Title
SIP4: Towards Automated Analysis of Minirhizotron Images

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Towards Automated Analysis of Minirhizotron Images

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Introduction: The scientific and technical challenges

Background
- What is a minirhizotron?
  A clear tube with graduated markings buried in soil with a camera that slides inside.
- Scientific goal:
  - Determine plant growth patterns by analyzing changes in soil structures over time
  - Image analysis currently performed manually (trained subjects count roots and other structures).

Technical challenges
- Can analysis of minirhizotron images be automated?
  - Need registration of multiple images in space (mosaics) and time (motion estimation for deforming structures).
  - Need a classification system to detect, localize and count various structures (roots, hyphae)

Problem Description: Automate the process of finding roots in images from a minirhizotron.

The Case For Automation
- Why should an automated system be created?
  - The ability to do robust, meaningful research with minirhizotron images is currently limited by the amount of time that can be spent by a human expert classifying the data.
  - Automating some or all of this process could speed it up dramatically, allowing more data to be collected from more locations.

Towards Automation: Planned stages

Developing a Suite of Algorithms
- Preliminary work
  - An interactive software application has been developed to facilitate manual classification.
  - This will be used both to speed up manual analysis, and to provide training data for automatic (supervised) classification.
  - A set of 8000 images have been classified so far (Figures 1 and 2).

- Off-the-shelf tools:
  - Hough transform to find linear structures in images (Figure 3).
    - Results in many false positives.
    - Fails to find small features or hard to see roots.
  - Edge co-localization after edge detection (Canny) (Figure 4):
    - Trained a naïve Bayes classifier on the distance between the segments and color information.
    - Marginal improvement over chance.

- Current research
  - Expanding the classification program to:
    - Allow general image processing operations to be used as plug-ins in order to aid in classification.
    - Allow the user to view multiple images tiled together vertically to increase effective resolution and remove edge effects.
    - Allow the user to navigate forward and backward in time at the same location.
  - Developing supervised learning algorithms to move toward automatic classification of the data using:
    - Multi-scale representations based on the response of filter banks (wavelets, ridgelets, curvelets) or super-pixels based on segmentation from local statistics (textures and color).
    - Adaboost and other methods involving banks of weak classifiers to represent the data.

Figures

Figure 1: Two easily recognizable images of roots. The green crosses are where the user clicked.
Figure 2: These images both contain roots and are more representative of the data. Presence and location of the roots is not immediately evident to the untrained eye.
Figure 3: The leftmost image of Figure 1 and 2 after the Hough transform. The white lines are edges and the red lines are linear structures detected in the image.
Figure 4: The same images with a candidate edge pair that was classified as belonging to a root. The algorithm failed on the rightmost image.