



Discover Bot



Members

- Team Members
 - Tim Sonnen
 - Joe Carter
 - Marshall Townsend
 - Brian Gift
 - Nathan Park
 - Kierra Ryan
 - Qinlin Xu
- Advisor
 - Dr. Joel Perry
- Mentor
 - Sarah Willis

Project Goal

To develop a single-user prototype of the telerobotic master/slave setup and validate function and durability

Design Considerations

- Required
 - Safety
 - Durability
 - Accessibility
 - Intuitive
 - Serviceability
 - Camera
 - Size
- Preferred
 - 3D Vision
 - Haptic Feedback

Planned Exhibit Overview

Current Status

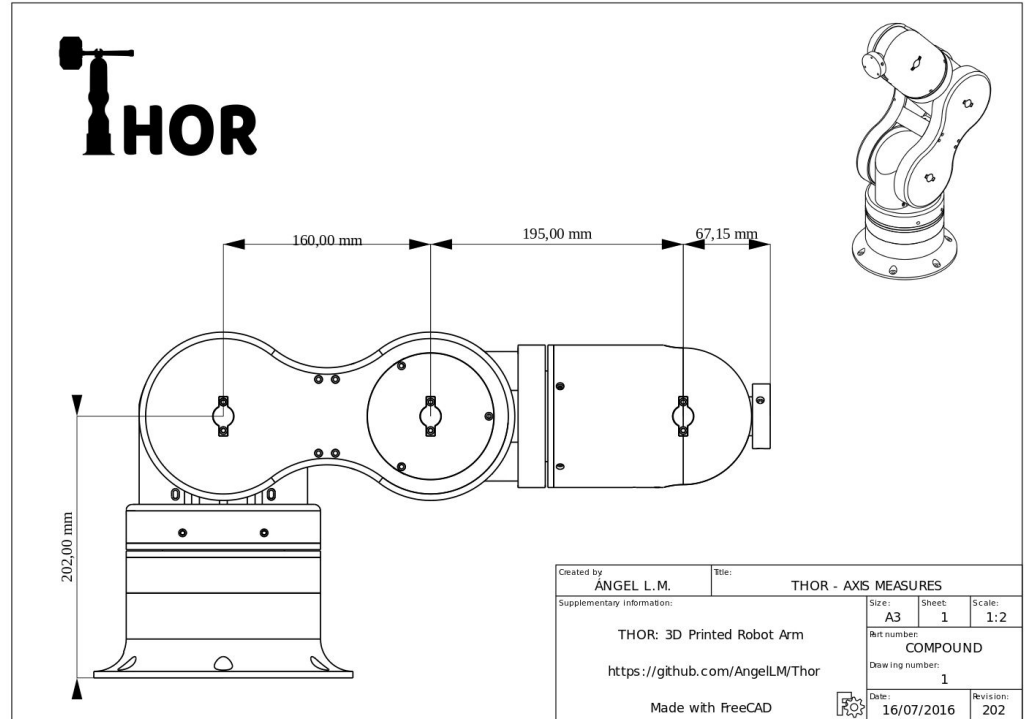
- Identifying weaknesses of initial design
- Development of replacement parts in arm design
 - Likely candidate is laser cut acrylic parts
 - Redesign simpler gear meshes to be machined from metal
- Focusing on development of Leap Motion control method

THOR - Open Source Robot Arm



THOR - Open Source Robot Arm

- 7 DoF arm (6 axis + gripper)
- ~1.4 ft (422 mm) horizontal reach
- Open source hardware and software
- 3D Printable for rapid prototyping

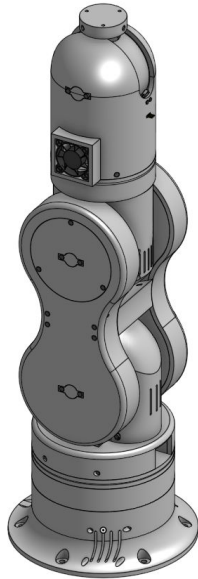




Arm Modifications



Mechanical Modifications of Arm



- Modification of 3D printed parts
- Fixing issues
- Design of end effector

Modification of 3D Printed Pieces

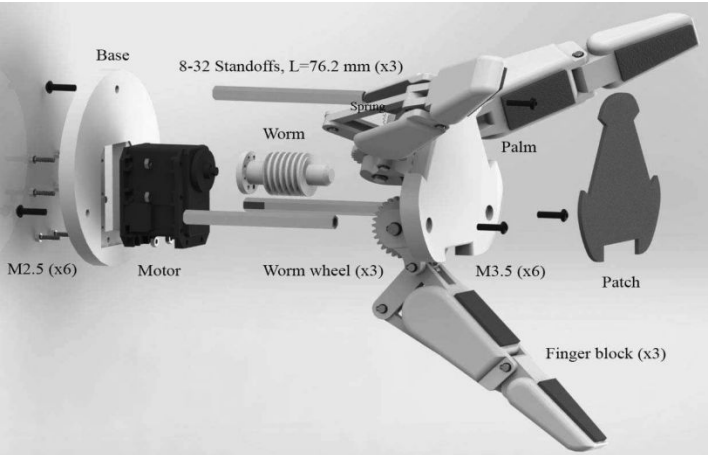
- Large, bulky 3D printed pieces waste filament and prints fail often
- Laser cut pieces
 - Rigid, clear frame satisfies other requirements
 - Easier to remake and more consistent results
- Gears could be redesigned and machined as metal
 - Better material properties
 - Much longer lasting

Improvements

- Assembly
 - Clear assembly instructions
- Cable management
- Modularity, to make maintenance easier
- Acrylic areas to show inside
 - panels in key locations
 - replacement of certain parts
- Addition of lighting (LED) in areas to be viewed

End Effector Design

- Astana Labs Gripper
 - Built around a Dynamixel MX-28T motor (~\$220)
- Laser Cut Design
 - Working on a low cost laser cut model (above)
 - May add a third finger if unable to grip objects





Control Method



Control Method

- Control Architecture
- Leap Motion Controller
- Leap Motion Workspace



Control Architecture

- Leap Motion requires a computer to interface with
 - Kinematics require computation-heavy calculations
 - Using a program on the host computer to calculate angles reduces input lag
 - Positional data needs to be smoothed to eliminate stutter
- Microcontroller used to control the THOR arm
 - Computer sends positional data to microcontroller
 - Microcontroller drives stepper motors to correct position

Leap Motion Hand Tracker

- Device detects hand and finger motion as input
- Hands free
- Movement of arm will depend on position of palm
- Computer will take hand data and send position information to arm
- Issues
 - Fingerprints/cleaning
 - Intuitiveness
 - Tracking

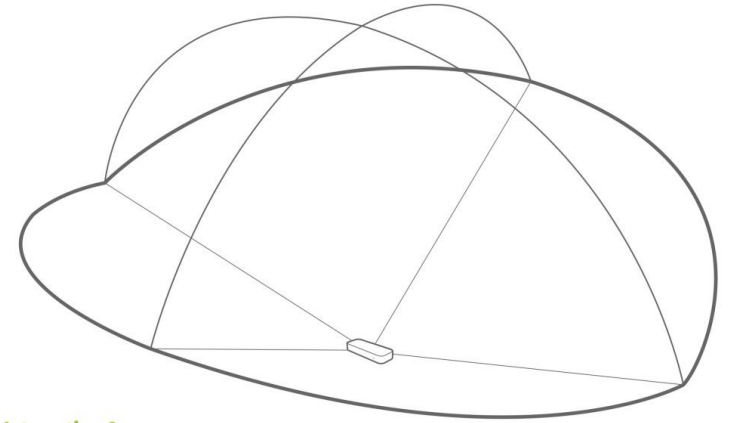
Leap Motion Hand Tracker

- Example Kinematics Function

```
function calculateInverseKinematics(x,y,z) {  
  z = -z;  
  var t1 = Math.acos((square(z)+square(y)-square(l1)-  
square(l2))/(2*l1*l2));  
  var t2 = Math.asin(((l1+l2*Math.cos(t1))*y-  
l2*Math.sin(t1)*z)/(square(l1)+square(l2)+2*l1*l2*Math.cos(t1)));  
  return {  
    theta1: t1,  
    theta2: t2  
  }  
}
```

Leap Motion Tracking

- Leap Motion interaction area
 - 2 feet above controller
 - 2 feet wide on each side (150°)
 - 2 feet deep on each side (120°)
- Constraining user hand movement will improve usability and reduce interference from outside users.



Interaction Area

Leap Motion Workspace

- User Arm Assist
 - User movement limited by movement of arm
 - Guide users movement
 - User interference could still be an issue
- Simple enclosure
 - Enclosure based on area of Leap Motion tracking area
 - Higher chance of preventing outside user interference





Usability and Safety



Usability and Safety Tests

- Test usability and safety of overall design
 - Includes hardware tests to determine parts likely to fail
 - Gather feedback on ease of use from a sampling of users
 - Determine and test software edge cases

Usability

- Get a random selection of users to test arm
 - Should contain all ages to test hand size and shape
- Post-Survey on experience
 - Sample questions
 - Did the arm move as expected?
 - Rank intuitiveness of the Leap Motion(1-10)
 - Rank how responsive the arm was (1-10)
 - Could you complete the task?
 - If task could not be completed, explain issues that arose.

Safety - Arm

- Arm Safety Tests
 - Mock-up area in size and shape of enclosure
 - Check for collisions with walls
 - Check collisions with floor
 - Check how the arm reacts with a stack of objects
 - Test limit switches
 - Can the arm break itself?
 - Test Gripper
 - Can it grip so hard that it breaks object and/or itself

Safety - Human

- If there is a guiding arm with the Leap Motion
 - Look at:
 - Pinch points
 - Sharp edges
 - Exposed wiring
- Can arm throw object out of enclosure
 - Try to throw an object
 - If object can leave enclosure, either:
 - Improve enclosure
 - Add a top cover
 - Net with smaller/less holes
 - Slow maximum arm speed



Project Management



Schedule

- Design and manufacture arm modifications
- Continue developing Leap Motion control system
- Design interface between computer and microcontroller
- Finalize arm design and test for safety
- Test usability of Leap Motion control method in conjunction with arm

Ordered Parts

- All parts from original Thor assembly have been ordered and received
- Others orders include:
 - Acrylic
 - Simple test arm (borrowed)
 - Extra nuts and bolts
- Soon to be ordered
 - Printer filament
 - More acrylic
 - Other sizes of bolts

Budget

Budget	Total	5000
parts received	Total	736.35
control system	leap motion	100
	cameras	150
	power supply	50
	computer	100
	other hardware	750
parts for final bot	metal bearing	30
	acrylic	150
	other	700
Travel	van	112
	gas	182
	food	100
	hotel	390
machining and mentor fees		1500
Unallotted funds		49.65

Gantt Chart

WBS NUMBER	TASK TITLE	START DATE	DUE DATE	DURATION (weeks)	PCT OF TASK COMPLETE	Spring 2018													
						Snapshot 3							Design EXPO						
						1/14	1/21	1/28	2/4	2/11	2/18	2/25	3/4	3/11	3/18	3/25	4/1	4/8	4/15
1	Snapshot 1																		
1.1	Team Contract	9/10/17	9/17/17	1	100%														
1.2	Project Learning - General	9/10/17	10/1/17	3	100%														
1.3	Client Interview	9/17/17	9/24/17	1	100%														
1.4	Specifications Summary	9/24/17	10/1/17	1	100%														
1.5	Portfolio Submission 1	10/1/17	10/8/17	1	100%														
1.7	Snapshot #1 Board	10/8/17	10/15/17	1	100%														
2	Snapshot 2																		
2.1	Project Learning - 3D Vision and Controls	10/15/17	12/3/17	7	100%														
2.2	Robot Arm Prototyping	10/15/17	12/3/17	7	100%														
2.3	Wiki Page Draft	10/29/17	11/5/17	1	100%														
2.4	Control Method Prototyping	11/5/17	12/3/17	4	100%														
2.5	Portfolio Submission 2	11/5/17	11/12/17	1	100%														
2.6	Design Review (with client)	11/12/17	11/19/17	1	100%														
2.7	Snapshot #2 Board	11/26/17	12/3/17	1	100%														
2.8	Finalize Wiki Page	11/26/17	12/3/17	1	100%														
2.9	Portfolio Submission 3	11/26/17	12/3/17	1	100%														
3	Snapshot 3																		
3.1	Robot Arm Design	1/14/18	3/18/18	9	40%														
3.2	Control Method Design	1/14/18	3/4/18	7	20%														
3.3	Design Review (with client)	1/28/18	2/11/18	2	0%														
3.4	Portfolio Submission 3	2/25/18	3/4/18	1	0%														
3.5	Snapshot #3 Board	2/25/18	3/4/18	1	0%														
4	Design EXPO																		
4.1	Final Implementation	3/11/18	4/8/18	4	0%														
4.2	3D Vision Development?	3/11/18	4/22/18	5	0%														
4.3	Wiki Page Review	3/25/18	4/1/18	1	0%														
4.4	EXPO Presentation Materials	4/15/18	4/22/18	1	0%														