Weed Warden: A Low-Cost Vegetation Detection Device for Agricultural Applications

Liam Duncan[1], Cara Walter[2], Dr. Chet Udell[2], Dr. John S Selker[2]

[1]Openly Published Environmental Sensing Lab, [2]Department of Biological & Ecological Engineering, Oregon State University

ABSTRACT: New methods for affordable vegetation detection

Controlling weeds during the off season is essential for farmers to protect resources and maximize crop yield. Traditionally weeds are taken care of by spraying herbicides on the field. Herbicides can be harmful to the environment and spraying the entire field is expensive. Robotic weeders are a good solution to minimize environmental impact and save money on herbicides, but they are expensive (>$100,000). The Weed Warden is a low-cost (<$500) weed detection sensor that can be mounted on rovers or tractors. The Weed Warden uses a spectral triad sensor to detect weeds and can then trigger a weed removal system such as a sprayer when weeds are detected. The system uses the normalized difference vegetation index (NDVI) to measure the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs) to produce a value that ranges from -1 to +1 which will indicate if there is plant life under the sensor.

Ecorobotix Smart Weeding Robot ($150,000) Credit: REUTERS/Denis Balibouse

PURPOSE

Motivation for the Weed Warden comes from the need for affordable sustainability on farms. The most common method for weed removal today is to spray herbicide onto a field which will eliminate the weeds. This method can introduce large amounts of pollutants into the environment and end up being very expensive. Robotic weeders are an emerging method that allows farmers to save costs by cutting down on the amount of herbicides needed to eliminate weeds in the off season. The issue with robotic weeders is that they are much too expensive for the average farmer to afford.

In contrast, the Weed Warden, a system for sensing weeds and triggering external equipment, is low cost (<$500) and modular. The Weed Warden utilizes a low-cost spectral triad sensor, and can detect weeds from up to three feet off the ground. The Weed Warden can be attached to any equipment that the farmer already owns (e.g. tractor) or put onto a dedicated rover to remove weeds autonomously. This allows farmers to save costs by using equipment that they already own and still getting the cost and environmental benefits of spot spraying.

A farm in the offseason

Contact Information

***Presenter:* Liam Duncan (duncanli@oregonstate.edu)**

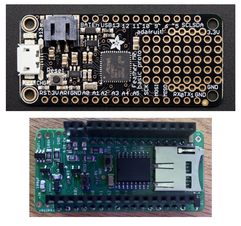
***Lab Director:* Chet Udell (udellc@oregonstate.edu)**

***Website/Projects:* (https://github.com/OPEnSLab-OSU/OPEnS-Lab-Home/wiki/WeedWarden)**

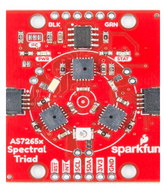
Scan Me to See to Our Project Page!

COMPONENT BREAKDOWN

- Adafruit Feather M0 – Main System Controller
- OPEnS Lab Hypnos Board with MicroSD card – Datalogging and voltage rail control
- Sparkfun Triad Spectroscopy Sensor – Spectral Data Sensor
- Nanuk 904 Hard Case - Weather-proof Case for Electronics
- 5V Buzzer - For testing to simulate external sprayer
- Adafruit Clear Weather-proof Box Lid - Protects the triad sensor on the outside of the hard case



Above, Adafruit Feather M0 Below, OPEnS Lab Hypnos Board



SparkFun Triad Spectroscopy Sensor

Top View of assembled Weed Warden. Triad Sensor can be observed inside of clear box lid with 5V Buzzer.

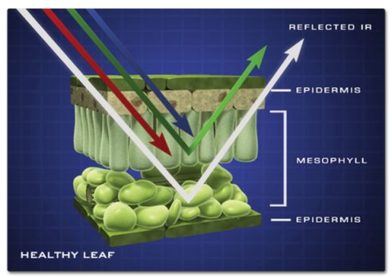
METHODS

The Weed Warden has access to 18 wavelength signals from the SparkFun Triad sensor. These wavelength bands are used to calculate the NDVI index which will indicate the presence of vegetation. The NDVI index works by comparing red light and near infrared light to output a value between +1 and -1. This works because healthy plants absorb red light and reflect near infrared light.

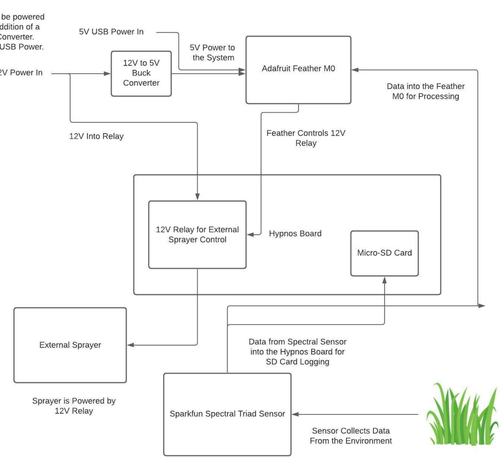
The NDVI algorithm is implemented on the Weed Warden by using the Triad sensor, Hypnos board, and Feather M0. The Triad sensor is first calibrated on a bare dirt surface to create a calibration threshold value. The Triad sensor can now be used to send data to the Feather M0 which will calculate the NDVI index and determine if there is vegetation or not by comparing the current NDVI value with the calibration threshold value. Once a decision is made, the Hypnos on board relay is triggered and any equipment (e.g. Sprayer) will be turned on. All data is logged to the micro-SD card.

$$NDVI = \frac{R_{800} - R_{670}}{R_{800} + R_{670}}$$

NDVI Index Calculation uses red and near infrared bands



Energy Absorption by Plants
Credit: Jeff Carns



Block Diagram of Weed Warden Components

TESTING

To test the Weed Warden, a replicable testing setup was created using a bag of potting soil, a measurable grass sample, and a rolling cart.

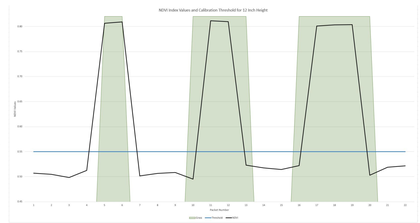
A patch of potting soil used as the base for testing the Weed Warden

A Grass Sample secured with a zip tie and cut to size

Full assembled testing setup with Weed Warden attached to cart and grass sample 'planted' in the dirt sample.

RESULTS

The Graph to the right shows the NDVI values collected from the system (black), plotted alongside the calibration threshold value (blue), and the presence of vegetation (shaded green). The graph clearly shows that the NDVI value spikes above the calibration threshold when vegetation is present meaning that vegetation is accurately detected by the Weed Warden.



Graph of NDVI values plotted next to the calibration threshold and the presence of vegetation

CONCLUSIONS: FUTURE DIRECTION

Affordable weed detection is a technology that can help farmers save money while simultaneously saving the environment. Although the Weed Warden is designed for weed removal applications, the system detects 18 different wavelength bands which can be easily configured to use whatever index the user desires. This means that the user is not limited to using the NDVI index and the Weed Warden can be used for applications other than weed removal.

In the future the OPEnS Lab would like to continue development to improve the system. Next steps for the Weed Warden include: deploying the system on an autonomous rover or a tractor boom to test the Weed Warden's capabilities, implementing multiple triad sensors connected to the same controller in order to cover more area, and a PCB design to include more power management options and a plug and play interface.

ACKNOWLEDGMENTS

Funding for the development of this project was provided by Agricultural Research Foundation Competitive Grants Program, Marcello Moretti, Ryan Graebner, Chet Udell, and Oregon State University.

This work is financially supported by the USDA National Institute of Food and Agriculture, Hatch project NI18HFPXXXXXG055 and the National Science Foundation award #1832170.

Special thanks to Dr. Chet Udell, Cara Walter, and Dr. John Selker for their continued support and guidance throughout this project.

The author acknowledges Brendan Miller, Colton Shaw, and Alissa Bergquist for their work during the early stages of this project.