



Discover Bot



Members

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- Advisor
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Project Goal

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

Planned Exhibit Overview

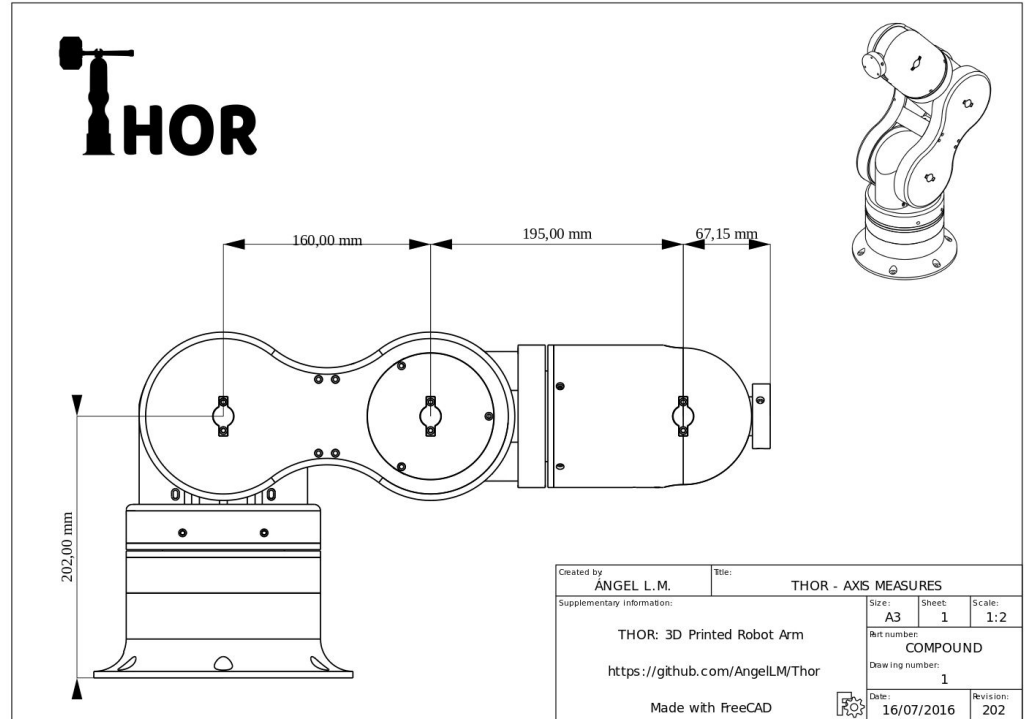
- Arm in a corner
- Hole under the arm for wires
- Computer Components on self below
- Foam blocks in workspace
- Acrylic case for user safety

Design Considerations

- Safety
- Durability
- Accessibility
- Intuitive
- Serviceability
- Camera
- Size

THOR - Open Source Robot Arm

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

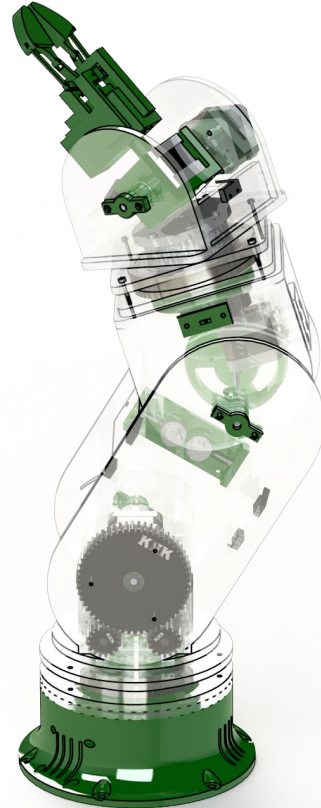
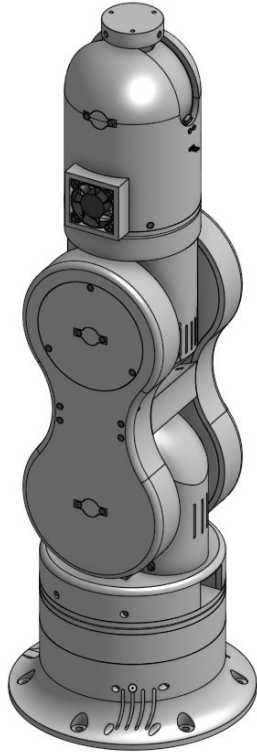




Final Design



Mechanical Modifications of Arm

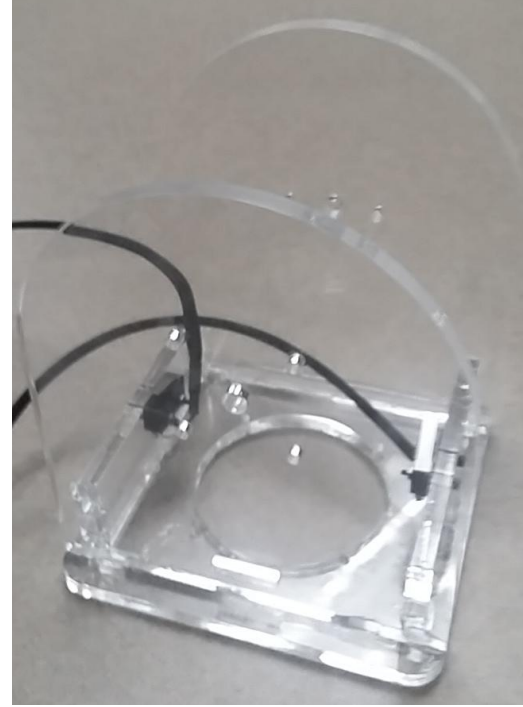


Major Changes

- Transparent structure
 - Laser cut parts
- Off the shelf components
 - Gears and bearings
- 3D printed parts
 - Simpler, smaller and only where needed
- Ease of assembly
 - Placement of bolts, cable management, and maintenance accessibility
- End Effector
 - Design options

Transparent Structure

- Laser cut pieces
 - Rigid, clear frame
 - Easier to remake with consistent results
 - Large, bulky 3D printed pieces were a waste filament and prints often failed
- Polycarbonate final parts
 - Discovery Center can cut these in-house
 - Stronger and more durable
 - A material they already use



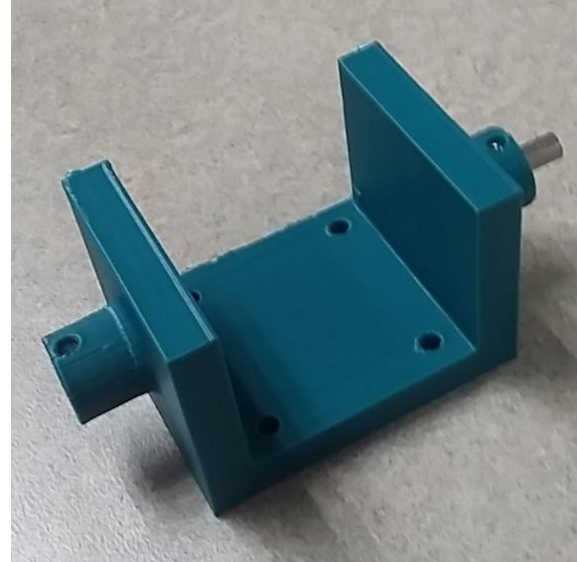
Off the Shelf Components

- Gears
 - Stronger, more durable, longer life
 - Required minor modifications
- Bearings
 - Sealed bearings
 - Longer life, can handle more load, smoother rotation



3D Printed Parts

- **Simpler**
 - Less complex shapes such as cubes and cylinders
 - These print more accurately
 - They require less supporting material
- **Smaller**
 - Parts fit easily on the printer bed
 - Parts print much faster
 - Parts do not require a raft
- **Reduction of printed parts**
 - It is faster to replace laser cut parts
 - Printed parts are not clear
- **Gripper**
 - Simple 3D printed gripper



Ease of Assembly

- Bolt placement
 - Bolt heads can be accessed when fully assembled
- Maintenance accessibility
 - The robot can be taken apart in sections or have just one section removed
- Cable management
 - Modular
 - Single sections can be unplugged and replaced without rerouting wires





Control Method



Control Method

- Leap Motion Controller
- ROS
- Kinematics
- Control Architecture

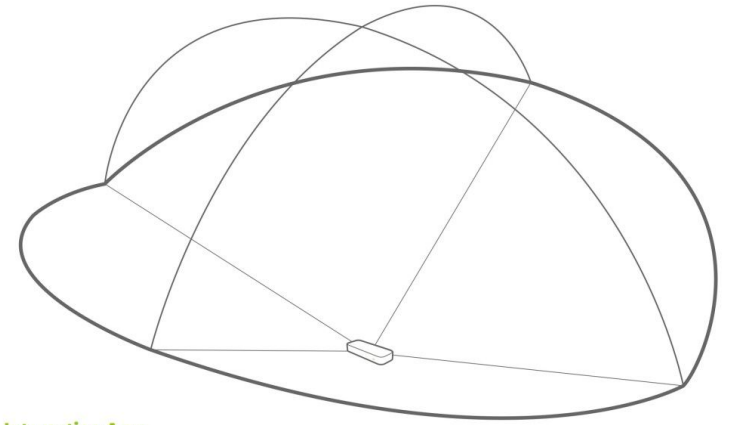
Leap Motion Hand Tracker

- Device tracks hand and finger position using two monochromatic IR cameras and three infrared LEDs
- Hands free
- Hand and finger data stored in frames
- Almost 200 frames per second of data



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°)
- Tracking of palm used for position of end effector
- Position between fingertips and palm used to tell if hand is open or closed



Interaction Area

ROS

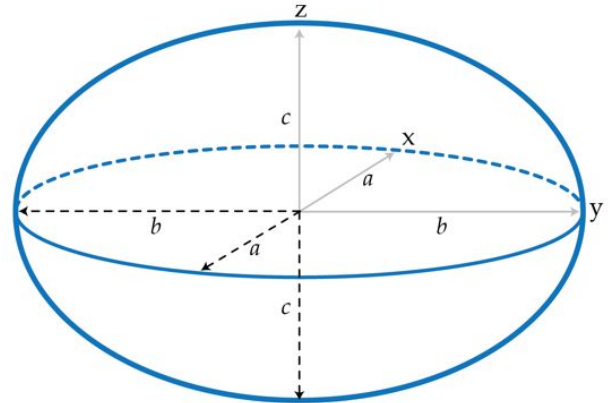
- Robot Operating System
 - Open source framework for writing robotics software
- Large collections of tools, libraries, and conventions available
 - Leap Motion
 - Kinematics
 - Visualization Software
- Nodes
 - Publishing
 - Subscribing



Coordinate Manipulation

- Leap Motion messages passed to inverse kinematics node
- Leap Motion coordinates must be normalized to robot arm coordinates
- Create Pose message with normalized coordinates
- Check if pose is valid
 - Range of arm can be bound with two ellipsoids
 - Use ellipsoid standard equation
 - If valid calculate kinematics

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

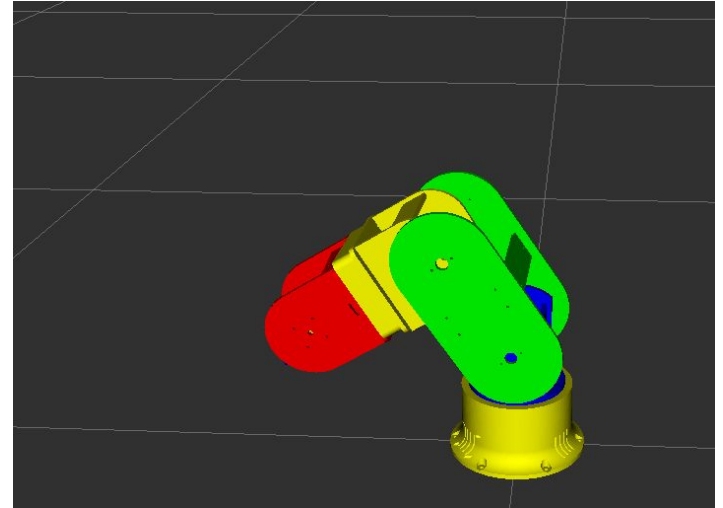


Kinematics

- MoveIt!
 - Software package for robot motion planning, kinematics, and manipulation
- Valid pose is sent to MoveIt! kinematics solver function
 - KDL kinematics plugin
- `setFromIK(joint_group, pose, attempts, timeout)`
- Function returns radian value for each joint
- Invalid poses can causes slowdown on kinematics solver
 - Eliminated with implementation of ellipsoid equation

Robot Visualization

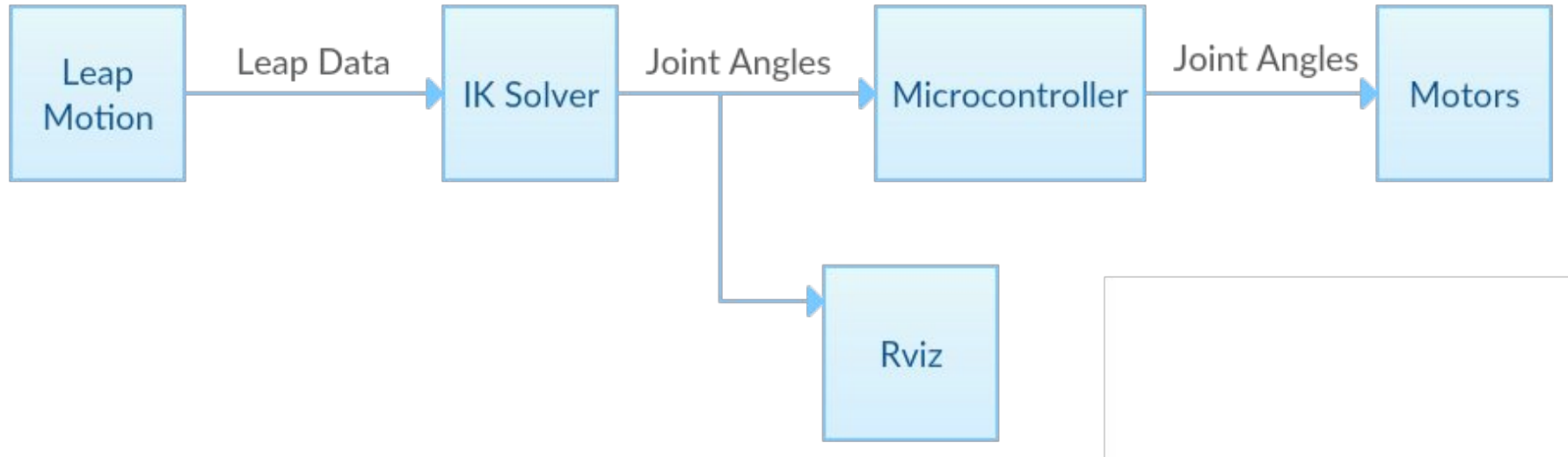
- Rviz
 - 3D visualizer for displaying robot sensor data and state from ROS
- Allows for visualization of virtual model of robotic arm
- Using MoveIt! and Rviz we are able to test control methods on virtual model of arm
- Send joint angles from solved kinematics to MoveIt! node which is then visualized in Rviz



Control Architecture

- Leap Motion requires a computer to interface with
 - Kinematics require computation-heavy calculations
 - Using a ROS on the host computer to calculate angles reduces input lag
- Microcontroller used to control the arm
 - Computer sends joint angles to microcontroller
 - Microcontroller drives stepper motors to correct position

Data Flow





Thank You
Any Questions?

