Mini Project 2: 3D Scanner

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This code is used to run the Arduino, collect 3D scan data while moving the scanner using a pan and tilt servo. The collected data is then processed and displayed. To use this code, change the Arduino port to match what it is in device manager, and make sure the pins of the IR sensor and servos match those in the 'setUp' function in the bottom section of the code.

```
% Initial setup
clc
clear
[robotArduino, rawRangeIn, blinkLED, panServo, tiltServo] = setUp('COM6');
disp('Collecting Data')
```

```
Collecting Data
```

```

% Create Calibration Data Manually
%distanceData = calibrationLoop(robotArduino,rawRangeIn,blinkLED);
%plot(distanceData(:,2), distanceData(:,1),'*');
%ff = createFit(distanceData(:,2), distanceData(:,1));

%This calibration data is taken from the specification sheet of the IR
%sensor. We also ran several trials where calibration data was manually
%inputted.
dataSheetCalibration = [15 2.75; 20 2.55; 30 2; 40 1.55; 50 1.25; 60 1.05; 70 0.9; 80 0.8; 90 0
```

```
dataSheetCalibration = 15×2
   15.0000    2.7500
   20.0000    2.5500
   30.0000    2.0000
   40.0000    1.5500
   50.0000    1.2500
   60.0000    1.0500
   70.0000    0.9000
   80.0000    0.8000
   90.0000    0.7000
  100.0000    0.6000
      ⋮
```

```
load("fitteddecaymodel.mat"); % fitted model for the data sheet

ff = fit(dataSheetCalibration(:,2),dataSheetCalibration(:,1),fittedmodel);
```

```
ff = 
     General model Power1:
     ff(x) = a*x^b
     Coefficients (with 95% confidence bounds):
       a =       60.79  (56.19, 65.4)
       b =      -1.117  (-1.241, -0.9919)
```

```
figure
hold on
x = linspace(.2,5);
y = fittedmodel.a*x.^(fittedmodel.b);
```

```
y = 1×100
  366.7544  287.8110  235.8651  199.2152  172.0400  151.1259  134.5575  121.1241 ···
```

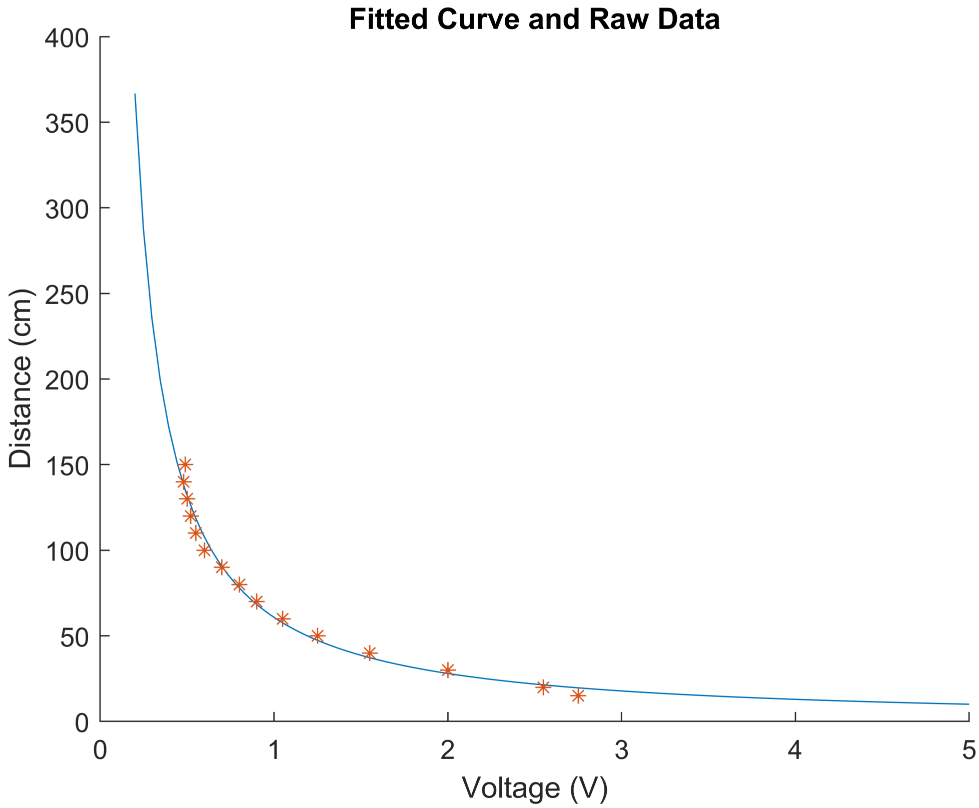
```
plot(x,y)
plot(dataSheetCalibration(:,2),dataSheetCalibration(:,1),'*');
title('Fitted Curve and Raw Data');
xlabel('Voltage (V)');
ylabel('Distance (cm)');
hold off

%Now collect the scan data
```

```
Time for Trials
```

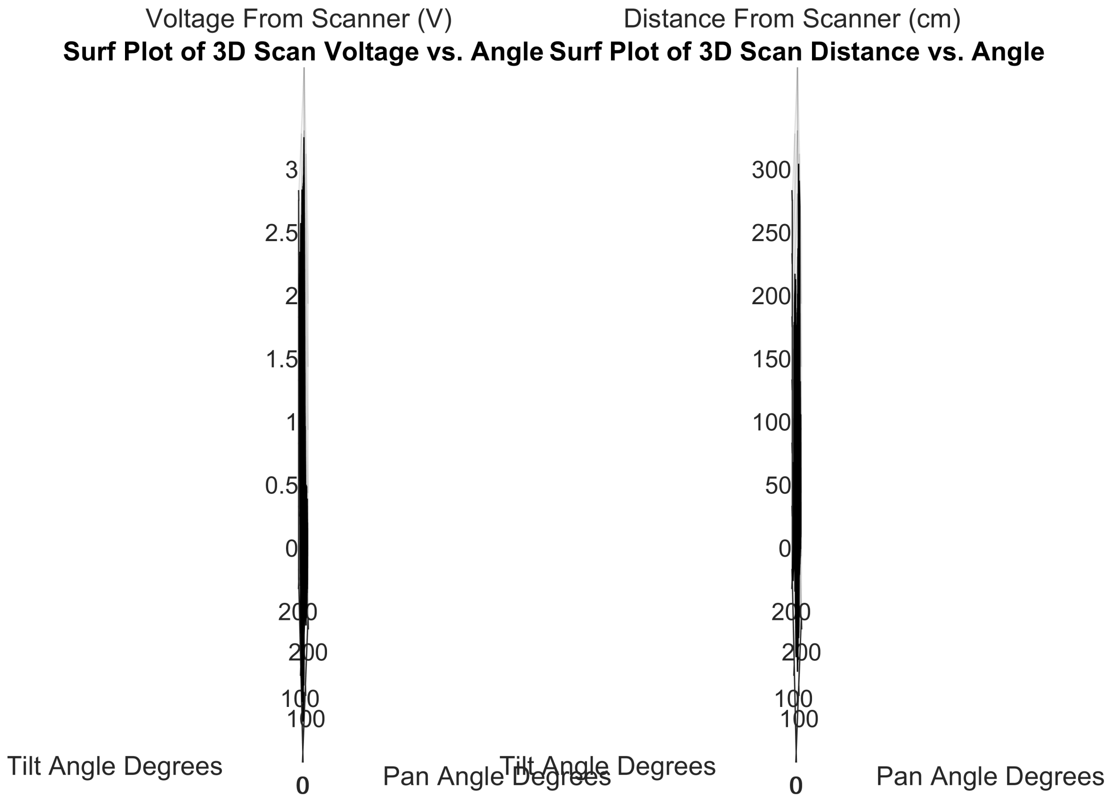
```
[numTests, trialData] = positionOverAngle(robotArduino, rawRangeIn, panServo, tiltServo, blinkL
```

```
Finished Collecting
numTests = 50
trialData = 2500×3
    0.8244         0         0
    0.8407         0    0.0204
    0.8309         0    0.0408
    0.8684         0    0.0612
    0.7348         0    0.0816
    0.7527         0    0.1020
    0.7071         0    0.1224
    0.6712         0    0.1429
    0.7022         0    0.1633
    0.6517         0    0.1837
      ⋮
```

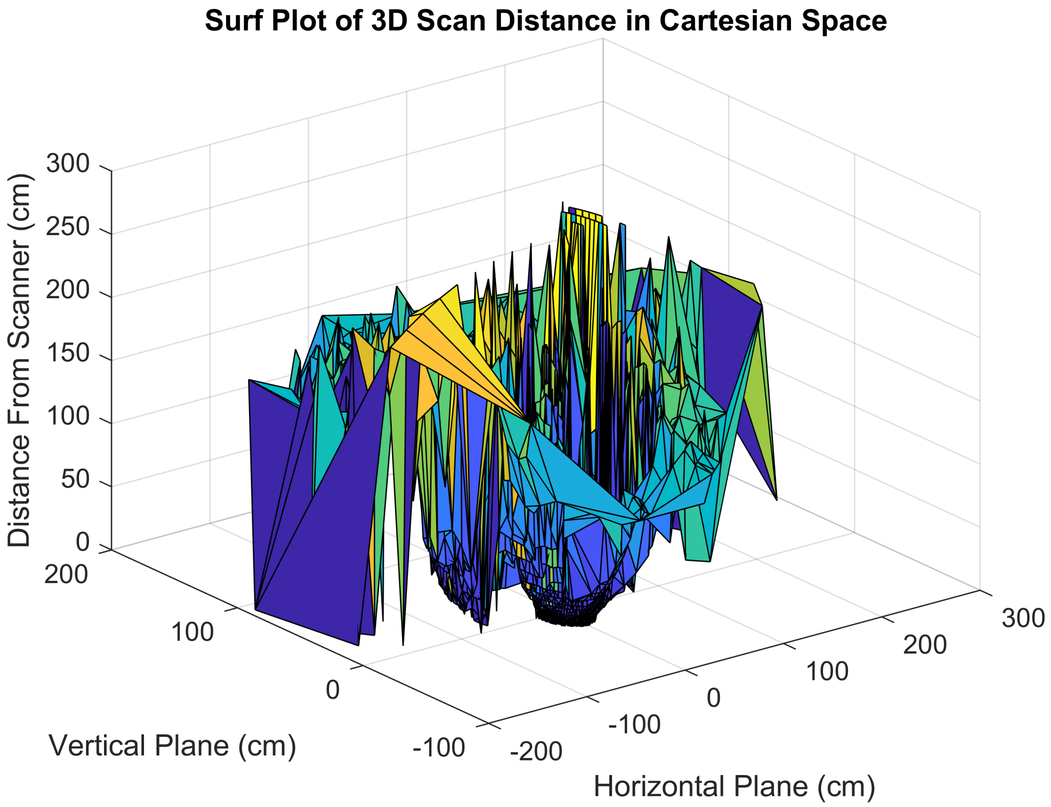
```

% Convert voltage to distance (cm) using calibration curve
distance = zeros(numTests,1);
voltage = trialData(:,1);
for i = 1:length(voltage)
    curr = (voltage(i));
    distance(i) = ff(curr);
    if distance(i) > 300
        distance(i) = 300; % Get rid of outliers due to exponential fitted curve
    end
end
```



```
% Graph results
% Surf plots
panAnglesRad = trialData(:,2)*3.14;
tiltAnglesRad = trialData(:,3)*3.14;
figure
subplot(1,2,1)
tri=delaunay(trialData(:,2),trialData(:,3));
trisurf(tri,trialData(:,2)*180,trialData(:,3)*180,voltage)
title('3D Scan Voltage vs. Angle')
xlabel('Pan Angle Degrees')
ylabel('Tilt Angle Degrees')
zlabel('Voltage From Scanner (V)')
subplot(1,2,2)
trisurf(tri,trialData(:,2)*180,trialData(:,3)*180,distance)
title('3D Scan Distance vs. Angle')
xlabel('Pan Angle Degrees')
ylabel('Tilt Angle Degrees')
zlabel('Distance From Scanner (cm)')
hold off
```



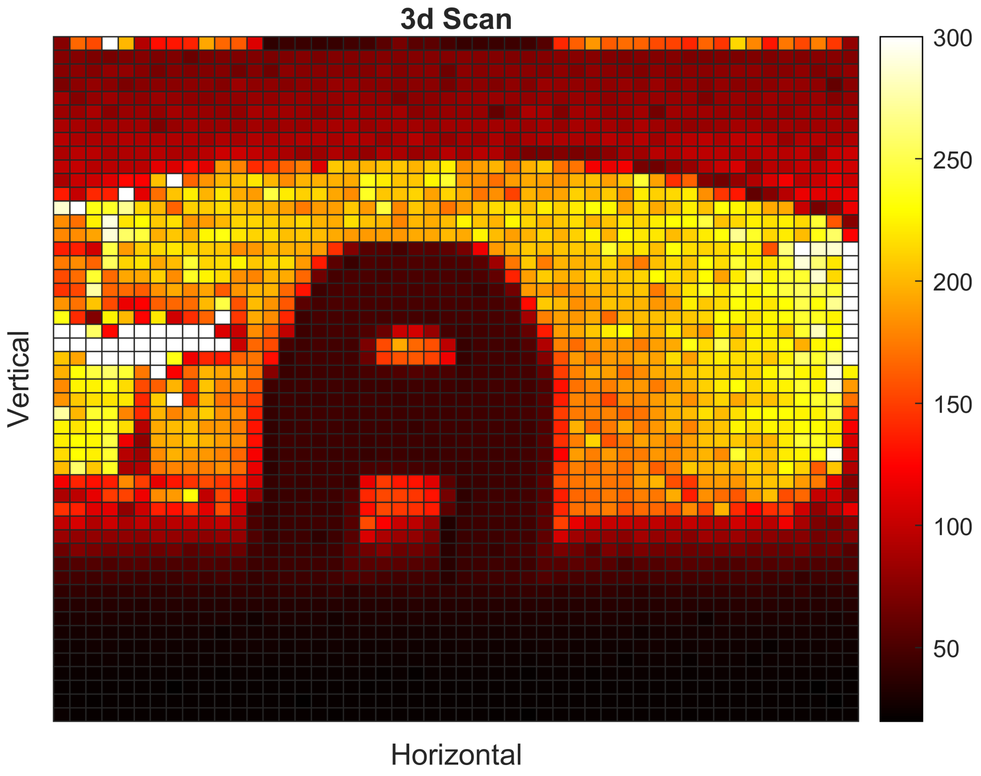
```
figure
[x,y,z] = sph2cart(panAnglesRad,tiltAnglesRad,distance);
tri = delaunay(x,y);
trisurf(tri, x, y, z)
title('3D Scan Distance in Cartesian Space') %This seems to have some issues
xlabel('Horizontal Plane (cm)')
ylabel('Vertical Plane (cm)')
zlabel('Distance From Scanner (cm)')
```



```
cartData = [distance panAnglesRad tiltAnglesRad]
```

```
cartData = 2500×3
   75.4260         0         0
   73.7956         0    0.0641
   74.7657         0    0.1282
   71.1722         0    0.1922
   85.7680         0    0.2563
   83.4909         0    0.3204
   89.5280         0    0.3845
   94.8828         0    0.4486
   90.2242         0    0.5127
   98.0668         0    0.5767
      ⋮
```

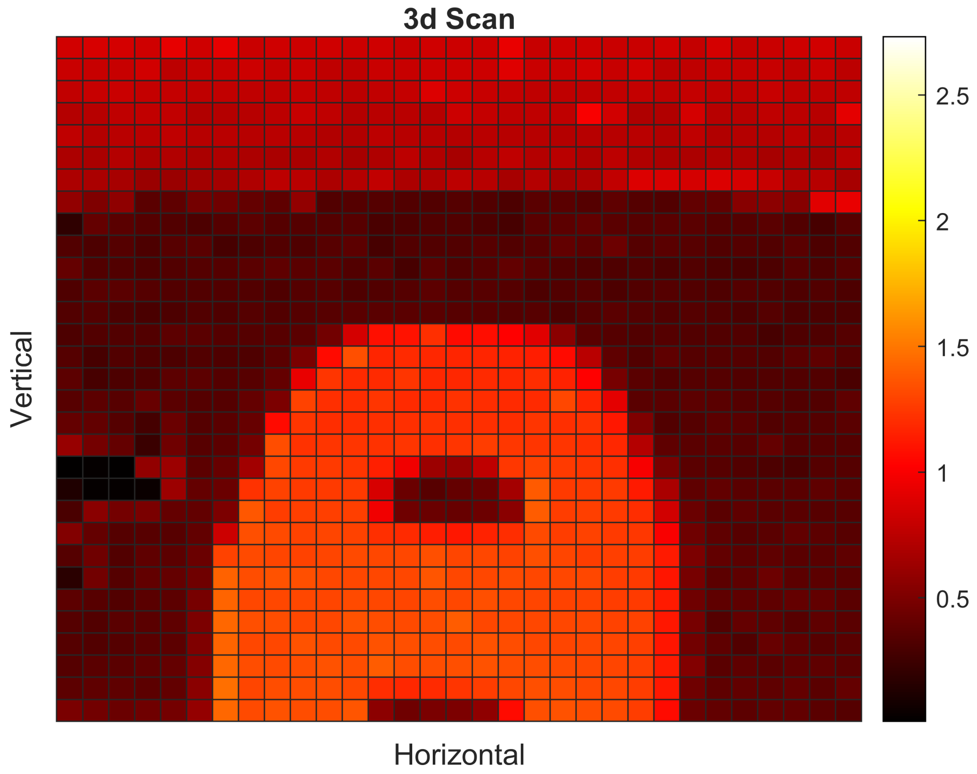
```
dataTable = array2table(cartData, 'VariableNames',{'Distance','Horizontal','Vertical'});
SCAN = heatmap(dataTable,"Horizontal","Vertical",'ColorVariable',"Distance","Title","3d Scan",
SCAN.XDisplayLabels = nan(size(SCAN.XDisplayData));
SCAN.YDisplayLabels = nan(size(SCAN.YDisplayData));
```



```
%Heat Plots
figure
title('Surf Plot of 3D Scan Voltage in Cartesian Space')
xlabel('Horizontal Plane (cm)')
ylabel('Vertical Plane (cm)')
zlabel('Voltage From Scanner (V)')
cartData = [voltage panAnglesRad tiltAnglesRad]
```

```
cartData = 2500×3
    0.8244         0         0
    0.8407         0    0.0641
    0.8309         0    0.1282
    0.8684         0    0.1922
    0.7348         0    0.2563
    0.7527         0    0.3204
    0.7071         0    0.3845
    0.6712         0    0.4486
    0.7022         0    0.5127
    0.6517         0    0.5767
       ⋮
```

```
dataTable = array2table(cartData, 'VariableNames',{'Voltage','Horizontal','Vertical'});
SCAN = heatmap(dataTable,"Horizontal","Vertical",'ColorVariable',"Voltage","Title","3d Scan",
SCAN.XDisplayLabels = nan(size(SCAN.XDisplayData));
SCAN.YDisplayLabels = nan(size(SCAN.YDisplayData));
```



```
figure
title('Surf Plot of 3D Scan Voltage in Cartesian Space')
xlabel('Horizontal Plane (cm)')
ylabel('Vertical Plane (cm)')
zlabel('Voltage From Scanner (V)')
cartData = [voltage x y]
dataTable = array2table(cartData, 'VariableNames',{'Voltage','Horizontal','Vertical'});
SCAN = heatmap(dataTable,"Horizontal","Vertical",'ColorVariable',"Voltage","Title","3d Scan", 
SCAN.XDisplayLabels = nan(size(SCAN.XDisplayData));
SCAN.YDisplayLabels = nan(size(SCAN.YDisplayData));

% Put pan and tilt servos back in neutral position.
writePosition(panServo, 0.5);
writePosition(tiltServo, 0.5);
clc
disp('Finished');
```

```
Finished
```

```
clear robotArduino
```

Function Block

```
function [robotArduino, rawRangeIn, blinkLED, panServo, tiltServo] = setUp(COMPORT) %setup code
    robotArduino = arduino(COMPORT, 'Uno', 'Libraries', 'Servo');
    blinkLED = 'D13'; %Optionally add an LED instead of print statements
    configurePin(robotArduino, blinkLED, 'DigitalOutput');

    rawRangeIn = 'A1'; %Attach IR sensor to this pin
    configurePin(robotArduino,rawRangeIn,'AnalogInput');

    panServo = servo(robotArduino, 'D9', 'MinPulseDuration', 10*10^-6,...
    'MaxPulseDuration', 1925*10^-6);
    tiltServo = servo(robotArduino, 'D11', 'MinPulseDuration', 10*10^-6,...
    'MaxPulseDuration', 1925*10^-6);
    writePosition(panServo, 0.5); % always start servo-command at 0.5
    writePosition(tiltServo, 0.5); % always start servo-command at 0.5
    pause(7.0); % wait for arduino to send stable PWM
end

% This function blinks an LED n number of times
%
%  @ params
% a     the arduino object
% LED   LED pin
% n     number of times to blink
function [] = Blink(a,LED,n)
        for bIndex = 1:n
            writeDigitalPin(a,LED,0);
            pause(0.2);
            writeDigitalPin(a,LED,1);
            pause(0.2);
        end
end

% This function returns the output voltage of the IR sensor
%
%  @ params
% robotArduino      the arduino object
% rawRangeIn        analog sensor pin
function rangeData = sensing(robotArduino, rawRangeIn)
    pause(0.01)
    rangeData = readVoltage(robotArduino, rawRangeIn);
end

% This function creates an array of voltage and input distance data that
% can be then graphed and turned into a calibration curve. The user must
% manually move an object a measured distance away and input the distance
% when prompted. The first distance is collected immediately after being
% asked for the number of tests.
%
% @ params
% robotArduino      the arduino object
% rawRangeIn        analog sensor pin
% blinkLED          LED pin
function distanceData = calibrationLoop(robotArduino, rawRangeIn, blinkLED)
    numTests = input(['Enter number of tests']);
    clc;
    distanceData = zeros(numTests, 2);
    r = rateControl(0.25);
    reset(r);
    index = 1;
    while(index < numTests+1)
        rangeData = sensing(robotArduino, rawRangeIn);
        distanceData(index,1) = input('Enter distance(cm): ');
        gtest = input('Move to new distance then hit enter', 's');
        distanceData(index,2) = rangeData;
        Blink(robotArduino,blinkLED,1);
        waitfor(r);                     % wait for loop cycle to complete
        index = index+1;      % increment loop
    end
end

% This function plots the calibration data created manually, but does not
% add a calibration curve. This was used for earlier testing rather than
% the final project.
%
% @ params
% distanceData      output of the calibrationLoop
function plotCalibrationData(distanceData)
    % Plot and store command postion data vs. actual postion
    plot(distanceData(:,1), distanceData(:,2), '*')
    xlabel('Actual position')
    ylabel('Measured Voltage')
    hold off
end

% This function collects analog sensor data over an inputted number of
% trials. This was also used earlier on in testing rather than the final
% product.
%
% @ params
% robotArduino      arduino object
% rawRangeIn        analog sensor pin
% blinkLED          LED pin
function [numTests, trialData] = positionOverTrials(robotArduino, rawRangeIn, blinkLED)
    numTests = input(['Enter number of tests for trial']);
    trialData = zeros(numTests,1);
    index = 1;
    while(index < numTests + 1)
        rangeData = sensing(robotArduino, rawRangeIn);
        trialData(index) = rangeData;
        Blink(robotArduino,blinkLED,1);
        pause(.2)
        index = index + 1;
    end
    disp('Finished Collecting')
end

% This function runs the panning and tilting code for the two servos while
% collecting data at every position. When prompted to enter the number of
% tests for the trial, the trial will be nxn samples.
%
```

```
% @ params
% robotArduino      arduino object
% rawRangeIn        analog sensor pin
% panServo          pan servo pin
% tiltServo         tilt servo pin
% blinkLED          LED pin
function [numTests, trialData] = positionOverAngle(robotArduino, rawRangeIn, panServo, tiltServ
    numTests = input(['Enter number of tests for trial']);
    trialData = zeros(numTests,3);
    angles = linspace(0,1,numTests);
    index = 1;
    for i = 1 : numTests
        writePosition(panServo, angles(i));
        pause(0.2);
        for j = 1 : numTests
            writePosition(tiltServo, angles(j));
            pause(0.2);
            %rangeData = sensing(robotArduino, rawRangeIn); %non averaged
            %value
            rdat1 = (sensing(robotArduino, rawRangeIn));
            rdat2 = (sensing(robotArduino, rawRangeIn));
            rdat3 = (sensing(robotArduino, rawRangeIn));
            rangeData = mean([rdat1 rdat2 rdat3]); %averaged to reduce noise
            trialData(index,:,:) = [rangeData angles(i) angles(j)];
            Blink(robotArduino, blinkLED, 1);
            index = index + 1;
        end
    end
    disp('Finished Collecting')
end
```