To Predict ▯ To Design ▯ To Perform

College of Engineering
Department of Mechanical & Industrial Engineering

ME, ECE, BE Capstone Design Programs

Team 39 Robo Power Rangers, ME 3603 Instrumentation Robotic Gripper

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Project Objective

Design and produce a new experiment for ME 3603 featuring:

- Robotic focus
- Associated fundamental theory
- Industry relevance

5 DOF Industrial Robot

Subsea Operations *Industrial Assembly*
Agriculture *Sorting & Inspection*

- 3D printed structural components
- Remote accessibility and operability

Background

New lab apparatus & experiment will:

- Modernize current curriculum
- Facilitate ME department transitions to:
  - Mechatronics course
  - Robotics Minor
  - Distance learning program
- Assist in outreach programs for local community

Engineering Solutions & Specs

Lab apparatus: Robotic Gripper

- 4 DC servos, 4 controllable degrees of freedom using Arduino Uno microcontroller
- Instrumented with Flexiforce Force Resistive Sensor (FSR)

Experiment & Lab Manual

- Educational objectives & lab assignments developed using ABET student outcomes

LABView GUI for Outreach Activities

- Allows outreach participants to easily control robot

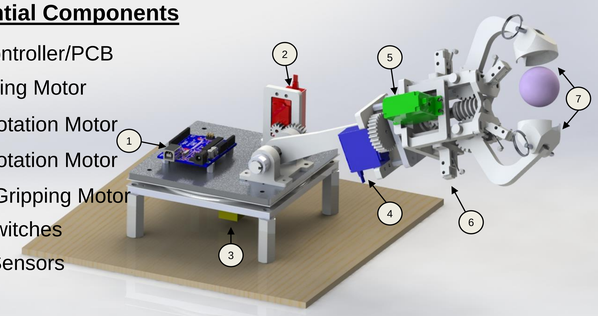
Measurable Engineering Specifications

Weight	*Physical Footprint*	*Range of Motion*	*Operating Voltage*	*Lab Duration*
7 lbs	1'x2'	1'x2'x1'	5.6-7 V	6 hours

Robotic Gripper Apparatus

Essential Components

1. Microcontroller/PCB
2. Arm Lifting Motor
3. Base Rotation Motor
4. Wrist Rotation Motor
5. Finger Gripping Motor
6. Limit Switches
7. Force Sensors (FSRs)

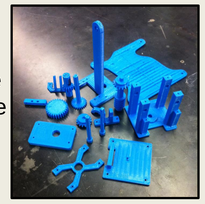


3D-Printing (Additive Manufacturing Process)

3D printers used for prototype fabrication:

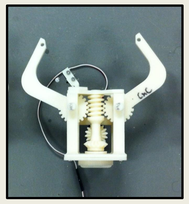
Makerbot Replicator:

- Prints PLA
- Crude & Error-prone
- Inexpensive



Stratasys:

- Prints ABS
- Support mat'l improves accuracy
- Precise



Manufacturing Testing

Comparison of Printer Deviations:

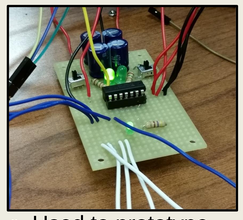
Part Name	Part Feature	Designed for (in.)	Stratasys Actual (in.)	MakerBot Actual (in.)
Finger Shaft v3				
	Shaft O.D.	0.242	0.2425	0.2455
	Cap O.D.	0.375	0.383	0.3785
	Cap Length	0.25	0.265	N/A
	Hole I.D.	0.134	0.135	0.1148
	Key Slot Width	0.09375	0.07	N/A
Collar v1				
	O.D.	0.5	0.496	0.491
	I.D.	0.289	0.285	0.278
	Length	0.325	0.335	0.334

Conclusions & Recommendations

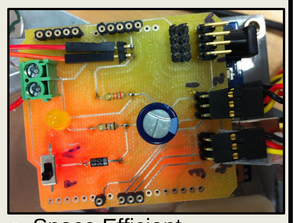
- Makerbot is an inexpensive way to prototype; large deviations and inconsistency preclude use for mass production
- Stratasys prints are stronger and more reliable as load-bearing components

Electrical Prototyping & Testing

Protoboard vs. Printed Circuit Board

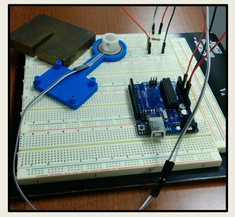


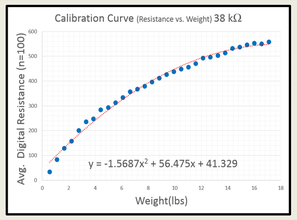
- Used to prototype
- Cluttered
- Faulty



- Space Efficient
- Well Structured
- Reliable

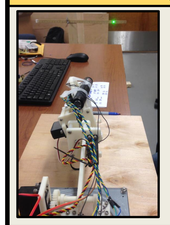
Generating FSR Calibration Curve





Structural Testing

Determining Angular Accuracy of Servos

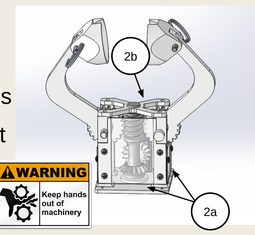


Attached laser pointer to base and arm and used simple trigonometry to measure deviation of angular position

	Average Error	Error Std. Dev.(σ)
Base Motor	-0.66°	0.80°
Arm Lifting Motor	-0.67°	3.16°

Safety in Design

1. Limit switches
2. Physical Guards
   a. Polycarbonate shields
   b. Worm gear X-bracket
3. Warning Stickers
4. Programming failsafes



Educational Objectives

1. Familiarity with various components of robotic systems: sensors, microcontrollers, and servo motors
2. Condition & calibrate a piezo-resistive force sensor
3. Produce calibration curve of a force sensor
4. Interface between components of a robotic system by programming simple control loop in C/C++
5. Perform uncertainty analysis on FSR readings using manufacturer datasheet

Microcontroller

- Arduino Uno
- C/C++ based coding

Sensors

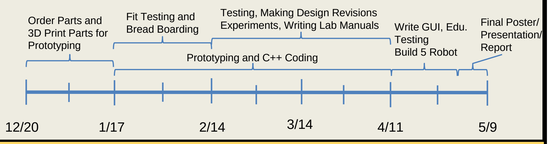
- FlexiForce FSR
- Uncertainty analysis
- Calibrate and instrument lab apparatus

Servos

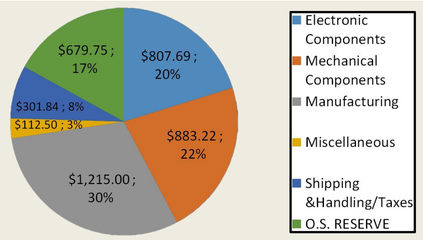
- 3 Hitec HS-645MG 180°
- 1 Parallax continuous
- DC Servo closed-loop control operation

Project Management

Timeline



Budget



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