Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment for Student Success

FINAL REPORT

I.   Project Title
Development of an Automatous Ground Robot for Strawberry Yield Monitoring

II.   Student(s), Department(s), and Major(s)

(1) Shane Thulin, Charlie Ross

(2) BioResource and Agricultural Engineering Department

(3) BRAE

III.   Faculty Advisor and Department
Bo Liu, BRAE

IV.   Cooperating Industry, Agency, Non-Profit, or University Organization(s)
Dr. Balaji Sethuramasamyraja, CSU-Fresno

V.   Executive Summary
This objective of this project was to design and build an autonomous agricultural robot platform that is ready to be adapted for strawberry yield predication. The robot was required to have an all-electric drivetrain as a requirement for the project. A key requirement for this robot is to have the flexibility to be used with different crops and with different applications. It is also designed to be able to change width for use in fields with varying row spacing. The end product of these design requirements is a robot platform that has the capability of supporting a payload in excess of 200 pounds, allowing for installation of equipment for many different applications. The robot has four-wheel drive and four wheel steering capability, all with electric motors and actuators.

VI.   Major Accomplishments
(1) Developed an autonomous ground robot for strawberry identification. A SolidWorks model of the robot was created based on the various design constraints of the robot. The current design featuring the wheels and hub motors is shown in Figure 1.

a)   b)

Figure 1. a) SolidWorks design b) actual robot

(2) A user interface has been developed using C#. The user interface can be used to plan missions, display robot parameters, sensor data collected. The user interface screen shot is shown in Figure 2.

Figure 2. Ground robot control user interface

(3) Developed a fully-automated strawberry yield forecasting system. One component of this system is a machine vision approach for counting strawberries at various stages of growth in images. These counts can then be used to forecast yield in the future. This paper focuses on such a machine vision system. Images can be gathered from drones or using cameras attached to existing tractors. These images can then be processed to determine how many strawberries are present at each stage of growth. For our experiments, a consumer-grade camera was used to take photographs of strawberries in a field on the California State University of San Luis Obispo. The challenging dataset includes more than 400 images from two different perspectives where many berries are severely occluded. The Overfeat neural network model was trained to detect berries. The model is able to identify most of the berries at the various stages. A major advantage of the system is that there is no need for fine-tuning parameters or customization, and the model performed well with just a few hundred labeled training examples.
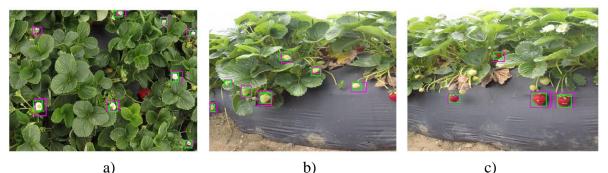
	a)	b)	c)

Figure 3. a) Flower identification b) Green strawberry identification c) red strawberry identification

VII. Expenditure of Funds

Unit	Price/unit	Price
Batteries	$ 812.1	$ 812.1
Motors	$ 1,374.1	$ 1,374.1
Metal, bearings	$ 1,317.2	$ 1,317.2
Electronics, wires and other supplies	$ 1091.94	$ 1091.94
	Total	**$ 4,595.34**

VIII. Impacts to Student's Learning

The students participated in this project were able to integrate electronics, electricity, control systems, sensors and computer interfacing and computer interfacing and computer programming knowledge learned at Cal Poly into the developed robotic system. Students learned how to use different knowledge sets and integrated them into on complex system to solve real-world problems.
This project exposed cutting-edge technologies used in agricultural industry and research to Cal Poly students. After this project, students are aware of some of the cutting edge technologies and methods used in agricultural productions, for example artificial intelligence, autonomous vehicles and big data. The results of this project will also be integrated into several on-going senior projects from CPE and BRAE departments at Cal Poly.

3