Limbitless Operating Manual

UCF Armory

This document provides detailed information on how to construct, wire, and operate the Limbitless arm. This is Version 1, and will be updated regularly. Please check for any additional versions that may be posted.

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Abstract

This manual is the first edition for the Limbitless Solution and Arm. This will be updated regularly as the device is improved and advanced with time. Please check back for the updates regularly. Further, by accepting these parts whether by choice through download or through direct build by a distributor, I accept full responsibility for the liability and performance of the device. I also agree to the release of liability found herein.

Safety Information

Safety is a combination of common sense, staying alert in the working environment and knowing how the machine and its individual components operate while the machine is in use. It is important that these safety precautions be followed to minimize any potential risk to you, the user, and to the machine during its operation. The following list will give some guidelines that can be followed to ensure safe use of this machine.

- Make sure **all** wires inside and outside the arm are in proper working order (no open or unsoldered wires) before plugging in the batteries. This will prevent shock or frying of any electrical component.
- Before performing any maintenance, make sure all batteries are unplugged from the machine.
- Do not handle the electrical components with wet hands. **The arm is not water proof** make sure when handling wet products that the liquid does not get on the arm. If the arm does get wet make sure to unplug all the batteries then try using a blow dryer to dry the components before plugging the batteries back in.
- Do not attempt to pick up the arm by pulling the battery cord. Do not close the lid on the cord or pull the cord around sharp edges or corners. Make sure there is enough slack for the sensor wires to ensure good contact at all times and prevent damaging the wire or components.
- **Do not hold onto large items for long periods of time**. Due to the movement of the motor holding onto large objects for long periods of time can cause the motors life and the battery operating time to be reduced. Because there is no variations in the closing of the motor it always goes to the ending position; which will draw more power when not reached. It is able to reach the ending position only when no object is in the hand.

Construction Comments

Some of the components were modified after printing. All of the modifications along with the original part will be discussed in the assembly section. All components that are not printed will be mentioned in the assembly section. In order to complete this build some knowledge is needed on soldering and tapping. If you do not know how to solder below is a link to a tutorial. Tapping is not necessary but is suggested, if you are unwilling to tap, then other options are available.

https://learn.sparkfun.com/tutorials/how-to-solder---through-hole-soldering

Individual Parts

Arm

It is obvious upon inspection that the machine itself is not a solid structure. Instead, the machine's structure is made up of several plastic parts. The arm itself has the express purpose of being a support and mounting structure for all of the components that perform individual tasks. It is made up of two individual parts the bottom structure which houses all of the components, and the cover.

Electronics

All of the electronic components are listed below. Each of these individual components have a specified task.

- Arduino Micro Board
- Break-away male headers
- Break-away right angle male headers
- Electromyography Sensor
- JST Breakouts x 2
- 1200mah 3.7V LiPo Battery x 2
- 1320mah 7.4V LiPo Battery
- High Torque Metal Gear Servo
- Perf Board with Soldering Pads
- 3 Colors of Wire

Hand

All of the individual hand pieces were 3D printed. Other than the palm, this is best to be done with solid infill. Be mindful that these will be played with hard. Solid infill will allow for a better, more solid structure. The palm is

printed in varying densities of sparsity, to accommodate for weight. If using a 3D printer that does not have a dissolvable support material, do not use support or the holes for the wires will get clogged and another will have to be printed.

Joints

The joints of the hand was made using Ninja flex material which is able to be 3D printed also. If you do not have a direct drive extruder then this material will not work. In order to make the joints place the infill on 10%, the feed rate of the material is 30%, the temperature needs to be 250 C, and the number of layers needed is 2. When placing the filament into the head of the extruder make sure that it does not get tangled in the gear. **It needs to feed slowly** if the rate is to fast it will tangle, if the feed rate is to slow it will cause uneven distribution of the material.

Bill of Materials

Part	Description	Unit	Qty	Price	Sub Total	Supplier #	Supplier
1	Arduino Micro	1	1				Amazon
2	Male Headers						Amazon
3	RA Male Headers						Amazon
4	Sensor	1	1				
5	JST Breakouts						
6	Battery 3.7V	1	2				
7	Battery 7.4V	1	1				Amazon
8	Servo Motor	1	1				Amazon
9	Perf Board						Amazon
10	Wires	3	1				Amazon
11	Screws						Mcmaster-Carr
12	Helicoils						Mcmaster-Carr
13	Ninja Flex	1 kg	1				Amazon
14	Rubber Bands						

Assembly

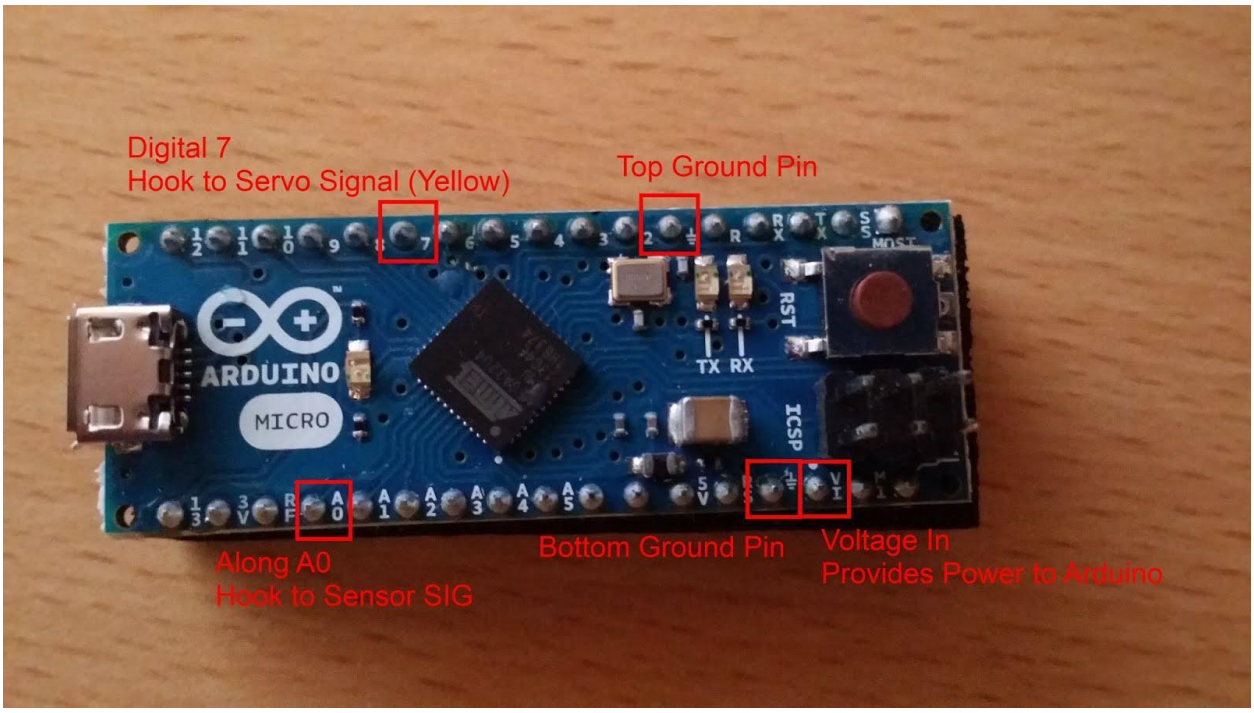
Tools Needed

- Soldering Iron with flat tip
- Solder 0.7mm silver solder
- Flush Diagonal Cutters
- Wire Strippers and Cutters

- Soldering Helping Hands (optional, but they make your life 100x easier)
- Phillips head screw driver #2. Flexible shaft preferred.
- Helicoils tap set

Circuit

Note: When identifying pins on the Arduino be mindful of which side the label is on. It can be a little confusing if you aren't careful. Use this picture to address the pins we will use.



1. Solder the Arduino Microcontroller to the left side of the perfboard with the USB port facing to the left. Be sure to leave at least 3 holes of perfboard on the top and bottom of the Arduino (4 to be safe).
2. Next, solder a set of 3 and a set of 2 male headers into the holes on the electromyography sensor. The short end of the headers should be inserted into the bottom of the sensor board and then soldered on top.
3. Following this, insert the muscle sensor into the perfboard to the right of the Arduino. Make sure to place it where there are 3 holes between the Arduino and the sensor. Also, be certain to solder it with the black headphone jack facing to the right (away from the Arduino).
4. Solder headers into both of the JST breakout boards and then solder them board into a separate perfboard next to one another with 1 hole between them.
5. Next, solder a set of 3 of the **right-angle** male headers to the pin above the top ground pin on the Arduino board. The ground pin is the pin labeled with 3 parallel lines (looks like an upside-down Christmas tree). Be certain to solder it facing to the left (towards the USB port).

6. Use solder to connect the ground pin to the closest pin of the 3-pin right-angle header you just soldered to the board.
7. Use a red wire to connect the VI pin on the Arduino to the middle pin on the 3-pin right-angle header.
8. Using a piece of yellow wire, solder the connection between the top-most pin of the right-angle male header to pin number 7 on the Arduino micro.
9. Solder a piece of red wire from the positive terminal of the first JST breakout to the hole next to the +Vs pin on your sensor. Then connect the two together with solder.
10. Solder a piece of black wire from the negative terminal of the same JST breakout to the hole next to the GND pin on your sensor (that would be the GND between +Vs and -Vs). Now solder a piece of red wire from the positive terminal of the second JST breakout to a hole connected to the same GND pin on the sensor. Then connect all three pins using solder.
11. Solder a piece of black wire from the negative terminal of the second JST breakout to the hole next to the –Vs pin of your sensor. Then connect the two with solder.
12. Next, you need to solder a black wire to connect the other GND pin of the sensor to the other ground pin on the Arduino. The second ground pin is on the bottom of the Arduino (remember the upside-down Christmas tree).
13. Following that, use a yellow wire to connect the SIG pin on the sensor to the hole below the Arduino's A0 pin.
14. Solder the red wire of the battery connector to the VI pin of the Arduino.
15. Lastly, solder the black wire of the battery connector to the bottom GND pin of the Arduino.

Now, you can plug in the USB cord to the port and upload the code to the board. Then unplug the USB cord. Plug the two 3.7V batteries into the JST plugs and plug the 7.4V battery into the battery connector you soldered last.

Structure

Parts Needed:

- Kevlar Survival Cord 0.036"
- Arduino Board
- EMG Sensor
- Batteries
- Hardware – 10x 6-32 nuts and bolts
- Helicoils for 6-32 bolts.
- L bracket
- Fishing Line

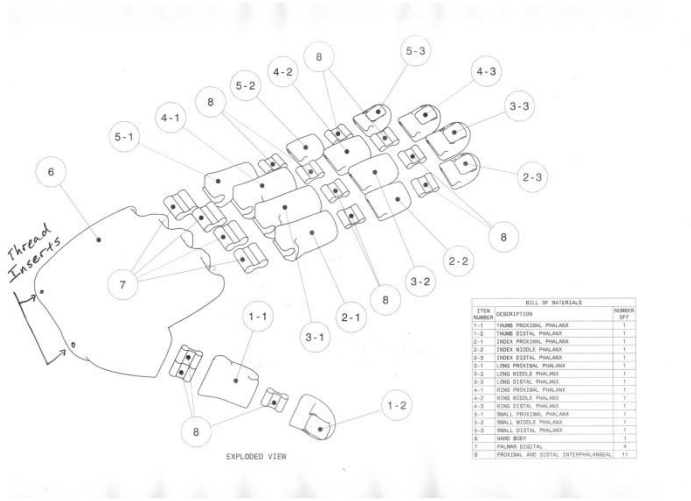
Optional:

- Shock Doctor shoulder brace.
- Velcro straps

Tools Needed:

- Flexible Shaft Bitholding Screwdriver:
- Helicoil installation kit.

1. Download all files.
2. Print all files.
3. Prepare Arduino board. See .pdf for instruction.
4. String fingers to Flexy-Hand by Gyrobot.
   We have found greatest success by exploring the holes with fishing line, then tying a knot to our Kevlar Survival Cord, and pulling the assembly through. Another successful method is to push both ends of the fishing line through the hole, leaving a loop through which the Kevlar cord can be ensnared, and pulled through that way.
5. Insert Helicoils. Ultimate Handyman has an excellent YouTube video here: https://www.youtube.com/watch?v=sQHRB2ElZJ0



Pic. adapted from Flexy-Hand;

6. Bolt the elbow to the forearm. We have used a Flexible Shaft Bitholding Screwdriver with great success.
7. Pull the lines from the Flexy-Hand into the forearm.
8. Bolt the hand to the forearm. We inserted Helicoils into the hand to prevent the bolts from pulling through. We printed our palm in a sparse mode to reduce weight, which made it less robust for holding threads. Helicoils have been very successful in reinforcing those areas. Using

9. Insert and affix the servo inside the forearm. In this version, we used an L- bracket, and affixed the servo as close to the hand as possible. In later versions, we plan to move the servo further back, to allow for a more natural form.
10. String the servo. We found the best way to judge the length of a finger tensioner was to close the grip, and place the servo in the "Closed Hand" position. Using a rubber band to hold the hand closed was handy. This allowed for an accurate judge of final cord positioning. Placing the servo in the "Open Hand" position allows for a little play in order to tie the knots. Double or triple the knots to prevent them from being pulled through.
11. Insert electronics. In this version, we placed the batteries in the walled off section closest to the elbow, with the Arduino just beside it.
12. Connect all electronics. Batteries to battery connectors, servo to Arduino, EMG sensors to microcontroller. In the future, we intend on adding an on/off switch, but our current method of activating and de-activating the Arduino is by plugging it in, and unplugging it into the battery connector.
13. Test functionality. Tapping the disconnected EMG sensor leads usually generates enough noise to activate the servo. If nothing happens, you may want to re-check your installation and activation of your Arduino board. Usually touching the black lead and any other lead simultaneously, with the board on, and all electronics connected, will result in a servo positon switch.
14. Close the lid. If everything is functional, now is a perfect time to secure the lid. Future editions will have a hinge mechanism, but for now, using elastic bands anchored to the external posts has provided a simple but effective solution.
15. Connect EMG Sensors to muscles. The red and blue should be connected to the muscle group intended to activate the servo, while the black should be placed away from that group to eliminate background noise.
16. Affix our arm. For Alex, we used a ShockDoctor shoulder brace, with supplementary Velcro straps to provide additional support.

Daily Inspection

Before the arm is used make sure a daily inspection is done. If something does not look right go the maintenance section of this report.

Arm

While inspecting the arm and hand look for anything out of place; for example the wrist and elbow should not move if they are able to move it is time to go to the maintenance section of this report. Also look for any broken parts or loose joints. If the joints are loose or parts are broken be sure to replace them.

Electronics

Every day the batteries should be placed on the charger. Make sure to test the motor by attaching the leads to the specified muscle group and flexing. If the motor does not work, check to see if the plug from the leads is installed to the sensor correctly. If it still does not work check the battery connections. If still no success there is a grounding issue or the batteries no longer work. Try re-soldering the board and checking the voltage to the batteries.

Operation

Operating the arm is fairly simple it may take up to 45 min. to learn how to use the arm efficiently. The hand is able to close after the sensor that is attached to the body detects a voltage going to that specific muscle group. After the voltage is sensed it is then amplified and sent to the Arduino board; which then interprets the signal and causes the motor to open or close.

Connecting the Electrodes

In the set of electrodes for this project, there are 3 leads to connect: red, black, and blue. When connecting the arm to yourself, each one has a specific spot relative to each other that they must go.

Red: The red wire must sit directly on top of the muscle you are targeting.

Blue: The blue wire must sit on the edge of the muscle you are targetting.

Black: The black wire must sit away from the targeted muscle where is won't be effected.z

See, the following link for more information :http://bit.ly/1lNZIoc

Maintenance

In order to keep this machine in working order, it is sometimes necessary to perform basic maintenance on it. This section will guide you through some common maintenance procedures that can be performed so that the machine will always be in working order and in like new condition after every use.

Tools Required to Maintain Machine

- Screw Driver #2. Flexible Shaft Preferred
- Battery Charger

Arm

After a couple of weeks of use the screws in the arm may become loose. If this occurs be sure to tighten them with the #2 screw driver. Do not over tighten for this will cause the plastic to

break and a new arm will then have to be created. Check the joints to make sure they are inserted correctly. Also the lines connected to the motor will need to look after for they may begin to fray over time. If fraying occurs be sure to replace them.

Plastic

ABS Plastic is recommended to be cleaned with 4 parts water and 1 part normal dish soap, with a non-abrasive cleaner. A traditional sponge is recommended for cleaning surface dirt. Be mindful that the arm is NOT waterproof at this time. Take extra care to protect the electronics by removing them from the arm when cleaning the plastic.

Electronics

Make sure the batteries are fully charged for everyday use. Charging can take anywhere from 1 to 3 hours depending on how low the battery is. Make sure the sensor plug is properly inserted into the sensor board. If this is not installed properly the motor might move on its own or not at all.

Waiver of Liability

By accepting any design, plan, component or assembly related to the so called "e-NABLE Hand", "Limbitess Arm", or any "mechanical costume referred to including the solution presented in this document , I understand and agree that any such information or material furnished by any individual associated with the design team is furnished as is without representation or warranties of any kind, express or implied, and is intended to be a gift for the sole purpose of evaluating various design iterations, ideas and modifications. I understand that such improvements are intended to benefit individuals having specific disabilities and are not intended, and shall not be used, for commercial use. I further understand and agree that any individual associated with e-NABLE organization, including the UCF Armory and its students, shall not be liable for any injuries or damages resulting from the use of any of the materials related to the e-NABLE hand. This statement has not been evaluated by the FDA. This product is not intended to diagnose, treat, cure, or prevent any disease. This solution is still being developed and is considered experimental and a mechanical costume.

Further, I understand the inherent risk of using Lithium based batteries and agree to follow the safe charging procedures and best care practices. I agree to take the responsibility for any issues that may arise from the use of the batteries.

Should I receive an arm built in full or in part by the UCF Armory or E-Nable, I also agree to the following: In consideration for receiving a Limbitless Arm Solution, I hereby RELEASE,

WAIVE, DISCHARGE, AND COVENANT NOT TO SUE E-Nable, the UCF Armory, and their officers, agents, or employees (hereinafter referred to as RELEASEES) from any and all liability, claims, demands, actions, and causes of action whatsoever arising out of or related to any loss, damage, or injury, including death, that may be sustained by me, or to any property belonging to me, while participating in such activity, while in, on or upon the premises where the activities are being conducted, REGARDLESS OF WHETHER SUCH LOSS IS CAUSED BY THE NEGLIGENCE OF THE RELEASEES, or otherwise and regardless of whether such liability arises in tort, contract, strict liability, or otherwise, to the fullest extent allowed by law. Further, I agree to hold harmless any of the RELEASEES for any harm that may come to others by my or my dependents use of the device, and accept full responsibly for my or their actions.

I further hereby AGREE TO INDEMNIFY AND HOLD HARMLESS the RELEASEES from any loss, liability, damage, or costs, including court costs and attorneys' fees that Releases may incur due to my participation in said activities, WHETHER CAUSED BY NEGLIGENCE OF RELEASEES or otherwise, to the fullest extent allowed by law.