Mississippi Corn Promotion Board

2023 Progress Report

Project

Title: UAV-based autonomous unsupervised weed detection for corn fields

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Project Summary (Issue/Response)

This project aims to develop an autonomous, and unsupervised methodology to generate weed maps for corn fields using RGB drone images. The proposed project will bring an adaptive, robust, low-cost solution to detect weeds in a new field without any expensive labeling task. The project will automatically map and qualify weed infestation in a cornfield during the early growing season of crops. Traditionally blanket spraying of herbicides without considering the spatial distribution of weeds results in the overuse of chemicals. This causes economic losses, affects human health, and reduces biological diversity. Site-specific weed management (SSWM) provides an optimal solution and can decrease herbicide costs by 50% and can save $7-25 million for corn growers in Mississippi state. This project will achieve the first and vital step of SSWM by providing the weed distribution map of corn fields.

Since the proposed methodology is unsupervised, it doesn't require any prior data collection and previously trained model and is directly applicable to new corn fields. The proposed method will first detect the line of each corn crop. The simple linear iterative clustering (SLIC) algorithm will be used to divide input images into superpixels. The inter-row vegetation outside the crop rows will be referred to as inter-row weeds. Any superpixel that does not intersect with the crop mask will be labeled a weed. A temporary dataset will be constructed by extracting patches that belong to corn and inter-row weeds from the original image. Finally, a deep learning model will be developed to classify the crop and the weeds in images. All patched superpixels belonging to the vegetation will be applied to the model to generate the weed maps of the corn field.

Project Results/Outcomes

In the first year of the project, we performed crop line detection and automatic labeling of parts of the overall proposed method. In 2023, we conducted more than 100 UAV flights over the area of 1.2 ha cornfield. By counting the previous year's flight campaigns, a total of 7000 ~1cm/pixel resolution RGB images of the corn field were collected. Around 10% of these images are randomly selected for the analysis part of the research. The RGB images that were selected for analysis were first converted into Excess Green Vegetation Index to distinguish between the vegetation lines and the background. The 2-D Fourier transform was then applied to these images to determine the average angle of crop lines and the average distance between two adjacent crop lines in the spatial domain. This information was used to implement the Hough transform method to identify the initial crop lines. The accuracy of the crop line detection was evaluated by comparing the crop lines detected with the actual crop lines. The Hough transform reached an average accuracy of 87% in detecting crop lines.

In the automatic labeling part, the superpixels are computed from the original RGB Image. The convergence between all the generated superpixels and the crop lines of an image is checked. Three different types of labeling are assigned to the superpixels of the image: the converged superpixels are crops, adjacent superpixels to the converged ones can be either crop or weed, and the vegetation superpixels that are not converged are considered weeds. The performance of these labeled images is being evaluated

Project Results

currently and will be the input of training and testing of the weed detection algorithm. Figure 1 shows an image from the corn field and the detected crop lines. Figure 2 shows automatic labeling results for Figure 1. Table 1 summurize the crop line detection performance for different corn growing timeline. The crop line detection accuracy exceeds 90% for field images taken 5+ weeks post-planting. In the first 4 weeks after planting, the crop line detection accuracy is low because the vegetation index is not enough to create a line. After 9 weeks, the top canopy of the corn starts to cover the space between rows, which can cause the Hough transform to fail in detecting corn lines.

Weeks after planting	Accuracy
4	0.78
5	0.96
6	0.94
7	0.94
8	0.94
9	0.74
10	0.82

Table 1. Corn Line Detection Performance for different corn growth time.

Fig. 1. An example image from corn field (7 weeks after planting). Green lines show detected crop lines by algorithm.

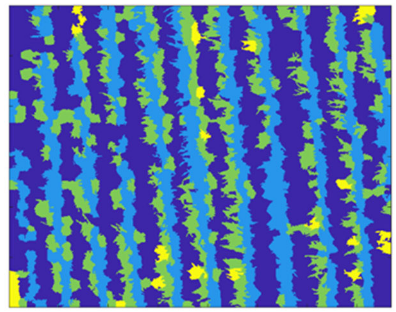

Fig. 2. Automatically labeled vegetation. Yellow for weed, light blue for crop, and green possible weed or crop.

Project Impacts/Benefits

The successful implementation of automated weed detection will help in applying weed treatments at the right time, location, and intensity. This will reduce the amount of applied herbicide (%50) and will save around $7-25 million for Mississippi corn growers. In addition to the cost benefit, using this method will also help to minimize the harmful effects of herbicides. The results of the first year of projects showed that the Hough transform and automatic labeling can provide the necessary training data for machine learning.

Project Deliverables

These preliminary results are submitted to the conference of Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping IX. The poster presentations are prepared for 2024 AI in Agriculture and Natural Resources Conference and The North Mississippi Research & Extension Center, Producer Advisory Council meeting.