

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

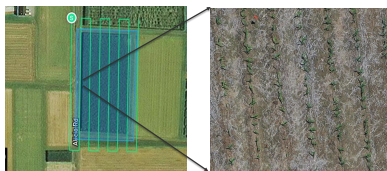


Figure 1. Example of a UAS flight path, and a UAS collected imagery representing a section of a corn field.

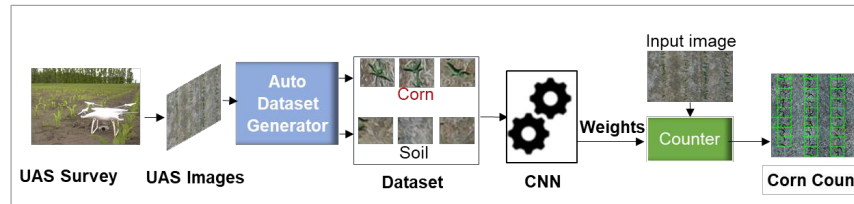


Figure 2. Architecture of corn counting using convolutional neural network algorithm.

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.

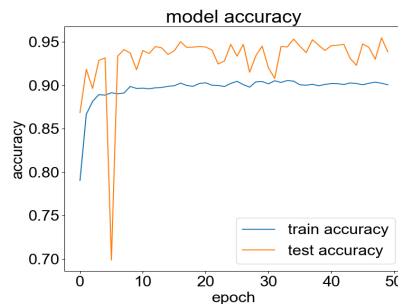


Figure 3. Classification accuracy with successive training epochs. [Note: Higher accuracy is one of the indicators of a good model performance]

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.

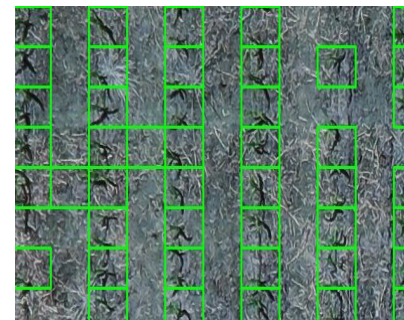


Figure 4. Example of a corn counting model output. The counter module will draw bounding boxes only around the corn plants.

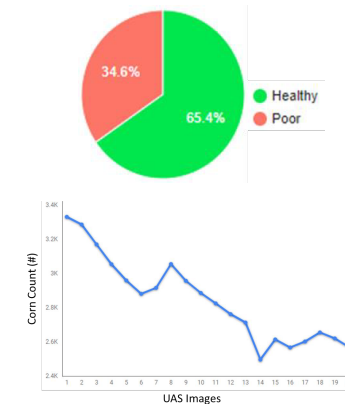
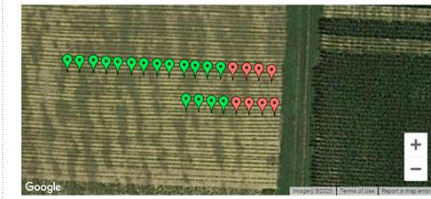


Figure 5. Snapshots from the crop health dashboard indicating the location, percentage and corn count variations of the healthy and poor sections of the field.

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 RCNN to develop robust corn counting model.

BIBLIOGRAPHY

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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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