PROPOSAL NARRATIVE

I. Project Title

Development of an Automatous Ground Robot for Strawberry Yield Monitoring

II. Abstract

This project proposes to develop an automatous ground robot equipped with a vision system, which is used to identify strawberries and estimate strawberry yield in field, so that labor and equipment demand for strawberry harvesting can be scheduled optimally and early based on the yield estimation. The proposed system has the potential to enable optimal labor and transportation demand scheduling for strawberry harvesting, and to reduce operation costs.

III. Introduction

Thanks to unique and moderate coastal environment year round, California is an ideal place to grow strawberries, and it is also the nation's leading producer of strawberries. California's yearlong growing season contributes to higher strawberry yields per acre than any other growing area. In California, strawberry plants continually produce new fruit throughout their season, and all strawberries are hand-picked. Strawberry growers need to schedule labor demands based on yields over time, which is a very challenging task because of experience-based strawberry yield estimation and labor availability. Shortages of farm labor will also likely persist in the long term regardless of possible changes to immigration law. Therefore, accurate and reliable estimation of strawberry yield determines optimal labor and transportation equipment demand planning, which play a critical role in in-time strawberry harvesting and profit saving for farmers.

We propose an innovated system that utilizes machine vision system on an automatous ground robot as a quick, cheap and reliable method for strawberry yield monitoring. The project's combination of research, design and fabrication aligns with Cal Poly's motto of "learn by doing", and provides the students and faculty an opportunity to develop solutions to real agricultural problems.

IV. Objective(s)

The objectives of this project are to:

1. Develop a vision system to estimate strawberry yield
2. Develop an automatous ground robot equipped with a strawberry yield estimation system

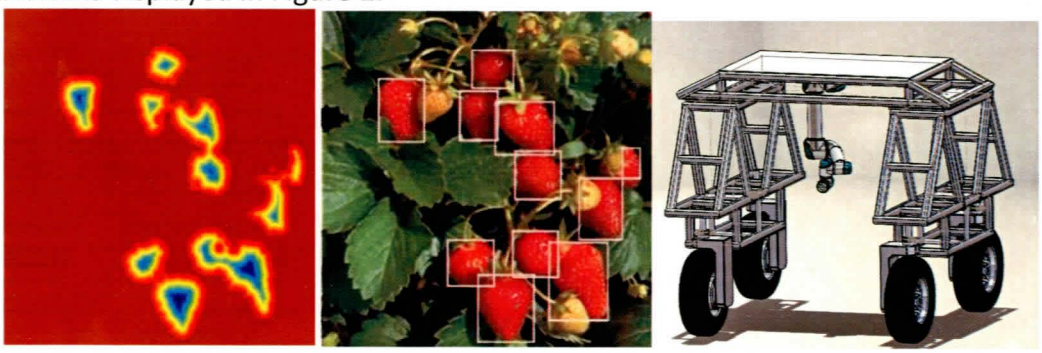
V. Methodology

1. Develop a vision system to estimate strawberry yield:

A stereo vison system based on Microsoft Kinect has been adopted and tested for navigation and objects identification. Images are processed frame by frame. First, we blur the image slightly to reduce sharp edges. Then we convert the color image into a matrix formed by the subtraction of the red channel from the green channel. Figure 1 shows this process.

Figure 1. Channel Subtraction and Preprocessing

The vision system is also used to indentify and locate object (strawberries for example). The distance transform is represented as colors corresponding to the distance value. An example of the distance transform is displayed in Figure 2.



a) b) c)

Figure 2. a) Straw identification, b) distance transform and c) robot platform

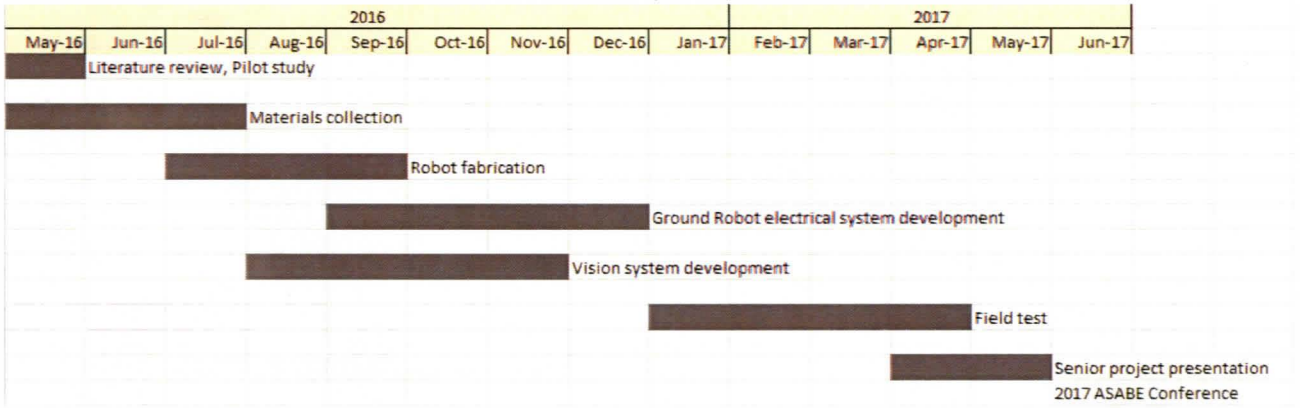
Note that the blue regions correspond to those points that are the farthest from non-red pixels, while the yellow pixels are closer to non-red pixels. Next, the output of the cluster assignment in the Watershed Algorithm is shown. The image in Figure 2-a) is an example of the Watershed Algorithm

output. Each distinct region is labeled with a different color. Figure 2-b) is the image with bounding boxes around the strawberries.We are currently finalizing the vision system to indentify strawberries and the algorithms to estimate strawberry field over time.

2. Develop an automatous ground robot equipped with a strawberry yield estimation system

The project also includes an automatous ground robot which is to be used as the carrier for the vision system of strawberry yield estimation. 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 2-c. Calculations were done in order to determine the power requirements of the robot. The drive motors, steering motors and batteries were selected based on the physical design of the robot. RTK GPS, a small industrial computer and other electrical control circuits will be placed on the robot for navigation and robot control.

Project Timeline



VI. Final Products and Dissemination

1. The final product will be developed and the results will be presented to the 2017 ASABE Conference for the student paper and poster presentation competition.
2. News about this robot will be sent to school and location newspapers, websites and magazines.
3. The final product will be used as senior projects and thesis as well. Poster will be displayed at the Cal Poly BRAE department senior project banquet and CPE department project show.

VII. Budget Justification

$4,600 for robot supplies and materials, which includes fabrication of robot frame, electric motors, motor controllers, metal tubing, electronics, and other necessary tools). 2017 ASABE conference cost (conference registration, traveling and hotel costs will be covered by Dr. Bo Liu's research funds).

PROPOSAL BUDGET

Student Applicant(s):	
Faculty Advisor: Bo Liu	
Project Title: Development of an Automatous Ground Robot for Strawberry Yield Monitoring	**Requested Endowment Funding**
Travel *subtotal*	**$0**
Travel: In-state	$
Travel: Out-of-state	$
Travel: International	$
Operating Expenses *subtotal*	**$ 4,600**
Non-computer Supplies & Materials	**$4,600**
Computer Supplies & Materials	$
Software/Software Licenses	$
Printing/Duplication	$
Postage/Shipping	$
Registration	$
Membership Dues & Subscriptions	$
Multimedia Services	$
Advertising	$
Journal Publication Costs	$
Contractual Services *subtotal*	**$0**
Contracted Services	$
Equipment Rental/Lease Agreements	$
Service/Maintenance Agreements	$
TOTAL	**$4,600**

CAL POLY
SAN LUIS OBISPO
College of Agriculture, Food & Environmental Sciences
BioResource and Ag. Engineering Department

4/25/2016

Baker and Koob Endowments Office of the Provost & Executive Vice President for Academic Affairs San Luis Obispo, CA, 93407

Dear Baker and Koob Endowments Committee,

It is my pleasure to write a letter in support of the application of Mr. Charles Ross for this year's Baker and Koob Endowments. Mr. Charles Ross is a junior student in the BRAE department and he has been one of my research students in the past two years.

He took BRAE 216 Fundamentals of Electricity with me last year, and he was one of the top students in my class. Since then he has been working on our aerial and ground robot research project at BRAE, Cal Poly. He is extremely interested in robots development and applications in an agricultural context, specifically, machine vision. This area is very new and promising, but also requires a multidisciplinary background to get involved in. Mr. Ross is one of the most intelligent and hard-working students I have met here at Cal Poly. He also has a strong background in electronics, engineering design, programming, and precision farming, therefore he is capable of doing this project. He has been making important progress during the past half a year. A ground robot prototype was finished and some machine vision system development has been done by him. One of the major barriers he is facing now is to build the ground robot this year. The award is very important for him to purchase necessary supplies and materials to develop a novel strawberry yield monitoring system to make this project successful and significant. As I know, he is also planning to present his project (conference paper) during the 2017 American Society of Agricultural and Biological Engineers (ASABE) Annual International Conference held July 16-19, 2017 in Washington USA.

I have been mentoring more than 10 students in the EE, CPE and BRAE department on their agricultural robots, wireless sensors network and machine vision related projects.

I strongly believe in Learning-by-Doing and engaging students with real world problems currently faced by agriculture and industry, and also highly encourage Cal Poly students to participate into research projects which can provide students with an ongoing source of one-on-one mentorship, experience of balancing collaborative and individual work, an opportunity of discovering their passion for research. Mr. Ross is a perfect example of discovering an area of interest through undergraduate research.

I am his faculty advisor and will provide technical guidance and support this year. I will also ensure the project budget is followed and all the purchased supplies are kept in good condition, once this project is funded. The Ag Mechatronics Lab in the BRAE department will provide space, essential electrical equipment, and software for him to complete the project. In conclusion, I fully support the efforts of Mr. Ross as he seeks this funding opportunity to support this research project, because the project's fruit will benefit him, our department, and the campus.

Sincerely,

Bo Liu, Ph.D.
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