EECS 280 Project Proposal: Plant Health Imaging For Improved Smart Irrigation

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1 Introduction

Smart irrigation techniques are becoming more common in agricultural environments. Sensor technology has become powerful and efficient enough to allow a network of sensors to be embedded into self improving irrigation systems capable of adapting to weather changes and specific local conditions [1]. This addresses the issue of water consumption relative to the environment. These systems are susceptible to local factors that prevent perfect irrigation such as a malfunctioning mote, blocked sprinklers, or coarse data points. Plant health data incorporated into the current processing pipeline can address this problem, by telling the system which areas need more attention. The focus of this research is to implement a non-invasive way to measure plant health and incorporate it into the PICS system, improving its robustness by providing finer granularity data points.

2 Project

2.1 System

2.1.1 Cameras

The system consists of two cameras, a thermal camera and an optical camera. Temperature data is needed for the plant health algorithm [2] that measures water stress, the optical camera provides more efficient segmentation, which is needed to accurately measure water stress. The segmentation will be performed by an OpenCV program and used to decide which data points from the thermal camera to use. There exists a method developed by Weiping et al. specifically for the task of using thermal cameras and optical cameras in conjunction to measure plant health. The algorithm uses a cross correlation method that aligns the two cameras to correctly decide the data points.

2.1.2 Processing Unit

Finding the proper device to handle the segmenting and computing water stress while also meeting energy requirements will be challenging. An important feature of the current smart irrigation system is complete self sustainability, which harvests energy from the water moving through the pipes. In order to maintain this level of sustainability, the proposed feature could potentially siphon excess energy from the system water source. However, if there is not sufficient energy from this source, introducing solar power is a sustainable alternative, hence finding a board that offers that support.

2.1.3 Image Processing

Plant health imaging technology is still in the early stages of development, and thermal imaging techniques are proven to be more reliable and efficient than others [2]. Segmentation of target plants from its background has a major effect on the accuracy of temperature measurement and health predictions. Properly identifying plants from the background by combining inputs (IR Camera + regular camera) is an existing method of improving the accuracy of thermal plant imaging [3]. The decision to use OpenCV over other image processing libraries is due to it's widespread use in the computer vision community and ease of implementation [4]. In case a pre-trained model for segmenting grass cannot be found, the task of training a model will be simplified, especially with access to publicly available plant image databases.

2.2 Analysis

The energy consumption goal of the implementation is to match the sustainability of PICS, or minimize energy consumption. Given the strict requirements for sustainability, comparing the accuracy of water stress index to better equipped systems can also show the value of the implementation. These measurements prove valuable because they quantitatively demonstrate the systems practicality. A final measurement is recovery time from an incident, inspired by the USB malfunction during PIC testing, the shorter time between irrigation adjustments will lead to better water usage, however this will act as the stretch goal, because it requires integration with the PICS system, which poses numerous, external to the project, challenges. Another interesting measurement is comparing the accuracy with the current PICS system, to show the improvement in granularity provided by the additional data.

Tab. 1: Project Timeline; 12 Weeks

Week of (day/month)	**Task**
16 September	Gather research papers and compile a list of sources
23 September	Design
30 September	Design
7 October	Begin OpenCV program, understand image stitching and segment
14 October	Find databases, continue iterating imaging program
21 October	Continue iterating imaging program
28 October	Understand CWSI calculation (4 different methods)
4 November	Implement CWSI calculation based on segmentation
11 November	Continue iterating programs
18 November	Port to test board and collect data
25 November	Refine program based on tests
2 December	Compile and analyze data
9 December	Finalize and Present Project

References

[1] D. A. Winkler, M. Carreira-Perpiñán, and A. E. Cerpa, "Plug-and-Play Irrigation Control at Scale," in *Proceedings - 17th ACM/IEEE International Conference on Information Processing in Sensor Networks, IPSN 2018*, pp. 1–12, 2018.

[2] L. Li, Q. Zhang, and D. Huang, "A Review of Imaging Techniques for Plant Phenotyping," *Sensors*, vol. 14, pp. 20078–20111, oct 2014.

[3] X. Wang, W. Yang, A. Wheaton, N. Cooley, and B. Moran, "Automated canopy temperature estimation via infrared thermography: A first step towards automated plant water stress monitoring," *Computers and Electronics in Agriculture*, vol. 73, pp. 74–83, jul 2010.

[4] G. Bradski, "The OpenCV Library," *Dr. Dobb's Journal of Software Tools*, 2000.