### USER MANUAL

Modular Robotic Arm

### 3D Printed Modular Robot Arm

A close-up of a toy

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This document explains how to construct, use, and troubleshoot a 3D printed Modular Robot Arm. This robot arm uses a Arduino board to register inputs made by the user on a controller and use those inputs to control the servos on the arm. The modular design of this robot also encourages users to create their own features. All components of this arm are openly available online so that anyone can gather the materials themselves and build it. The open source code is also available so a user can modify to match their needs.

**Note** Read through the entire manual before assembling the robot. This will ensure no important information is missed before assembly.

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# Open Source Resources

All Files can be found on the git hub page.

* Git hub files are found at this [link](https://github.com/JamesEO5/Modular-Robotic-Arm---UC-Senior-Design-Project).
* If this is not a pdf document then they can be found at:
  + https://github.com/JamesEO5/Modular-Robotic-Arm---UC-Senior-Design-Project

# Tools Required

# A picture containing tool, wrench Description automatically generated

# A picture containing indoor, red, tool, electronic Description automatically generated

# A picture containing tool Description automatically generated

# A knife with a red handle Description automatically generated with medium confidence

# 

# #25 Allen Key

# #25 Phillips Head Screwdriver

# Soldering Iron

# Pliers

jjbjbjb

jij

# Safety Guidelines

**Caution** Observe all instructions and cautions in the user documentation. Constructing the robot arm in a manner not specified can damage the robot arm and injure the user.

**Caution** The protection provided by the model can be impaired if it is used in a manner not described in the user documentation.

**Caution** Electrical shock hazard. This device contains electrical components and capacitors. Do not disassemble the electronics ofhe robot while it is in operation and be sure to discharge the capacitors before disassembly.

**Caution** Risk of fire if electrical shorts occur. Some 3D printed plastics can burn and catch on fire.

# EMC Notices

Refer to the following notices for prevention measures necessary to ensure the specified EMC performance.

**Notice** For EMC declarations and certifications, and additional information, refer to the [*Product Certifications and Declarations*](#_bookmark11) section.

**Notice** The performance of this product can be disrupted if subjected to Electrostatic Discharge (ESD) during operation. To prevent damage, industry- standard ESD prevention measures must be employed during installation, maintenance, and operation.

# Purchasable Parts

Mechanical Components

A close-up of a speaker

Description automatically generated with low confidenceA picture containing text

Description automatically generated

A pair of gold coins

Description automatically generated with low confidence

1. #25 Screws
2. Servo Horns
3. M3 x 5mm Female Press In Inserts

Cables

A close-up of a speaker

Description automatically generated with low confidenceA picture containing electric organ

Description automatically generated

A picture containing connector

Description automatically generatedA picture containing electronics

Description automatically generated

1. 8 Pin Ribbon Connectors
2. 20 Pin Ribbon Connectors
3. 8 Pin Ribbon Cable
4. 20 Pin Ribbon Cable

Electrical Components

A picture containing electronics, adapter, charger

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1. Power Adapter
2. Power Supply
3. 25kg Servo
4. 10kg Servo

# 3D Printed Parts

Base

1. Base
2. BP\_Center
3. BP\_EBox
4. BP\_EBox\_Lid
5. HoldingBar
6. Turntable
7. ClampFoot
8. ClampSHaft
9. ClampPlate
10. BearingShaftA
11. DriveshaftLower

Link 1

1. Link1
2. JB\_EEPlate
3. JB\_Link1

Link 2

1. Link 2
2. BearingPlate
3. JB\_Lid\_EEPlate
4. EEPlate
5. JB\_Lid
6. JB\_Link2
7. DriveshaftUpper
8. UpperLinkWasher

Gripper

1. ClawBody
2. Gripper\_Right
3. Gripper\_Left
4. Driveshaft\_Claw
5. Claw\_Shaft
6. ClawShaftSpacer

Controller

1. Controller\_Top
2. Controller\_Bottom

# Before Assembly

Complete the following tasks before building the Modular Robot Arm. It is very important that you complete the tasks before building to ensure easy assembly and best performance.

1. Purchase all necessary parts.
2. Print all parts that need to be 3D printed.
3. Be sure your work surface is completely free of other materials not related to the build.

# Wiring Instructions

# 

# Controller

|  |  |  |
| --- | --- | --- |
| 1 | Start by soldering the 8 and 20 pin connector to the controller motherboard.  Then solder the straight 8 pin connector to the bottom section of the controller board |  |
| 2 | Flip the board over and solder 5 wires to the underside of the board according to the picture seen  Then connect the J3 joystick to the wires as seen |  |
| 3 | Turn the board back over to the top side and solder 5 wires to the top of the board  Then solder those wires to the J1 joystick as seen |  |
| 4 | Solder the J2 joystick in the same way as J2 on the opposite side of the board. | A picture containing electronics  Description automatically generated |
| 5 | Solder two wires to the underside of the controller board and then connect these wires to the button |  |

# 

# Link 1

|  |  |  |
| --- | --- | --- |
| 1 | Take a small board and solder 2, 8 pin connectors to it |  |
| 2 | On the other side of the board solder the Link 1 Servo as shown |  |

# 

Link 2

|  |  |  |
| --- | --- | --- |
| 1 | Start by soldering 2 8 pin connectors to the top of a cut board | A circuit board with wires  Description automatically generated with low confidence |
| 2 | Solder the link 2 wrist swivel servo to one 8 pin connector according to the picture to the right |  |
| 3 | Solder the link 2 wrist bend servo to the other 8 pin connector according to the picture to the right |  |

Gripper

|  |  |  |
| --- | --- | --- |
| 1 | Solder the 8 pin connector to a small board |  |
| 2 | Solder the gripper servo to the board as seen on the right |  |

Main Board

|  |  |  |
| --- | --- | --- |
| 1 | Solder an 8 pin connector, a 20 pin connector, and 2 3 pin connectors to a Arduino cover board as shown | A picture containing text, electronics, circuit  Description automatically generated |
| 2 | Solder 3 black wires and 3 red wires to the side of the board as shown | A picture containing text, electronics, circuit  Description automatically generated |
| 3 | Flip the board over and solder red and black wires to the board as shown to the right |  |
| 4 | Solder the rest of the blue and green wires to the board as shown to the right. These wires are for the pin outs for the servos and controller | A picture containing text, circuit, electronics  Description automatically generated |
| 5 | Take another small board and solder the red and black wires coming off the board in parallel with their respective colors.  Then solder 3 capacitors in parallel with the red and black wires | A circuit board with wires  Description automatically generated with low confidence |
| 6 | Finally solder a power input in series with the red and black wires and add a switch to the red wire.  Wire it according to the picture to the right | A picture containing cable, connector, adapter  Description automatically generated |

# Build Instructions

When building the robot arm use the #25 screw driver on all Phillips head screws and a #25 allen wrench on all other fasteners. Follow the instructions carefully and follow each step to ensure no components are damaged during the build process. Be sure to also follow all wiring guides mentioned so no wires get entangled during operation.

Gripper

|  |  |  |
| --- | --- | --- |
| 1 | Parts Required:   1. 10 short screws 2. 2 medium screws 3. 1 servo bracket screw 4. gripper pin 5. Washer 6. Aluminum servo interface bracket 7. Gripper interface pin 8. Servo circuit board cover 9. Left and right grippers 10. 10 kg Servo 11. Servo Bracket 12. Hand Connector bracket |  |
| 2 | Place the Hand connector bracket on the large flat surface of the servo bracket and secure it with 4 short screws |  |
| 3 | Snap on the aluminum servo interface bracket onto the 10kg servo and secure it with the servo screw |  |
| 4 | Secure the gripper interface pin on the aluminum bracket using 2 short screws |  |
| 5 | Place the left hand gripper in the slot located on the hand connector bracket and slide the gripper pin in the slot to secure the hand.  Secure the pion using a short screw and washer. | Screw  Washer |
| 6 | Place the right hand gripper in the other slot and interface the gears with the left gripper  Secure the right gripper with the servo assembly and fasten 2 medium screws through the servo holes and into the servo bracket |  |
| 7 | Place the circuit board connected to the servo in the circuit board slot on the servo bracket |  |
| 8 | Secure the circuit board using the circuit board cover and fasten it down using 2 short screws |  |

Link 2

|  |  |  |
| --- | --- | --- |
| 1 | Parts Required:   1. 2 10kg Servos connected with circuit board 2. Wrist/Elbow bracket 3. Circuit board mount 4. Circuit board cover 5. hand Servo Bracket 6. Bearing 7. 8 short screws 8. 2 aluminum servo interface bracket 9. 3 medium screws 10. 2 servo screws 11. wrist interface pin |  |
| 2 | Place one of the aluminum servo interface brackets on the wrist servo and secure it with a servo screw |  |
| 3 | Place the wrist interface pin into the slot located on the Wrist/Elbow bracket |  |
| 4 | Insert the wrist servo assembly into the Wrist/Elbow bracket and secure it with 2 short screws |  |
| 5 | Secure the wrist pin to the aluminum servo bracket using 2 short screws |  |
| 6 | Place the circuit board mount onto the Wrist/Elbow bracket and secure it with 2 short screws |  |
| 7 | Place the circuit board for the servos into the circuit board mount |  |
| 8 | Place the other aluminum servo bracket onto the servo and secure it with a servo screw |  |
| 9 | Mount the hand servo to the hand servo bracket and secure it with 2 short screws |  |
| 10 | Place the bearing onto the hand pin |  |
| 11 | Secure the hand bracket assembly to the hand pin using a medium screw |  |

Link 1

|  |  |  |
| --- | --- | --- |
| 1 | Parts list   1. 25kg servo 2. Circuit board mount 3. 6 medium screws 4. 4 short screws 5. Aluminum servo interface bracket 6. Elbow pin 7. Servo screw 8. Circuit board cover 9. Elbow/Shoulder |  |
| 2 | Secure the circuit board mount to the elbow/shoulder bracket using 2 medium screws |  |
| 3 | Snap on the aluminum servo bracket and secure it with the servo screw |  |
| 4 | Mount the servo to the elbow/shoulder bracket assembly using 2 medium screws |  |
| 5 | Attach the elbow pin to the aluminum servo bracket using 4 short screws |  |
| 6 | Place the circuit board onto the circuit board mount |  |
| 7 | Attach the circuit board cover to the circuit board mount using 2 medium screws |  |

EEBox

|  |  |  |
| --- | --- | --- |
| 1 | Parts list   1. Main Circuit board 2. Main Board box 3. Main board box cover 4. Arm base 5. 3 long screws 6. 6 medium screws 7. Switch washer 8. Switch nut 9. Wide washer |  |
| 2 | Hot glue the switch and power plug to the bottom of the main board box |  |
| 3 | Secure the switch using the switch washer and nut | Nut  Washer |
| 4 | Place the main board and auxiliary board in the main board box and secure them with 3 medium screws and the large washer  The auxiliary board is secured using one of the screws and washer  The main board is secured using 2 of the screws |  |
| 5 | Use 3 medium screws to secure the main box cover to the main board box |  |
| 6 | Use 3 long screws to secure the arm base to the main board box |  |

Turntable

|  |  |  |
| --- | --- | --- |
| 1 | Parts list   1. Main board box assembly 2. Lower swivel base 3. Upper swivel 4. 4 medium screws 5. 6 long screws 6. Aluminum servo bracket 7. Servo screw 8. 2 Swivel base supports 9. 25kg Servo |  |
| 2 | Place the lower swivel base on the main board box assembly |  |
| 3 | Secure both swivel base supports using 4 medium screws on the main board box assembly |  |
| 4 | Place the 25kg servo on the lower swivel base, be sure to feed the servo wire through the hole in the lower swivel base |  |
| 5 | Secure the servo using 4 medium screws |  |
| 6 | Snap on the aluminum servo bracket onto the servo |  |
| 7 | Snap on the upper swivel onto the lower swivel |  |
| 8 | Secure the upper swivel to the 25kg servo using the servo screw |  |
| 9 | Secure the upper swivel base to the aluminum servo bracket using 2 medium screws |  |

Shoulder Joint

|  |  |  |
| --- | --- | --- |
| 1 | Parts list   1. 25kg servo 2. 4 long screws 3. 2 medium screws 4. Aluminum servo bracket 5. Bearing 6. Servo screw 7. Shoulder pin |  |
| 2 | Snap the aluminum servo bracket onto the 25kg servo and secure it with the servo screw |  |
| 3 | Attach the shoulder pin to the servo and secure it with 4 medium screws |  |
| 4 | Place the bearing onto the shoulder pin |  |
| 5 | Place the shoulder servo assembly on the upper swivel base  Be sure to place the bearing into the upper swivel bearing brace | Insert Bearing Here |
| 6 | Secure shoulder servo to the upper swivel using the 2 short screws |  |

# Final Assembly

During final assembly the robot will need to be turned on before attaching all of the finished joints together. To prevent electrical shock or damage to your components be sure all wires are free from entanglement prior to turning the robot on. Also make sure the electrical box is closed so the power cables inside are not accidentally touched.

|  |  |  |
| --- | --- | --- |
| 1 | Parts List:   1. Base 2. Link 1 3. Link 2 4. Connector Bracket 5. Gripper 6. 3, 8 pin Cables 7. 1, 20 pin Cable 8. Controller 9. 12 screws 10. 1 screw with washer |  |
| 2 | Remove the BP\_EBox\_Lid from the BP\_EBox |  |
| 3 | Connect a 8 rib cable to the 8 rib connector |  |
| 4 | Connect the other end of the 8 rib cable to the lower connector on Link 1 |  |
| 5 | Connect another 8 rib cable to the upper connector on link 1 |  |
| 6 | Connect the other end of this 8 rib cable to the lower connector of link 2 |  |
| 7 | Connect another 8 rib connector to the upper connector of link 2 |  |
| 8 | Connect the other end of this 8 rib cable to the connector on the Gripper |  |
| 9 | Connect the turntable servo connector to the 3 pins closest to the turntable |  |
| 10 | Connect the shoulder servo connector to the 3 pins furthest from the turntable |  |
| 11 | Connect the 20 rib connector to the Arduino board and then the controller |  |
| 12 | Be sure the switch on the side of the BP\_EBox is switched to the off position |  |
| 13 | Plug in the power supply to the BP\_EBox and plug the power supply into the wall |  |
| 14 | Make sure all cables and parts are free to move before switching the switch to the on position |  |
| 15 | Move the switch to the on position |  |
| 16 | Now the final assembly of the robot can begin  When the robot is first switched on all of the servos will move to their middle position and this will make sure that during assembly the connected positions will be correct |  |
| 17 | Attach link 1 to the base  Make sure link 1 is pointing straight up  Connect Link 1 by first sliding the shaft into the turntable hole and then securing the servo to the mounts using 4 screws. |  |
| 18 | Attach link 2 to link 1  Make sure link 2 is pointing straight up  Attach link 2 by sliding the lower portion onto the axle and then securing it with the washer and screw |  |
| 19 | Attach the connector bracket to Link 1 using 4 screws  Be sure it is pointing straight up |  |
| 20 | Attach the gripper to link 1  Be sure the gripper is pointing straight up  Attach it to the connector bracket using 4 screws |  |
| 21 | The robot is now fully functional and can be controlled using the controller |  |

Using the Robot

After you have finished building the robot it is ready to be operated. You can use the controller to move the robot around and the gripper can be replaced with a marker that allow the user to write. There is also 2 main functions that the robot can do based on certain inputs you can find below

Controller:

* Joysticks
  + J1
    - Up and down controls the Shoulder joint
    - Left and Right controls the turntable
    - Pushing down the joystick performs the wave
  + J2
    - Up and Down controls the Elbow
    - Left and right controls the wrist
    - Pushing down the joy stick makes the robot draw UC
  + J3
    - Up and down controls the gripper swivel
    - Left and right controls the gripper arms
* Other
  + Home Button
    - Returns the robot arm back to the home position
  + Screen
    - Once the camera is connected the screen shows the camera feed

Troubleshooting Tips