UNIVERSITY OF TEXAS RIO GRANDE VALLEY

THESIS PROPOSAL

Using Convolutional Neural Networks in Sustainable Agriculture: Semantic segmentation of cover crop mixes

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Author:
Matthew KUTUGATA

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UNIVERSITY OF TEXAS RIO GRANDE VALLEY

Abstract

Matthew Kutugata
School of Earth, Environmental, and Marine Sciences

Masters of Science in Agricultural, Environmental, and Sustainability Sciences

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by Matthew KUTUGATA

There is an increasingly load call for improving agricultural production while reducing environmental degradation. Cover cropping, a conservation agriculture practice is seen as a possible solution to this, however, much remains unknown about implementation of mixes, a growing cover cropping trend. Machine learning may provide a solution in helping researchers and farmers understand the efficacy of using multiple species within a mix. Our project plans to use a convolutional neural network (Mask R-CNN) created using Tensorflow 2, to classify individual species in a multispecies cover crop mix. Doing so will allow us to understand the effectiveness of individual species and their likelihood of germinating successfully in the field. Additionally, we plan to create easy-to-read error visualization reports using matplotlib.

Chapter 1

Using Convolutional Neural Networks to classify cover crop species

1.1 Introduction

There is an increasingly loud call for improving agricultural systems that meet growing demand while preventing natural resource degradation. As a result, conservation agriculture practices are gaining global recognition for their ability to simultaneously improve productivity while decreasing environmental impact. Cover crops, non-harvested plants that provide multiple agroecosystem services are seen as a solution to curbing environmental impact while optimizing yield (Dabney et al., 2001; Snapp et al., 2005; Blanco-Canqui et al., 2015; CSTIC, SARE, and ASTA 2016). Yet implementing this practice is difficult especially in areas with unique environmental and agronomic condition like South Texas.

While cover crops have been well established as beneficial, regionally specific implementation practices are still considered highly nuanced and much remains unknown about cover cropping in south Texas. A solid understanding of successful implementation practices is needed to prompt evidence-based management decisions. This fine resolution understanding - solutions adapted to local conditions – depends on collecting and processing high-resolution information on the state of physical and biological parameters and is thus essential in furthering our understanding. Machine learning therefore appears to be a powerful, yet still under-estimated tool in developing insight into complex agroecosystems. Recent advances in deep learning, computer-vision and ever-evolving neural network architectures, however, may provide a solution. These tools could be used to interpret the efficacy of cover crop mixes, a technique used and heavily promoted by the United States Department of Agriculture Natural Resource Conservation Service (USDA NRCS), agribusiness, and conservation agriculture organizations across the US(citation here).

Much remains unknown however, about the efficacy of using individual species within each mix. This project is but a first step in addressing the question: if a cover crop mix that contains X number of species is planted, will all X species emerge?

While finding a solution to this question is beyond the scope of this project, our goal is to take the first step in using convolutional neural networks to classify individual species within a mix. This includes data pre-processing, network architecture search and implementation, and hyperparameter tuning. The goal of this project is to become familiar with Tensorflow deep learning libraries by creating a convolutional neural networks. We plan on doing this by accomplishing three objectives:

1. Building Tensorflow data input pipelines

2. Searching for and implementing a sufficiently deep neural network architecture
3. Creating easy to read and visualize error metrics reports

1.2 Methods

This project's methods will focus on using custom data to train a convolutional neural network. We aims to use the newly released Tensorflow 2 deep learning library in python integrated with an Nvidia geforce 1080 gpu.

Labeled images will make the training set. Labels will include the various species. Species will be labeled with Infraview. Images will be resized to 400 x 400 using Agisoft. Large portions of the cover crops will be labeled. Fully visible plants will be preferred. Annotation for broadleaves and grasses involved labeling the entire plants and labeling clusters of plants when plants become larger (Sharpe, 2019). Our approach to classifying species is to use Mask R-CNN, a region-based convolutional neural network that combines object detection and semantic segmentation (He et al., 2017). Mask R-CNN adds to previous Faster RCNN by adding a branch for prediciting segmentation masks on each region of interest (RoI) in parallel with the classification and bounding box regression tasks (He et al., 2018). Data augmentation will take place by altering training set images. By flipping, rotating, and altering color, variability of input images and training set size will increase resulting in less overtraining on irrelevant features. Network training epochs will occur until validation accuracy or average loss error ceases to change. We will break our project up into three key tasks:

1.2.1 Data input

We will use image data gathered by an unmanned aerial system (UAS) with an onboard multispectral sensor. Image will be of cover crop mixes at various stages of growth anc taken on a farm located in Lyford, Texas and part of a larger 5-year cover crop study. Labeled training data will be reformatted to match tensorflow 2 data input pipeline.

1.2.2 Neural Network Architecture

This project will attempt to use Mask R-CNN, an architecture that combines a regional proposal and semantic segmentation networks. One neural network identifies the object and the second network classifies it (see figure 1). Mask R-CNN is preceded by both fast R-CNN and Faster R-CNN, both region based proposal networks.

1.2.3 Error Reporting

An important step in our project will the visualization and understanding of several error metrics. Precision, recall, and F1 score will all be used to evaluate the neural networks ability to classify crops.

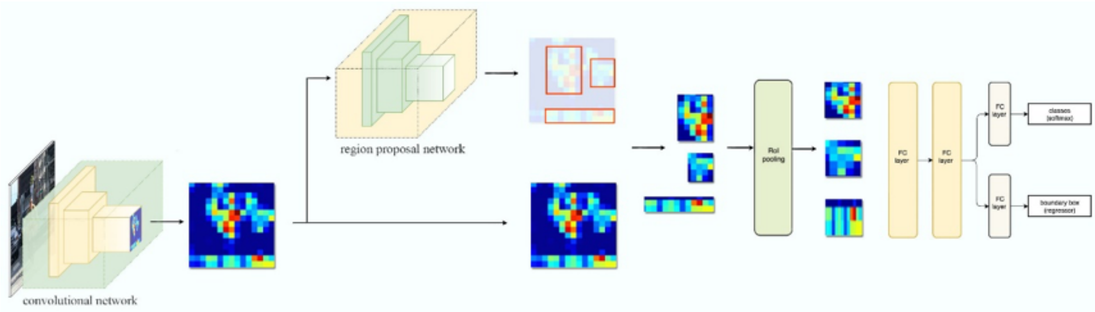

FIGURE 1.1: Mask R-CNN

1.3 Timeline

Data collection has started and will continue until early Decemeber making sure to collect sufficient amounts of training data. Labeling of training data will involve using LableMe webapp (LabelMe, Los Angeles, CA).

Creating a tensorflow data input pipeline will occur throughout the first 1.5 weeks of the project until the 24th. Implementing code to create Mask RCNN will occur throughout the last week of November. Testing and error visualization will be done through the first week of Deember.

1.4 Broader Impacts

This multiclass classifier will be a first step in mapping cover crop mix species distribution across agricultural landscapes. This information can then be used to help key decision makers understand the efficacy of including certain species in a mix of cover crops, potentially saving cost and labor.

1.5 Bibiliography

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