Karl Preisner
Senior Design - Design Document

Overall Description

The goal of the project is to develop a system that can generate a point cloud model of a biological sample. At the conclusion of this research, botanists will be able to measure plant development by analyzing point cloud data.

The project will introduce an affordable means of quantitatively measuring plant samples via point cloud data collected from a 3D scanning device. The device is a 4’ diameter circular table with a motorized camera arm that can circumnavigate the table to produce a 360-degree model of the table.

Description of the Users

Botany researchers will use this device to create a sequence of three dimensional models over a long duration of the plant’s development. From this model, the researchers will be able to extrapolate data regarding plant shape, volume, color, and temperature.

Produce agriculturalists will use this device in conjunction with the Schunk Robotic Arm to automatically harvest produce. The 3D scanner will gather data on the plant. An algorithm will use the data identify ripe fruit. Then the Schunk Robotic Arm will use the 3D model to move to the fruit’s location and harvest it from the plant.

Use Cases

Moving the camera arm:

After a signal is received from the program to move the Kinect camera to a specific location, a Python script calculates the inverse kinematics of the motors in the arm. The result of this calculation is what position each individual motor must move to in order to position the camera in the proper place. Now, a signal is sent to the motor controller Python script to move the individual motors.

Greedy camera scan:

This function contains a predefined set of camera locations to travel to in order to completely scan an object. This function does not take into account redundancies in image scans. For example, a scan from two nearby locations can capture an image of the same location of the scanned object.

Major Hardware Components

Raspberry Pi 3

- Ubuntu distribution
- Controls stepper motor and linear actuators

Stepper Motor:

- Nema 23 Stepper Motor
- 2/4 phase Nema 23 Stepper Motor Driver 24-50VDC 1.5A-4.5A 256 Microstep M542T
- Switching Power Supply 350W 24V 14.6A for CNC Router Kits 115V/230V S-350-24
- Moves the arm 360 degrees around the circumference of the table by spinning a timing belt that is attached to the camera arm.

Linear Actuators:

- ServoCity 12" Stroke 25 lb Thrust Heavy Duty Linear Actuator (2x)
- Assembled Actobotics® Dual Motor Controller
- Switching Power Supply 350W 24V 14.6A for CNC Router Kits 115V/230V S-350-24
- Controls the major joints in the camera arm

Servo Gearbox:

- CM-785HB Servo Gearbox
- Attached to the end of the camera arm with Kinect Camera mounted to this
- Provides a means of tilting the camera for a larger field of view

Kinect Camera:

- Captures images for the scan
- Mounted at the end of the camera arm

Major Software Components

Stepper Motor Controller (Aug 2016 - Sep 2016)

- Python script to control the stepper motor.
- Function to turn the motor by a predefined number of steps either clockwise or counterclockwise.
- Function for acceleration and deceleration when travelling a large number of steps. This prevents damage to the motor by accommodating for inertia in the camera arm.

Linear Actuator Controller (Nov 2016 - Dec 2016)

- Python script to control the linear actuators.
- Function to move the linear actuator to a predefined position using the potentiometer readings from the linear actuator.

Servo Gearbox Controller (Dec 2016 - Jan 2017)

- Python script to control the servo gearbox.
- Function to move the servo gearbox to a predefined position using the potentiometer readings from the servo motor.

Inverse Kinematics (Jan 2017 - Feb 2017)

- Python script to move the camera arm to a predefined location.
- This will use inverse kinematic calculations to determine the correct combination of angles in the joints that will position the Kinect camera in predefined location.
- Once the angles for the joints are calculated, a signal will be sent to move the motors to those positions.

Greedy Scan (Feb 2017 - Feb 2017)

- Python script to create a greedy 3D scan of any object on the observation table.
- This will move the motors to a predefined set of positions so the Kinect camera can record a scan at each of those positions.