Small Business Innovation Research Program Phase I NSF Proposal Attempt 2
Topic: Electronic Hardware, Robotics and Wireless Technologies (EW) Subtopic: Robotics and Human Assistive Technologies (RH): RH2. Robotic Applications.
Joseph Crandall - Characters: 3923 (with spaces)

Box 1: Overview, Key Words, and Subtopic Name:
The topic is Electronic Hardware, Robotics and Wireless Technologies (EW) and the subtopic is Robotics and Human Assistive Technologies (RH): RH2. Robotic Applications. Joseph Crandall is conducting Schuck Robotic Manipulation and computer vision research in order to develop a robotic system that can image and manipulate a plant. This point cloud based imaging research has the potential to generate savings for agricultural products that require human labor and dexterity to harvest. The system will also provide point cloud over time data for botanists working to quantitatively measure plant development. The following resources are being used for the robotic component of the project and can be treated as key words, Schunk ROS Package (http://wiki.ros.org/schunk_canopen_driver), Peak-systems Linux (http://www.peak-system.com/PCAN-USB.199.0.html?L=1), ROS Kinetic Kame (http://wiki.ros.org/kinetic), ROS Control (http://wiki.ros.org/ros_control), ROS Gazebo Integration (http://gazebosim.org/tutorials?tut=ros_overview), and Yale OpenHand Project (https://www.eng.yale.edu/grablab/openhand/).

Box 2: Intellectual Merit

The Robotics component of the research encompasses three main technical challenges, gaining a working understanding of a prebuilt ROS package for the Schunk LWA 4P in order to drive the arm, a working understanding of the Gazebo robotic simulator in order to run a simulation of the Schunk LWA 4p, and using sensory point cloud data from an Xbox kinetic inside of a simulation world in order to give the robot arm sensory information. Once functional, the arm will be able to perceive, through the point cloud, complex geometric structures and be able to interact with them via a point cloud to mesh conversion software.

This project will require the developer to become familiar with all of these packages mentioned in the overview section in order to integrate them for the Schuck Robotic System. Many of the basic features needed for this project have already been implemented and refined by the robotic operating system open source community. To use one's development time wisely it is beneficial to become well versed in what has previously been done to avoid duplication of code.

This research should be viewed as both a learning experience and a development process. The student will gain a better understanding of ROS and its community in order to drive the robotic system. The student will also implement software to interpret the point cloud data to make it usable for the robot.

Box 3: Broader/Commercial Impact:
This project will make Robotic tools for interacting with biological processes more useful to biological researchers and more commercially viable across many agricultural sectors. Although automation in machining and manufacturing has been well developed, the same principles for these controlled closed environments do not always lend themselves to dynamic ones.
However, many dynamic biological environments could be automated with this technology. One example is for fruit harvesting and indoor/vertical farming. The orientation of the plant sites can

be controlled, and with this system a point cloud to mesh interpretation of the plant would allow the robotic arm to grasp the biological structure and harvest it.

Small Business Innovation Research Program Phase I Elevator Pitch
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The Customer

The natural world is chaotic and continuous. Researchers trying to find the patterns in its many intricacies are faced with a gauntlet of challenges. Greater still are the challenges faced by businesses whose economic viability depends on natural processes that can be disrupted, through no fault of the produced, by natural cataclysms. In such a world, it is helpful to implement some form of mechanization in order to both produce quantitative biological studies and reap greater returns when natural conditions are favorable for industrial agriculturalist.

The scientific botanist or biologist would benefit from using a plant imaging and manipulation platform because it would provide the scientist with systematic and reproducible point cloud and mesh data of the the plant under investigation over an extended duration of time. Certain plants could be monitored from origin to death with minute to minute precision. This data could then be used to create 3 dimensional movies of the plant development. The level of accuracy provided by the xbox kinect point cloud camera is what distinguishes our platform from any manual data gathering alternative. Even the most diligent and observant single graduate student does not have the stamina to observe and record plant development every minute for a 3 to 6 month period. A team of graduate students could be employed to do this, but this would take time away from their study and analysis of the data. When comparing opportunity cost of time spent for these graduate students, and astute PI would see the value of our plant imaging and manipulation platform data acquisition process.

The industrial agriculturalist would have the ability to use our prototype system to explore harvesting techniques in traditional and indoor farming for monitoring and harvesting of delicate produce. The plant imaging and manipulation system is **not mobile** so its manipulation range is limited to the area of the circular stand on which it is mounted. A potted fruit or vegetable plant could be placed on table. The plant growth would be monitored and when the fruit coloration and size met a predetermined characterization, perhaps based on a continuously refined machine learning algorithm, the Schuck arm and gripped would be manipulated to grasp the fruit, harvest it, and place it in a desired location within the range of the arm.

The Value proposition

Our plant imaging and manipulation system will save the research or industrialist man hours that would be monotonous, and in some cases impractical for a single human to conduct. When deciding whether to purchase our system, the buyer would only have to ask themselves what their current labor costs are, factor in elongated costs such as pensions or healthcare for the industrialists, or opportunity cost for the the PI's graduate student's whose time would be better spent analysing the now autonomously acquired data. If the buyer believes that this cost is greater than the cost of our system, we think that an intelligent consumer would decide to purchase the plant imaging and manipulation system.

The innovation

Our innovation is **not** the development of a new technology, rather the pairing of two separate fields within computer science in order to develop and system that can succeed in imaging and harvesting the polysemous low hanging fruit. We are going to utilize a computer vision algorithm the translates point clouds to meshes. We send this data to a Gazebo simulation. The simulation will give a frame of reference for the robot and the plant. We will then calculate the prefered route for the Schunk arm to move. These movement commands will be sent as instructions and implemented via the ROS operating systems. This pairing of physical manipulation, simulation, point cloud sensory data, and mesh conversion is what makes our product unique. All though autonomous harvesting of grains has been available since the invention of the combine harvester, there is a lack of options for autonomous harvesting of delicates items such as produce, which is primarily harvested by hand. We hope to add another options to the researcher and or farmer's toolbox if they see fit to buy our product.