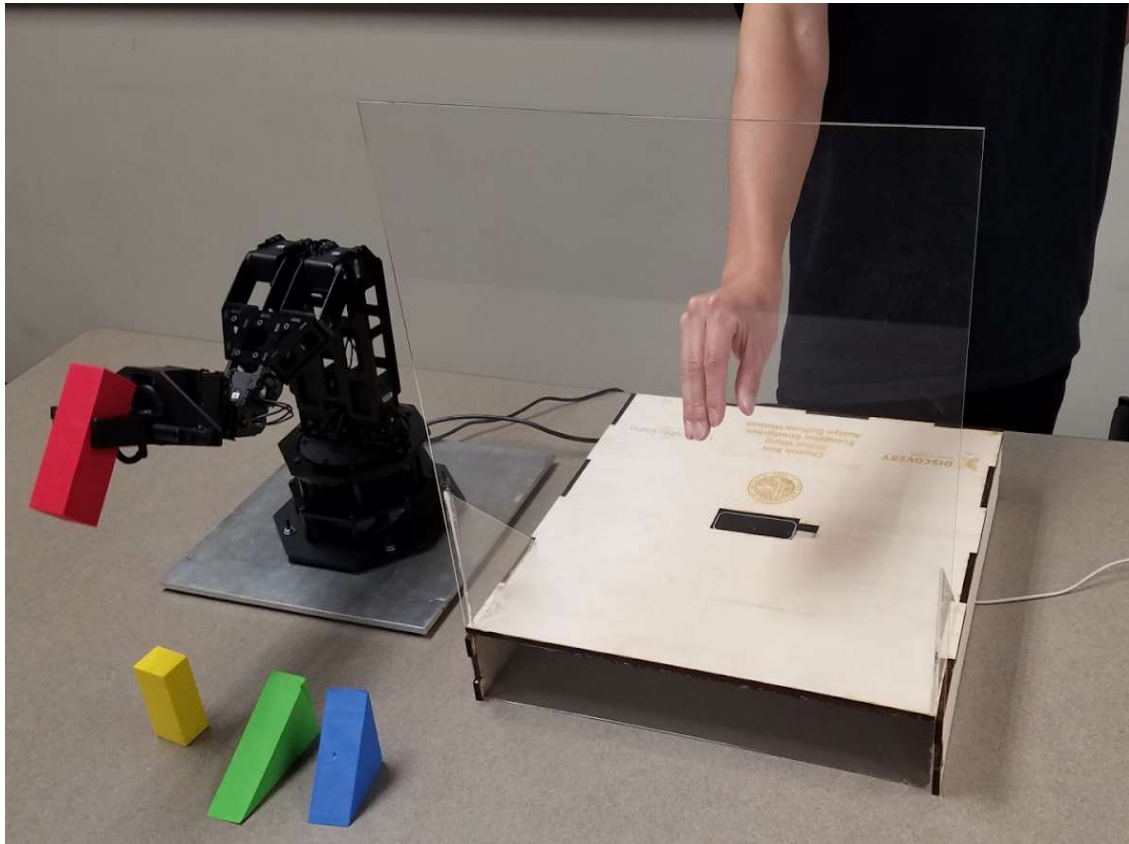




DISCOVERY
Center of Idaho



Gesture Controlled Robotics Exhibit

Owner/User Manual

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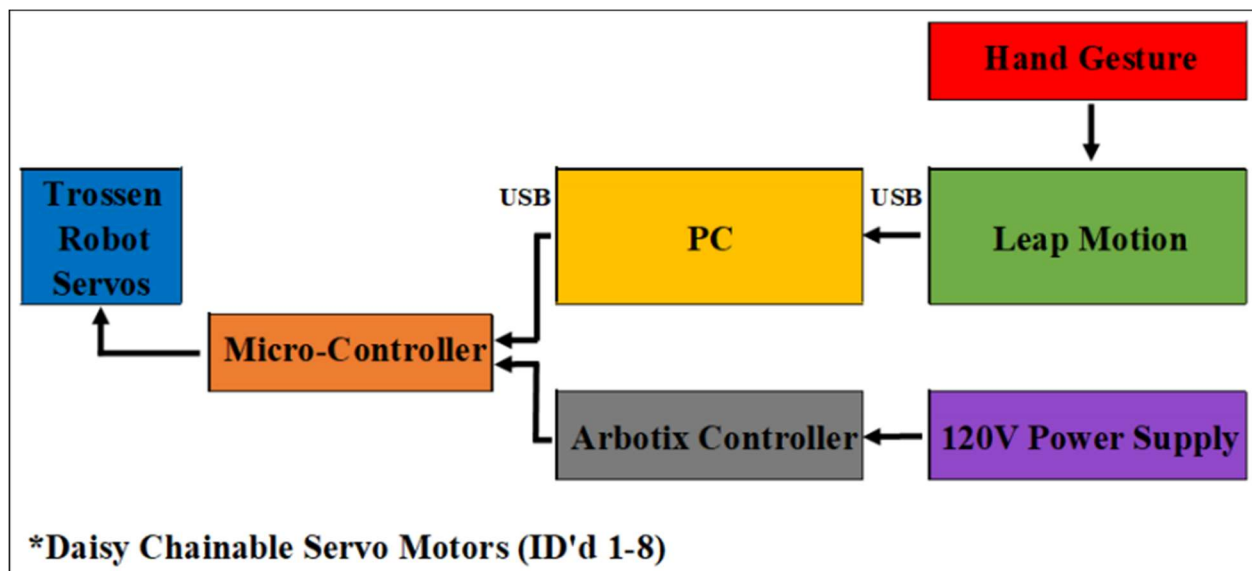
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Objective Statement: Create an interactive robot exhibit that exposes K-12 students to modern robotics technology. The robot should perform a number of sorting activities based on hand motion in free space, without direct physical contact with an actuator.

Product Requirements:

- Motion-Controlled Robot Arm
- Fun & Educational
- Activities-Based
- Repeatable Results
- Durable & Maintainable Design

Data Flow Diagram:



Servo-Motor Call-Outs:



Servo-Motor ID and Call-Outs

1. **Base Servo-Motor:** 300 degrees of rotation allotted
2. **Shoulder Servo-Motor:** Vertical Motion Actuation, mainly upward and downward. Approximately 180 degrees of true motion capability. Works in series with Servo-Motor #3
3. **Shoulder Servo-Motor:** Vertical Motion Actuation, mainly upward and downward. Approximately 180 degrees of true motion capability. Works in series with Servo-Motor #2
4. **Elbow Servo-Motor:** Vertical Motion Actuation, mainly upward and downward. In series with Servo-Motor #5. The “Motion” of Servo-Motor #4 is inputted opposite that of Servo-Motor #5. This is due to the fact that the servos are mounted this way.
5. **Elbow Servo-Motor:** Vertical Motion Actuation, mainly upward and downward. In series with Servo-Motor #4.
6. **Wrist (Lateral Motion) Servo-Motor:** Mainly upward and downward motion.
7. **Wrist Rotation Servo-Motor:** 300 degrees of rotation available, though not specifically going to be implemented for actual use.
8. **Gripper Actuation Servo-Motor:** Uses rotation, and mounted “actuation arms” to fully close the gripper, and open it to approximately 30mm.

System Requirements

- Windows® 7+ or Mac® OS X 10.7+
- AMD Phenom™ II or Intel® Core™ i3/i5/i7 processor
- 2 GB RAM
- USB 2.0 port

Software Requirements

- Arduino IDE v1.0.6
- GNU g++ compiler
- dynaManager

Software Installation Guide

1. Download and install Arduino IDE version 1.0.6 at <https://www.arduino.cc/en/Main/OldSoftwareReleases#previous>
2. Download and install version 2.3.1 of the Leap Motion SDK at <https://developer.leapmotion.com/sdk/v2>
3. If not previously installed, download and install the GNU G++ compiler <https://www.gnu.org/software/gcc/>
4. Download and install FTDI driver at <https://www.ftdichip.com/Drivers/VCP.htm>

Daily Quick Start Guide

1. Open `LeapArbotiX-M.ino` under `GestureControlledRobot/ArduinoFiles/DiscoveryIdaho_Sketches/LeapArbotiX-M`
2. Upload the Arduino code to the board by pressing the arrow button located in the top left corner of Arduino IDE.
3. Open given Visual Studio project solution `DCI.sln` under `GestureControlledRobot/Windows/Project1`
4. Run program by hitting the Local Windows Debugger button located in the top center of Visual Studio IDE
5. Once the Command Window pops up, enter "1" in the Visual Studio console.
6. Fix your hand in the activation zone until the robot is activated.

Initial System Set-Up

Upload Arduino Program into ArbotiX-M Robocontroller

1. Unzip provided GestureControlledRobot.zip file into a local directory.

2. In Arduino Files folder, there will be 3 folders

- **DiscoveryIdaho_Sketches** : this folder contains the Arduino codes.
- **hardware** : this folder contains the hardware definitions to allow the Arduino IDE to build programs for the ArbotiX-M.
- **libraries** : this folder contains the libraries that are necessary for the Arduino codes to run.

Move these 3 folders into the 'Arduino' user folder, which is located at

- **Windows 7+**
Documents/Arduino/
- **Mac/Linux**
~/Documents/Arduino/

3. Open Arduino IDE.

4. Go to **File -> Sketchbook -> DiscoveryIdaho_Sketches**, and open the Leap ArbotiX-M sketch.

5. Go to **Tools -> Board**, and select ArbotiX.

6. Connect the ArbotiX-M Robocontroller, which is installed in the bottom of the robot arm, to the desktop computer via USB.

7. To check if the configuration is set up correctly, go to **Tool -> Serial Port**.

If you see the name of your USB Serial Port in the list then you are good to move on.

8. Upload the program onto the Robocontroller by hitting the arrow button located in the top left corner of Arduino IDE.

Run C++ Leap Motion Program - Windows 10

1. Connect the Leap Motion Device with your desktop via USB.

2. Give a moment for Leap Motion Device to start tracking. The Device is tracking your motion if

- 3 red LED lights can be seen on the Leap Motion Device, or
- The Leap Motion Control Panel icon on the desktop is lit green.

3. Open given Visual Studio project solution `DCI.sln` under `GestureControlledRobot/Windows/Project1`
4. Run the program by hitting Local Debugger located in the top center of Visual Studio IDE.

Activate the Robot - Windows 10

1. Enter '1' in the Visual Studio console to initiate the serial communication between ArbotiX-M board and C++ program.
2. Fix your hand in the "activate" zone over the Leap Motion device.
3. The robot will start to position itself to its default home position, then follows your hand movement

Run C++ Leap Motion Program - Mac/Linux

1. Connect the Leap Motion Device with your desktop via USB.
2. Give a moment for Leap Motion Device to start tracking. The Device is tracking your motion if
 - The Leap Motion Control Panel icon on the desktop is lit green, or
 - 3 red LED lights can be seen on the Leap Motion Device.
3. Locate given `Mac_Linux` folder in unzipped `GestureControlledRobot` folder, and remember the pathname to it.
4. Open Terminal application.
5. Follow the commands below to execute C++ program.
 - a. change current directory to Mac_Linux folder
`cd /pathname/to/provided/Mac_Linux/`
 - b. run make
`make`
 - c. run executable
`./main`

Activate the Robot - Mac/Linux

1. Open Arduino Serial monitor by hitting magnifier icon in the top right corner of Arduino IDE v1.0.6.

2. Enter '1' in the Arduino Serial Monitor to initiate the serial communication between ArbotiX-M board and C++ program.
3. The robot fixes itself to the default home position until there is gesture input.
4. Place your hand in the "activate" zone over the Leap Motion device.

Deactivate the Robot

1. Move your hand out of Leap Motions sensor range, then after approximately 7 seconds, the robot will go back to the default home position.
2. To completely turn off the robot, simply unplug the power.

Flash Drive Contents

The flash drive contains several items, including the Solid Modeled Parts, which are identified within the *Solid Modeled Parts* section of this paper, as well as specific documentation in regards to usability of the robot arm. The initial file folder is labeled *U of I Discovery*, and contains everything, needed to run the system. The rundown of what is located in the file is provided in order of appearance on the Flash Drive:

<u>File</u>	<u>Description</u>
U of I Discovery	Folder that contains everything pertaining to the robot arm. Select this file to retrieve any further information inside.
Faux Servo Parts	File contains the assembly for the Faux Servo Motor acting off of Servo-Motor #7
Final Design Report	Contains two files, the PDF, and Word Document. The Word Document is open for edits, as the robot may change over time.
Gripper STL	Contains the .STL files that are used for 3D printing purposes. If a part is broken, access this file for loaded part files. Depending on the software used with the 3D printing, .gcode will need to be made, prior to USB to 3D print connection.
Grippers	This file contains the parts used within the gripper, which are listed below within the <i>Solid Modeled Parts</i> section of this document. If you change, or edit any of the parts within this document, make sure to save the corresponding .STL files.
Laser Cutter	Contains the laser cutter drawings needed for the U of I Discovery Leap Motion Control Volume Setup.
Leap Motion Box	Contains the Solidworks Files for the U of I Discovery Leap Motion Control Volume Setup.

Servo Motor 8 Modified Servo Connector Plate Parts	Contains the connecting plates that were modified for the wrist rotation servo motor #8 connection.
Owner-User Guide	This is the current document that you are viewing. Explains overall system setup, system quick start, and Gripper/Faux Servo Part assembly/descriptions.
Solid Part Renderings	Renderings of both the Gripper and Faux Servo-Motor

Replacements Parts

Replacement parts are both available and manufactural. In regards to the parts that are readily available, the servo-motors are one of the only parts available, and least expensive parts to replace. In regards to acrylic, or any of the other robot arm pieces, disregarding the gripper/faux servo-motor setup, the best location to find replacement parts for the robot arm is Trossen Robotics website, which like said above, sell individual servo-motors, but the outer acrylic and metal robot shell structure isn't sold individually, regarding parts, though the kit is purchasable. However, with access to the actual website, a 3D model visualization, which is depicted in *Figure 1*, is available for modeling purposes, and could be a possible cost saving opportunity for the Discovery Center. Without SolidWorks modeling, and/or other CAD based drawing systems, the route to take would be to repurchase the kit, as this is the least expensive option.

Dynamixels support up to 300 degrees of motion, which results in an extraordinary range of motion and reach on the PhantomX Reactor. Temperature monitoring, positional feedback, as well as voltage levels, load, and compliance settings are user accessible as well.



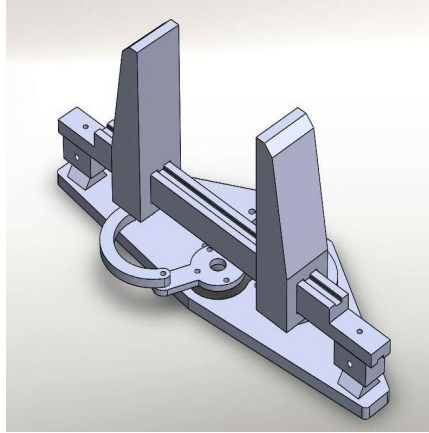
Figure 1: 3D Robot Visualization provided at [Trossen Robotics Website](https://www.trossenrobotics.com/). The assembly can be pulled apart, and parts can be measured in any legitimate units system to satisfy any replacement needs.

Solid Modeled Parts

As stated within the *Parts List & Basic Functions* portion of this document, the gripper, faux servo-motor and servo-motor center-link, are not stock parts that can be found on Trossen Robotics website. Instead, these parts were modeled, and 3D printed, using PLA plastic. Each part is listed out below, beginning with the assembly, and piecing each part out, as it is assembled.

The greatest thing about any of the robot arms parts is that they can be modeled, and then made via either 3D printer, or Laser Cutter, depending on the part. If anything should break, the parts are replaceable, but must be modeled first. Due to lack of any main structure inheriting any failures during the duration of testing, the robots skeletal structure has not been altered in any way. If the structure does break, the replacement material is ¼" black acrylic, which can be modeled using basic dimensioning, and SolidWorks solid modeling software, prior to Laser Cutting the material, and reassembly.

Gripper Parts

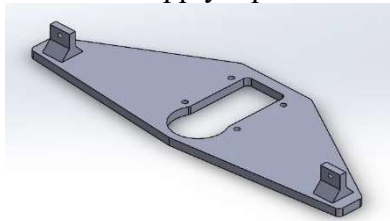


Full Gripper Assembly: A visualization of what the gripper looks like, when it is fully assembled.

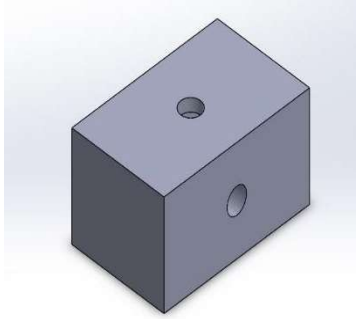
How to Assemble:

Prior to putting everything together, make sure that contact surfaces are sanded. The main contacting surfaces that should be sanded, prior to assembly are the Gripper Bar, and the upright tabs on the Gripper Bed, which will vary due to tolerances.

1. Attach the Gripper Plate, to the Gripper Drivers using M2 x 8mm screws. With the tight tolerances on the parts, the threads will have to be made. However, with PLA's properties, it allows the screws to cut the threads, and form a secure fit, that still allows rotation.
2. Attach each Gripper Driver, to individual Gripper, using M2 x 8mm screws. Again, threads will have to be cut, make sure to stay perpendicular to the part, as you screw into the PLA material.
3. Maneuver the Gripper Plate, Driver, sub-assembly, so that the grippers are in line with one another, but the Gripper Plate is in its compacted state (fully closed)
4. Take the sub-assembly, and guide it along the rail, and let it sit.
5. Now, place the Gripper Bar supports on the Gripper Bar. To do this, screw M2 x 8mm screws perpendicularly through the provided hole.
6. Now, make sure to sand down the upright tabs on the Gripper Bed prior to assembly. Place the Gripper Bar Supports, on top of the Gripper Bed's upright tabs. This will be a somewhat of a tight fit, make sure to apply equal amounts of light pressure to each side.



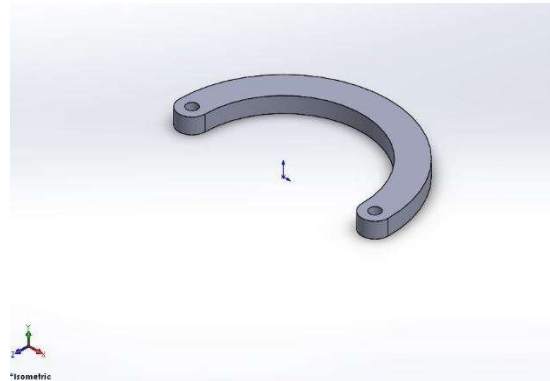
Gripper Bed (Base): The base plate of the entire assembly, which connects directly to the Faux Servo, which will be covered within the *Servomotor Center Link & Faux Servomotor* section of the paper.



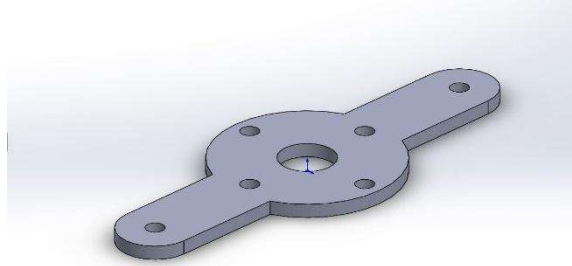
Gripper Bar Support (x 2): Fit snugly on top of the protruding triangular/rectangular uprights, and are securely fastened with an M2 x 8mm screw, and M2 Hex nut. This helps hold the gripper cross-bar in place, at the correct height.



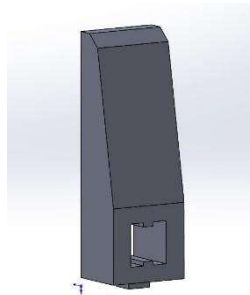
Gripper Bar: Is fastened directly to the Gripper Bar Supports, with an M2 x 6mm screw, which threads directly into the PLA. Be careful not to continuously remove, and replace the part, as this will cause the threads to degrade, increasing the chances of failure.



Gripper Driver (x 2): Works simultaneously with the Gripper Plate and Grippers. Attaches to the Gripper Plate, using M2 x 6mm screws to form an ‘S’ type orientation, when compact.



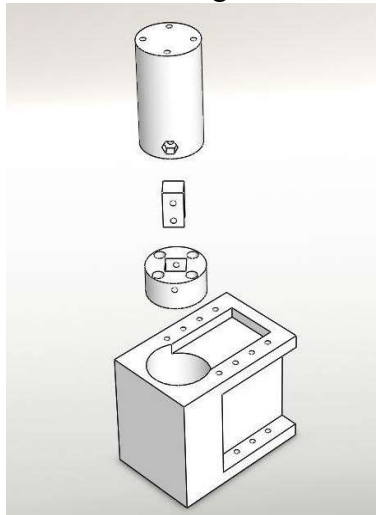
Gripper Plate: Attaches directly to the Gripper Drivers, in the ‘S’ type orientation, and to the face of the Upper Center Servo Link, using M2 x 8mm screws.



Gripper (x 2): Attaches to the Gripper Drivers using M2 x 8mm screws, and is guided linearly along the Gripper cross-bar.

Servo-motor Center-Link & Faux Servo-motor

In regards to the Servo-motor Center-link & Faux Servo-motor assembly, there are four main parts that make up the entirety of the assembly. These parts include the faux-servo motor, the upper center-link, lower center-link and the internal center-link. Each piece is fitted so that the assembly is quite easy to assemble, and remains rigid while undergoing rotational motion.

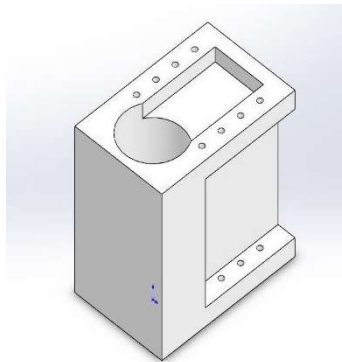


How to Assemble:

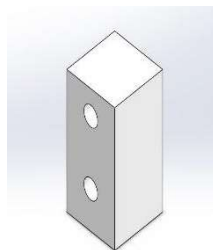
Prior to putting everything together, make sure that contact surfaces are sanded. The main contacting surfaces that should be sanded, prior to assembly are the Internal Center Servo-Link, and the Lower Center Servo-Link Base, and Upper Center Servo-Link top surface. Don't take too much off the surface, but make sure that it's flat, to avoid any misalignment inside the Faux Servo.

1. Begin by attaching the Lower Center Servo-Link to the base of servo-motor #7. Securely fasten by using four M2 x 8mm screws, and make sure that the piece is flat/flush with the servo-motor base.
2. Once the Lower Center Servo-Link is attached, lightly sand down and insert Internal Center Servo-Link into the Lower Center Servo-Link. To attach the link, screw an M2 x 8mm screw into the Lower Servo-Link and securely fasten it.
3. Once the Internal Center Servo-Link is attached to the Lower Center Servo-Link, attach the Upper Center Servo-Link by using an M2 x 8mm screw, and M2 Hex nut to securely fasten the two structures together.
4. Now, attach the Faux Servo to the horizontally extended tabs on servo-motor #7. Use M2 x 14mm screws, as the nuts are already captured inside of the servo-motor. If you're using a brand new servo-motor, make sure to place captured nuts on the servo-motor.

Center Servo-Motor Assembly: The Assembly includes four main parts, as stated above in the summary.

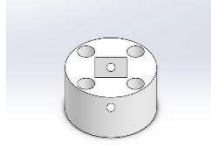


Faux Servo: The main extension, acting in place of the wrist rotation that was pivotal within the overall extension of the robot arm. Rather than reduce the extension length, the faux servo was created! Screwing in place using M2 x 10mm screws and M2 Hex Nuts w/ attachment to servo-motor #7.

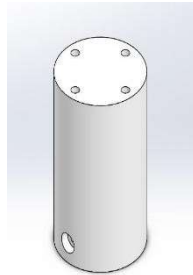


Internal Center Servo-Link: The integral piece that literally holds the whole set up together. With the attachment of the Lower Center Servo-Link to the Servo-Motor Base, there is the need to both attach to the Servo, while also attaching to the gripper. Without using 5 cm plus screws,

the solution was to create three sections. With this simple structure, and M2 x 8mm screws, the connection between the Lower and Upper Servo-Links is almost seamless.



Lower Center Servo-Link: The lower portion of the Center Servo-Link attaches directly to the servo-motor face with four M2 x 8mm screws. Once attached, the Internal Center Servo-Link can be added, along with the Upper Center Servo-Link, to create the entire Center Servo-Link.



Upper Center Servo-Link: Acting as a center drive shaft for the servo, transferring rotational power, through its connection to the Lower Center Servo-Link, from the servo-motor face, to the Gripper Plate. The Gripper Plate screws securely into the face of this part. Make sure that it mounts flush to the face, as the parts will deform, or possibly fail, if not assembled correctly. Inset placement for the screw hole and hex nut are located on the side, for ease of rotation, when encased by the Faux Servo.