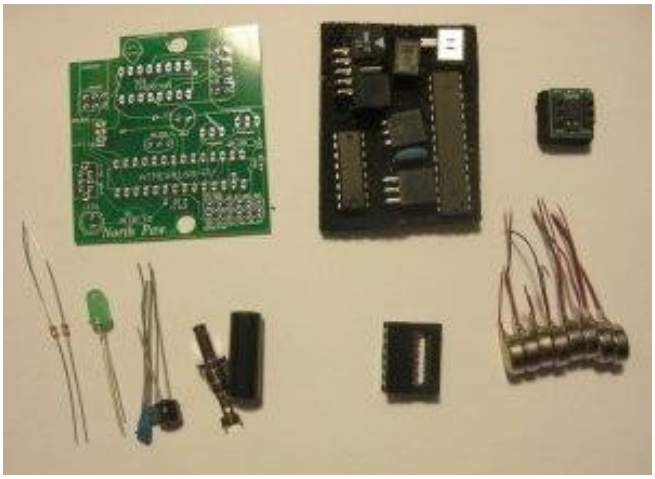
North Paw V1.0 Kit Instructions

http://sensebridge.net/projects/northpaw/instructions/

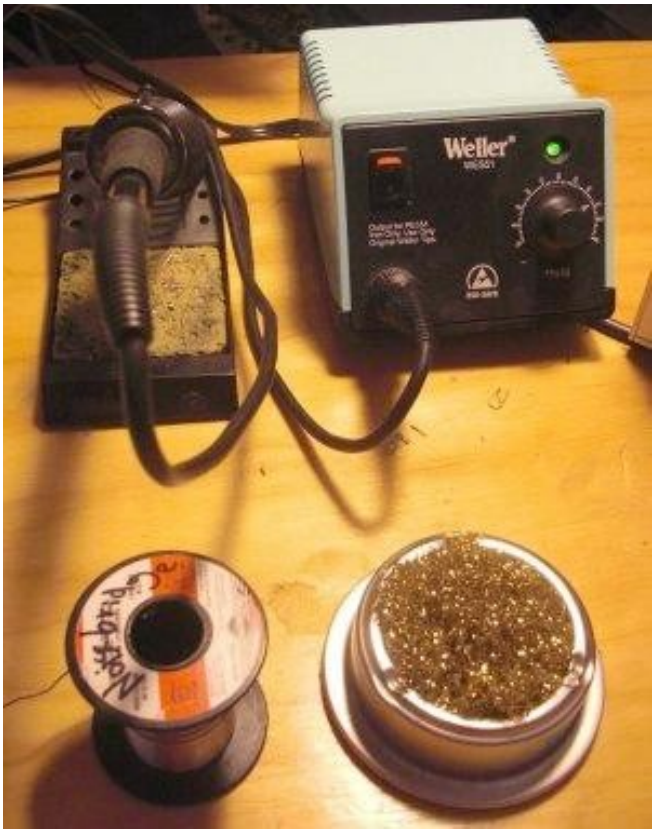
	Step 0: Overview
	Total Kit Contents • Electronics bag (see Step 2 for complete contents) • 3 pieces of sticky-back velcro • 12″ of 10 conductor ribbon cable • 8″ piece of 1/16″ shrink tubing • Small piece of stretchy white fabric • JM22 enclosure • 3xAAA enclosure • 10.5″ custom armature enclosure • HM55B compass module in silver bag • Sensebridge business card
	Tools you'll need: • wire cutters • wire strippers • soldering iron, solder • scissors • phillips screw driver • optional: hot air gun
	The assembly consists of 4 step: • Step 1: Electronics • Step 2: Enclosures • Step 3: Display • Step 4: Final Assembly & Calibration
	Step 1: Electronics



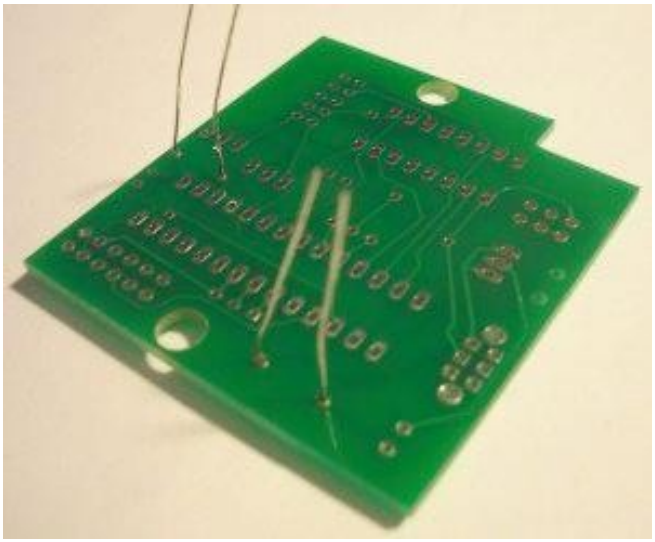
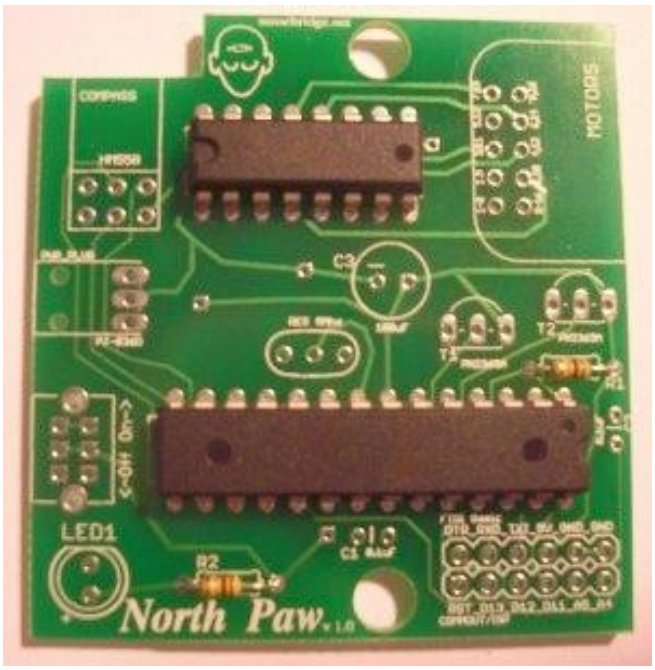
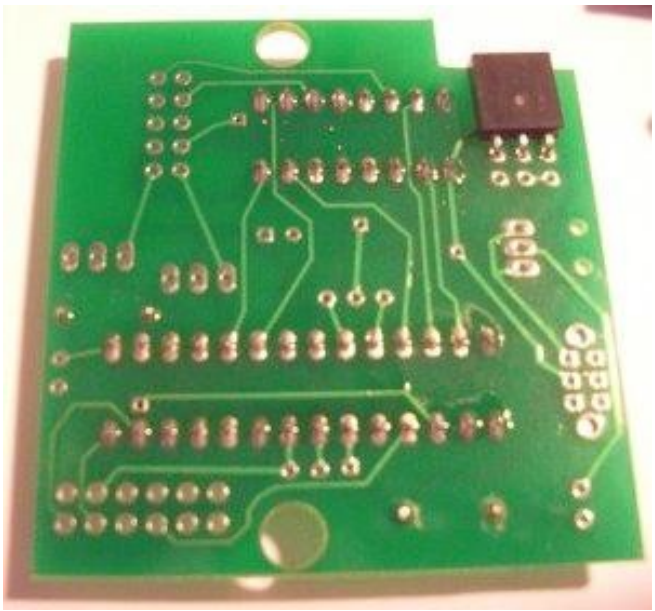
The little electronics bag includes all of this.

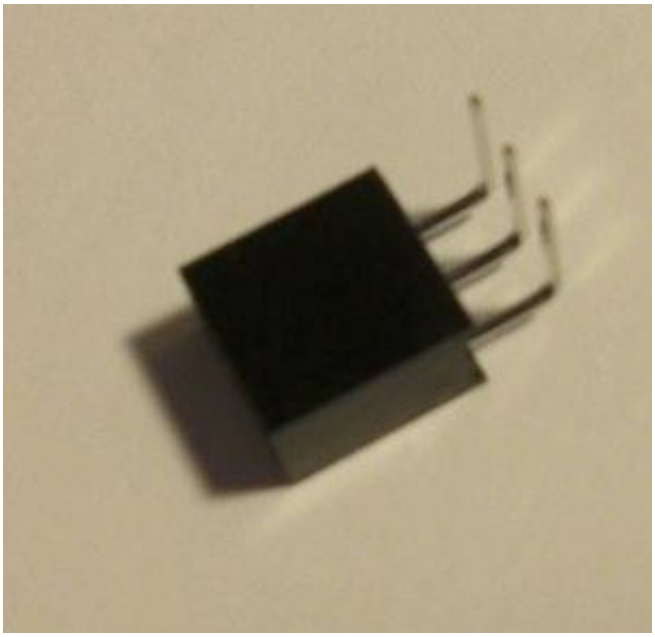
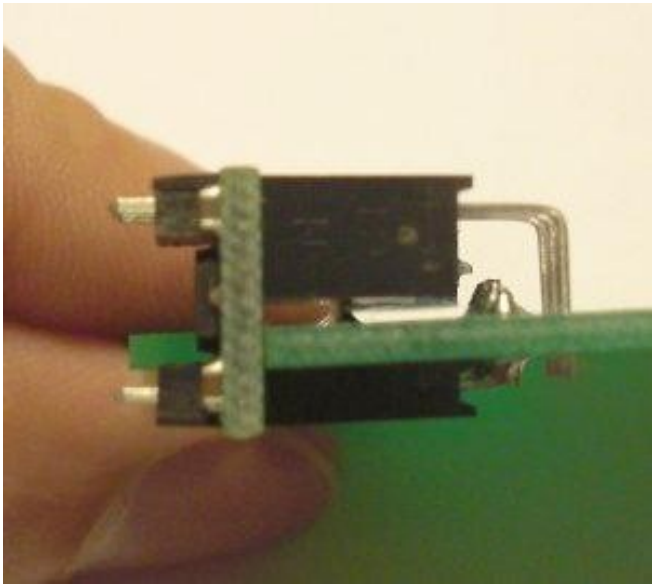
- Custom North Paw V1.0 PCB
- 2 10kOhm resistors
- 1 green LED
- 2 0.1uF caps (little blue ones)
- 1 large 47uF electrolytic cap
- Battery jack + black cover + socket
- ATMEGA168 28DIP IC
- TPIC 16DIP IC
- 1×3 and 2×3 right angle female header sockets for compass
- 3 pin resonator (blue)
- switch STDP
- 2×5 male right angle motor socket
- HM55B compass module (comes in silver bag)
- ribbon cable snap
- 8 coin-type vibrating motors

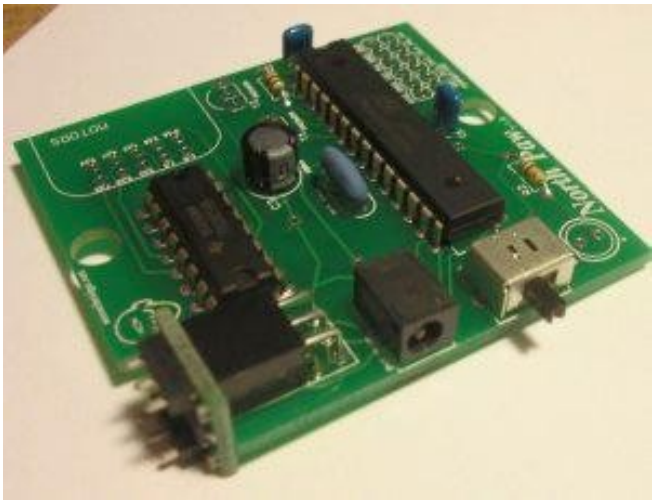
For this set of instructions, you won't need either the ribbon cable snap or the motors, so set them aside in a safe place.

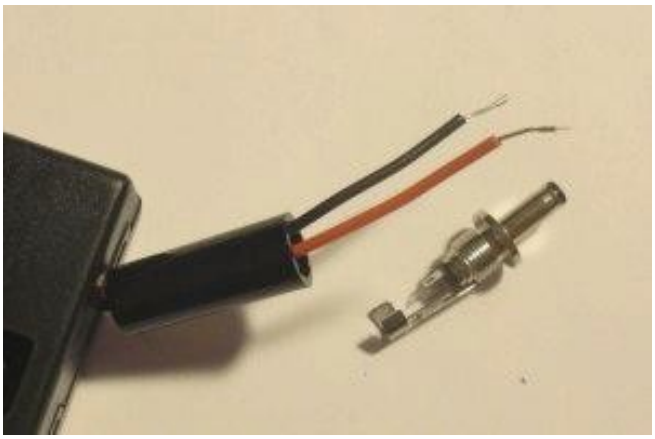
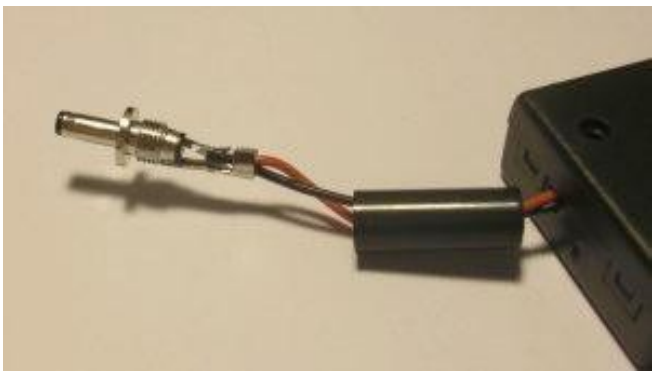


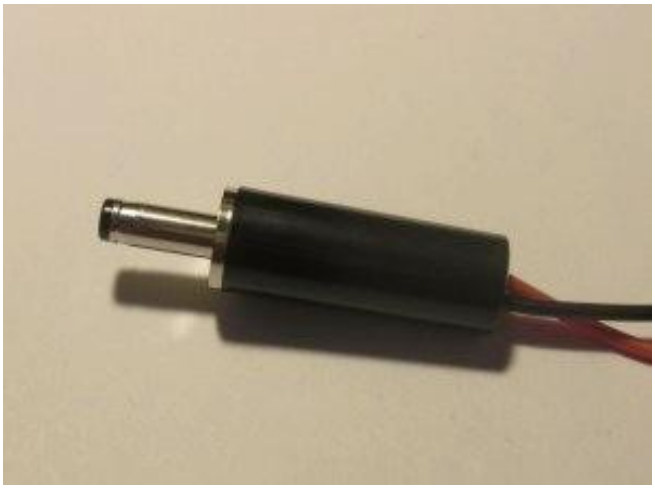
You'll need a soldering iron and some solder.

	Start soldering with the shortest components first… this makes it easy to turn the board over and solder on the bottom, where nothing is in your way. So we start with the resistors, they are both the same so bend them up and put the through the holes marked R1 and R2 (both are near the ATMEGA footprint)
	Next do the two ICs. Be careful to get the orientation of the ICs correct – the ATMEGA pin one is to the right, whereas the TPIC pin one is to the left.
	Next mount the 1×3 female header on the *back* of the board. The HM55B compass will slot into this later. Solder it tightly in place

	For the other half of the compass socket, you'll need to chop the shorter pins on the 2×3 female header socket. This should leave 3 longer legs. Chop the short ones all the way back – otherwise the little leftover leads could contact the pins from the 1×3 from the other side
	Once you've got the short legs cut, place the 2×3 into the holes, and before soldering mount the HM55B compass into the resulting socket (the RoHS label goes towards the center of the board. If your HM55B lacks the RoHS mark: the three small surface mount resistors go towards the board). You'll see that the 2×3 actually doesn't quite touch the PCB. Also make sure that the short leads that you cut are not contacting the pins from the 1×3 socket. Once you're happy square it all up and then solder the 2×3 in place.
	Now do the switch and the barrel connector. For the switch, there are two much larger holes, these will need a lot of extra solder. They provide a firm mechanical hold to the board, so that you can flip the switch without worrying. The barrel connector has two little pegs at the front which should fit into the holes provided.

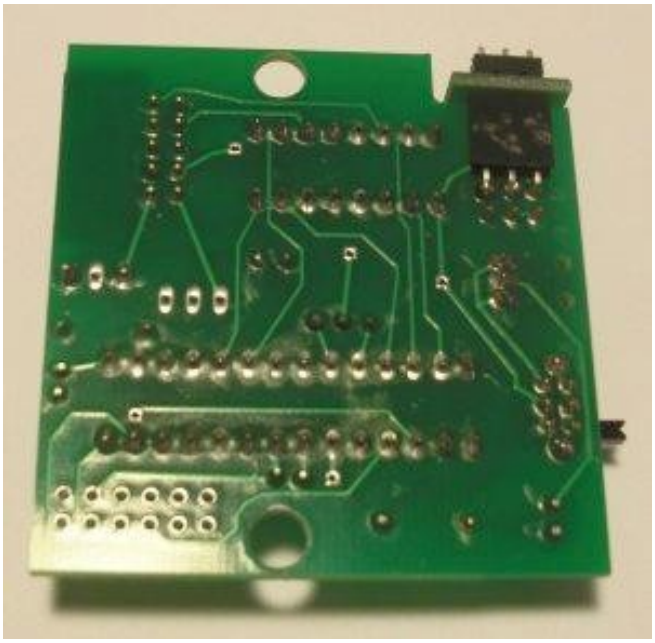
	Now solder on the three pin blue resonator (orientation does not matter) and the two 0.1uF caps (orientation does not matter)
	The large electrolytic capacitor is polarized. The stripe down one side is the negative terminal. On the board, the negative hole is marked. The negative side is towards the barrel jack. If you're not sure, compare to the photo.

	Solder in the motor socket. You'll also need to bypass "T2″, which is a switch controlling the actions of motors 1-8. Use one of the leads that you cut off a resistor or cap. Bend it over and solder it between the two outside pins of T2 (see photo). The North Paw V1.0 circuit board supports up to 16 motors via the T1/T2 switch. The kit contains only 8 motors, so for the kit, it makes sense to simply bypass the switch by hardwiring it high.
	Put the battery wires through the black cover (very important – impossible to do later!). Cut the wires down to ~2 inches in length. Tin the wires with solder.
	Solder the red wire unto the outside contact, and the black wire unto the inside contact. (yes we know this is backwards, our bad). Make sure not to put any solder/bumps/wires/etc on the outside of the outside contact, as this makes it difficult to get the cover over later.



Once both leads are soldered, use pliers to close the strain relief crimp at the end of the outside contact. Then you should be able to slide the cover over the contacts and screw it shut.

The final step is the LED. If you check carefully, you'll fine that the package has a flat side. The silkscreen on the PCB shows a flat side, simply align the two. Alternately, the silk screen also shows a small "+" on the bottom side of the LED footprint. The longer leg of the LED is positive side and should go through the bottom hole.



Your circuit board is done! Take a couple of minutes now to inspect all of your solder joints, make sure they are all shiny and complete. A quick glance now could save you the agony of a flaky North Paw later.

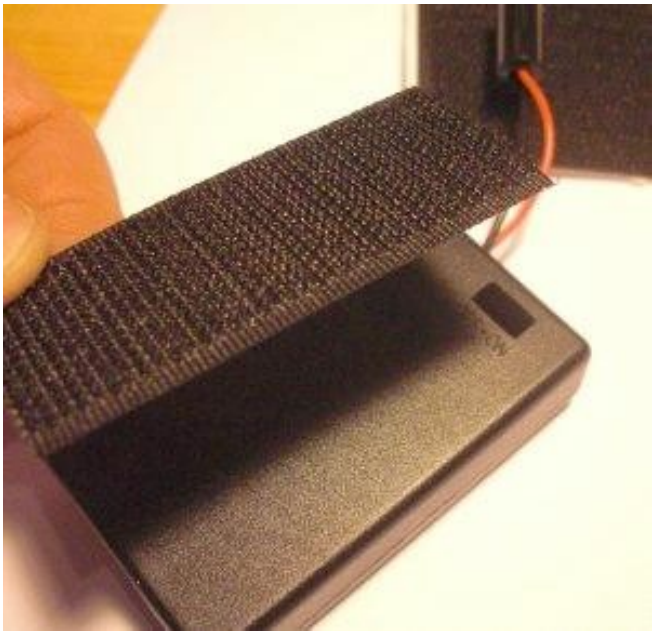
Step 2: Enclosures

During this step we're going to put the electronics into the enclosure, and prepare the enclosures for mounting on the armature with velcro. You'll need:

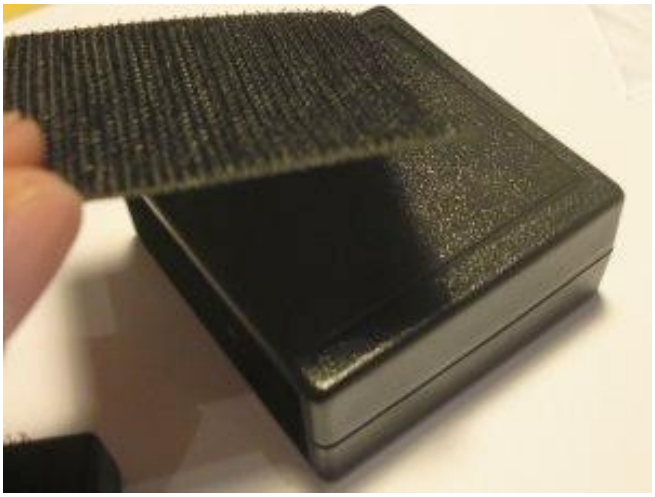
- Finished North Paw V1.0 PCB
- PacTec JM22 enclosure
- Battery Case
- Two pieces of black sticky-back velcro (skinny and fat)

Open up the enclosure bag. You won't need the end panels, but do keep the two screws. Place the PCB into the enclosure (the mounts are not symmetrical, so it only fits properly one way)

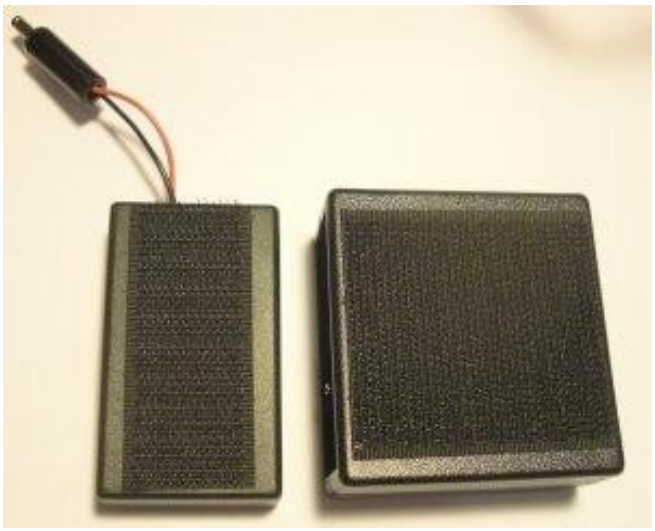
Close the enclosure with a small phillips screw driver.



Peel the white backing off the smaller of the velcro pieces, and stick it to the non-opening side of the battery enclosure. This is the side with the (useless) “on/off” labeled hole (as pictured).

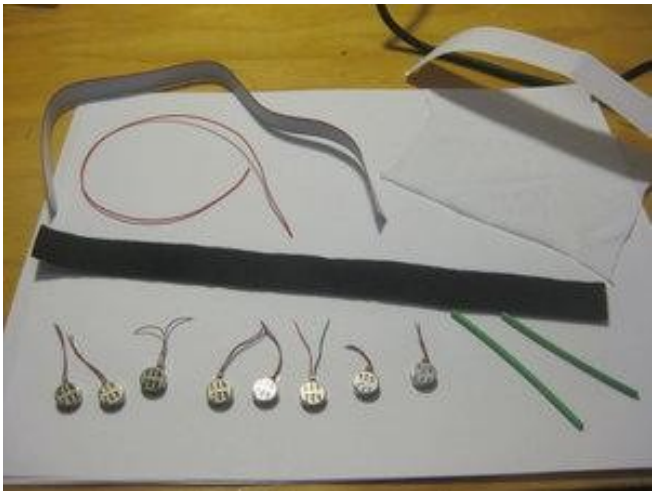


Peel the white backing off the other piece of velcro, and stick it to the non-screw side of the JM22 electronics enclosure. This ensures that if you ever need to open the enclosure up again, you won’t have to ruin your velcro. Orient the bare-edged strips of the velcro to run along the closed-face edges of the enclosure.



Congratulations, your enclosures are ready for use.

Step 3: Display



During this step we're building the North Paw's haptic "display". This display consists of **eight vibrating pager motors** attached one by one to a length of **ribbon cable** and mounted on a **Veltex foam backing**. You'll need:

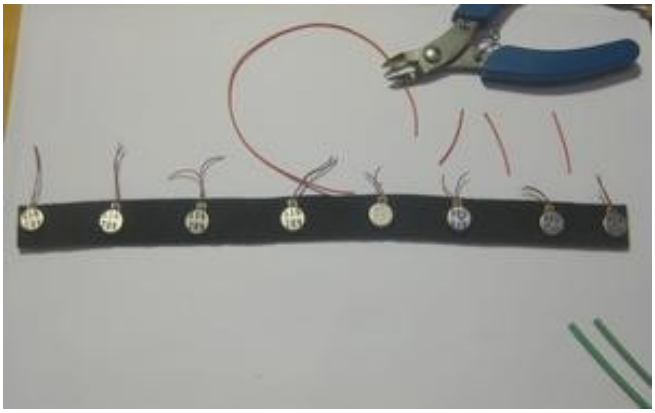
Supplies (incl. in kit)

- 8 pager motors
- 10 inch strip of Veltex foam
- 12 inches of ribbon cable
- Extension wire (for any pager motors with shorter wire leads)
- Shrink tubing
- Strip of sticky back hook Velcro.
- Square of soft, thin fabric.

Tools (not incl.)

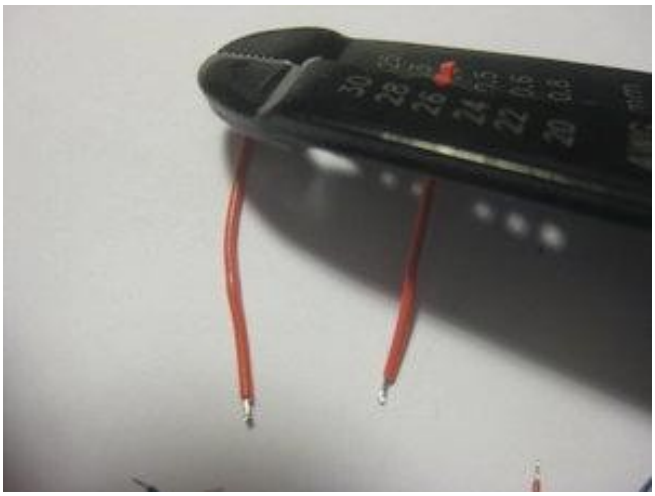
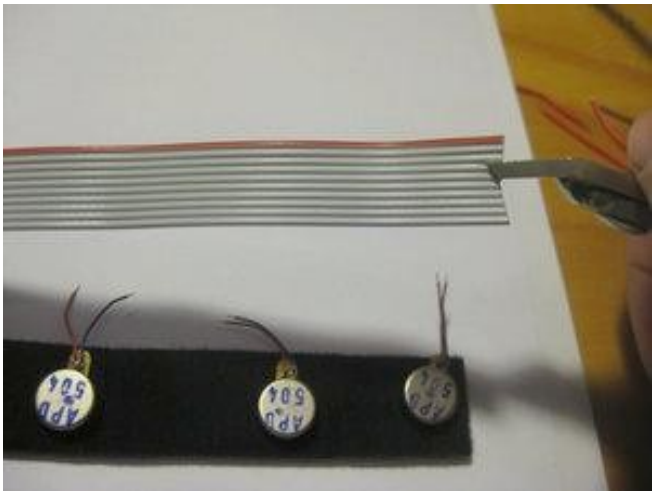
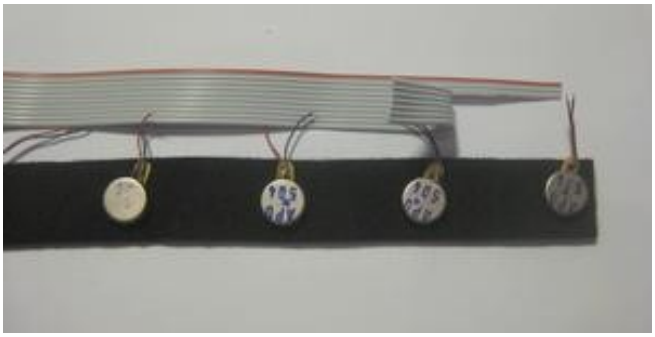
- Soldering iron
- Wire cutters
- Wire strippers (recomended, but wire cutters can work if you're careful)
- Heat gun (recomended for shrinking the shrink tubing, but soldering iron can work too)
- Scissors

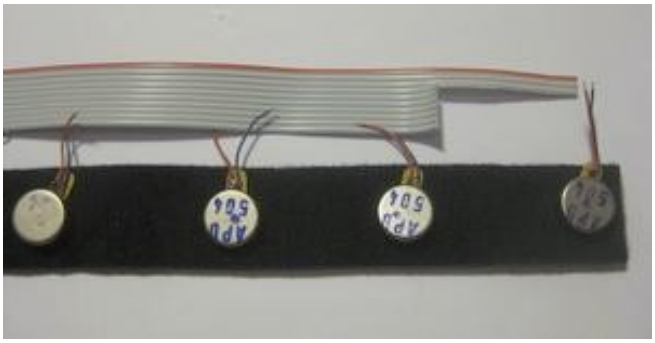
This is the most difficult part of the kit! It is quite concievable that you could snip the wrong wire at various points in the procedure, so please take your time and be careful.



To get things started, place the strip of veltex flat on the table. On top of that, **space the eight motors out evenly**. The motors won't be affixed to the veltex until the end of this process, but having them spaced out on it will be a handy length reference as you cut the ribbon cable.

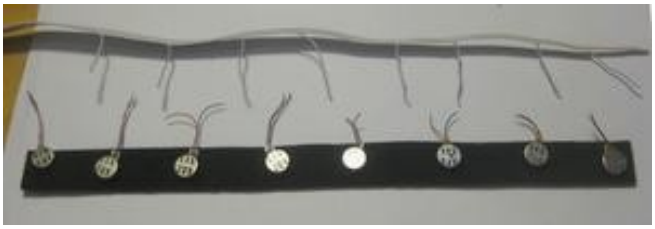
Once the motors are spaced evenly on the fabric, **take note of how long their wire leads are**. You might have eight motors with long leads (congrats, that saves you a couple steps!), or you might have eight with short wire leads (sorry!), or even a combination. **If you have any of the motors with short wire leads**, you will need to **cut some extension wires** from the length of wire included in the kit. Now is a good time to do this, so cut as many extension wires as you have motors with short wire leads, less the last motor. In this picture I have

	4 long wire motors and 4 short wire motors. There is 1 short wire motor at the end which doesn't need an extension wire, so I cut just 3 extension wires.
	These extension wires should be just **about one inch long**. While you're at it, go ahead and **strip the ends** of these wires. You should have a bit of extra wire in case you mess up, but not too much so be careful!
	Now you need to start separating **the different strands of the ribbon cable**. The easiest way to do this is to get your wire cutters in between two strands and gently snip the insulation. You only need to snip a millimeter or two, after that you can peel the strands apart by hand. With the **red wire on top** snip **below the third strand**. *A brief explanation: The first (red) strand will be the common power line for all the motors. The thrid strand is the sink for the first motor which will be turned on or off by the controller. If you were making a belt with more than eight motors the second strand would be a second power line, but you're only making an 8-motor anklet, so just leave the first three strands together for now.*
	Next **peel back** the lower seven strands until **just to the right** (2-3mm – it doesn't need to be super exact) **of the next motor.**



Cut those seven strands there.

Now separate the fourth strand from the next six strands. Peel back until just to the rigth of the next motor and cut again. **Continue in this fashion to the left, peeling and cutting each strand in turn.** When you're done, each strand will terminate just to the right of each motor.

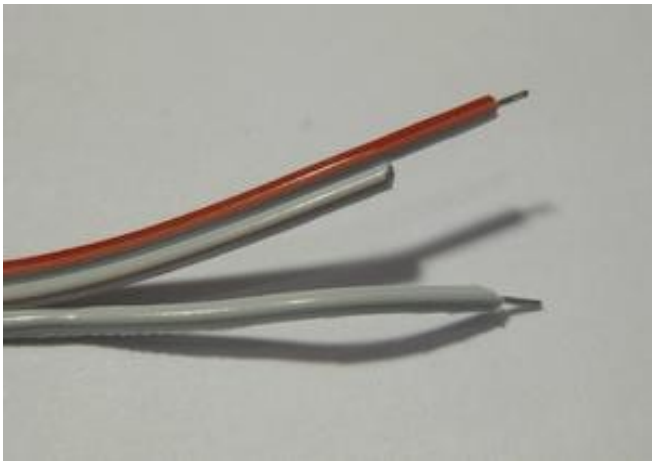


<u>If you have all short wire motors</u>
Peel each strand away from the rest of the ribbon cable so that there is **about 1.5 inches of wire**

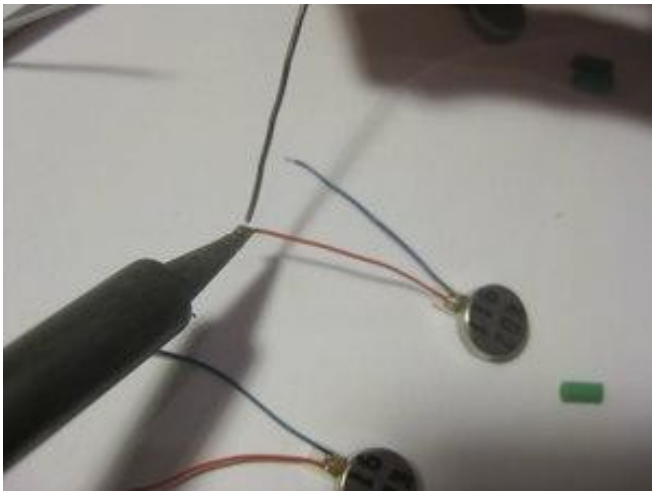
<u>If you have all long wire motors</u>
Peel each strand away from the rest of the ribbon cable so that there is **about 0.5 inches of wire**

<u>If you have a combination of short and long wire motors</u>
Peel each strand away from the rest of the ribbon cable so that there is **about 1.5 inches of wire** and then **snip the wires down to 0.5 inches where there are long wire motors.** (See three images below.)

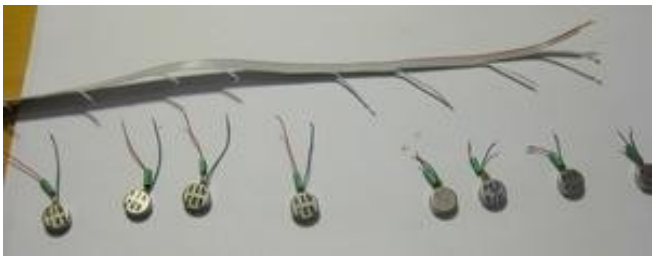
Sorry if this confusing! It's important to ensure that the spacing of the motors ends up even in the end.



Strip the insulation off of all of these wires. For the end two, it might be helpful to cut the second (no connection) strand to keep it out of the way.

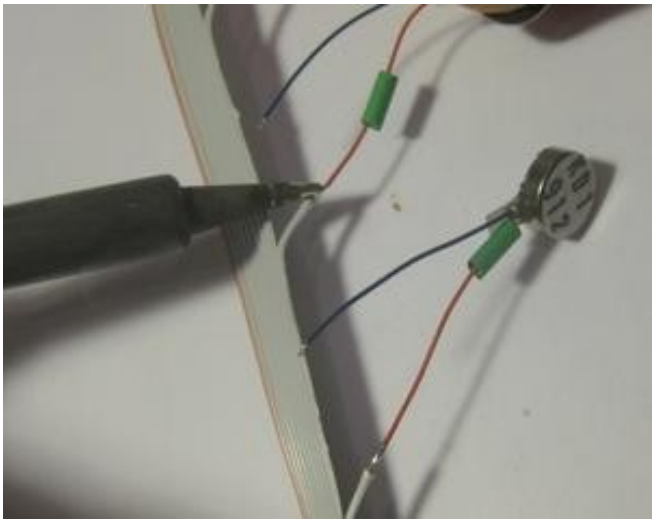


Tin everything in sight. To tin, all you need to do is heat up the exposed bit of metal wire and melt a little solder over it. Don't worry if it seems that the pager motors' little tiny wires aren't picking up too much solder. Also, make sure not to forget to tin both ends of any extension wires you cut.



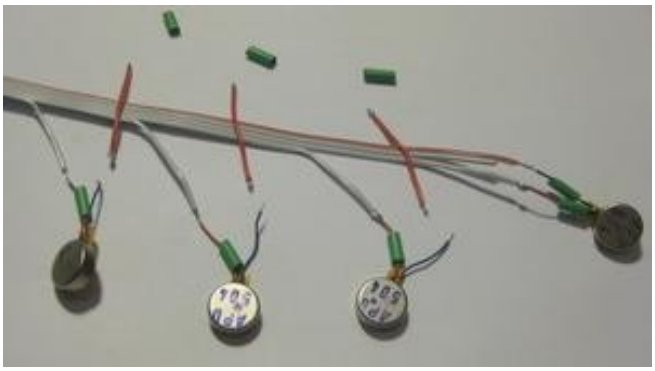
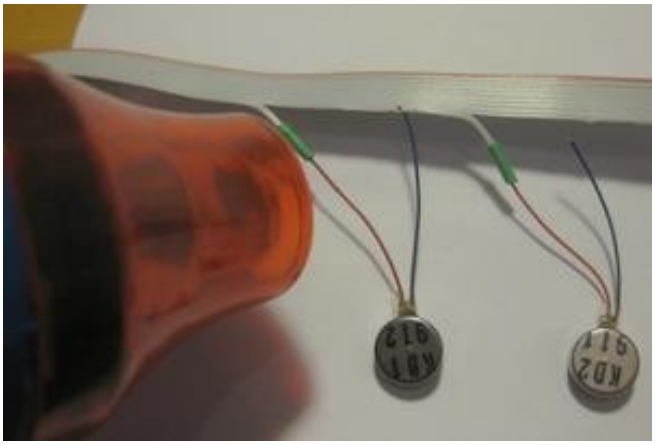
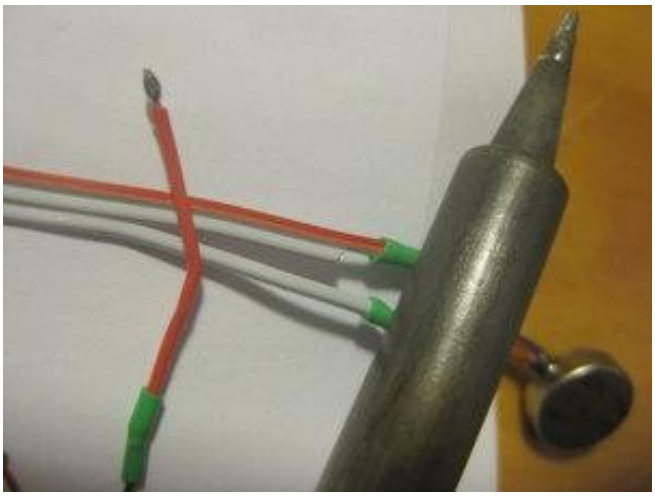
You're almost ready to start actually soldering things together! But, you've got to get the shrink tubing on *before* soldering, of course. Now's the time to **cut a bunch of 1/3 inch pieces of shrink tubing**.

The number of pieces you need will depend on the number of short wire motors you have: cut 1 piece for each long wire motor, cut 2 for each short wire motor, and cut 2 for the last motor at the end, regardless of whether it's short or long. I have 4 long and 4 short, with one of those short ones at the end, so I need 12 pieces of shrink tubing.



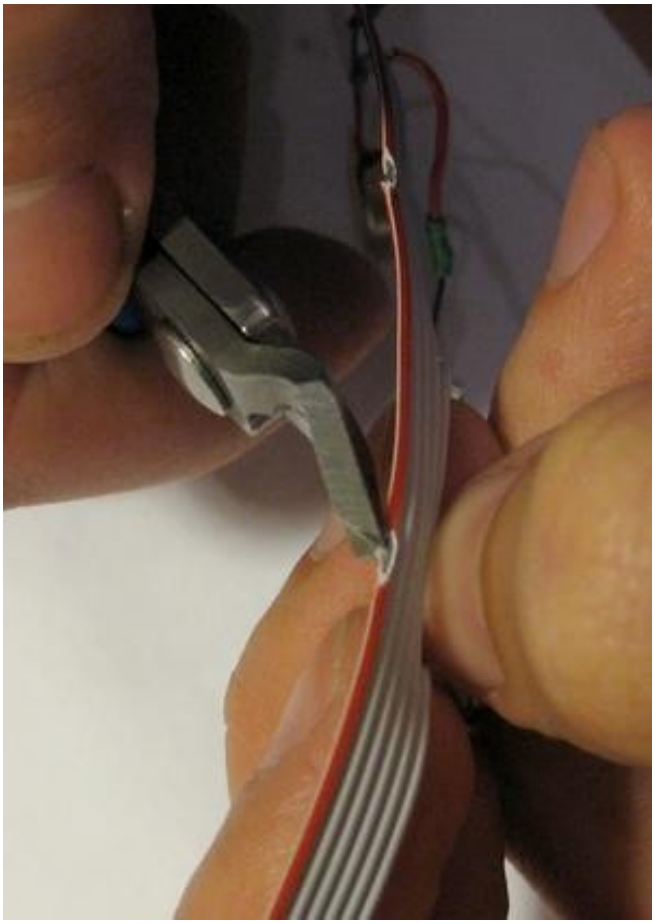
Making sure to put the shrink tubing on first, **solder up one lead of each motor to each exposed strand** of the ribbon cable. If you tinned everything properly, this will be as simple as holding the exposed ends of the two wires together and heating them up with the tip of the soldering iron. As soon as the solder on the to wires melts together, slowly remove the iron. Wait a second or two before letting go of the wires – if you let go too soon, the solder will not yet be solidified, and the wires won't be stuck together yet.

These DC motors are non-polarized, meaning it doesn't matter which lead of the motor you solder up now. That being said, if you solder the red lead, the little bit of adhesive on the motors will be facing a more convenient direction later. It's a small point, so don't worry about it too much.

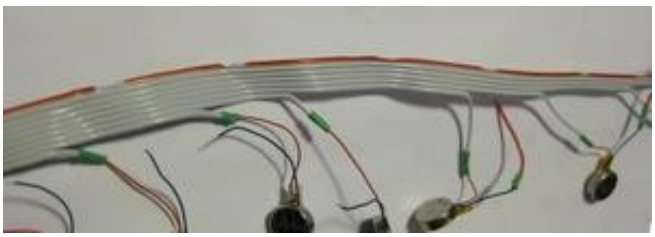
	On the very last motor, go ahead and **solder the second lead** to the red (power) line.
	On any short wire motors, **solder on the extension wires** now. You don't need to put the shrink tubing on before soldering this time of course, but it's probably a good habit to do so anyway.
	If you are lucky enough to have a heat gun, go crazy **shrinking up all that tubing** over the solder joints.
	If you don't have a heat gun, you can shrink the tubing with the soldering iron. But, don't go crazy! Gently slide *the barrel* of the iron across the shrink tubing. DO NOT use the tip of the iron, as this can have the unfortunate side-effect of melting the solder under the shrink tubing, ruining a solder joint which you now can't see because it's under the shrink tubing. Fixing that is always a pain.

Don’t despair, you’re almost done! There just one tricky bit left.

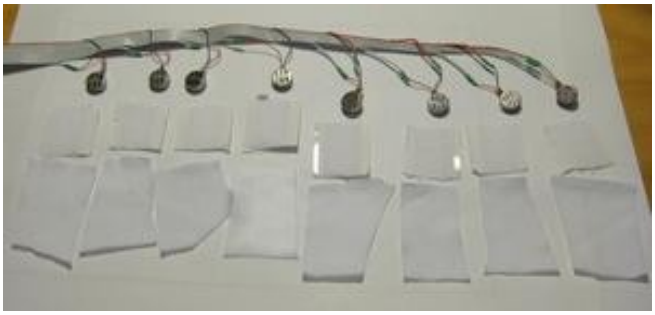
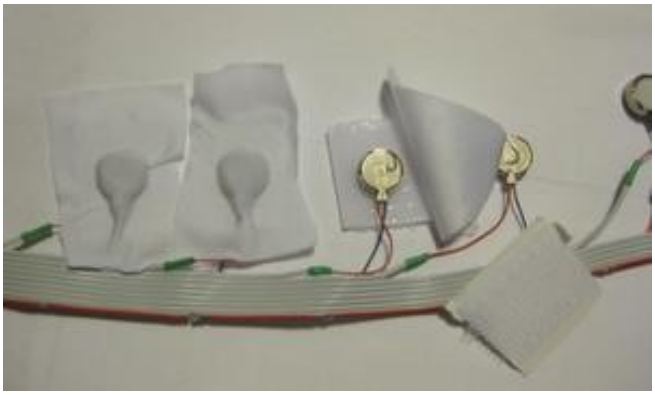
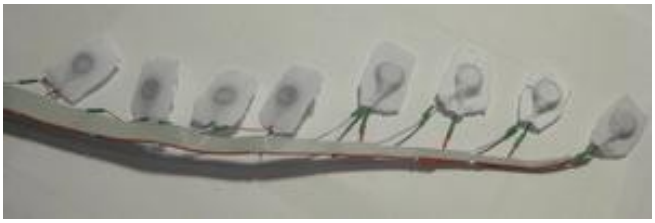
Take each motor and line up each free lead against the red power line. **Where the end of that lead meets the power line, you need to trim off the insulation without cutting the whole wire. That’s it, that’s the last tricky bit.**



The best way to do this is to take a number of **small, gentle cuts** at the insulation with your wire cutters. Once a tiny bit of the metal wire is exposed, stop cutting away and instead use the sharp edge of the cutters to **scrape a bit more insulation away**. After that it can also be helpful to pull at the side of the opening to widen it slightly. If you do accidentally cut the whole wire, don’t worry! Just solder it back together.



You should now have seven exposed sections of the first strand of the ribbon cable. **Tin them all.**

	**Solder the other lead of each motor** to these exposed sections. Congratulations, the hard part is over! You're really, really good at soldering by now, for what it's worth.
	The motors now need Velcro backing so they can be adjustably affixed to the Veltex strip. So, the next step is to **cut the long thin strip of sticky-back Velcro into 8 equal pieces**. The motors will be sandwiched between these Velcro squares and some thin, stretchy fabric, so take the bit of **fabric included in the kit and cut that into 8 equal squares as well**.
	Take the little bits of paper off of the motors to reveal their own adhesive side. Keep that side *up*. Take the paper off of one of the Velcro squares, lift up one motor, and then **push the motor down into the middle of the sticky side of the Velcro square**. Finally, grab **one of the fabric squares, and place that on top**. Push down hard all around the motor so the fabric adheres really securely.
	You have lots of extra fabric, don't you? This is what you needed the scissors for. **Trim away.** You can even trim off some of the Velcro, just *don't cut any wires*!
	**Stick the motors onto the Veltex strip** (the Velcro will only stick to the soft side of it). Space them out evenly, then **fold the ribbon cable *behind* it .**
	If it looks like this, you're done! And don't worry, final assembly is about one fifth as many steps as this was, and there's absolutely no soldering.
	## Step 4: Final Assembly

In this, the final step, you'll **stuff the motor array into the armature**, position the controller and battery onto the exterior of the armature, **and hook them all on up together**.

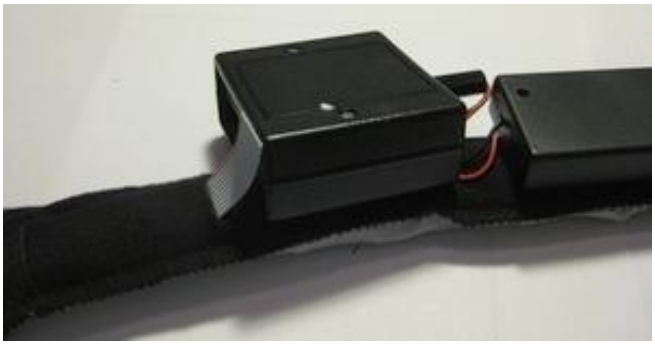
Supplies (incl. in kit / made by you already)

- Completed North Paw V1.0 board in enclosure
- Battery enclosure
- Pager motor array on Veltex backing
- Ultra-chic North Paw anklet

Tools (not incl.)

- Pliers
- A second pair of pliers (highly recommended)
- – or –
- A vise (insted of the two pairs of pliers)
- 3 x AAA batteries

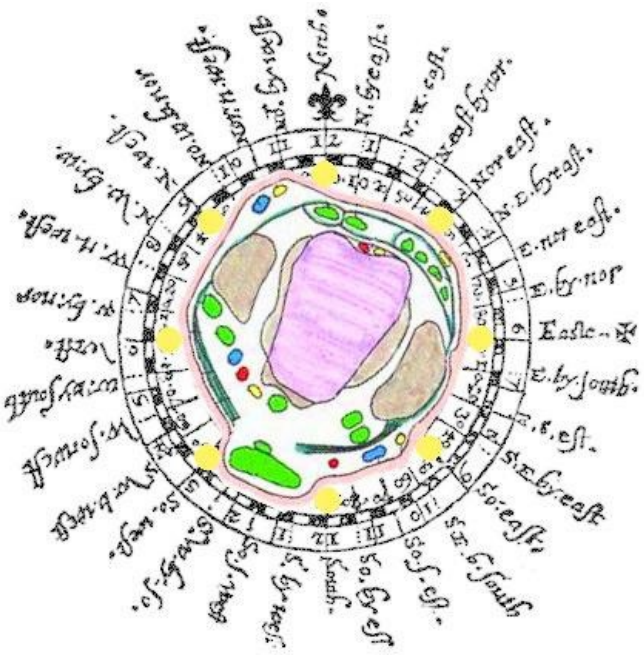
Take note of the position of the slit cut into the armature. Unzip the anklet and **insert the pager motor array**. The thickest part of the ribbon cable should be towards the end of the anklet with the slit. Make sure the pager motors face the soft silver fabric – that's the side of the anklet that is held against your skin and we want the motors right on you! As the zipper is slightly shorter than the whole anklet, you may need to pinch from the outside and wiggle the last motor up to the edge.



Once the motor array is snug, fold over the left-over length of ribbon cable and pull it through the slit. Now affix the controller to the anklet such that the edge is 0.5 inches from the slit.

This part is a important and seems to be a little tricky to explain, so here goes: the controller is fairly stupid. All it know is what the compass chip tells it, it doesn't know anything about where the motors are relative to itself. So, if it thinks it's pointing North, it will turn on motor number 1, regardless of where motor number one is. If it think it's pointing South, it will turn on number 5, and so on. The orientation of the motors and the controller relative to each other is vital, as you'll see later on during the calibration phase.

	**Place the crimp with the notch up and move it to the best position for it plug into the controller**. If you look closely you can see the teeth that will be grabbing onto the strands of the ribbon cable and making electrical connections. Make sure these all line up with the strands properly.
	The easiest way to crimp is to **hold both sides with pairs of needle nose pliers and squeeze them at the same time**. It may take a fair amount of force and the crimp may not snap perfectly; that's ok. If it's holding, it's in well enough and you can squeeze laterally to get the ends to snap. Another way to do this is to set the crimp and cable just right in a vise and turn it shut.
	If you have much ribbon cable left over, trim it with some scissors then go ahead and **plug the display into the controller**. Congrats, you should be done building! Slowly turn the North Paw in a circle, and make sure that all eight motors are connected. Put it on and see how it feels!



The final step in this process is the calibration phase. Grab a normal compass, or go somewhere that you know exactly where North is. Put your North Paw on, and turn around slowly. You'll notice that the motors will sometimes point in different directions. This is because in step 3 you spaced the motors out evenly, but actually this would only work if your ankle was perfectly cylindrical. It's not, so you now need to move the motors around until they all point to the same North. It's best to do this one motor at a time. Find a motor that points the same way as your compass does, and then turn until your North Paw changes to another motor. Feel and remember the amount at which that motor is pointing away from North. Take off your North Paw, unzip the motors, and move that motor over by the amount you felt. Put it back on, and repeat, this step will only work after a bit of trial and error. While you do this, be careful not to bend you solder joints too much as they can break.

Looking at the diagram to the left might give you a better spatial understanding of why the motors need to be spaced differently depending on each individual ankle's unique shape. Note the length of the arcs between the yellow dots, that's the space that should be between the motors those dots represent. You should also consider that spacing the motors in this way means that if you change ankles, or wear the North Paw turned from how you calibrated it, then it will no longer be perfectly calibrated. Keep that in mind!