Get Around Garment (GG)

I. Bill of Materials

II. Assembly Instructions

III. Arduino Software

IV. Data Processing (Excel or LabVIEW)

Written By: Move 2 Learn Innovation Lab
Designed by: Ben Greenspan & Michele A. Lobo
http://sites.udel.edu/move2learn/

I. Bill of Materials

Materials

Item	Potential Source	Cost
Purchase a desired garment (E.g., 0-6 Month and/or 6-12 Month, Short-Sleeve Unisex, Adjustable Snap-N-Grow) **100% Cotton Bodysuit)**	MiracleWear (https:// miraclebabyusa.com/product/panda-adjustable-bodysuit-short-sleeve/)	$ ~10.00 (typical baby garment)
Belt - Elastic Belting 2" Wide	Jo-Ann's Fabrics & Crafts https://www.joann.com/2in-elastic-belt-black/2599413.html; Item# 2599413)	$ 5.99
Vinyl pocket – Marine Vinyl 100% PVC face/100% Polyester back	Jo-Ann's Fabrics & Crafts (https://www.joann.com/marine-vinyl/prd23669.html#q=Marine%2BVinyl%2B100%25%2BPVC&start=1; Item # 12214052	$ 13.99 /yd
Microcontroller, Adafruit Feather 32u4 Adalogger	Adafruit Industries (https://www.adafruit.com/product/2795 ; Item #2795)	$ 21.95
ADXL335 - 5V ready triple-axis accelerometer (+-3g analog out)	Adafruit Industries (https://www.adafruit.com/product/163 ; Item # 163)	$14.95
Lithium Ion Polymer Battery, 3.7v, 150mAh	Adafruit Industries (https://www.adafruit.com/product/1317; Item # 1317)	$ 5.95
Lithium Ion Polymer Battery, 3.7v, 150mAh	Adafruit Industries (https://www.adafruit.com/product/2750; Item # 2750)	$6.95

SanDisk 4GB Micro SDHC Memory Card	https://www.amazon.com/SANDISK-Micro-SDHC-Memory-SDSDQM-004G/dp/B001C0DJL4	$8.74
PLA 3D-Printer Filament	https://www.amazon.com/Polymaker-Polylactic-PolyMax-Spool-Diameter/dp/B00YXBNMU2/ref=sr_1_2?dchild=1&keywords=polymaker%2Bfilament&qid=1588564101&refinements=p_n_feature_four_browse-	$39.99 per spool
Micro slide switch	https://www.amazon.com/uxcell-SS-12F16-Position-Miniature-Latching/dp/B01N235HVR/ref=sr_1_7?dchild=1&keywords=slide+switch&qid=1589179745&sr=8-7	$7.45 for 10 pack
Micro-Lipo Charger for LiPo (optional)	https://www.adafruit.com/product/1904	$6.95

Required Equipment:

- 3D-printer
- Soldering iron
- Wire strippers
- Computer with internet access
- MicroUSB to USB cable
- Superglue

II. Assembly Instructions

Step 1 — Select Garment Style

- Choose which onesie style you would like for your Get Around Garment.
- Suggestion: choose a soft onesie, with additional rows of snaps at the bottom that adjust to "grow" with the baby. A snug fit and crotch component of the onesie can help to maintain the sensor position.

Note: The GG was design for babies before they were consistently rolling (0-6 months of age). A 0-6-month onesie should fit, but some babies might require a 6-12 month one.

Step 2 — Creating a vinyl pocket with an adjustable elastic belt

- The vinyl pocket with an adjustable elastic belt helps to keep the sensor in place to address the challenge of drifting.
- Elastic Belt:
  - Cut Elastic Belting 2" Wide (~ 17", ~43cm)
  - Attach 1/2" Velcro adhesive tabs (one to end of the belt and one approximately 1 1/2" or 4 cm apart).
- Vinyl Pocket:
  - Cut 2 squares from vinyl fabric (3 1/2", 9 cm)
  - Sew the squares in a "U" shape (along one side, and across bottom). Before continuing up other side, sew belt into it (end part without the Velcro).

Designed by Martha Hall & Bai Li

Step 3 — Adding the pocket and belt

- The padded vinyl pocket with the belt should be stitched into the side of the onesie (at the level of the anterior superior iliac spine).
- You can also sew belt loops into the onesie (2 in front and 2 in the back) using the same vinyl material (1 1/2" long and 1/2" wide)
- The sensor should easily be removed from the vinyl pocket for ease of cleaning the onesie.

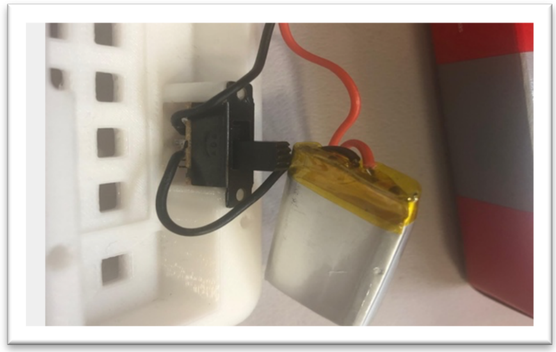
Note: Placement of the sensor unit on the lateral aspect of the trunk allows movement in the sagittal plane to be effectively detected while also being comfortable for infants who do not often place weight on their sides.

Step 4 — 3D-printed case

- A custom 3D-printed case was designed to fit both a 150 and 350 mAh battery option. The 150 mAh will last around 12 hours and the 350 around 28 hours of recording time.
- The case was designed in SolidWorks and originally printed on a Printrbot Plus 3D printer
- The .STL files for both versions of the case are available on the website below
- Each case has 2 parts, a top and bottom. Print both parts with the flat end in contact with the print bed so no support material is necessary
- The files can be printed on any standard 3D printer in PLA, ABS or PET plastic
- If you are interested in purchasing your own personal 3D printer, the lowest cost option we recommend now is a Creality Ender-3 Pro. To compare other 3D-printers available now please click here.
- The dimensions of the 150mAh case are: 2" (5 cm) long by 0.95" (2.4 cm) wide and 0.45" (1.1 cm) deep. The 350mAh case is the same width and depth but slightly longer.
- For best results, follow filament temperature printing guidelines
- We printed with PLA plastic and the following settings:
  - Nozzle temperature: 210 °C
  - Bed temperature: 60°C
  - Minimum 2 perimeter layers
  - 30% infill

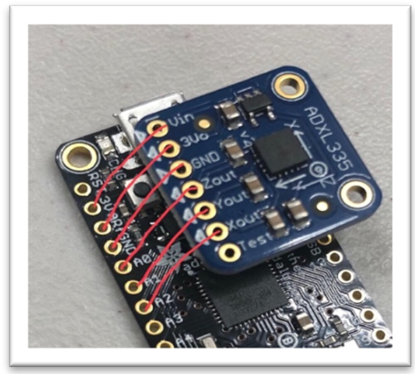
Step 5 — Electronics

Battery and switch



- First, cut the black wire of the battery in the middle, use a wire stripper to strip both sides of the wire exposing the copper. Solder the two leads of the black wire to the top 2 positions of the slide switch. Having the switch connected to the on position when the switch is up is advantageous when putting the sensor into the onesie to not accidently switch the deice off. Use super glue to glue the two flanges of the slide switch to the bottom of the 3D-printed case.

Attaching the accelerometer to the microcontroller



- First solder the short end of the included male to male headers that came with the accelerometer to the underside of the accelerometer. (Break off the strip of headers to the correct number of headers needed). Clip the header coming from the 3Vo on the accelerometer because a reference voltage isn't necessary for the accelerometer. Place the headers into the microcontroller so that the pins match up as the figure to the right. Solder the headers to the microcontroller.

Assembly

- Plug the battery into the microcontroller and place the microcontroller into the 3D printed case. Bend the wires to fit accordingly so that they will fit
- Place the top portion of the 3D printed case into the bottom
- Before any data collection, place a piece of tape over the switch to ensure the sensor won't accidently stop recording during the data collection

III. Software

Step 1 — Download software and drivers

- Download software from "https://www.arduino.cc/en/Main/Software"
- Install accelerometer library:
    - Tools → Manage libraries → Accelerometer ADXL335
- Install board driver:
    - Tools → Boards Manager → Arduino AVR Boards

Step 2 — Upload sketch to microcontroller

- Download "Get_Around_Garment_v2.ino" file from website https://www.thingiverse.com/thing:4702029
- Open file
- While the battery is off, connect the microcontroller to the laptop through the USB cable
- Select the correct port:
    - Tools → PORT → whatever is the port selected "COM__"
- Upload the sketch
    - Sketch → Upload

- **Note:** To charge the battery, first remove the microSD card. Then slide the switch to the on position and connect the microcontroller to the USB port on the laptop. The battery will charge slowly through the microcontroller. For faster charging, you can purchase the optional micro-lipo charger. In this charging configuration disconnect the battery from the microcontroller then slide the switch to the on position. Then plug the lipo battery into the charger and connect the charger to a USB port.

IV. Data Processing (Excel or LabVIEW)

Step 1 — Raw data from SD card

- Currently data from the infant is collected and stored on a Micro SD card.
- Raw accelerations across the 3 axes and a time stamp are recorded as it can be seen below.

- Example of sample data:

  - **X , Y , Z , millisecond**
  - 581,525,541,403
  - 573,565,572,1390
  - 449,559,580,2377
  - 482,559,578,3366
  - 480,569,568,4354
  - 481,538,608,5343
  - 517,544,607,6330
  - 497,515,605,7319
  - 505,530,607,8306
  - 501,559,603,9295
  - 503,525,612,10283

Step 2 — Processing data in Excel

- If a researcher/ clinician is only interested in identifying the percent time an infant was in certain positions from a simple data set, then Microsoft Excel can be used to process the data.
- First, Import the data into an Excel file (Columns A-D)
- Type the pitch angle formula into cell E1 to generate the pitch angle
  - =ATAN((B2-510)/ (SQRT(((A2-510) ^ 2) + ((C2-510^2)))))
- This converts the accelerations to radians
- Type the below equation to convert from radians to degrees into cell F1
  - =E1*180/PI()

- Sample Excel Data

	A	B	C	D	E	F
1	581	525	541	403	0.05	2.80
2	573	565	572	1390	0.18	10.49
3	449	559	580	2377	0.40	22.79
4	482	559	578	3366	0.27	15.68
5	480	569	568	4354	0.33	19.00
6	481	538	608	5343	0.16	9.19
7	517	544	607	6330	0.15	8.58
8	497	515	605	7319	0.03	1.45
9	505	530	607	8306	0.10	5.48
10	501	559	603	9295	0.24	13.57
11	503	525	612	10283	0.07	4.17

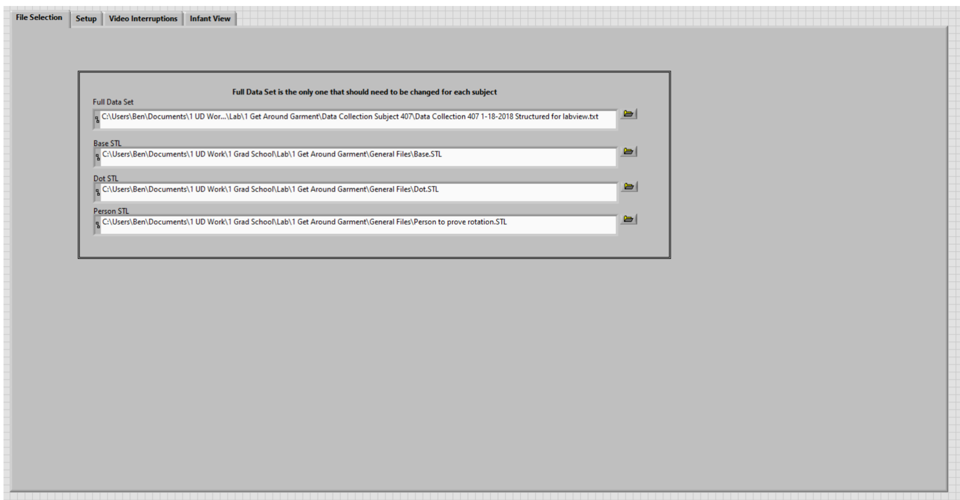
- A: raw x-axis accelerations
- B: raw y-axis accelerations
- C: raw z-axis accelerations
- D: millisecond sample
- E: accelerations to radians
- F: radians to degrees

- Once the correct data is represented you can use a scatterplot to view the data with column F on the y-axis and column D on the x-axis.
- If using this approach, you may want to divide column D by 1000 so it is on the order of seconds instead of milliseconds.
- If the researcher/clinician is only interested in the number of seconds in each position, then the pitch angle can be sorted, and data filtered that meets the position cutoff thresholds which are:
  - Prone: 0°- 30°
  - Inclined: 30°- 55°
  - Upright: 55°- 115°
  - Reclined: 115°- 150°
  - Supine: 150°- 180°
- To normalize the data into percentage of time, first you have to sum the number of seconds in each position (Total duration of each position) and sum all positions to obtain the Total duration time. Then, you can calculate percentage time of each position using this formula.
  - % of each position= Total duration of each position * 100/ Total duration time

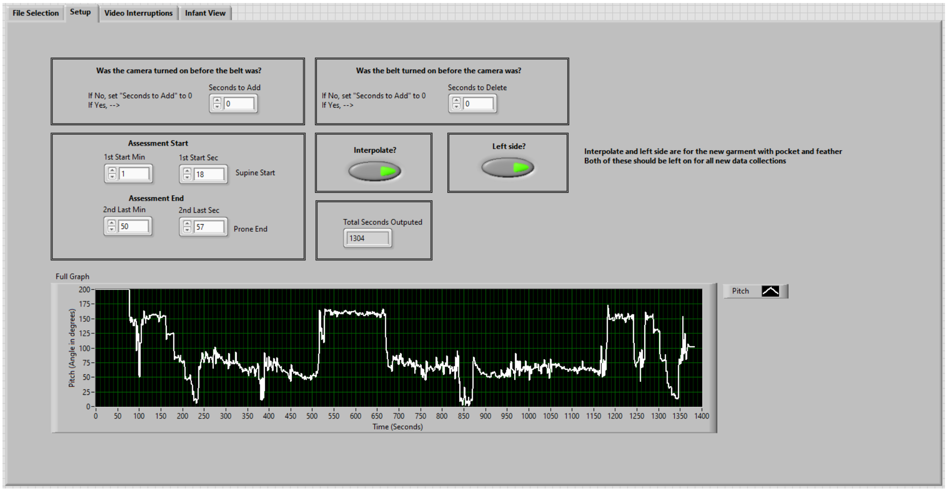
* A delay of 970 ms is set between samples (allowing for sampling to be as close to 1 Hz as possible without a real time clock) but it isn't possible to sample at exactly 1 Hz in this version of the Arduino code. To process the data by exact seconds, not by percentage of time in each position, LabVIEW is needed to interpolate the data before processing

Step 3 — Processing data in LabVIEW

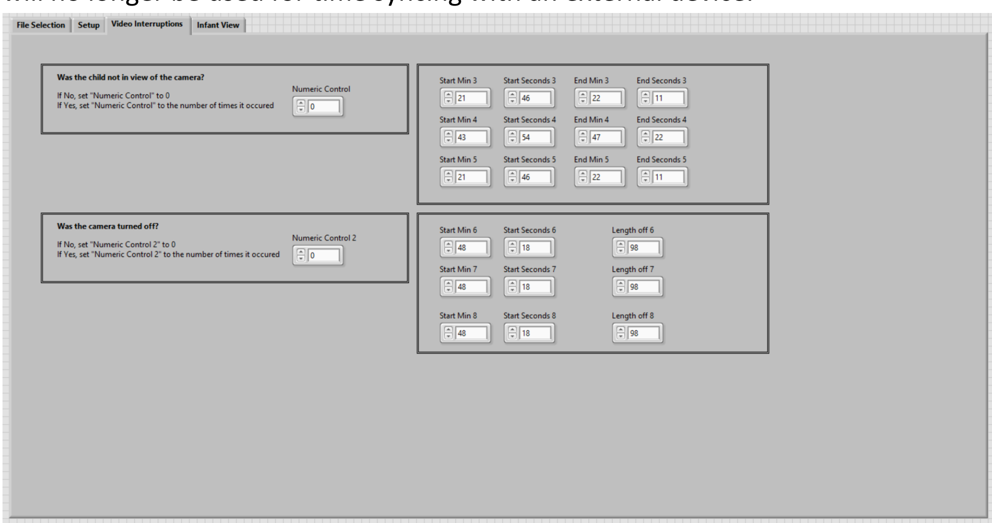
- Download the following LabVIEW files:
  - “Get_Around_Garment_Processing_To_Be_Shared.vi”
  - “1_Interpolate_Master.vi” (sub vi)
  - “Axes_New.vi” (sub vi)
  - “Base.stl”
  - “Dot.stl”
  - “Person_to_prove_rotation.stl”
- Open the “Get_Around_Garment_Processing_To_Be_Shared.vi” program and select the associated files in the “File Selection” tab
- The top file “Full Data Set” is the exported data from the SD card



- For the purposes of our own validation, we time synced the data by starting and ending the program and a specific infant position during a structured assessment
- For general use, in the “Setup” tab use “Assessment Start” to select the time the data collection begins (this is used if the device is turned on before it is on the infant)
- For general use, in the “Setup” tab use “Assessment End” to select the time the data collection ends (this is used if the device is kept on after it is taken off of the infant)



- “Total Seconds Outputted” will show the amount of usable seconds
- If there is a portion of the data you would not like to include in the results, portions of the data can be deleted from the “Video Interruptions” tab
- Most likely only the “child not in view of the camera” option will need to be used because this will no longer be used for time syncing with an external device.



- The “Infant View” tab will give a visualization of the infant at any given time, and on the right will output the total seconds and percent time the infant was in each position during the data collection