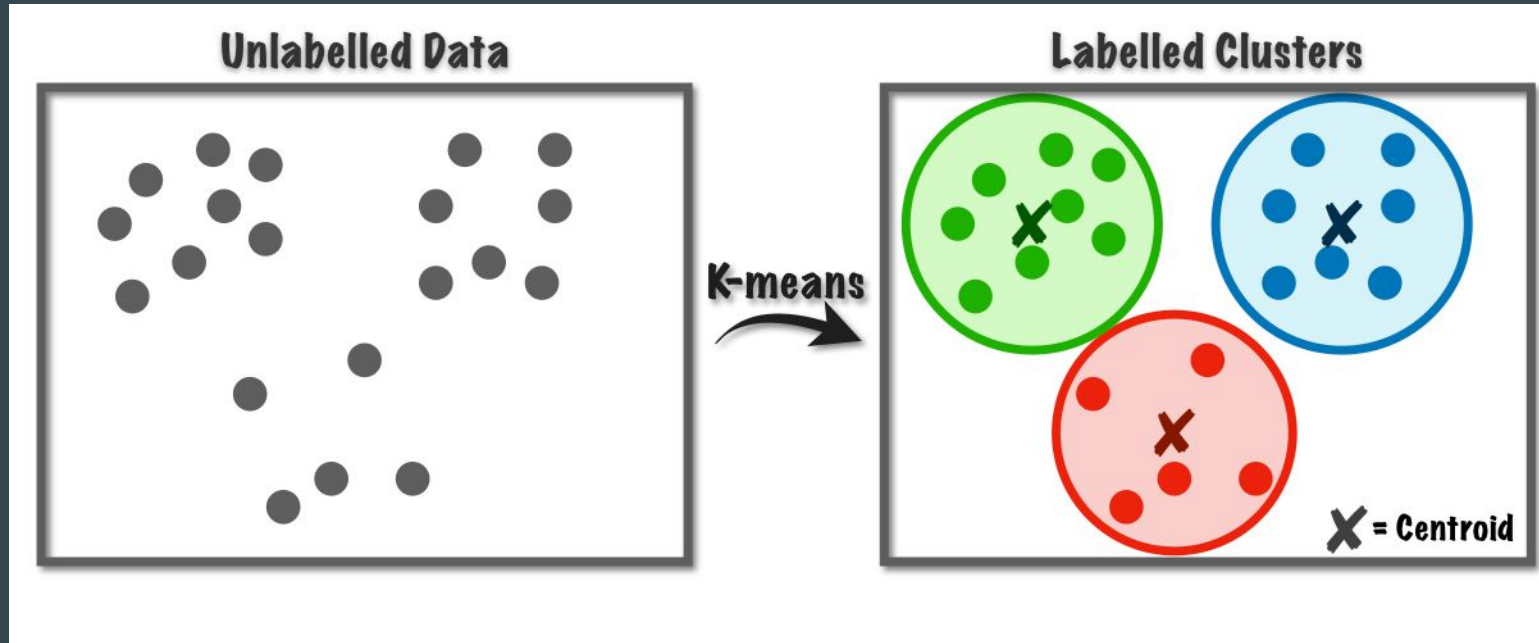
- Can domesticated pea plants perform sanctions as well as wild pea plants?
 - Yes! This result was part of Niall's PhD defense.
- Another researcher at WSU is currently using the Nodule Distances program to do analysis. Results incoming!
- Preparing to submit to JOSS. Both projects are on Github with actions that build and auto-create documentation website.
 - Hopefully it will be added to the ImageJ update site for easier accessibility.

Future Work

- Develop methods to handle root crossings
- Add machine learning capabilities (in progress)
- Add compatibility to other forms of biological imaging processes.
 - Some research labs used a different process for taking these images.

QUESSTIONNNNS???

Methods - K-means Clustering



Methods - K-means Clustering

- Applied in several different settings:
 - Initial segmentation phase of nodules
 - Initial segmentation phase of root system
 - Breakup clumps into separate nodules