Machine Learning for Maize Plant Segmentation

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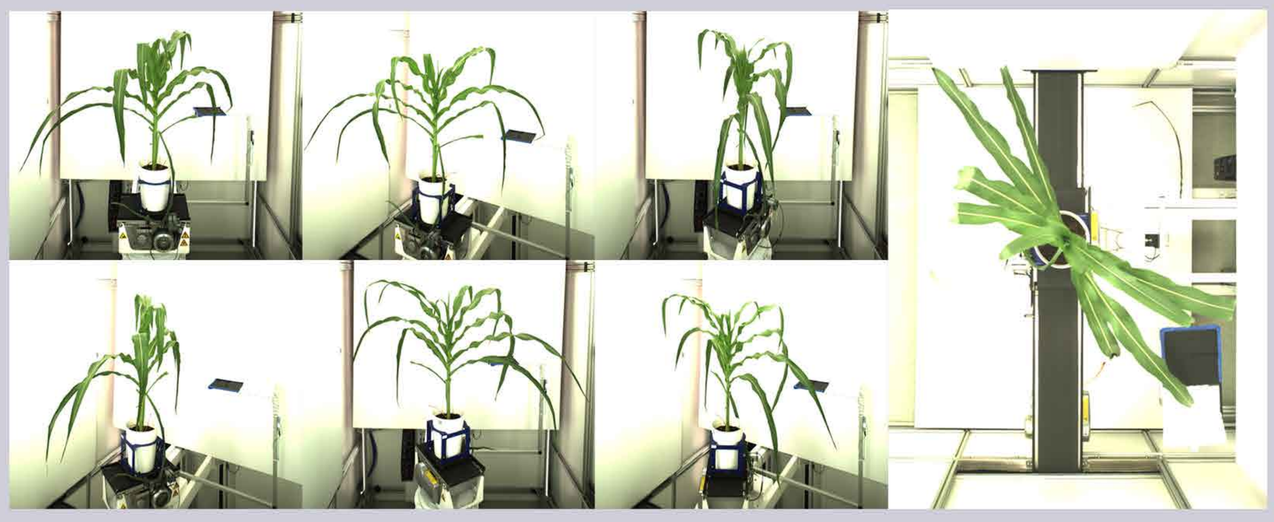
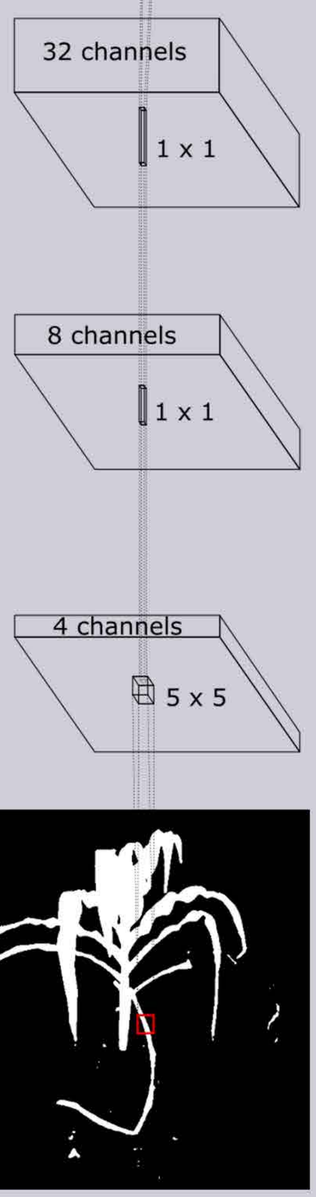


The camera input from the PHENOVISION system comprises 180° views and a top view of the object maize plant. Because of the enormous volume of data, we require a fast and accurate 3D reconstruction technique. Voxel carving fits well, but requires segmented input images.

Using a convolutional neural net (CNN), we can perform this segmentation swiftly and accurately.

The convolutional neural network is a generalization of linear convolutional approaches, i.e. simple color-based decisions. We train the network and its decision rules on the actual input.



The first layer transforms the RGB input to 32 lower-level features, using a large spatial support.

The next two layers transform the lower-level features into high-level colour features using the combination of convolutions and rectified linear units (ReLU's) to good effect.

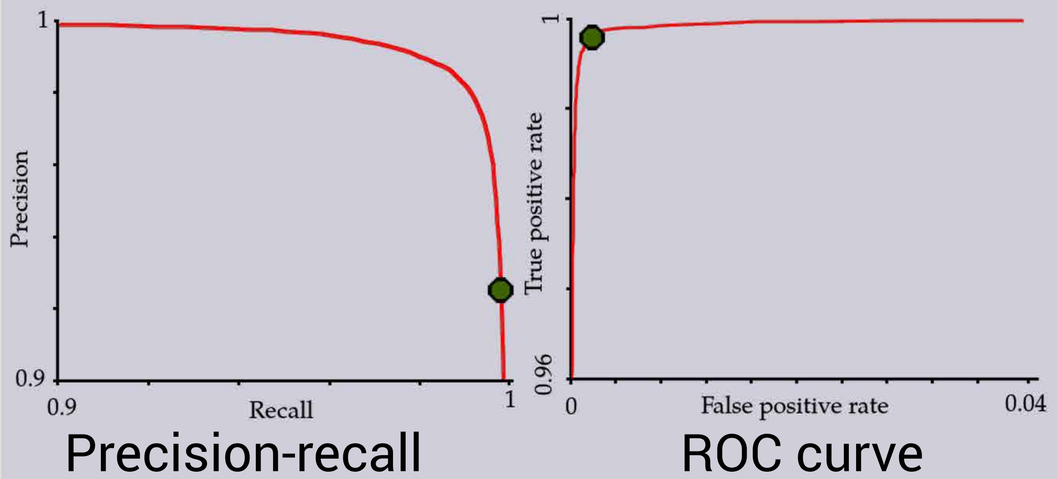
The final layer combines the high-level features into a response map that is thresholded to arrive at the (binary) segmented image.

Training The Network

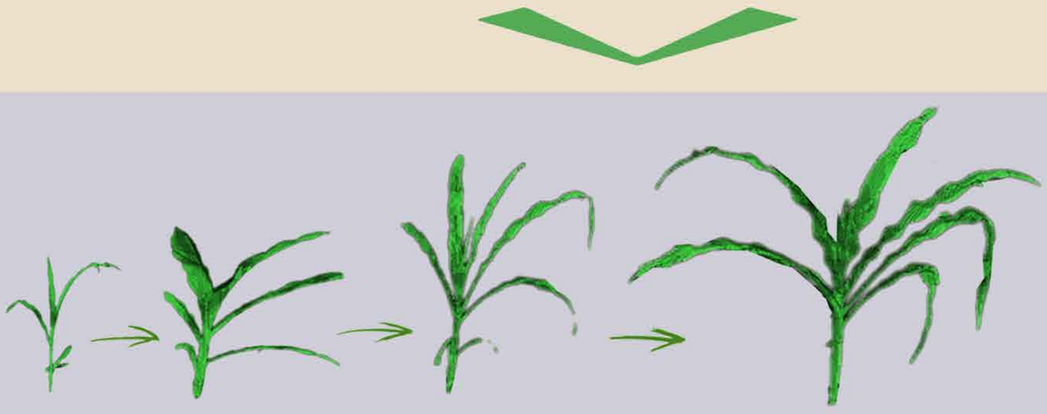
The network is trained using stochastic Gradient descent, with momentum terms and shrinkage applied on the filter weights to mitigate the effect of local minima.

The training input consists of manually annotated images, with some pixels set to *don't care* near image border regions.

The output of the network is a response map that can be thresholded with an arbitrary value. The default value of 0.5 results in the characteristics shown below. There are fewer plant pixels than back-ground, which means precision is sacrificed in favour of recall.



Precision-recall ROC curve



The resulting segmented images are used as input to the voxel carving method, which churns out the 3D models. These can then be used for, e.g., temporal modeling of the plant growth.

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