Baby Smarty Pants construction 3rd Documentation/Manual

By Timothy Sellers (DREU Student), Katelyn Fry (Ph.D Student), & Dr. Ayanna Howard (Mentor)

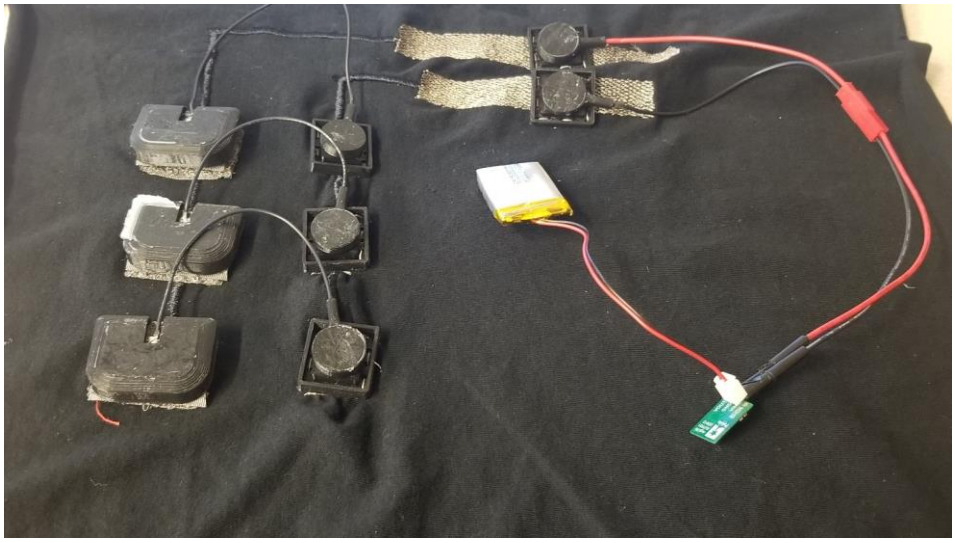


Table of Contents

Introduction

Newborn babies have a major risk of developing different birth defects. One of these major risks is the development of cerebral palsy, which is one of the most common types of neuro-developmental motor disorder among children. Cerebral palsy affects between 2 to 2.5 births per 1000 live births. This disease affects the motor function of newborn babies and causes them to have abnormal motor functions. The purpose of my research is to find a way to detect these abnormalities in babies motor development through spontaneous kicking. Once spontaneous kicking can be recorded effectively, it can be analyzed to show if a baby is developing abnormal leg motor control. There have been previous attempts to collect this type of data, one way they have tried to collect this type of data is using is using motion tracking systems which was used to gather pose and tracing infant movement. Another method is using electromagnetic tracking to examine upper and lower limb motions in in infant. Although these methods give precise reading, the defects of these methods are that they require specialized equipment that is not suitable in a clinical setting. One way this can be overcome is by developing an embedded circuit suit design.

Previous designs

The embedded circuit suit or Baby Smarty Pants has had two previous designs. The first design was created using two series circuits that used 3D printed casings for the sensors, metal connector snaps and conductive thread. The original suit was bulky, and the connectors plugged holes in the baby clothing which could cause future tearing in the fabric. The next suit design stop using the previous 3D casing and the terminals. The second suit design started using conductive Velcro, Insulating felt fabric, and used an embroidery machine to build the Baby Smarty Pants. The conductive Velcro allow power to be sent through the circuit, which cut down on the use of wires in the design. The felt (with adhesive) is used to cover and insulate the traces of conductive thread. In this design they had cut down on the size of suit but need to make new 3D casing for the sensor and the voltage regulator. In the newest design the casing were added, and the layout of the embedded circuit was changed.

Equipment/ Materials

- Conductive Velcro (3.3V)
- Conductive fabric (3.3V and GND)
- Snap fasteners (GND)
- Felt with Adhesive (Insulation)
- Super Glue
- Wire glue
- Wires
- Embroidery machine or Sewing machine
- 3D casings for the sensors and voltage regulator
- Battery
- Sensors (MMC – Meta MotionC)
- Voltage Regulator (Step Up/Step Down Polulu S7V8A Voltage Regulator)

Embroidery machine

The embroidery machine is located within the invention studio (IS) in the MRDC building. In order to use the embroidery machine, you must first receive training on how to use the Hatch software and the embroidery machine itself. You must contact the crafts masters at crafting@inventionstudio.gatech.edu to set up a training session with a PI. Once you meet the PI make sure to mention that you will be using conductive thread and the process called applique to construct the Baby Smarty Pants.

Later on we discovered that there are two more embroidery machine located in the TSRB building room 245, one is a regular embroidery machine and the other is an industrial embroidery machine used for conductive threads. In order to receive access to these machines you must contact Timothy.trent@cc.gatech.edu and clintzeagler@gatech.edu. They may allow the regular embroidery machine to put in Dr. Howards lab since it belongs to the Gyro lab and they are only storing it there until they find a place for it. Dr. Zeagler(clintzeagler@gatech.edu)said he would help with picking a new baby fabric to create the embedded circuit design on.

Baby Smarty Pants construction

Note: Start with a regular piece of fabric before construction it on a pair of baby pants.

1. First Cut two strips of conductive fabric. Make sure that one strips is longer than the other by 38.1mm. Then cut four square conductive fabric patches used for the GND connection. Finally, cut the conductive Velcro 31.76mm long and 26.57mm wide. You will need three sets of conductive Velcro.
2. In the second step, de-solder the battery holder off the sensors and made sure to not damage any of the nearby components by the connector pins.
    a. Take a wire and strip a small section of the rubber off the wire. Solder that side of the wire to one of the four ground pads on the back of the sensor.
    b. Then take the other side of the wire wrap it around the bottom part of the snap fasteners' holes. Next, solder them together and make sure to completely solder the inside and outside of the loop made with the exposed wire.
    c. Lastly apply super glue to the end of the wire connected to the ground pad. This will help with the stress put on that section of the wire.
3. Then take the bottom half of the 3D casing, a sensor, and the non – soft or the hard side of Velcro and sew them together.
    a. First take the conductive Velcro and sew it to the casing using the holes two sets of the outer holes and the set of holes located at the bottom of the casing. Use regular thread for this:
        i. There are three sets of additional holes inside and outside where the sensor sits. Use nonconductive thread to sew it to the conductive Velcro.
    b. Put the sensor in the casing and make sure it sits completely flat. Next take a needle and thread it with the conductive thread, make sure that the needle use fit in the power connector pins.
    c. Finally, take the needle and run it from the rough side of the Velcro through the hole in the bottom of the casing through the positive pins on the sensor and back down through the nearest connector pin. Repeat this at least three to secure the connection.

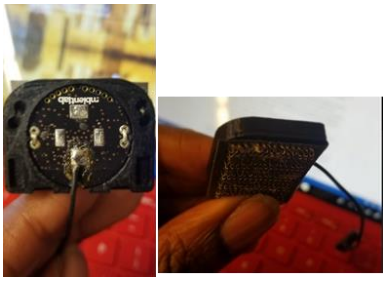


Figure 1&2. Example of how the sensor is constructed

4. Next, take the voltage regulator and solder the Voltage (input and output) and GND (input and output. The assembly to the voltage regular is a little tricky, because the voltage regulator only has one pin for the GND input and output.
    a. First solder the connector to the voltage input and the GND pin but leave space between the voltage regulator and the bottom of the connector. Note: Make sure the orientation of the connector corresponds correctly with the battery.
    b. Then take the GND part of the wire connect, that connect to the circuit, and strip a small section of the rubber of the wire.
    c. Then using the gap you create to wrap the wire of the around the ground connection pin and solder them together. Once this is done you have successfully created your GND output, and then solder the power wire to the Voltage output pin.

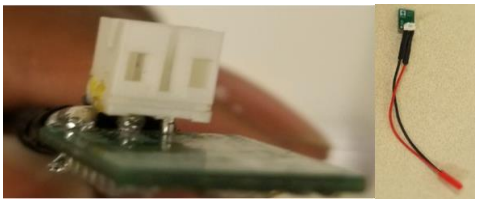
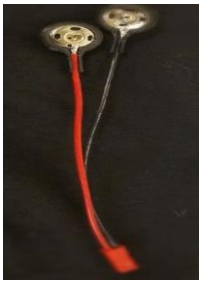


Figure 3. Female connector and Voltage Regulator

5. After soldering the power and GND connection, take the other side of the wire connector and solder one snap fasteners to the power and GND wires. For the power wire connect the top part of the snap and the bottom part of the snap to the GND connection. The reason for this is to separate how the power and ground connection are made.

Figure 4. Male connector to the voltage regulator.



CONT. with Sewing machine

6. Now it time to construct the base of the suit. Take a piece of fabric about a foot long and wide. Take the long strip of conductive fabric you cut earlier and use the wire glue to connect them to the fabric.
    a. Make sure the top strip is the longer strip of conductive fabric and the shorter one is centered about 29mm below the longer strip. Now the top strip will be used as the power strip and the shorter one will be used as the ground strip. Now use the wire glue to glue the conductive Velcro in the designated positions along with its conduct fabric patch across from it.
7. Then pick three colors out of red, black or blue, and white to each section of the embedded circuit. Next thread the sewing machine and completely sew down each patch of Velcro, conductive fabric, and make the connection or traces between them. Take the red thread and sew down the long strip of conductive fabric and around each of the Velcro strips. Then take the blue and black threads and sew around the shorter piece of conductive fabric and the conductive fabric patches.
8. Next, take a bobbin and wind it with conductive thread and place it in the sewing machine. Then use the white thread as the regular sewing thread. Make sure the back of the test fabric is facing upward and connect the power strips to all the Velcro patches and connect the ground strip to all the square conductive fabric patches. Then cover all the traces above and below with the insulating felt.

9. At this stage, sew the top part of a snap to the ground strip and the square patches. Make sure that the hole in the snap is facing upward sew it down tightly. Then do the same for the power strip but use the bottom part of the snaps in its usual orientation.
10. Finally, connect all the components together and make sure the voltage regulator is set to 3.3V and make sure it is consistent throughout the circuit.

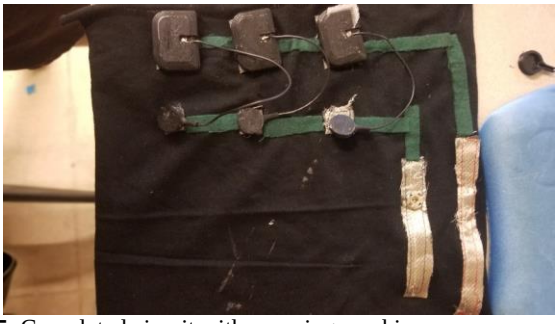


Figure 5. Completed circuit with a sewing machine.

CONT. With Sewing machine & Gyro Lab Embroidery machine

Note: The Gyro embroidery machine cannot use the applique process.

1. First go into the software used for that embroidery machine and construct the design without using a pang file. The software uses inches instead of millimeters.

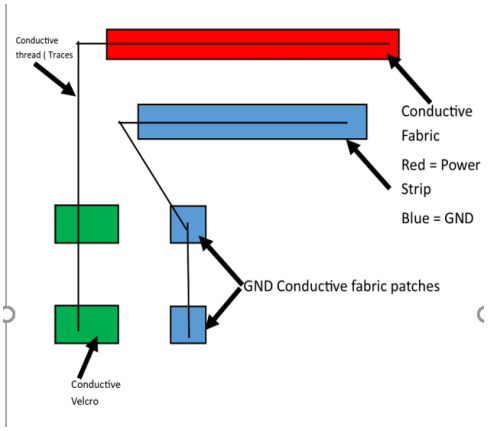


Figure 6. Example of how to construct the circuit in the Software.

   a. Draw the squares and traces on the program.
   b. In this design conductive thread is used to make the conductive strips and patches.
   c. Then embroider around the traces as long and make sure to not embroider the traces that run through each patch.
   d. Since this machine does not use the applique function the areas for the conductive Velcro are empty.
2. Second take a piece of fabric and stabilizer that is big enough to fit inside the embroidery hoop.
   a. Make sure that the fabric is completely flat and there are no bumps or wrinkles in the fabric.
3. Thirdly, run the program and make sure the strings does not break.
4. Now, sew on the conductive Velcro take a needle and conductive thread and loop through and around the open part of the trace and then through the conductive Velcro about three times.
   a. Then Use a sewing machine and secure the conductive Velcro to the fabric.
5. Then hand sew on the 4 female base snaps with the corresponding snap and 1 male base casing.
   a. The female base casing and snaps go on the GND strip and patches made of conductive thread. The male casing goes on the power strip.
   b. Make sure to use nonconductive thread on the outer holes and conductive thread to sew the patches and the snaps together.
6. Next, print out 4 male snap covers and 1 female snap cover.
   a. The male snaps cover goes on the ground connection wires to the sensors and the GND connection for the voltage regulator. The female snap cover goes to the voltage regulator power connection.
7. Finally connect all the components together and make sure the voltage regulator is set to 3.3V and make sure it is consistent throughout the circuit.

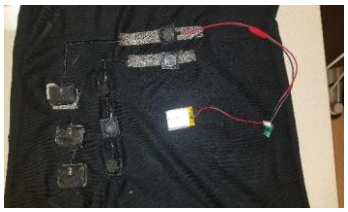


Figure 7. Completed circuit diagram using the GYRO lab Embroidery machine

CONT. With Embroidery machine in the Invention Stuidio

1. Create the circuit design with Microsoft publisher and save it as a PNG file.

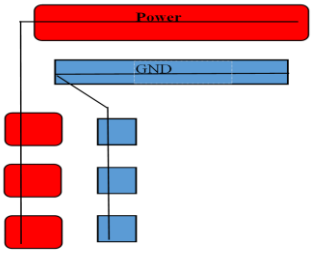


Figure 8. Example PNG file used for the circuit.

1. Prepare the file in hatch embroidery software, make sure to export it as VP3 file.
    a. Use the 360 x 200 hoop.
2. Load the file using the embroidery machine and load the correct thread.
    a. In order to use the embroidery machine you have to save the VP3 file to a USB and depending on the USB the embroidery machine may not be able to read it. There are three invention studio flash drives available to use with the machine.
3. Run the machine for first layer of applique.
    a. The color thread used for the circuit does not matter if you know what section you are embroidering.
    b. This will stitch the shape around the size you want it. You can run this section at medium speed.
    c. Before you put the baby fabric in the hoop use 2 layers of regular stabilizer or 3 layers of water-soluble stabilizer.

4. Put the conductive fabric on the suit.
    a. Cut out conductive fabric slightly larger than the outline shape and apply a thin layer of wire glue to each section and put the conductive fabric on each patch.
    b. Wait 3 minutes before starting the process back to give the glue enough time to dry and to secure it properly.
5. Complete applique process by starting up the machine at the second to lowest speed.
6. Finally, connect the pads electrically by loading the conductive threads on the embroidery machine properly. Note: depending on the conductive thread it may not be able to be used in the embroidery machine.
7. Unload the newly made suit and sew on all the snaps and snap bases.

Testing

There were two tests conducted on the final circuit, the one being that it was constructed using the GYRO lab embroidery machine and sewing machine. The first test was a stress test to see if the current or voltage, over a period of six hours, would change. There were no changes in the current or voltage supplied throughout the circuit in that period. The next test was a washable test to see how well the stitching, fabric, 3D printed casings, and traces held up in a washing machine. The washing machine was set to a normal (Regular) load of clothes and Downy washing detergent enough for one load. After the embedded circuit was washed all the materials were still functional the next morning. When repeating this test make sure to keep a close eye on traces, 3D casings, and anything connected with conductive thread.

What To Do Next

- Add Flame resistant material to the Embedded circuit Design
- Find a way to conceal all the wires and sensors in the circuit
- Create a 3D casing for the voltage regulator
- Construct the Embedded circuit design on a pair of baby pants
- Test on NAO
- Insulating battery

- Shortening the universal voltage and GND patch
- Find a way to insulate the patches instead of using 3D casings
- Use a more durable baby fabric for testing
- Test on an actual baby

References

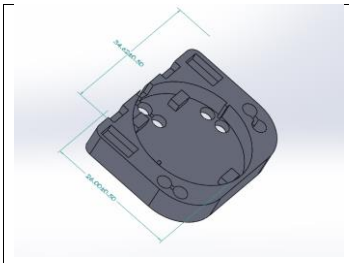
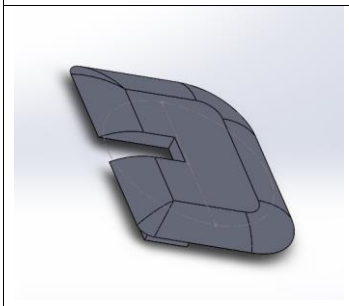
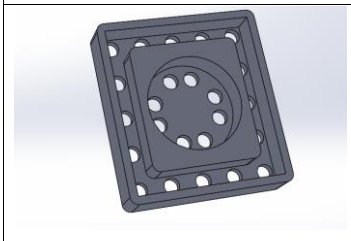
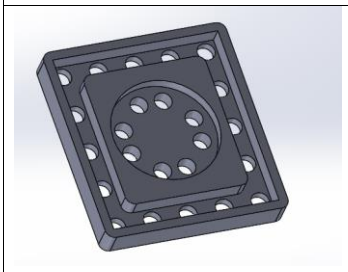
1. **Yousuf, Faraz.** *Baby Smarty Pants infant kicking ssytem user manual.* Atlanta : s.n., 2017.

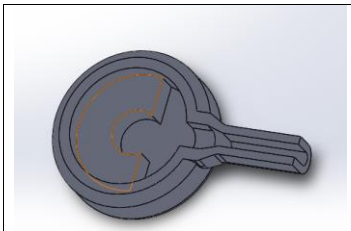
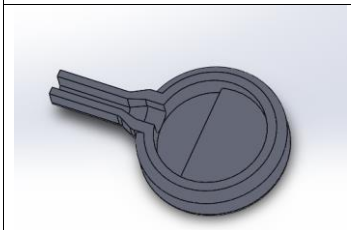
2. **Yeh, Yvonne.** *Infant smary pants Documentation* . Atlanta : s.n., Sprint 2019.

3. *Detection of Infant Motor Activity During Spontaneous Kicking Movements for Term and Preterm Infants Using Inertial Sensors.* **Katelyn E. Fry, Yu-ping Chen, and Ayanna Howard, Member, IEEE.** Atlanta : s.n.

4. *Discriminative Models of Spontaneous Kicking.* **KATELYN E. FRY, YU-PING CHEN, AYANNA HOWARD.** Atlanta : s.n., 2019.

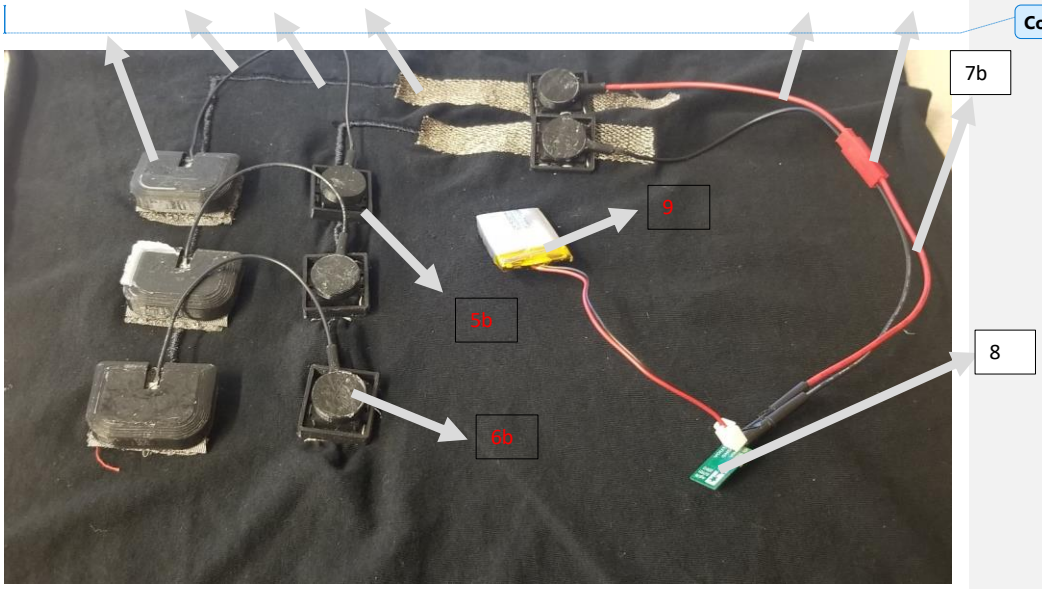
3D Casing Descriptions

	Sensor Casing	Used to insulate the sensor from the conductive Velcro and stabilize the sensor during testing
	Sensor Casing Top	Used to cover the top part of the sensor and to help with stabilization
	Female base Connector	Used to insulate the conductive thread or fabric and hold the female snap in place.
	Male Base Connector	Used to insulate the conductive thread or fabric and hold the male snap in place.

	Female Wire Connector	Used to stabilize the solder connection between the wire and the female snap. Also helps with insulation the rest of the connection
	Male Wire Connector	Used to stabilize the solder connection between the wire and the Male snap. Also helps with insulation the rest of the connection

Suit Function

Commented [WU1]:



1. Sensor Casing
2. Ground connection
3. Traces – the connection between each pad and patch. We used embroidery thread to insulate and protects them.
4. Conductive thread strip - This strip supplies power to the whole circuit and the smaller strip grounds the whole circuit.
5. Female/Male base Connector – the male and female part can only be differentiated when they are apart.
    a. Male
    b. Female
6. Female Wire Connector – the male and female part can only be differentiated when they are apart.
    a. Female
    b. Male
7. Wire connector between the Voltage regulator and the Circuit
    a. Female wire connector

   b. Male wire connector
8. Voltage Regulator – regulates the voltage to the circuit
9. Battery – supplies power to the circuit