Robotic Arm

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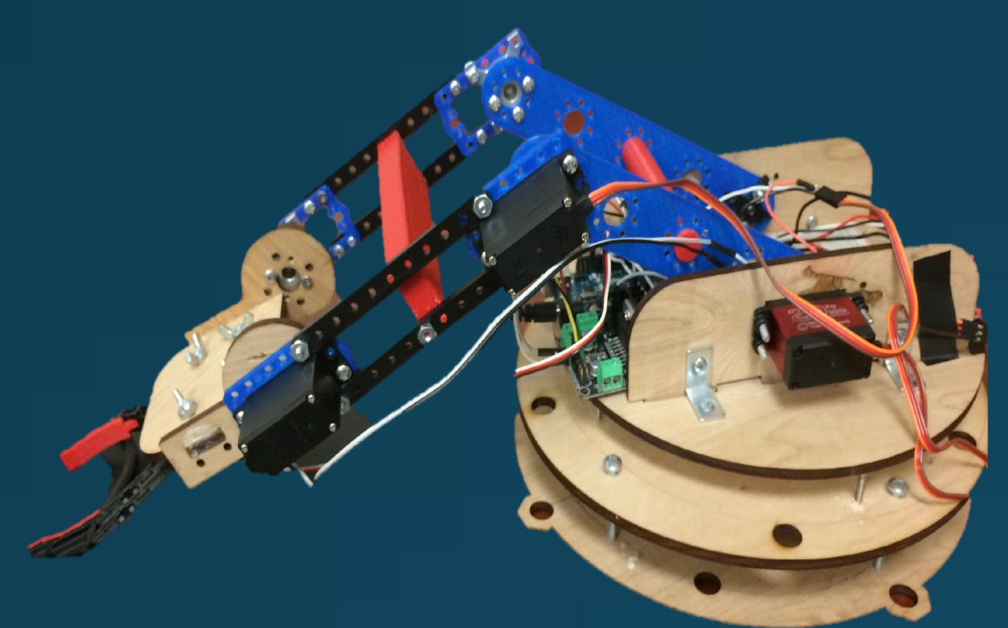
Goal and Objective

The goal of this robotic arm project is to create a fully autonomous mechanical arm capable of identifying the objects it grabs, and sorting these arbitrary objects by its physical characteristics. The position of the object in 3D space, along with the dimensions and colors of the object, will be obtained through the use of cameras. The team designed and fabricated an arm with the proper degrees of motion necessary to achieve these tasks.

Bigger Picture

Understanding the artificial intelligence and robotics of this project allowed us to develop an arm capable of obtaining feedback from its surroundings. This research can be applied to further the abilities of robots used in situations in which humans cannot be involved due to hazardous risks. This project aims to grow by applying additional sensors continue recording physical characteristics of the objects the arm picks up.



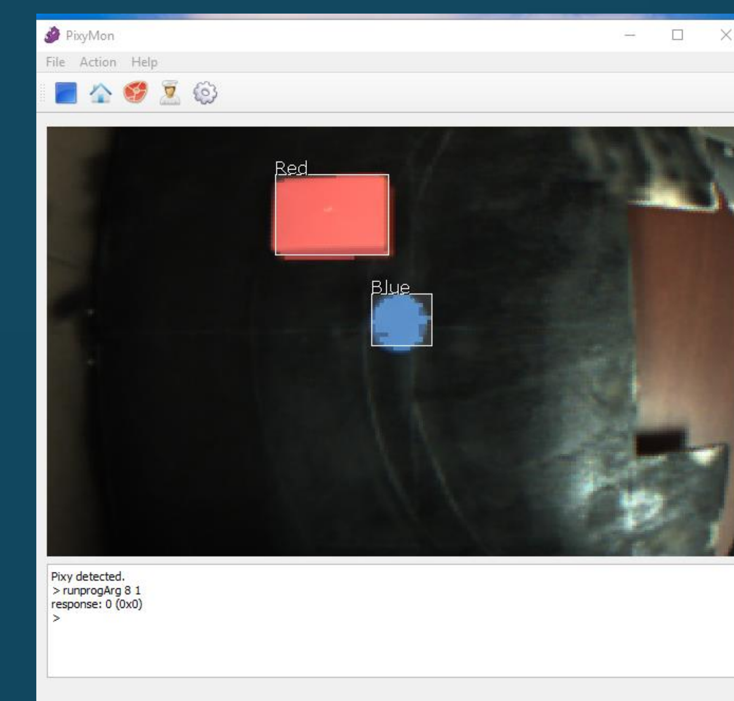
Budget

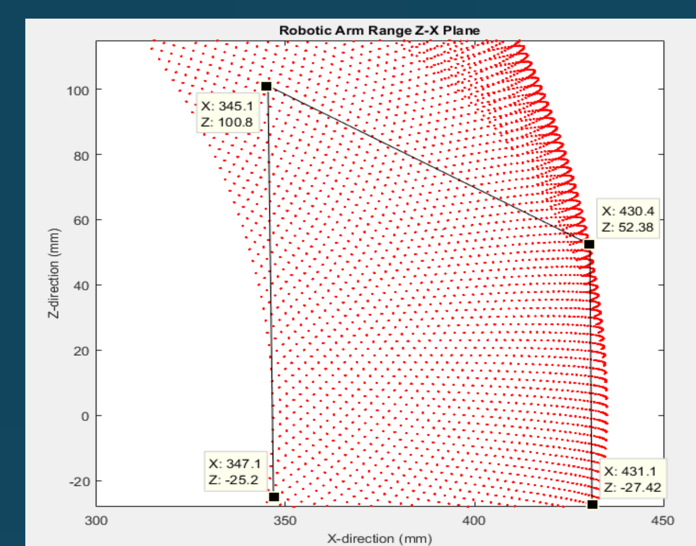
Cost of one Robot Arm Prototype			
Part/Material	Cost	Quantity	Total
Plywood/Hardwood	$20.00	1	$21.55
3D Printed Parts	$17.33	1	$18.67
Joint Bearings and servo components	$26.99	2	$58.16
Standard metal bearing servos	$6.21	2	$13.38
Large metal bearing servo	$19.00	2	$40.95
Standard plastic bearing servo	$12.27	4	$52.88
Wall adapters (standard servos)	$5.69	5	$30.65
Wall adapter (large servo)	$10.48	1	$11.29
Nuts & Bolts	$15.00	1	$16.16
Arduino	$27.08	2	$58.36
Arduino Mega	$52.35	2	$112.81
Pixy Cameras	$69.00	2	$148.70
Bread Board and Wires	$17.86	1	$19.24
H-Bridge	$9.99	1	$10.76
Robotic Claw	$15.00	1	$16.16
		total	$629.74

Current Status

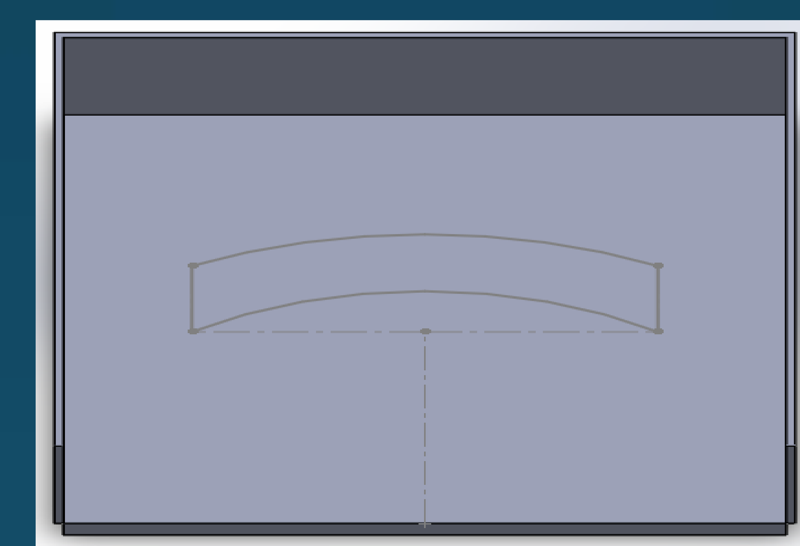
Color detecting cameras and platform:

Using Pixy cams, which can be programmed to detect colored objects, we created a platform with 3 surrounding walls to enclose our working system. A camera at the top and another placed perpendicular to it at the bottom allowed for a 3D space profile. We then calculated the distance per pixel to obtain a coordinate system and dimensions of the object.





Matlab generated plot of X-Y range of the robot arm.
Actual Range:
346.85 (mm) < X < 431.55 mm
-28.1 (mm) < Z < 130.125 (mm)
Equation: Z = 330.6 - .578X
Describes the max height possible for an object within the X-direction range as X changes.The difference in height at different X values is due to the angle at which the pixy cam operates. Z begins at -28.1 mm because the first joint of the arm is 28.1 mm above the ground.



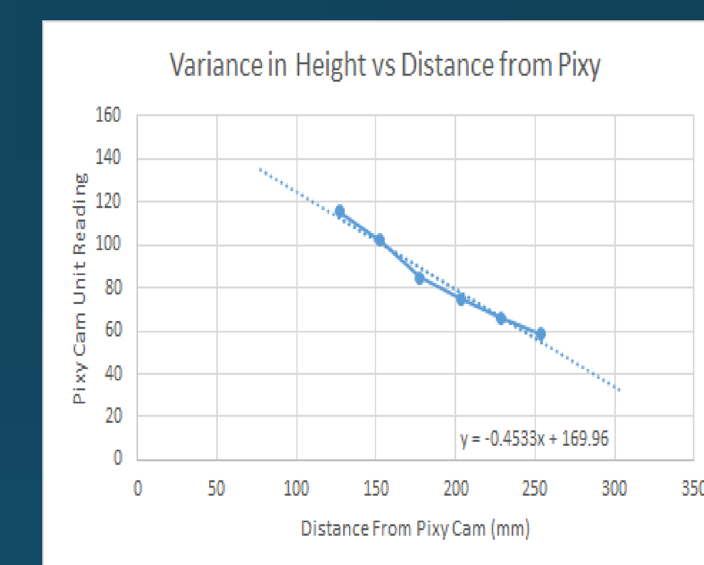
Arm Range Equations
$(X^2) + (Y^2) = (R^2)$
346.85 (mm) < R < 431.55 (mm)
346.85 (mm) < X < 431.55 mm
-183.36 (mm) < Y < 183.36 (mm)
Y limits set by the imaging range of the top pixy cam
X limit determined by the mobility of the arm

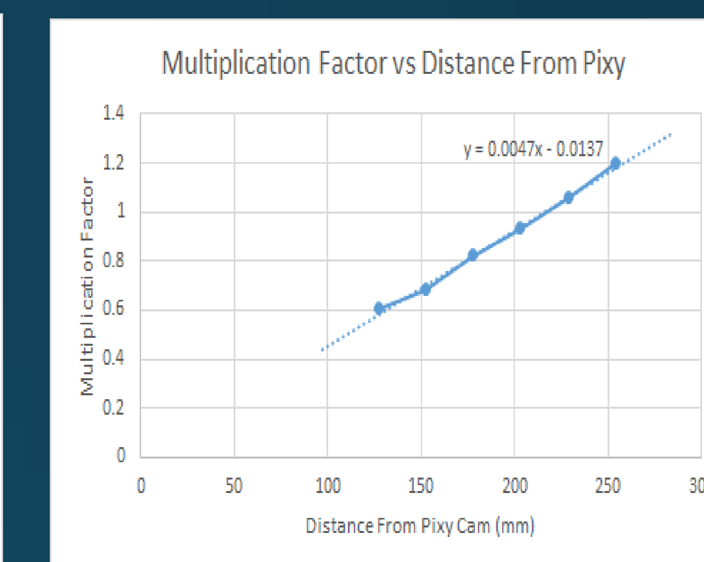
Inverse Kinematics:
Application of inverse kinematics was necessary in order to achieve proper arm motion. Successful integration involves writing trigonometric equations in our code. These equations take into account the degrees of freedom as well as the total linkages and their lengths in our system. By obtaining the 3D coordinates of the object using cameras, the coordinates will be input into the trigonometric equations which will then output the angles at which the joints of the linkages must be placed in order for the arm to be able to lift the object.

Results

	Width-in	Height - ir	W - mm	H - mm	W reporte	H reporte	WRange m	Hrnge mm	W-Deviati	H-Deviatio	W-% Err	D-%Error
Small	0.9375	0.9375	23.8125	23.8125	13	13	1.832	1.832	0.132	0.068	7.748869	3.839613
med	3.5	2.375	88.9	60.325	55	36	1.616	1.676	-0.084	-0.088	4.919786	5.005984
large	3.5	7	88.9	177.8	52	102	1.710	1.743	0.010	-0.021	0.565611	1.182695
largest	8.66	7.50	219.87	190.50	133.82	105.4545	1.643	1.806	-0.057	0.042	3.350533	2.407342
average							1.700	1.764	0.074	0.054	4.377094	3.065802

Results	Multiplication Factors (mm/unit)	
	Width	Height
Value	1.7	1.764
Standard Deviation	0.074	0.054
Confidence	95.6	96.9





Interpretation: As the distance of the object from Pixy increases, the multiplication factor to obtain proper unit conversion, from Pixy units to mm, increases. This is due to the decrease in registered Pixy units. The following equation will allow us to predict the multiplication factor as the distance increases in order to have accurate units.
$F = .0047(609.6-((x^2+y^2)^{.5}) .0137$
Our X-direction coordinate is read starting at the arm, and the camera is on the opposite side of our platform, resulting in the equation above.

Next Step

In the future, we would like to add additional sensors to further the applications of this arm. Attaching heating pads to certain objects and adding heat sensors to the arm could allow for heat detection which can be useful in various fields or projects. This continuation in the project can be very useful to us or other students when it comes to applying this knowledge in the real world.

Another major part of the project that needs follow up is the control of the arm through serial monitor input. Although the arm is autonomous, we would like to be able to give commands, such as changing the color of the object it is supposed to find, through serial communication. This gives us the ability to control the arm, while still having the artificial intelligence to find an object.

October
- Begin initial research of robotic arms. We must decide on a specific task we want the arm to accomplish to have a better understanding of a design and materials needed.

November
- Begin the process of cutting, printing, and buying the necessary parts needed for mechanical model.
- Have a semi complete functional robotic arm that is fully mechanical to asses any errors that may have occurred during manufacturing.

December
- Finalize the mechanical prototype of the robot arm and have it ready to be wired up electronically.
- Investigate potential codes that will be useful for our robot and begin applying them for a trial and error process.

January
- Continue working on the code and start assembling the electrical components to verify how they work with the mechanical design of the arm
- Obtain final materials that are best suited for a functional arm

February
- Assemble a platform that encloses the robotic arm's physical range of motion.
- Begin testing cameras and codes necessary to acquire the data needed for our project

March
- Asses the mechanical structure of the arm and make any necessary changes needed to finish building the circuit and wiring the arm
- Have a preliminary code used to control and test the range of the arm

April
- Obtain information from camera and analyze data in order to apply to arm
- Obtain working code for inverse kinematics
- Finish arm circuit board and wiring

May
- Plan for UCI's undergraduate research symposium, where we will be presenting all the work that was accomplished throughout the year.
- Begin optimization of inverse kinematics code that functions using camera information

June
- Continue optimizing inverse kinematics code.
- Establish communication between Arduinos in order to retrieve Pixy cam information
- Plan for final senior design presentation