Real-time vision-based spot spraying development for high efficiency and precision weed management

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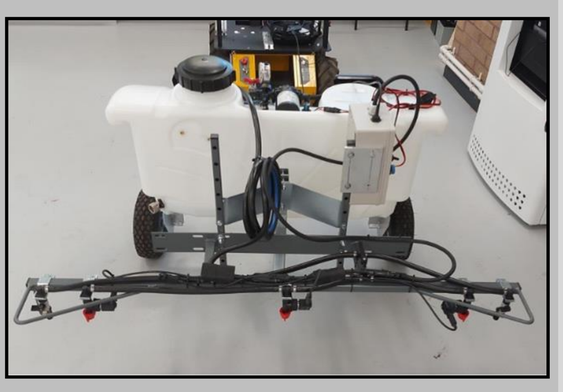
Introduction

Spot spraying, as a spatially variable weed management strategy, targets only weed species in fields to minimize the use of chemicals. This is opposed to broadcast spraying where herbicides are applied uniformly across a field. Spot spraying can significantly reduce the amount of herbicide usage across a field, saving the farmers money and reducing the environmental damage from groundwater pollution.

To spot spray autonomously, weeds in a field must be detected and then subsequently accurately sprayed.

Summary



This project involves the use of a prototype sprayer system to precisely spray weeds in fields. Weeds are detected using computer vision and sprayed by controlling solenoid valves individually.

Industry

In recent years spot spraying has seen increased development from companies in industry. A couple examples of such companies are John Deere[1] and Bilberry[2] who have started selling the precision weeding systems that use machine learning for weed detection to farmers.

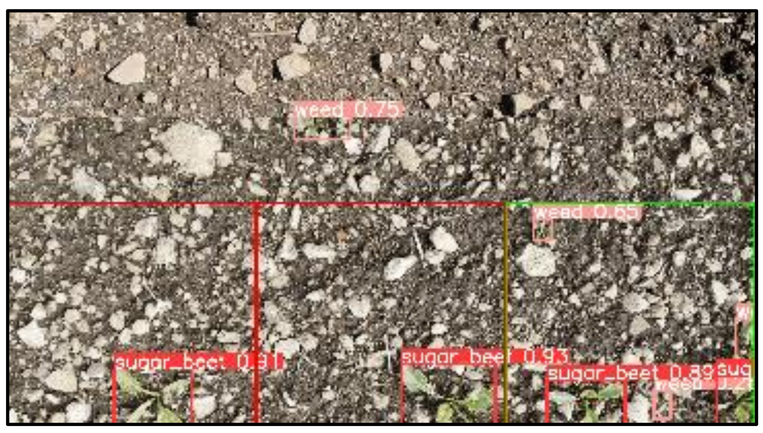
This image shows the John Deere See and Spray™ Ultimate. Image reproduced from [1].

Prototype Sprayer

The prototype spraying system includes solenoid valves to control the flow of liquid to the spraying nozzles; cameras to detect the presence of weeds in a field; and a box of electronics that is used to control the solenoid valves.
The prototype spraying system has a box filled with electronics components that controls the solenoid valves.
So far, the system has been towed by a husky robot when driven.

Computer Vision

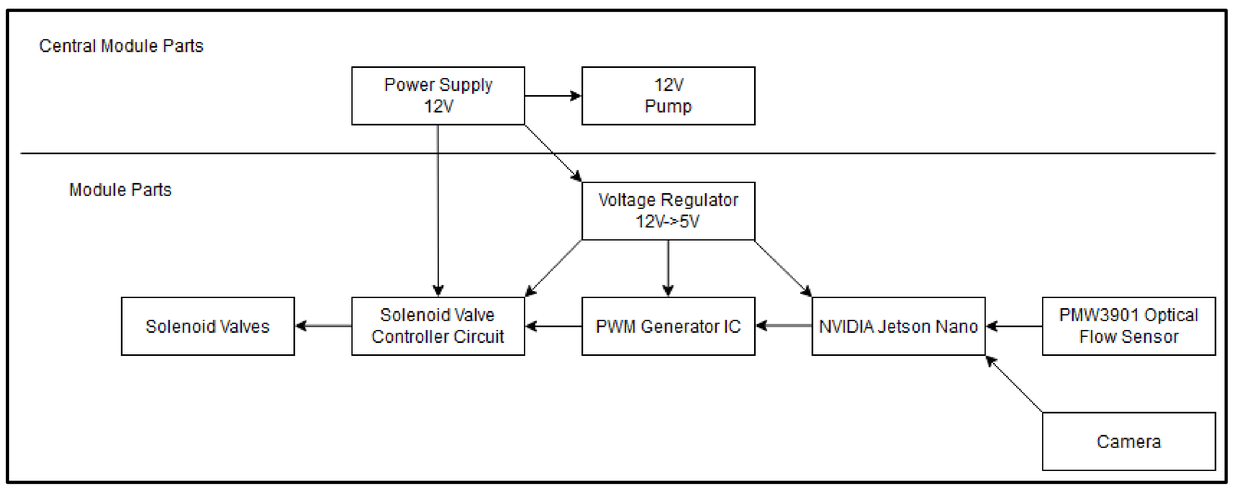
To get image data of fields a camera can be attached to the robot. To detect weeds in sugar beet fields, Yolov5s was trained on a dataset of images of weeds in sugar beet fields. This dataset is called the “Lincolnbeet” dataset and contains 4402 images containing 16399 sugar beets and 22847 weeds[3]. The detection system is run on a Jetson Nano. The network was chosen to be relatively computationally inexpensive to run so that it could run on the Jetson with low inference times, allowing for faster detection of weeds.



Control of Spraying Valves

The image shown below shows a block diagram for the next design of the sprayer. This version of the sprayer will be built with a central module that houses the power supply and pump with a set of modules that each control a section of boom and contain a camera, jetson nano and the solenoid controller circuit.

The solenoid valve controller circuit for each valve contains an optocoupler followed by a MOSFET which drives each valve. The valves are to be driven off the 12V power supply of the battery which is regulated to 5V to power the Jetson Nano.



Future Work

A combination of wheel odometry and optical flow sensors will be used for the localization of the vehicle and to calculate our spray timings to spray weeds precisely.
In future the spray boom will be extended with more spray nozzles and cameras so that we can treat a larger area with more precise herbicide application.
In-field testing will be conducted with the in the fields surrounding the University of Lincoln’s Riseholme campus.

References

[1] *See & Spray™ Ultimate | Precision Ag | John Deere US*. (n.d.). Retrieved August 28, 2023, from https://www.deere.com/en/sprayers/see-spray-ultimate/
[2] *Bilberry – A Trimble Company*. (n.d.). Retrieved August 28, 2023, from https://bilberry.io/
[3] Salazar-Gomez, A., Darbyshire, M., Gao, J., Sklar, E. I., & Parsons, S. (2021). *Towards practical object detection for weed spraying in precision agriculture*. https://arxiv.org/abs/2109.11048v1

Collaborators

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