ENME489C/ENME808M
Resources for Final Project

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Fall 2018
Demo in class (December 3 or 5); Report due Friday, December 7th at 4:59PM

November 13, 2018

1 Introduction

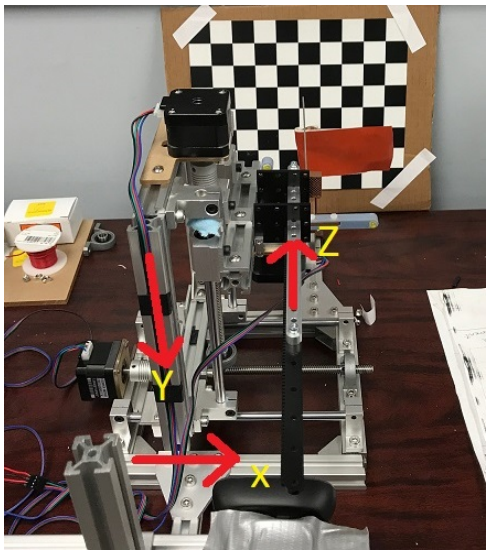


Figure 1: Complete Setup with chosen X, Y, Z axis that represents the Robot Frame.

In this final project you will put together pieces from your Problem Sets 2, 8, and 9 and together with forward and inverse kinematics and your general robotics knowledge you will assemble and control a needle insertion brain-surgery robot. We are providing you with the following resources and components to accomplish this task:

- Robot Camera Calibration
- Needle Insertion Drive
- Electrical connections & Starter code

2 Robot Camera Calibration

From Problem Sets 8 and 9, you know the position of target points in the fiducial frame and position of the fiducials in the camera frame. The transformation you still need to find is the targets in the robot frame and how the camera is positioned and oriented w.r.t to the robot frame. We figure out this transformation by a technique called Robot-Camera calibration. For exact steps of this procedure you should refer to your lecture notes on hand-eye calibrations. An important tip before you attempt the Robot-Camera Calibration is to know various dimensions of your robot, especially the position of the needle in the reference frame of the robot. This will depend on where you choose to assign the frame on the robot body and your assembly. So it is recommended that when you complete your assembly following the steps in the next section, you measure the position of the needle in the robot frame based on your setup and home position.

3 Needle Insertion Drive

We are using a Rack and Pinion set as our needle drive (Z-axis of the cartesian robot). The design is mostly inspired from Actobotics components as sold by Servocity. The design is modified a little so that we can use one of your steppers to drive the needle. Note that you can consider sharpening the tip of the steel shaft (which we are calling the needle) to obtain necessary sharpness to pierce through fake skin. Of course, please be careful when dealing with sharp objects. You may follow the assembly steps to build the Rack & Pinion looking at the figures on the next few pages.

4 Electrical Connections & Starter code

For the electrical connections, you will use your three stepper drivers, two breadboards and a single Arduino as shown in Figure 2. Use the Digital pins from 2-13 on Arduino to control the three steppers. Make sure you have your terminal blocks soldered on the drivers if you did not do this in PS2. You will supply power this time externally to the steppers through these terminal blocks. For power supply, use the provided **12V 2A** power supply along with the female barrel connector as shown in Figure 2. (Note, you can tie the 3 power wires together when connecting directly to the power source, as seen in Figure 2). You may use solid core wires as extensions if required. **Make sure that everything is grounded to a common ground (including the negative terminal on the female barrel connector)**. Please double check your connections before you try to spin the motors.

For the final project you are only provided two files: *three_stepper_move_matlab.ino* and *finalproject.m*. These two files give you example code to spin three motors (not simultaneously) through the MATLAB interface using a single Arduino. You can upload the provided sketch on Arduino and go through the example in serial communication in the matlab file. You are expected to build up on these snippets, combine code that you already wrote in the last problem sets and write some extra required code to achieve a functioning prototype of needle insertion Robot. Good luck!

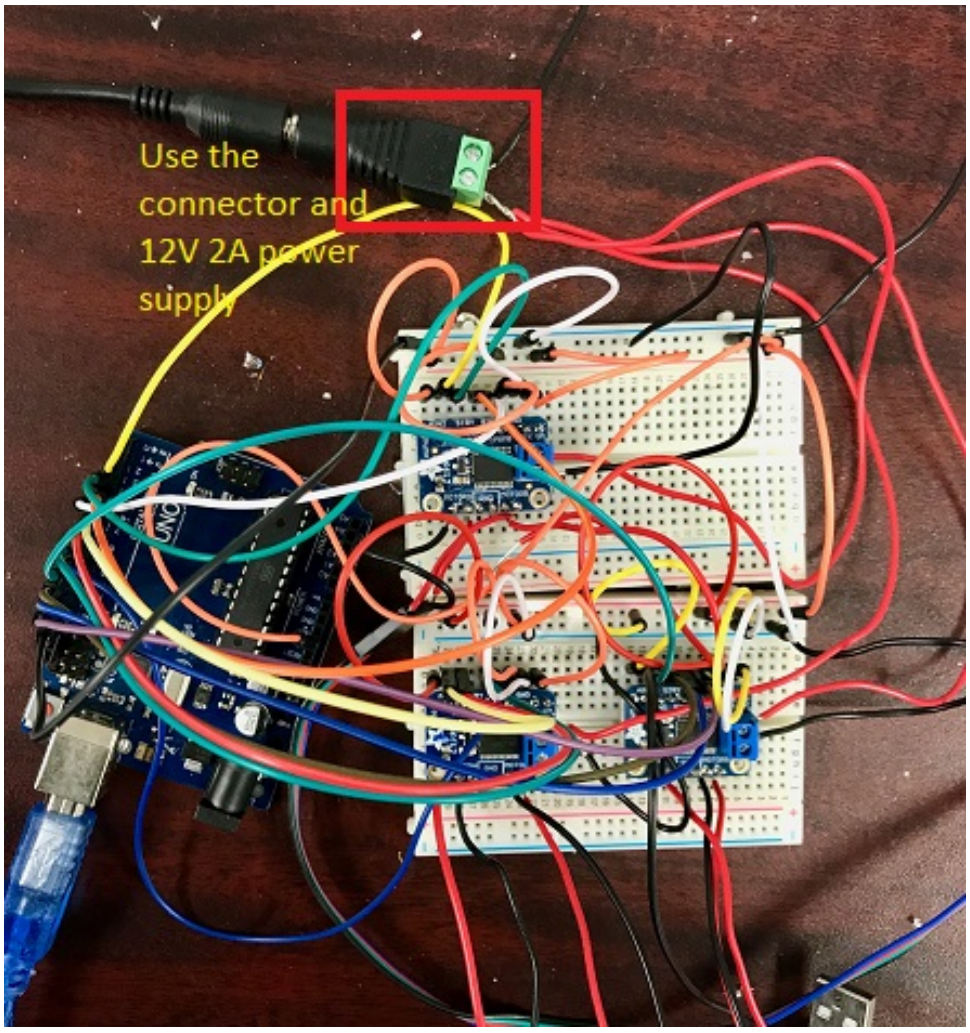
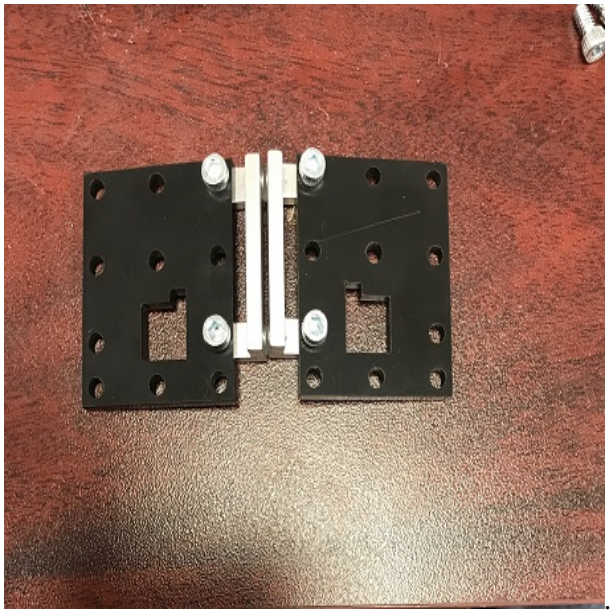


Figure 2: Clubbing three stepper drivers is a simple extension of Problem Set 2. Use the 2-13 digital pins on Arduino. Again, make sure you supply the 12V power supply (using the female barrel connector) through the terminal blocks on the driver and that everything has a common ground



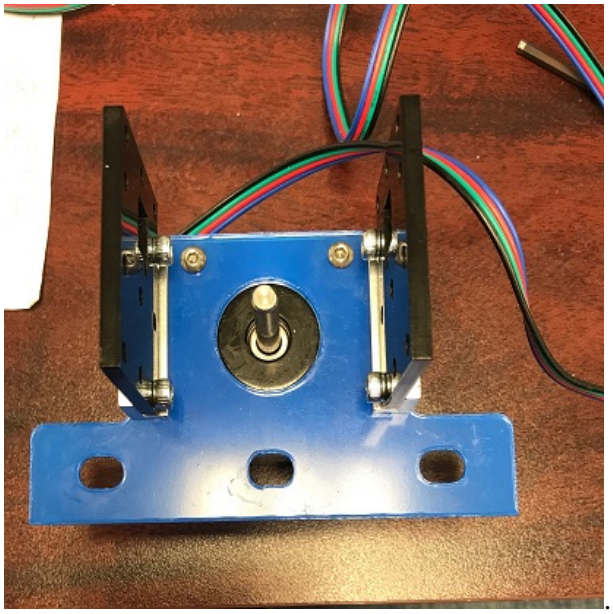
(a) Use 4 1/4" screws to fasten the silver side mounts on the black plates. Use the provided 7/64" hex key for this

(b) The L of the side mounts should face each other when stood upright. The assembly is rotated such that small square notch on black plate is pointing vertically down

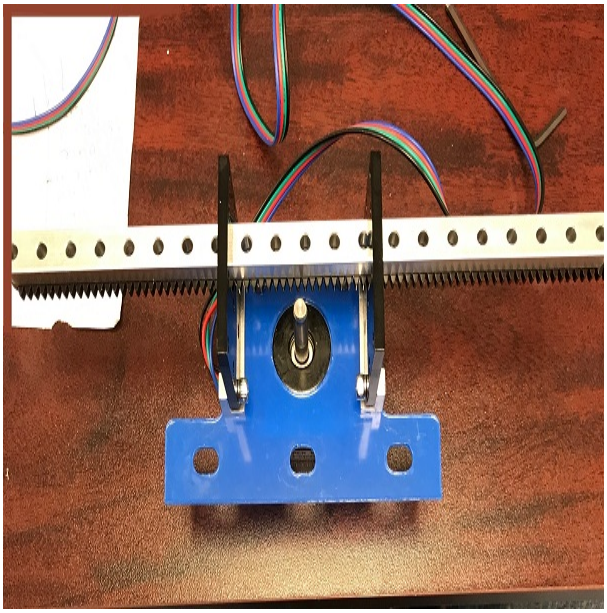
(c) Use the remaining 4 1/4" screws and fasten the black plates on the new mounting plate provided with the kit. Fasten them from the side of the mounting plate

(d) This figure is flipped 180 degrees from last one. Make sure the holes in the black plate are on the top

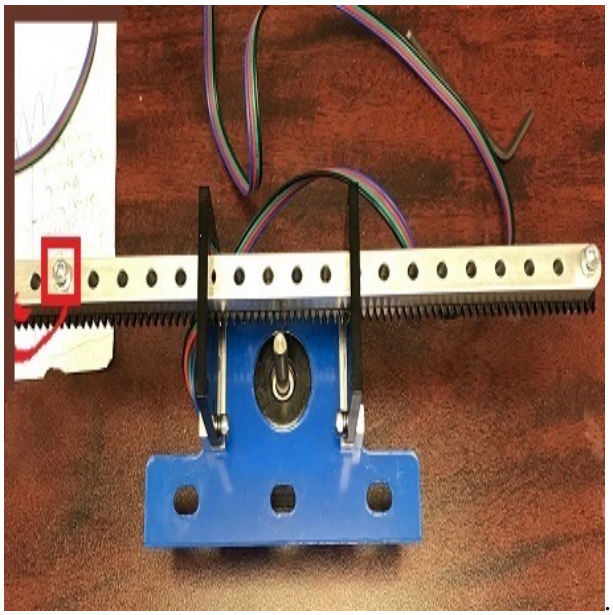
Figure 3: Assembling End Effector (part 1)



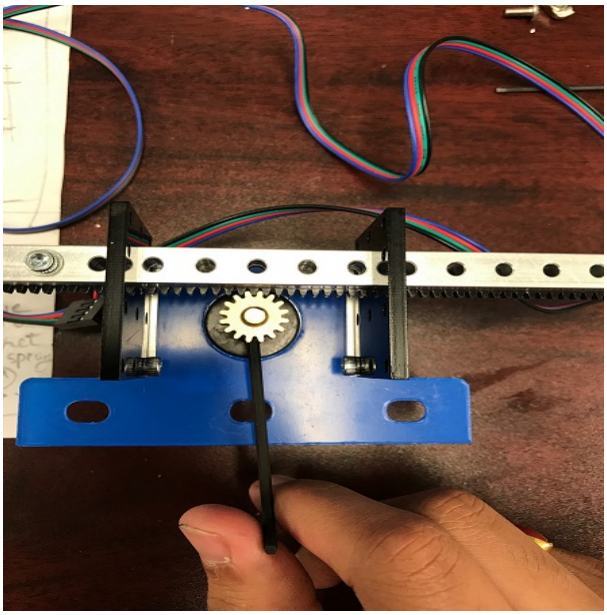
(a) Attach this new mounting arrangement to the stepper motor using the same M3x6 screws



(b) Slide the aluminium beam and the rack together through the slots on the black plate. Align the holes on the beam (and cut the extra rack length if desired)



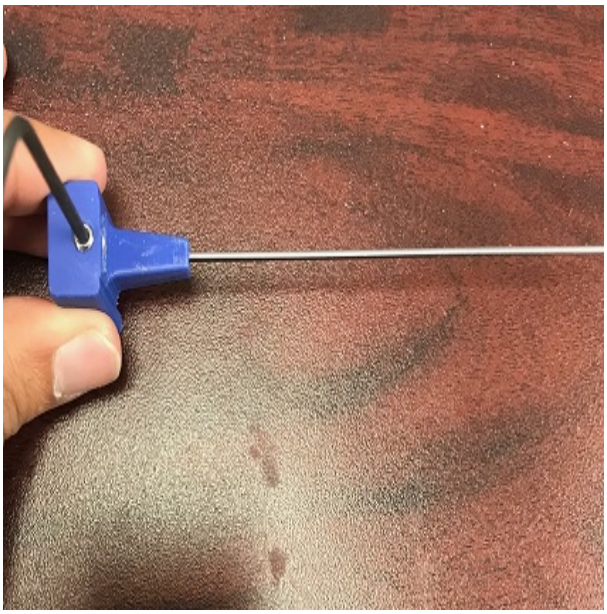
(c) Use the two 5/8" screws, washer and lock nut to fasten the beam and rack together. Put one screw at the start and one at the end.



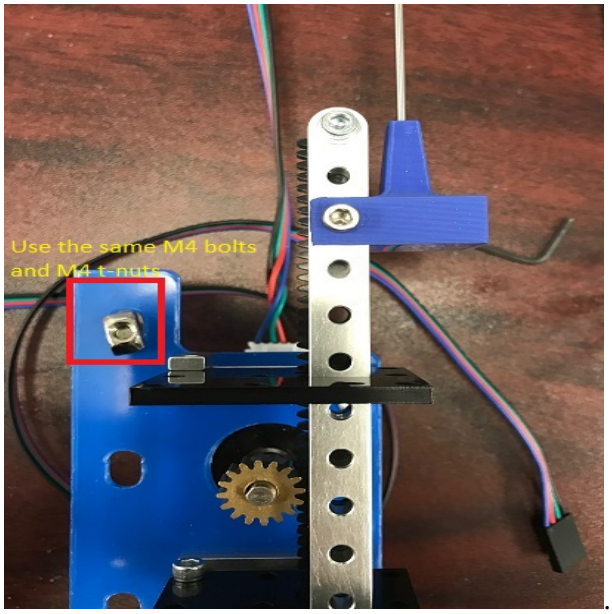
(d) Slide the gold pinion from the top and fasten it in a position such that teeth are in aligned with the rack. Use the provided 3/32" Hex key to lock it together. **The Pitch Diameter of the pinion is 0.5"**. You will need this value to correlate translation to rotation.

Figure 4: Assembling End Effector (part 2)

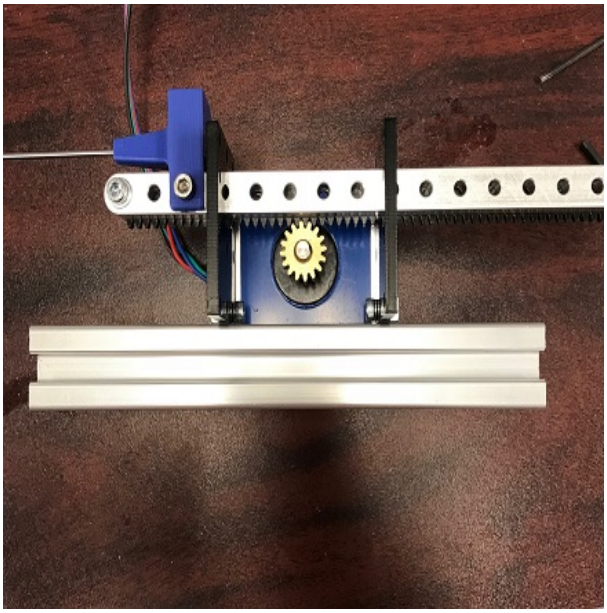
(a) Take the needle holder and insert the provided M4 nut such that the shorter length of the hexagon is parallel to the slot depth. File the slot as needed if the nut is not going in the slot.



(b) Slide the needle through the circular hole at the front and use the provided set-screw along with the previously given 2mm hex key to fix the needle from the top



(c) Use the single 7/8" screw along with the last lock nut to fasten the needle holder on the beam and rack as shown.



(d) Fasten this assembly to the 150 mm beam using M4 bolts and t-nuts as shown

Figure 5: Assembling End Effector (part 3)

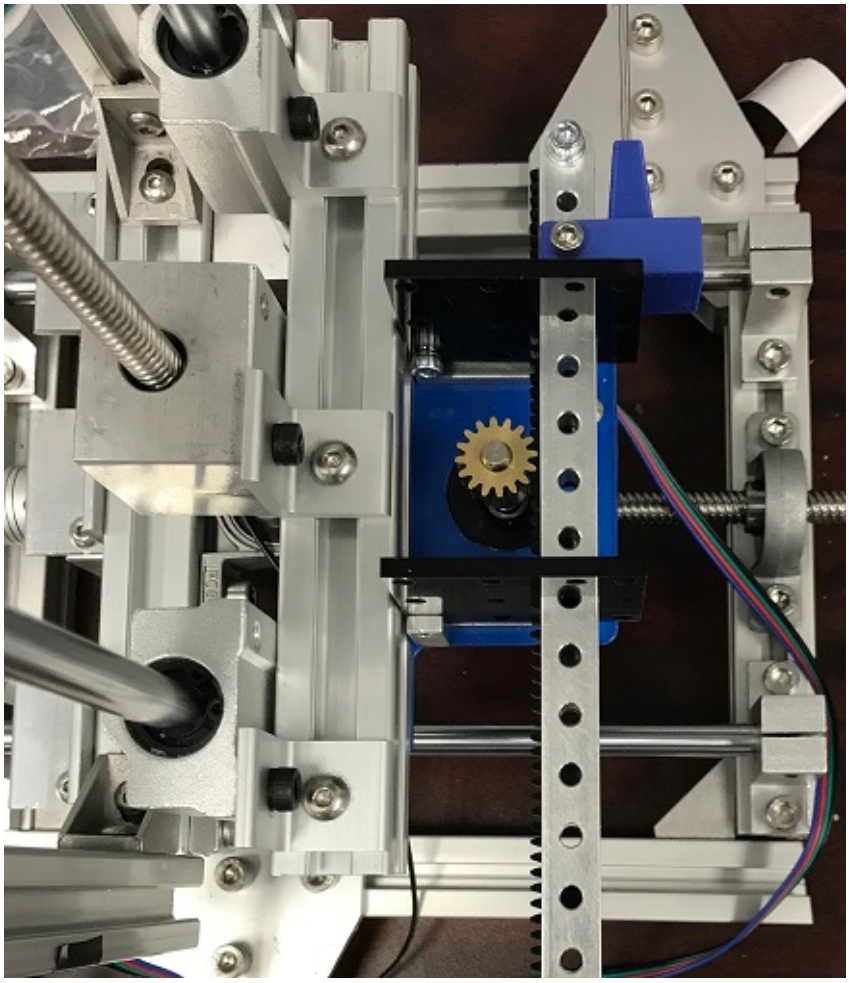


Figure 6: Fasten the end-effector using the 150 mm beam and the machined brackets. Make sure the base stage can move smoothly after the assembly. It is at this position that you should know where the tip of your needle is in the robot frame

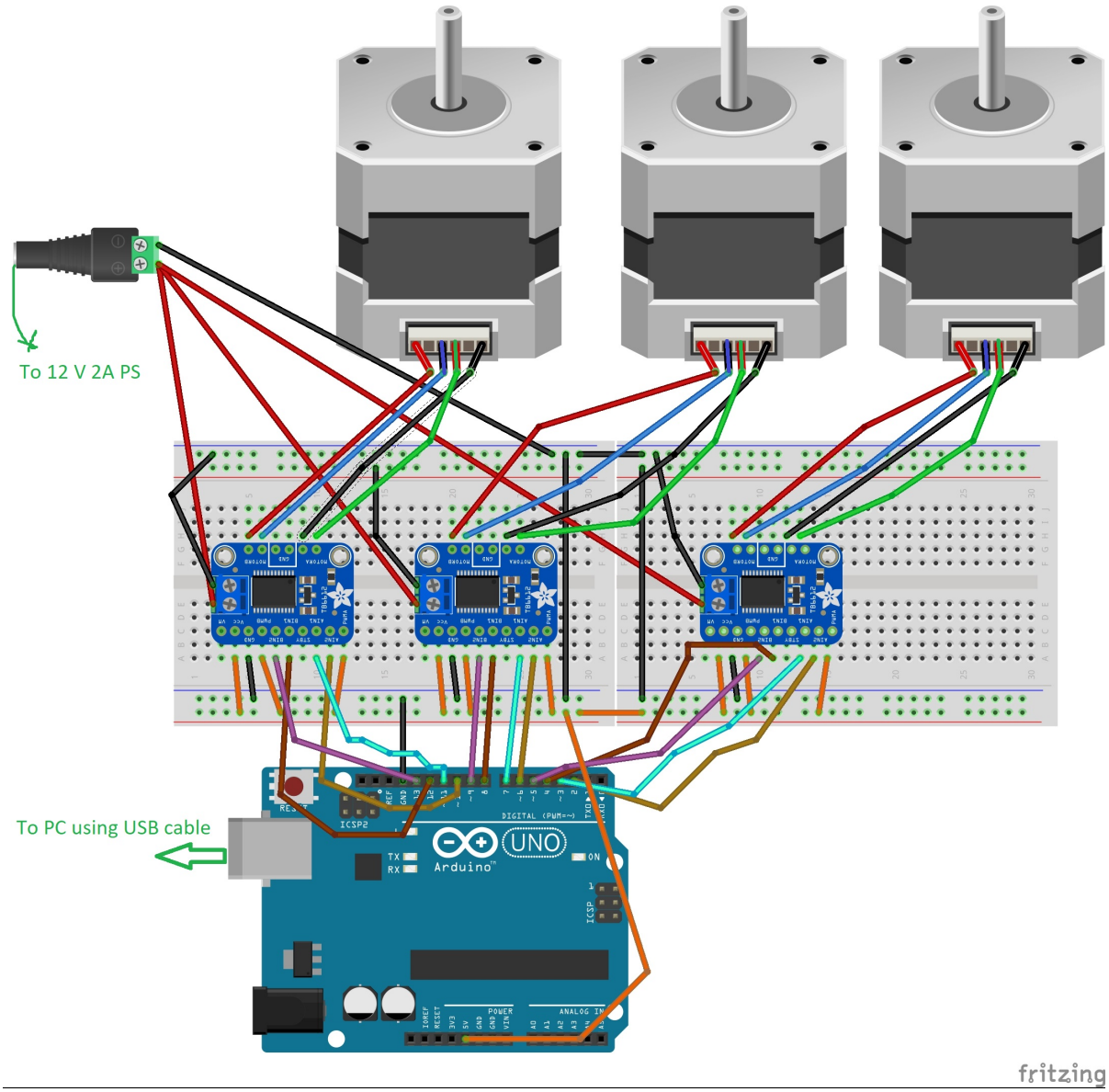


Figure 7: Schematic of the Electrical Connections. Use 2-13 digital pins on Arduino to connect with three steppers. wires from the steppers are going to the right terminals on the drivers. Make sure everything is operating on a common ground