AgRPA

Purdue University | The Data Mine

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INTRODUCTION

Objective:

Our objective is to develop a multi-drone weed detection and treatment system for a cost-effective and eco-friendly solution to help farmers reduce pesticide use

MISSION PLANNING

Objective: Determine the optimal flight path for the drones to fly and take satellite images of a field, while taking into account battery of each drone and the different acreages and shapes of farms.

Tools:
- MAVSDK → Python library that provides APIs to communicate with MavLink based drones
- PX4 and Gazebo → Software to create simulated drones to control and map a field
- QGroundControl → Used to generate .plan file and to track simulated drone's movement

Methodology:
- Start with a .plan file from QGroundControl containing waypoint coordinates
- Evenly and sequentially distribute waypoints across multiple drones.
- Convert each waypoint into a Mission Item with predefined actions
- Drones follow a continuous Mission Plan to survey the field efficiently.

Results:
- Enables multiple drones to survey a field after splitting.
- Communication system for drone coordination and task handoff.
- Captured images are sent to the Image Processing team for stitching and analysis.

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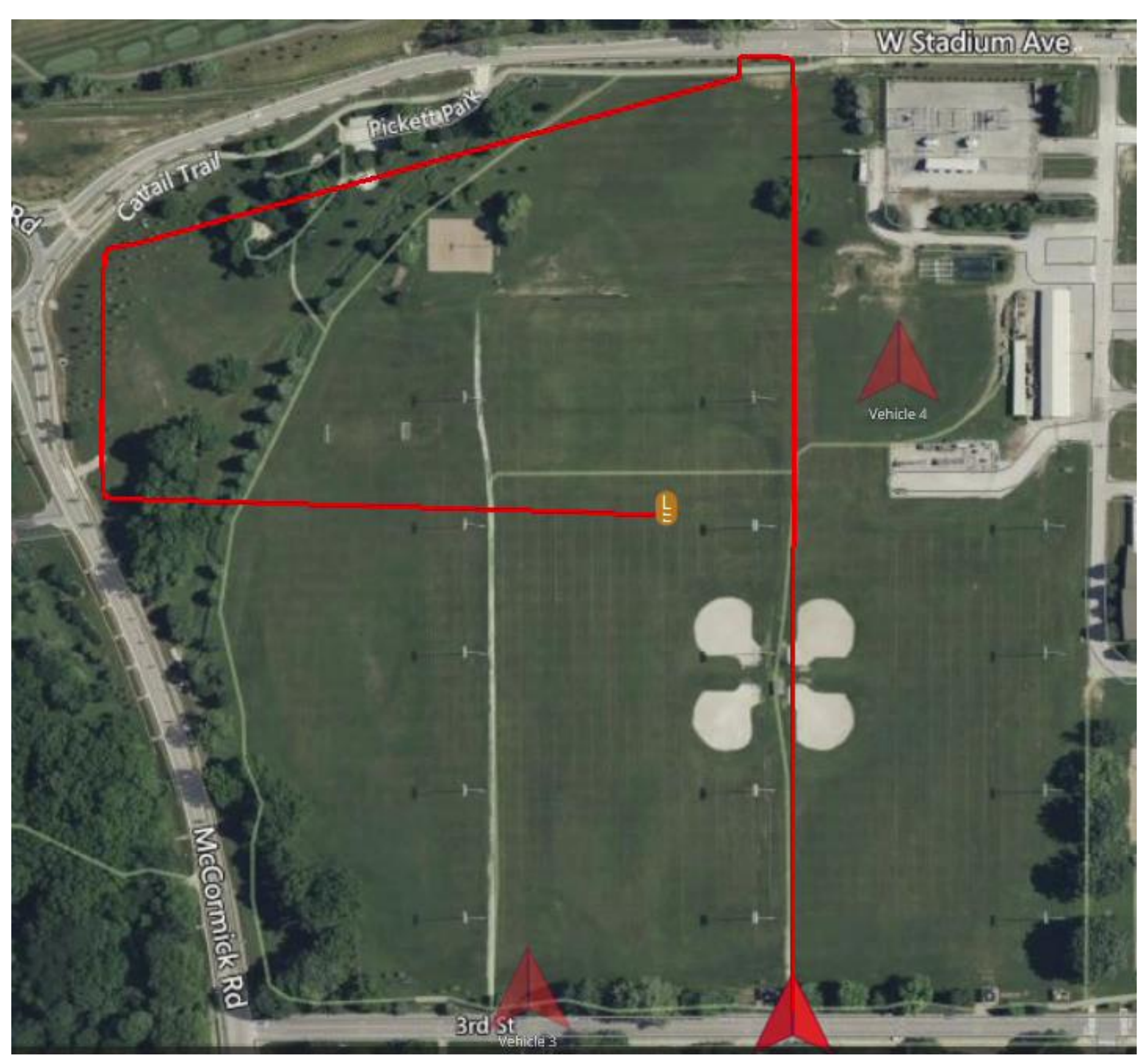


IMAGE PROCESSING

Objective: Take images captured from the drones into a high-resolution map for analysis

Tools:
- Open Drone Map, Docker, Apptainer

Methodology:
To create a single orthophoto Open Drone Map finds key features in individual images to determine how images fit together. Image overlap is key for features to show up in multiple images. Then, Open Drone Map warps and stitches the images together to create a single orthophoto which can be analyzed further. We utilized Python scripts to generate the orthophotos, optimizing as we saw fit. To the right is one of the images used in our orthophoto generation:

Results:
We successfully generated an orthophoto of the field. Using Anvil's GPU for acceleration, we were able to cut down the time taken to generate the photos to approximately 30 minutes.

WEED DETECTION

Aim/Objective: To train an AI model that can detect weeds in a given field

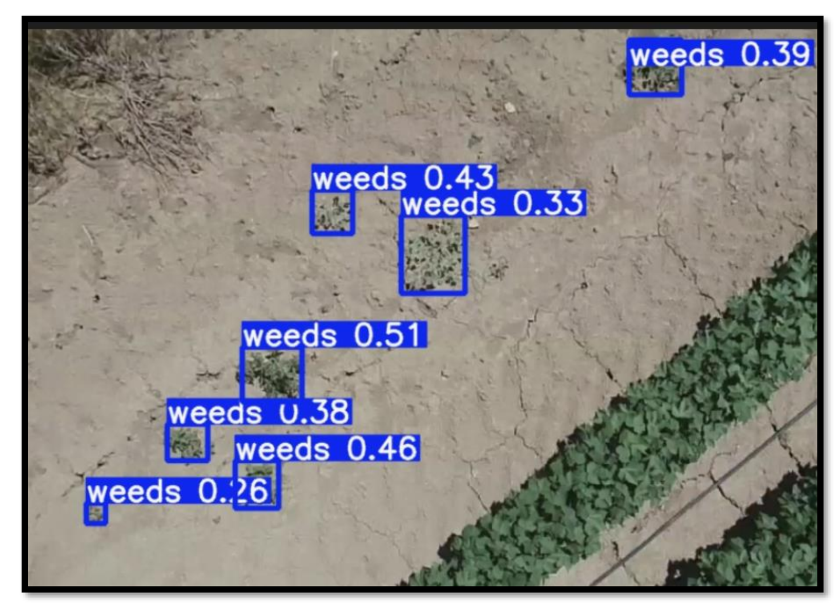
Research: We trained our model with three different data sets, Corn, Soy, and No vegetation. A significant portion of our research included finding multiple UAV datasets of the three different crops with clear labeling to enhance performance.

Tools: YOLO V8, Roboflow, Docker, Apptainer

Methodology: We collected drone imagery from various agricultural fields, organized it into training, validation, and test sets, and used a custom script to convert annotated weed overlays into bounding box coordinates for training a fine-tuned YOLOv8 model with optimized hyperparameters. The model was trained using Anvil's GPU platform and evaluated using precision, recall, and loss metrics.

Results: Throughout the semester, we focused on data collection and resource analysis to support the development of our YOLO model, which has been trained on two distinct datasets. To improve accuracy, we're exploring optimization techniques such as dataset augmentation, parameter tuning, and model refinement.

Below is an image of a sample weed detection run:



GEOSPATIAL ANALYSIS

Objective: Transform detected weed locations into prescription plans to be used by sprayers and drones to treat fields.

Tools: PyQGIS, NumPy, Flask, Docker, Apptainer

Methodology: CSV files of weed coordinates are received from the image Processing team and transformed into formats suited for each target platform, including .plan files, shapefiles, and KML files. The .plan files are shared with the Mission Planning subteam such that the waypoints can be divided among drones for greater efficiency. The shapefiles can be uploaded to John Deere Operations Center organizations and transferred to equipment through a custom Flask app. The KML files can be shared with Hylio AgroDrones to generate a pesticide application with spot treatment.

Results: Three main outputs of drone flight plans were derived.

1. .Plan file: a flight plan/mission plan file with instructions for the drones to follow. This file contains mission data for the drone: ie, information about the areas where weeds are present, waypoints, the path for the drone to follow, and other information for the drone such as speed, altitude, etc. This file was sent to the Mission Planning team for splitting of the flight plans and prescription area to release a fleet of drones for efficiency.

2. Shapefile: a geospatial data file that stores polygons and other geospatial data. It contains the areas where there are weeds to be treated with herbicide, this file is to upload directly to the drones.

3. KML: a XML based geospatial data file that can contains points, lines, polygons, or other attributes. It contains the total bounding area in which the drone is spraying as well as the points in which the drone will spray.

CONCLUSION/FUTURE GOALS

Next steps:

Weed Detection: Improve accuracy by using different optimization techniques like dataset augmentation, hyperparameter adjustment, and refining model architecture.

Mission Planning: Optimize coverage control for fields and generate waypoints using a satellite image

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