DEPARTMENT OF FOOD, AGRICULTURAL AND BIOLOGICAL ENGINEERING

Corn Counting Using Unmanned Aircraft Systems and Convolutional Neural Networks

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INTRODUCTION

- Crop emergence influences many aspects of agricultural operations, including water, fertilizer and herbicide application, and eventually **crop productivity and farm profitability**.
- Information on crop emergence is **critical for plant breeders** to maintain the integrity of the plant such as performance, quality, progress and stress responses.
- Current approach for monitoring crop emergence is based on **visual counting at ground level**, which is time-consuming and labor-intensive.
- **Unmanned aircraft systems (UAS)** offers cost-and time-effective approach to monitor soil and crop health at high spatial and temporal resolution.
- Recent advancements in computational systems, particularly graphical processing units (GPU) embedded processors, facilitate applications of **advanced deep learning models** for agricultural studies.
- Deep learning models based on UAS collected imagery offer promising approach to **automatically count crop plants**.

AIM

- Explore the application of deep neural network models to estimate corn population using high resolution visible imagery collected using UAS.
- Assess the accuracy of various neural network models for plant counting under various crop growth stages and imagery resolutions.

METHODS

Study Site: Synder Farm, Wooster, Ohio
Crop Studied: Corn
UAS Survey:

- *UAS*: DJI Matrice 200 V2
- *Sensor*: Visual
- *Flight Time*: 11, June 2019 at 12:50 PM
- *Flight Height*: 30 m (~100 ft)
- *UAS speed*: 1 m/s
- *Windspeed*: 10 miles/hr
- *Total number of images collected*: 172
- *Frontal overlap*: 85% and side overlap: 75%
- *Corn growth stage*: V4
- Image resolution: 11 mm pixel size

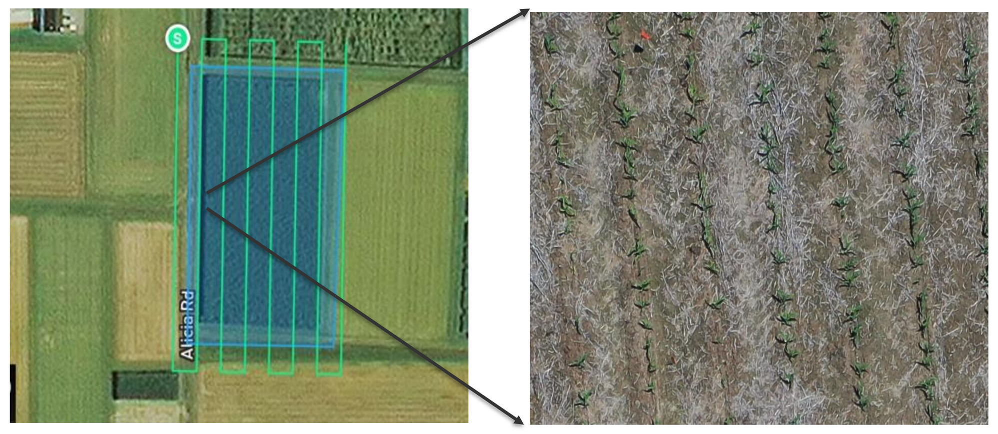

Figure 1. *Example of a UAS flight path, and a UAS collected imagery representing a section of a corn field.*

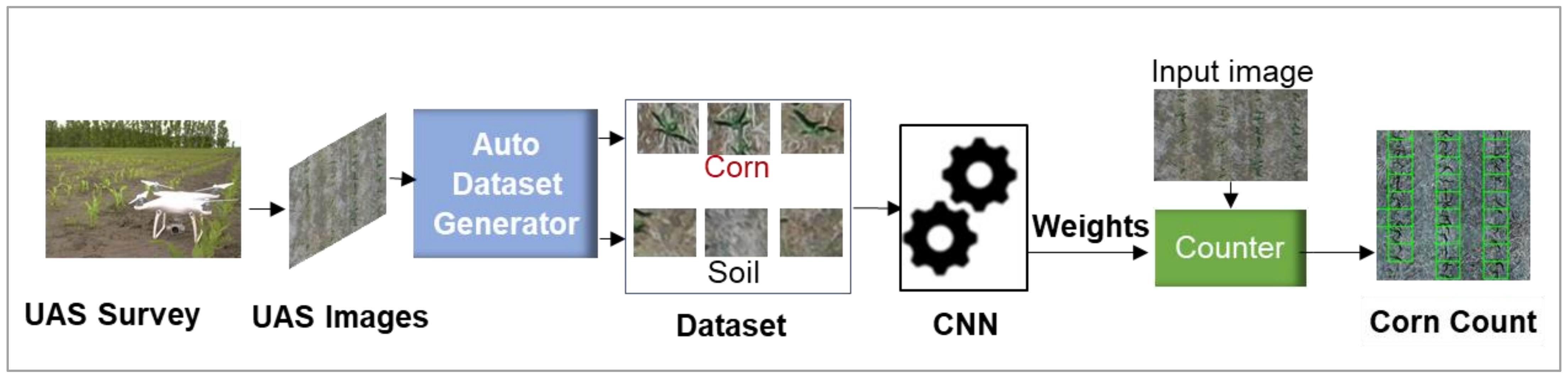

Figure 2. *Architecture of corn counting using convolutional neural network algorithm.*

1.Corn counting framework based on Convolutional Neural Network (CNN) algorithm**:**

- **You only look once (YOLO)** – the most widely used CNN architectures for object detection and classification.
- **Auto Dataset generator –** High-resolution images cropped into 40*60-pixel boxes in a sliding window manner and each image is classified as either corn or soil images.
- **Training Neural Network Model –** CNN model trained for the dataset of size 5K corn and soil (non-corn) images (Figure 2), each using TensorFlow.
- **Counter –** The corn in the input images are recognized and counted using the neural network and weights generated from the training phase.
- The weights and the neural network used to identify and count the corn plants in input image.
- Training a CNN takes more than a few cycles through the full training dataset.

2. Crop Health Dashboard:

- Locations associated with images displayed.
- Based on fraction of greenness in UAS collected imagery, images classified to indicate poor or healthy locations within the fields.

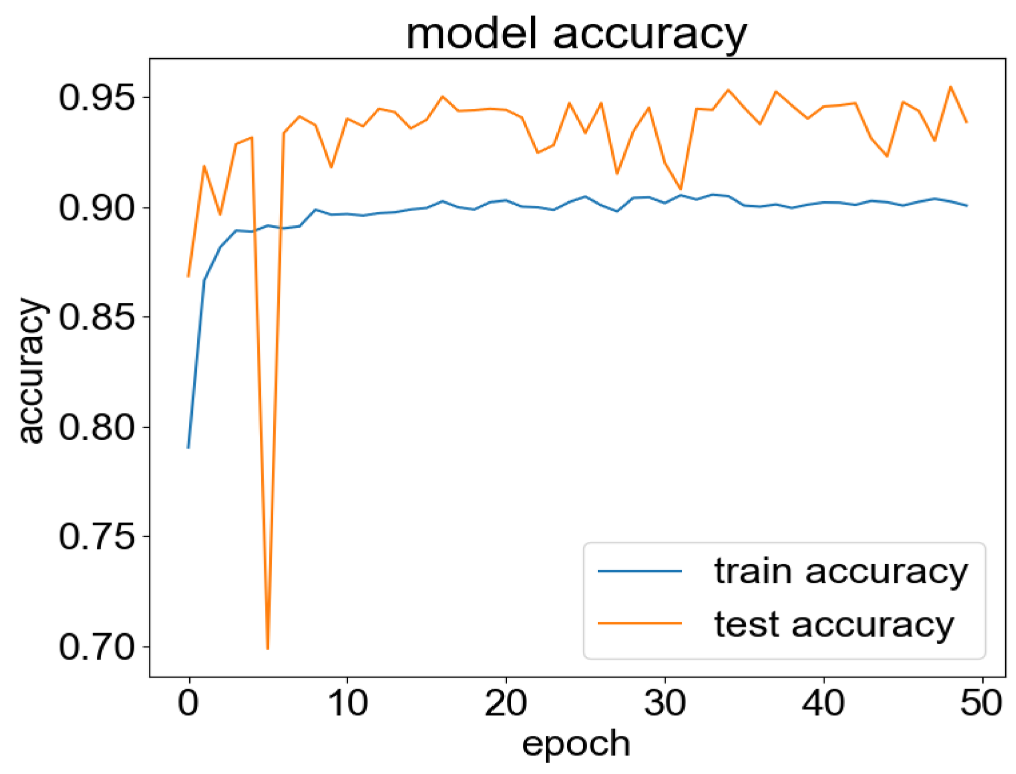

Figure 3. *Classification accuracy with successive training epochs. [Note: Higher accuracy is one of the indicators of good model performance]*

RESULTS

- Classification accuracy improved to greater than 90% with over 50 iterations (i.e., epochs) on the training dataset.
- Corn counting accuracy went up to 95% when trained model applied to UAS based high-resolution imagery.

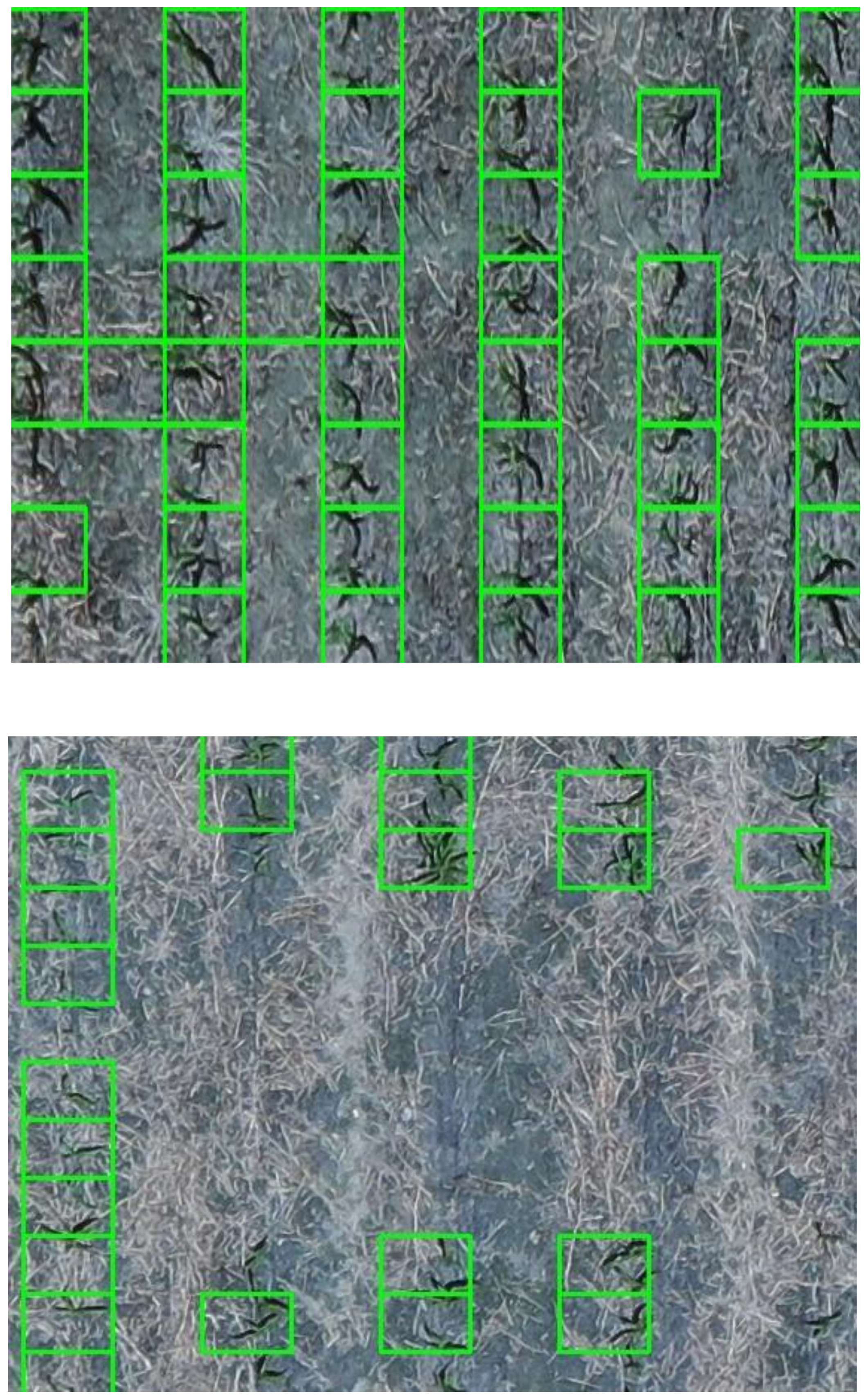

Figure 4. *Example of a corn counting model output. The counter module will draw bounding boxes only around the corn plants.*

Figure 5. *Snapshots from the crop health dashboard indicating the location, percentage and corn count variations of the healthy and poor sections of the field.*

CONCLUSION AND FUTURE WORK

- The use of UAS provided time- and cost-effective approach for monitoring crop emergence.
- Presence of weeds could lead to miscounting.
- Model performance will be made robust by incorporating additional imagery with non-corn objects such as weeds.
- Future works will involve the evaluation of various neural networks like VGG16, ResNet, and RCCN to develop robust corn counting model.

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2. Kitano, B., Mendes, C., Geus, A., Oliveira, H., and J. R. Souza, J., (2019) Corn Plant Counting Using Deep Learning and UAV Images, in IEEE Geoscience and Remote Sensing Letters.

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SEEDS

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