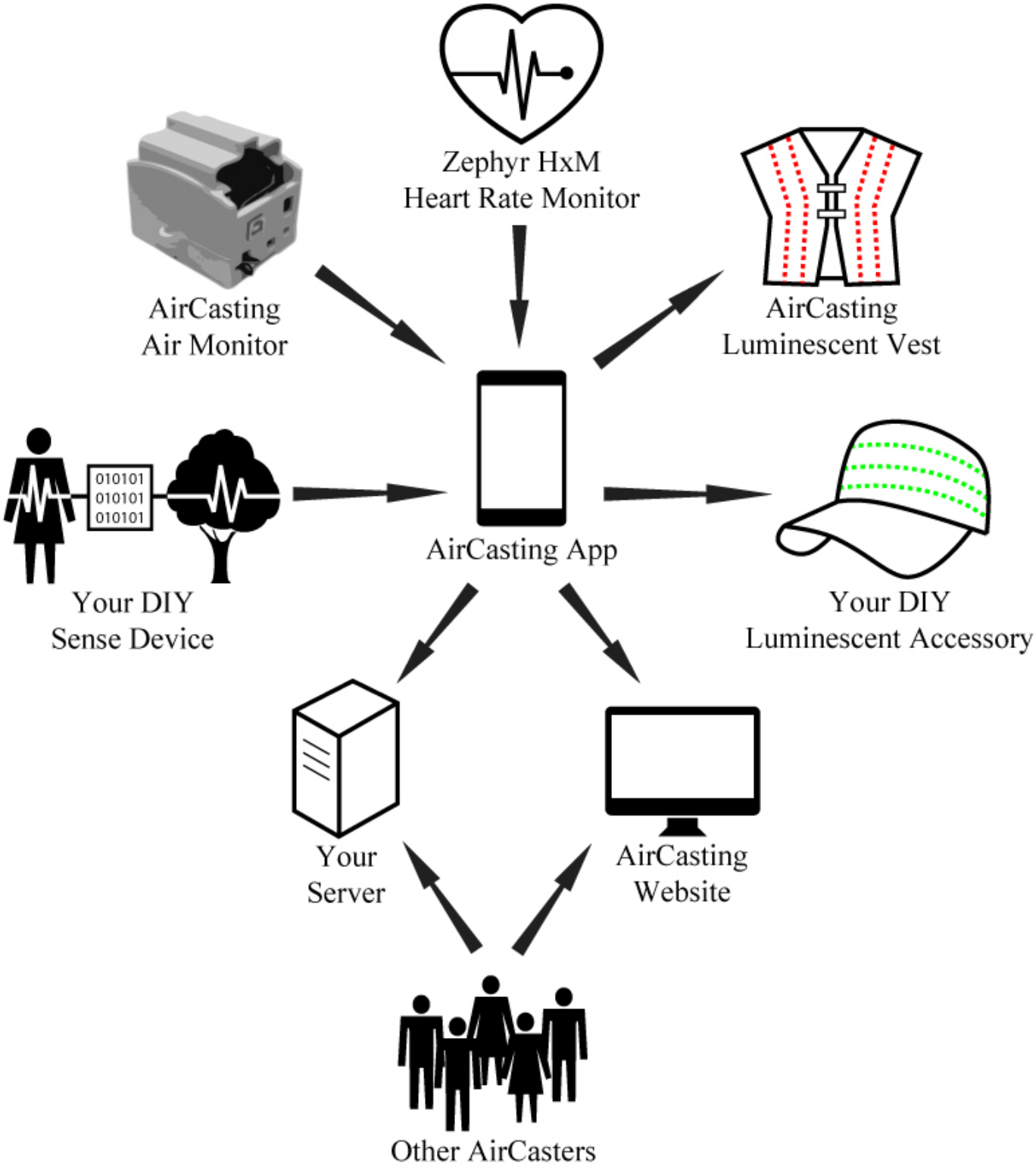
How to Build an AirCasting Air Monitor

Funding for the AirCasting Air Monitor was provided by the New York Hall of Science, the New York State Dept. of Environmental Conservation Environmental Justice Community Impact Grant Program, and the National Science Foundation (NSF ATE No 1003712). The Monitor was created at the Mechatronics Technology Center (MTC) of the New York City College of Technology (City Tech). The electronics were designed and programmed by Dr. Iem Heng and Raymond Yap and the casing was designed by Dr. Andy Zhang. AirCasting is a collaborative project lead by HabitatMap in partnership with City Tech's MTC and the New York Hall of Science.

The AirCasting Platform

AirCasting is a platform for recording, mapping, and sharing health and environmental data using your smartphone. Each AirCasting session lets you capture real-world measurements, annotate the data to tell your story, and share it via the CrowdMap.

To start recording, mapping, and sharing sound level data for your neighborhood, simply download the AirCasting app to your Android device and press record. Don't have an Android device? Check out the AirCasting maps to see if someone has already contributed data for your area.



The AirCasting Air Monitor

The AirCasting Air Monitor (ACAM) is equipped with carbon monoxide (CO), nitrogen dioxide (NO2), temperature, and relative humidity sensors. The ACAM connects to the AirCasting Android app over Bluetooth. When the ACAM is connected to the AirCasting app and an AirCasting session is initiated, the app begins receiving, mapping, graphing, and enumerating the data from the ACAM sensors.

Currently there is insufficient data available on the ACAM gas sensors to characterize or calibrate their true performance. However, the sensors are sensitive enough and their detection limits are low enough that they are capable of measuring relative changes in CO and NO2 concentrations within ranges that are commonly encountered in the urban environment. Reflecting the uncertain accuracy of the gas sensors, the ACAM is programmed to report gas concetrations using a generic response indicator (RI) scale rather than a parts per million or parts per billion unit of concentration.

The temperature and relative humidity sensors are affected by the heat generated from the operation of the ACAM electronics. Because the gas sensors are sensitive to changes in temperature and humidity, we elected to locate the temperature and humidity sensors in close proximity to the gas sensors. In the future, this will enable the calibration of the gas sensors based on the temperature and humidity. However, this proximity compromises the ability of the temperature and relative humidity sensors to accurately measure ambient air. We may add a fan to future ACAM designs to improve the air flow around the sensors which will enable more accurate ambient air temperature and humidity readings.

ATTN Hardware Developers

It's simple to connect your own custom-designed sense device to the AirCasting app to display and record sensor measurements. Just do the following:

1. Download the AirCasting Arduino sketch, which controls the sensors and sends data to the app via Bluetooth, https://github.com/LunarLogicPolska/AirCastingAndroidClient/blob/master/arduino/aircasting/aircasting_tmp36.ino
2. Alter the Arduino sketch to communicate your sensor data
3. Use the AirCasting app to send your data to the AirCasting servers for display on the AirCasting website. Want to send the data to your own servers, just specify the URL in the AirCasting app settings, "Menu" > "Settings" > "Backend settings".

AirCasting is Open Source

AirCasting is an open source project. You can access the code repositories for the AirCasting Android app and the AirCasting web app through GitHub.

AirCasting Luminescence

AirCasting Luminescence uses a IOIO microcontroller connected to the AirCasting app over Bluetooth to illuminate LEDs in response to the sensor measurements received by the AirCasting app. Download the AirCasting Luminescent Apparel DIY guide, http://www.habitatmap.org/habitatmap_docs/MakeYourOwnAirCastingLuminescentApparel.pdf, to make a fashion statement with your sensor measurements.

Monitor Your Heart Rate with AirCasting

Connect the Zephyr HxM heart rate monitor to the AirCasting app and measure how your heart rate responds to your activity level, location, and exposure to noise and air pollution.

Future Development

We're not done! Next we'll be connecting the Dylos DC1700 and Shinyei PPD42NS laser particle counters to the AirCasting platform. We also plan to continue making improvements to our first generation ACAM and begin developing methods for laboratory and in-field data validation. If you have any suggestions on how to improve the ACAM, the app, or website please send them our way.

Thanks!

To Dr. Iem Heng and Raymond Yap for designing, programming, assembling and testing the AirCasting Air Monitor electronics; to Dr. Andy Zhang for designing and printing the AirCasting Air Monitor casings; to Lunar Logic Polska for coding the AirCasting app and website; and to Tim Dye of Sonoma Technology for big ideas and constructive feedback.

AirCasting Partners

HabitatMap is a non-profit environmental health justice organization whose goal is to raise awareness about the impact the environment has on human health. Our online mapping and social networking platforms are designed to maximize the impact of community voices on city planning and strengthen ties between organizations and activists working to build greener, more sustainable cities. In addition to our online platforms, habitatmap.org & aircasting.org, HabitatMap conducts workshops that teach grassroots groups and their members how to leverage our online map making tools to strengthen their organizing and advocacy efforts.

City Tech's Mechatronics Technology Center provides a multidisciplinary platform for students to master the latest mechatronics and robotics technologies and gain experience through hands-on projects. The principle of hands-on education gives students an opportunity to experiment and understand why science, technology, engineering, and mathematics (STEM) are important in the context of solving real world problems.

The New York Hall of Science is New York City's hands-on science and technology center. Since 1986, NYSCI has served over seven million children, parents, and teachers. NYSCI's mission is to convey the excitement and understanding of science and technology to children, families, teachers, and others by galvanizing their curiosity and offering them creative, participatory ways to learn. NYSCI features the largest collection of hands-on science exhibits in New York City. Visitors of all ages can explore over 450 interactive exhibits.

Contact Us

Do you have questions, comments, or constructive feedback regarding our DIY guide? Contact Michael Heimbinder, Executive Director, HabitatMap: info@habitatmap.org, 347.410.9499

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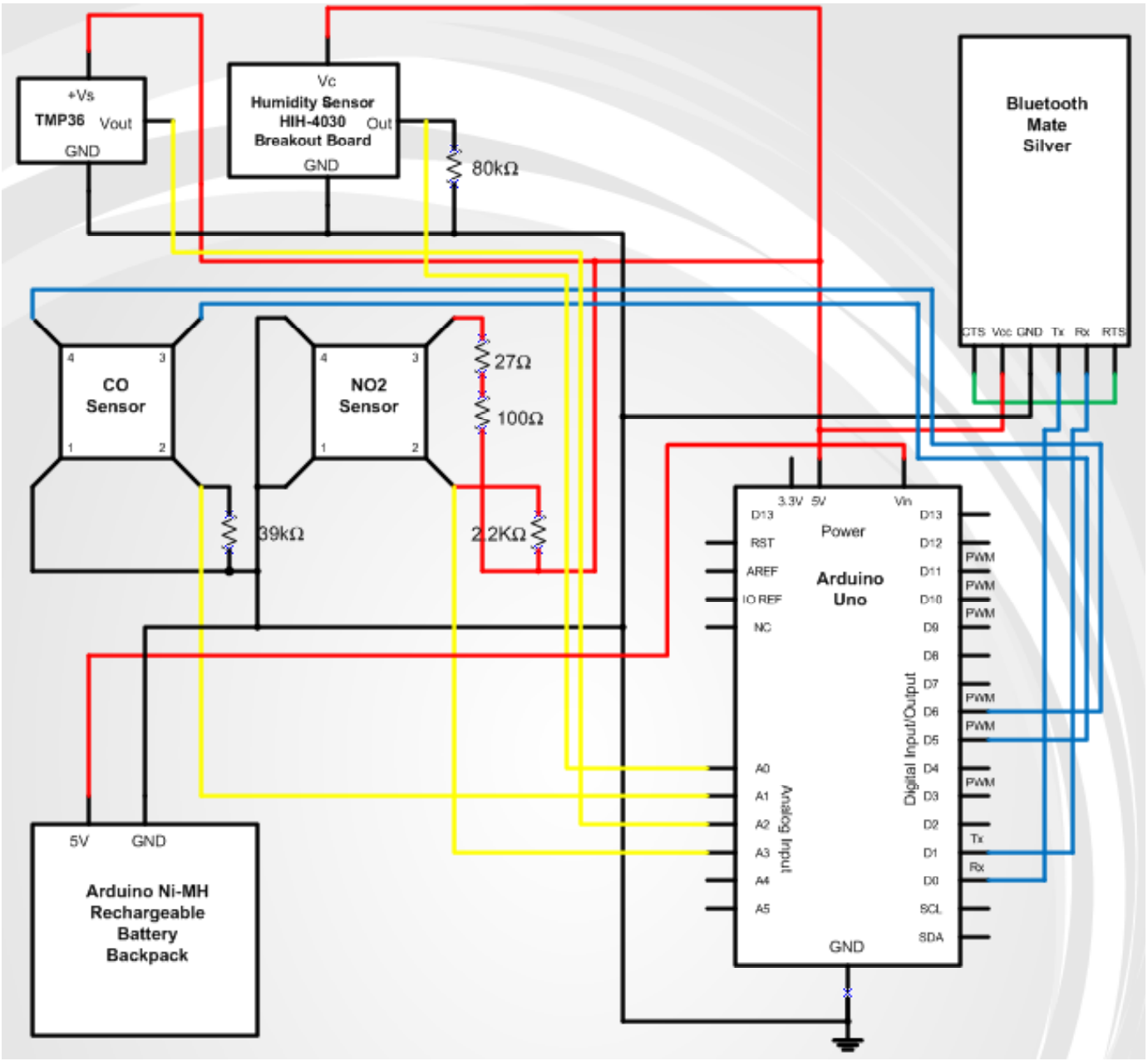
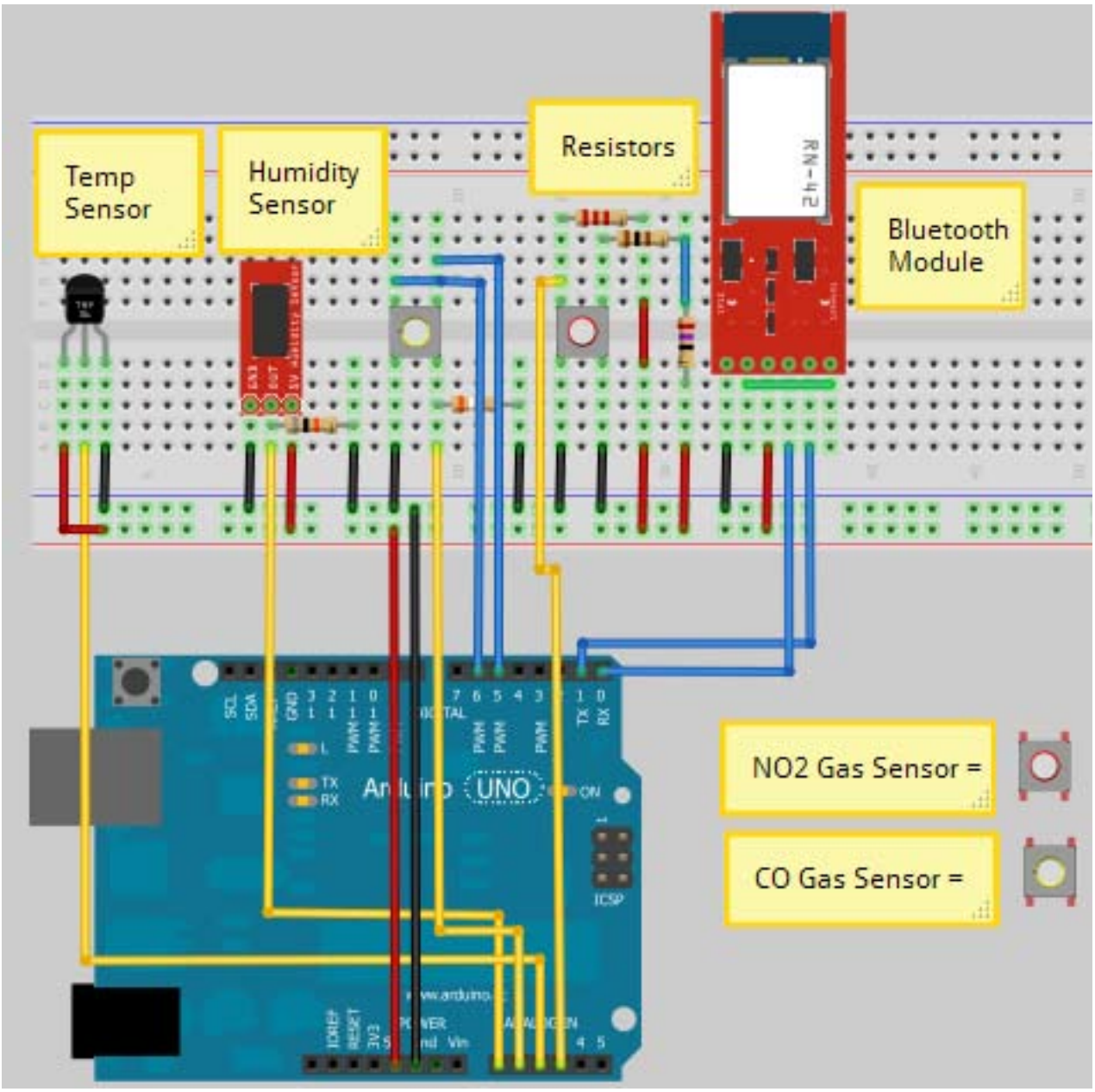
Schematic Layout of ACAM Using Visio



Schematic Layout of ACAM Using Fritzing



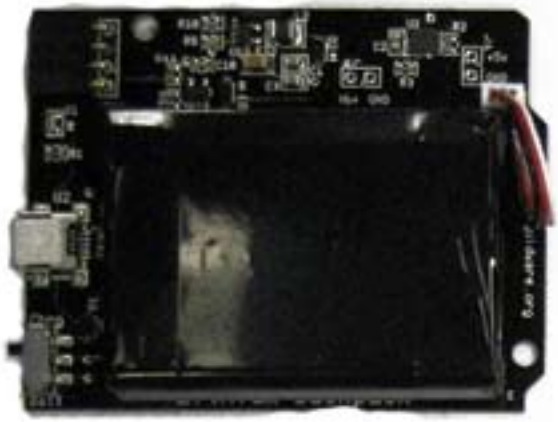
Parts & Tools

The electronic components for the AirCasting Air Monitor cost approximately $180. Vendor web links for these components are not an endorsement of the vendor; they are provided for convenience only. In order to assemble the Monitor you'll need a soldering iron, solder wire, a wire cutter/stripper, and long nose pliers.

Item Name	Vendor	Vendor Web Link	Price/Unit
Dual Mini Board with 213 Holes	Radioshack	http://www.radioshack.com/product/index.jsp?productId=2104052	$2.19
Adjustable Boost Regulator 4-25V	Jaycon Systems	http://www.jayconsystems.com/product_detail.php?prod_id=291	$11.95
MiCS 2710 NO2 Gas Sensor	Component Distributors	http://www.cdiweb.com/ProductDetail/MICS2710/333415	$5.53
Hi-Cap Lithium Backpack	Liquidware	http://www.liquidware.com/shop/show/MBP/Lithium+Backpack	$47.36
Arduino Uno R3	Sparkfun	http://www.sparkfun.com/products/11021	$29.95
Bluetooth Modem - Blue SMiRF Silver	Sparkfun	http://www.sparkfun.com/products/10269	$39.95
Humidity Sensor HIH-4030	Sparkfun	http://www.sparkfun.com/products/9569	$16.95
Temperature Sensor TMP 36	Sparkfun	http://www.sparkfun.com/products/10988	$1.50
Figaro TGS 2442 CO Gas Sensor	Figaro	http://www.figarosensor.com/	$16.00
AirCasting Air Monitor Casing	Shapeways	Print your own - www.thingiverse.com/thing:26555. Or buy one - www.shapeways.com/shops/AirCasting	----
Stranded Breadboard Jumper Wire: 4 orange - 5V, 4 blue - ground, 1 blue & 1 green - CO power cycle, 1 white & 1 yellow - BT comm, 4 yellow - sensor signals	----	----	----
Solid Core Breadboard Jumper Wire: 1 gray - insulation			
1k Ohm Resistor: brown, black, red (4 units)	----	----	----
39k Ohm Resistor: orange, white, orange (3 units)	----	----	----
22k Ohm Resistor: red, red, red	----	----	----
100 Ohm Resistor: brown, black, brown	----	----	----
27 Ohm Resistor: red, purple, black	----	----	----
10 Pin Breakaway Headers	----	----	----

1k Ohm Resistor

Hi-Cap Lithium Backpack

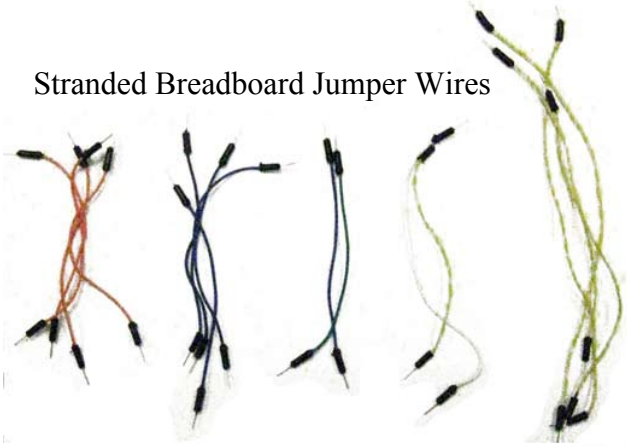


39k Ohm Resistor

22k Ohm Resistor

100 Ohm Resistor

Stranded Breadboard Jumper Wires



27 Ohm Resistor

Figaro TGS 2442

Straight Breakaway Headers

MiCS 2710 NO2

Humidity Sensor
HIH-4030

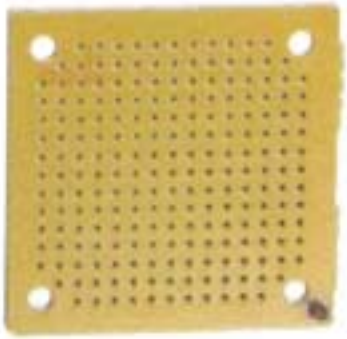
Temperature Sensor
TMP 36

Adjustable Boost
Regulator 4-25V

Bluetooth Modem
Blue SMiRF Silver

Arduino Uno R3

Solid Core
Breadboard
Jumper Wire

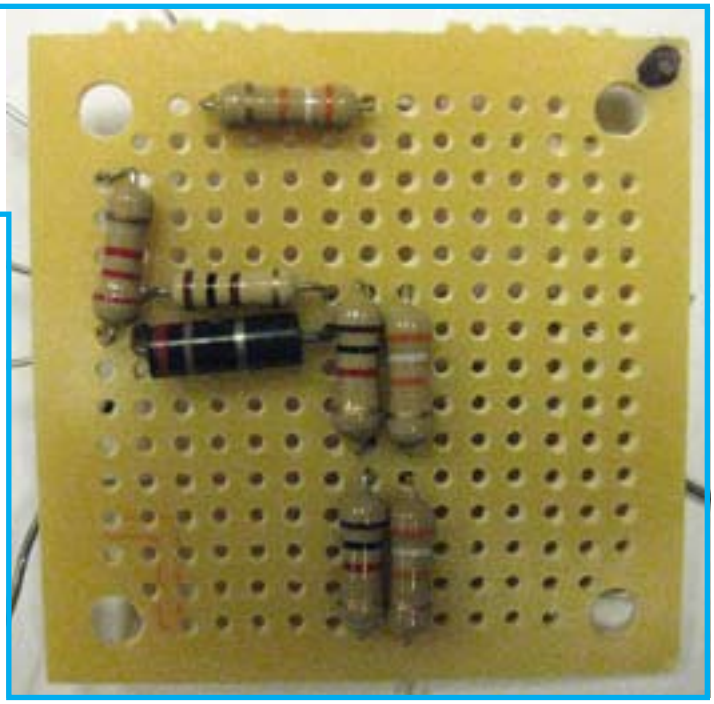


Dual Mini Board with 213 Holes

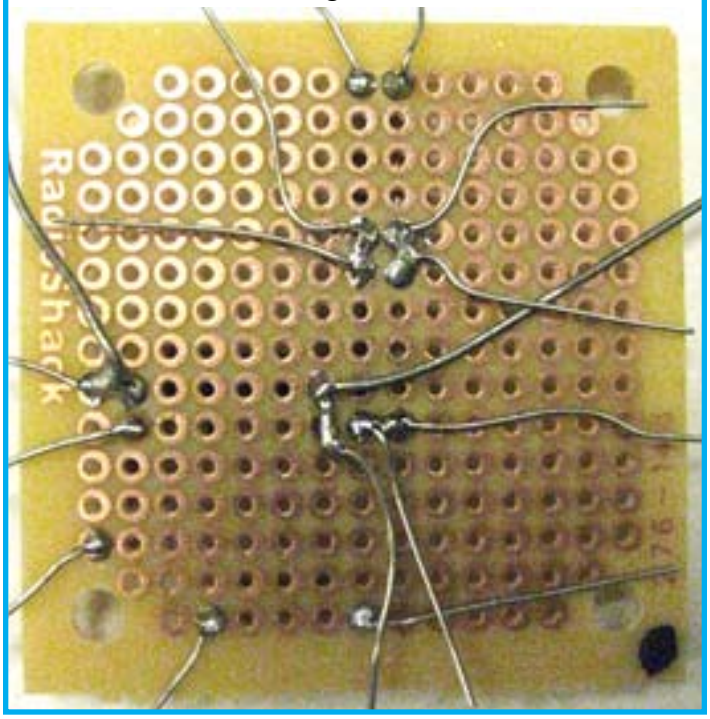
Step by Step Instructions

1 Snap the Mini Board in half. Take half the board, orient it top side up, and rotate it so the snapped side is up. Take a permanent marker and mark the upper right hand corner with a dot to orient yourself while building up the board. Then flip the board upside down and mark the same corner on the other side of the board.

2 Place resistors on the board. Be sure to pull the resistor wires all the way through the board until the resistors are nearly flush with the top of the board. Bend the resistor wires against the back of the board to keep them in place.

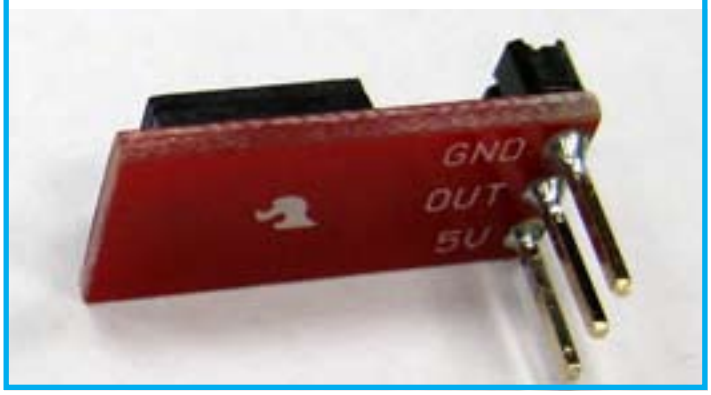


3 Solder the resistors to the board. Bridge the shown connections using solder.



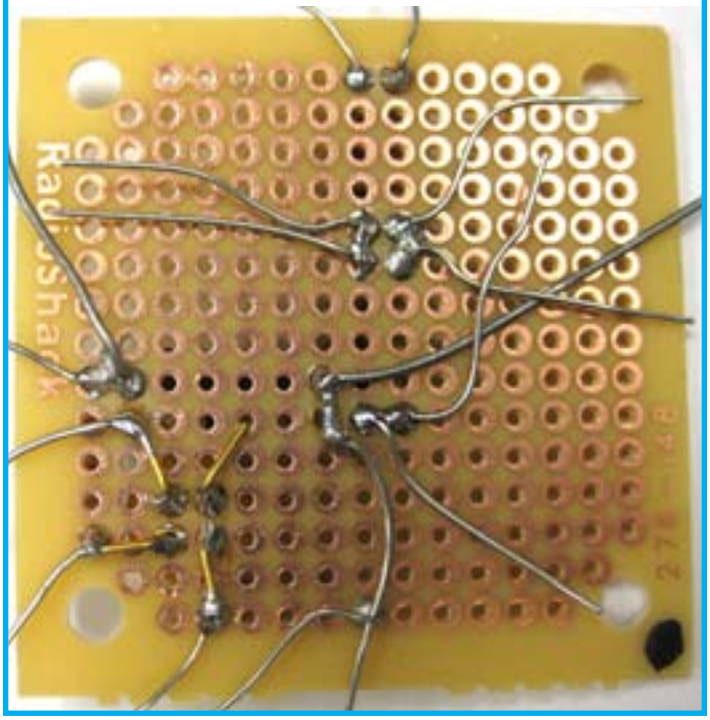
4 Use pliers to break away four pins from the strip of straight break away headers. Use a hard surface to push the black plastic on the straight break away headers to one end. Insert straight break away headers into BT. Solder straight break away headers to BT. Solder together the two small plates located on the back of the BT above the letter “n”.

5 Use pliers to break away three pins from the strip of straight break away headers. Use a hard surface to push the black plastic on the straight break away headers to one end. Insert the straight break away headers into the humidity sensor and solder them in place.

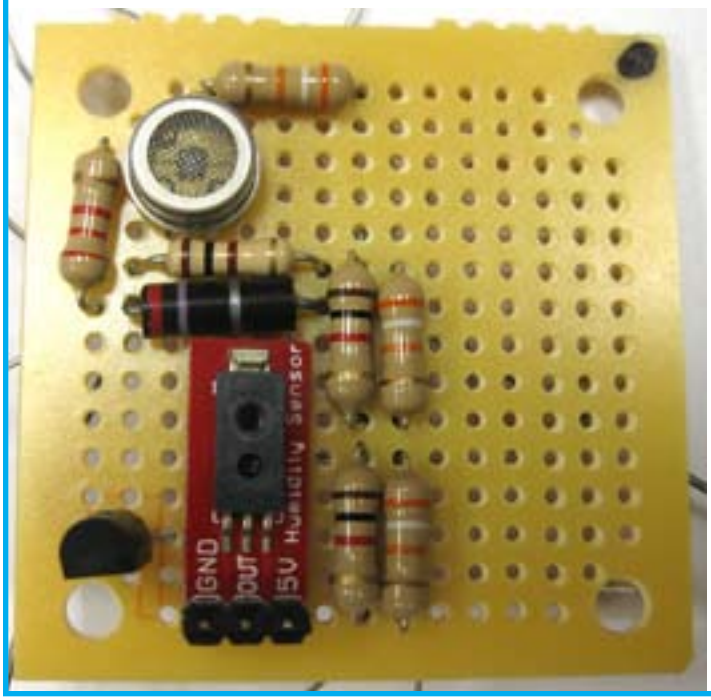


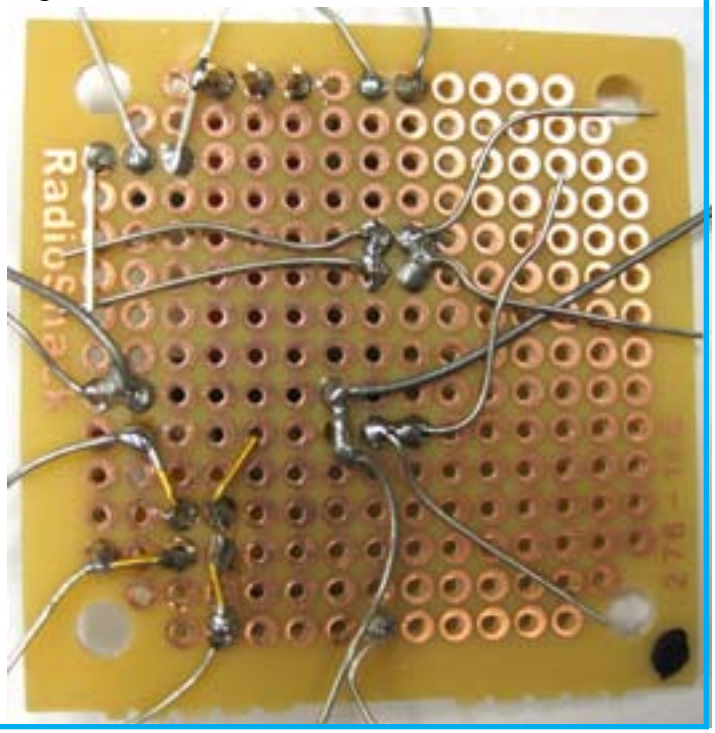
6 Insert the NO2 sensor into the breadboard. Make sure the reference tab (the copper piece of metal protruding from the packaging) is facing up.

7 Bend the bottom left leg, the top left leg, and the bottom right leg of the NO2 sensor as shown and solder the legs to the resistors. Solder the legs on the right side of the NO2 sensor together (note that this last step is not shown here.)



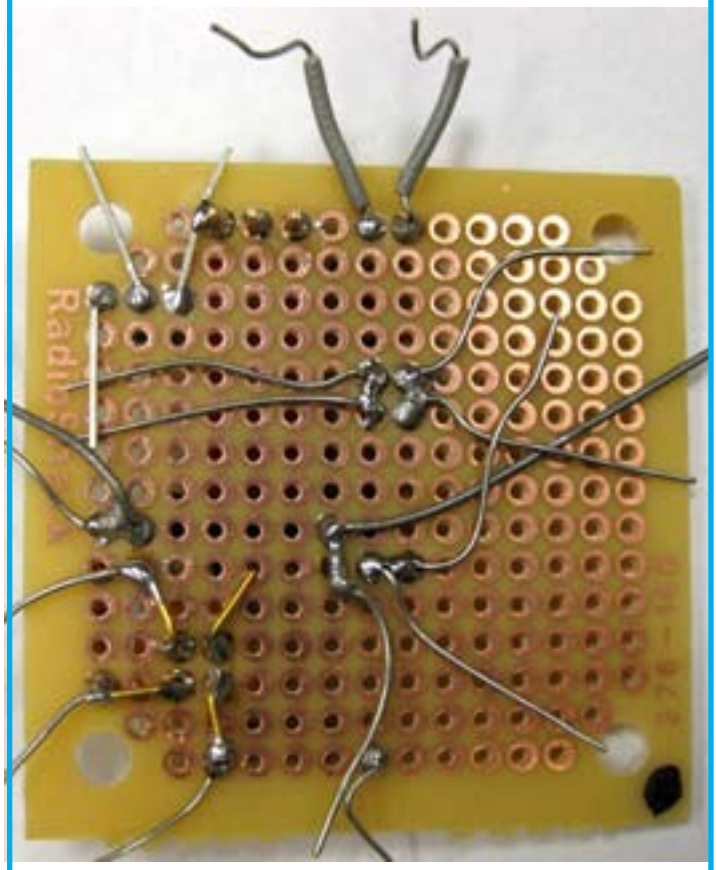
8 Insert the humidity and temperature sensors. Solder the humidity sensor to the breadboard. Bend the right leg of the temperature sensor up and solder it to the left leg of the humidity sensor. Then bend the center leg of the temperature sensor up and bend the left leg down.

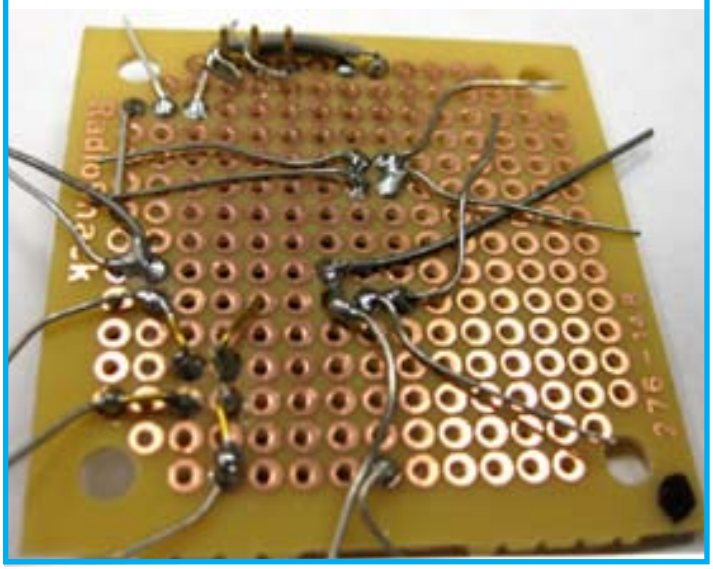




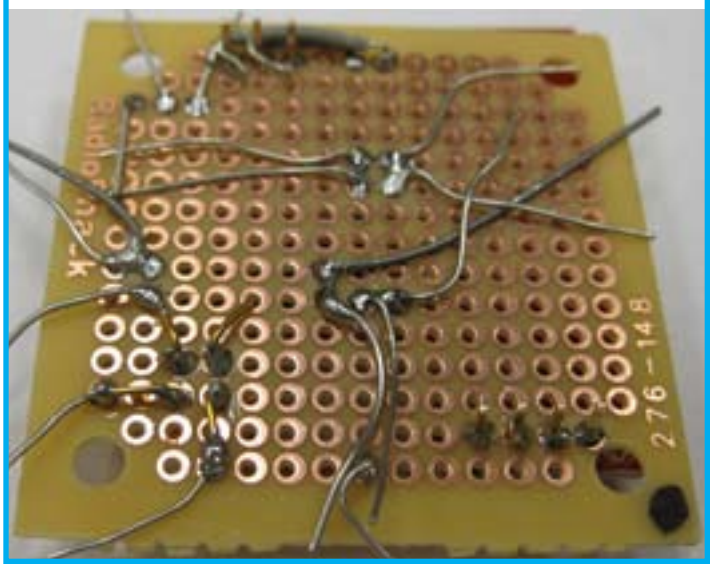
9 Note: To prevent the wires from shorting when they overlap you'll need to insulate them. To insulate the wires, strip the plastic insulation from the solid core breadboard jumper wires, then measure and cut to fit.

Insulate the two resistor wires at the top of the board and wrap the ends around the left and center legs of the humidity sensor, left to left and right to center, then solder in place.

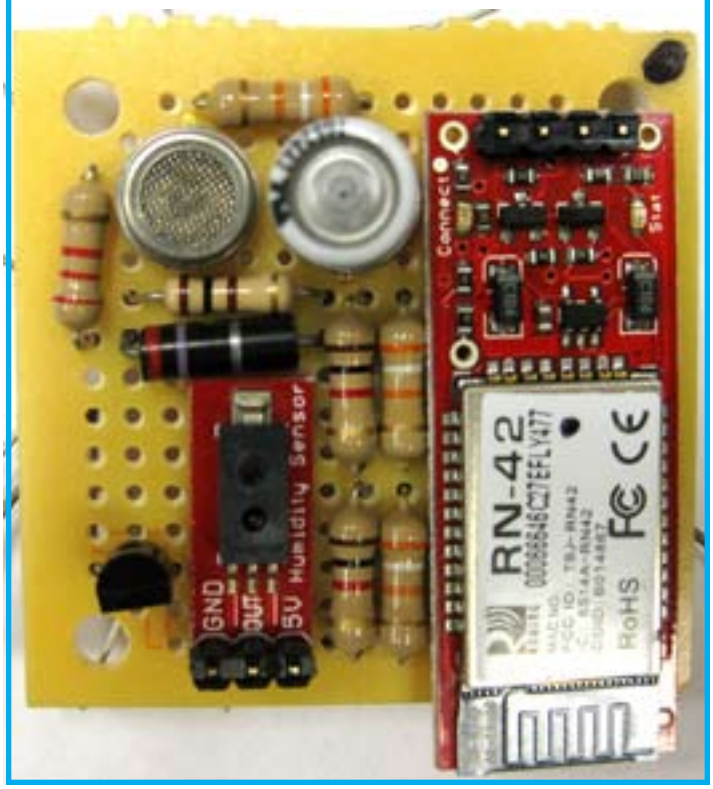




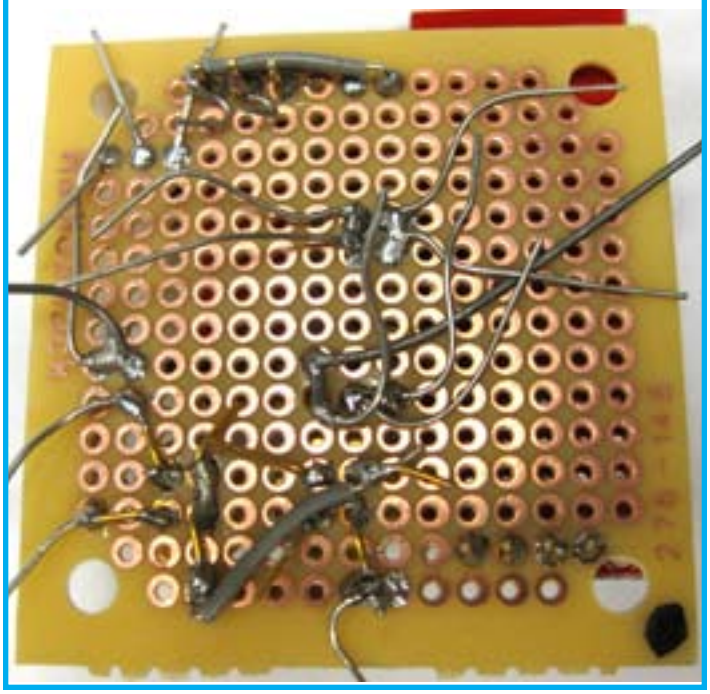
10 Insert and solder the Bluetooth modem to the breadboard.



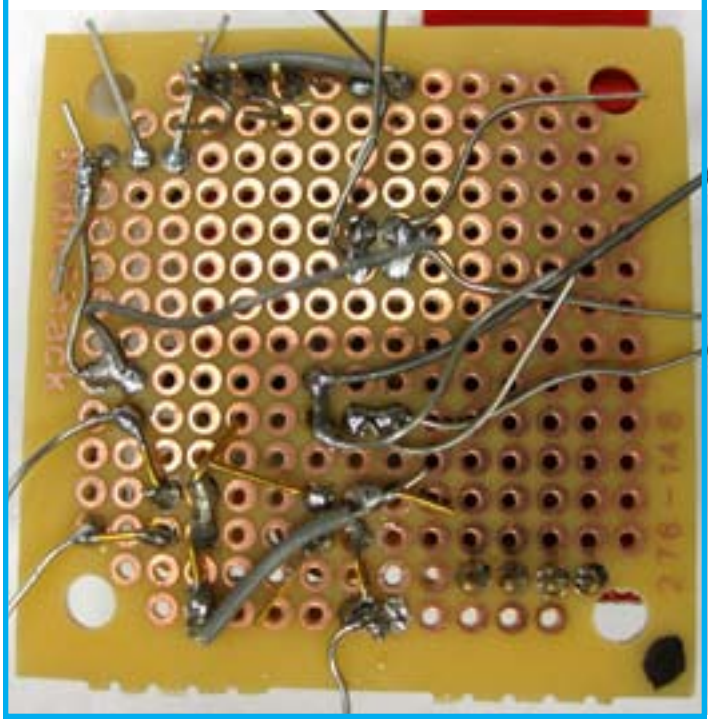
11 Insert the CO sensor into the breadboard. Make sure the reference tab (the copper piece of metal protruding from the packaging) is facing down.



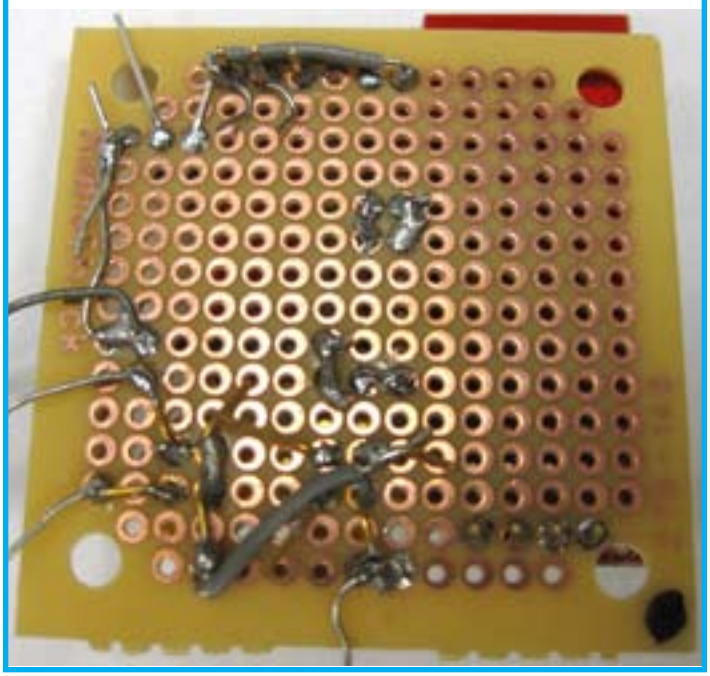
12 Bend the legs of the CO sensor as shown and solder the bottom right leg to the resistor. Insulate the resistor wire at the bottom left side of the board, then connect and solder the resistor wire to the top right leg of the CO sensor.



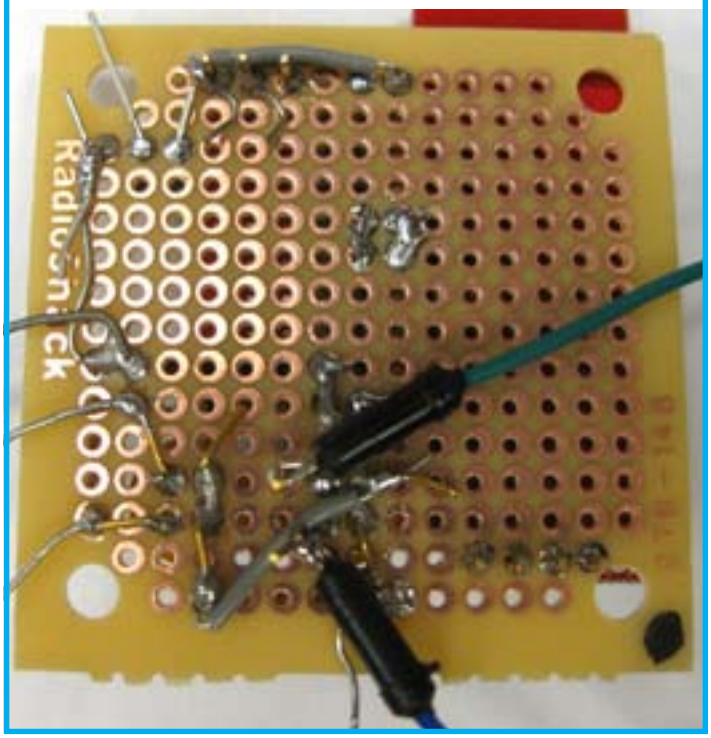
13 Solder the left leg of the temperature sensor to the resistor on the left side of the board.



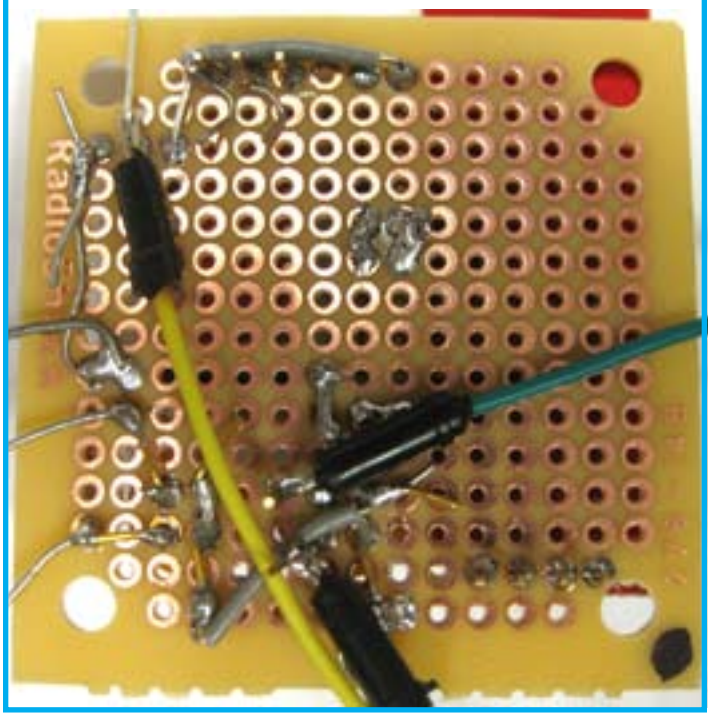
14 To make the board easier to work with, remove some of the resistor wires sticking up from the board. Using a gentle circular motion, wiggle the eight resistor wires in the center of the board until they break loose.



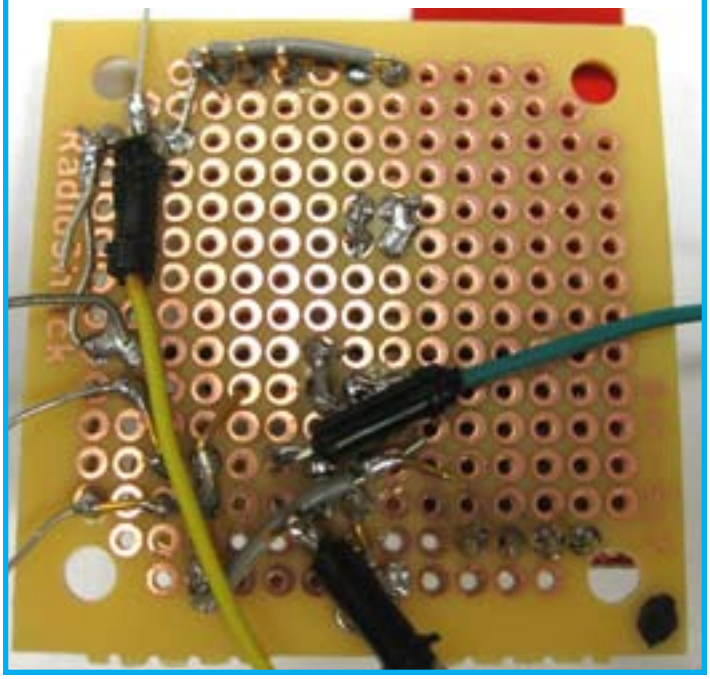
15 Use the mini pliers to create a hook at the end of a blue jumper cable and hook and solder the bottom left leg of the CO sensor. Next, hook and solder a green jumper cable to the top left leg of the CO sensor.



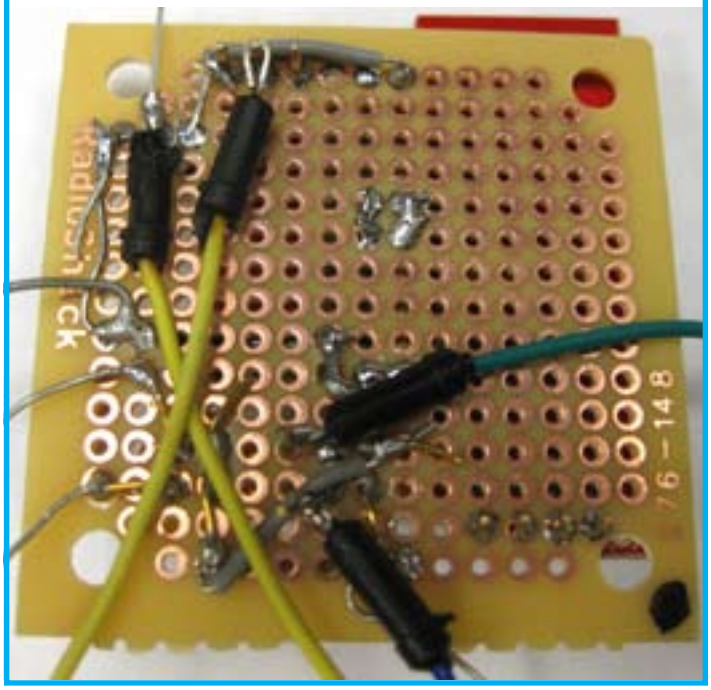
16 Hook and solder a yellow jumper cable to the middle leg of the temperature sensor.



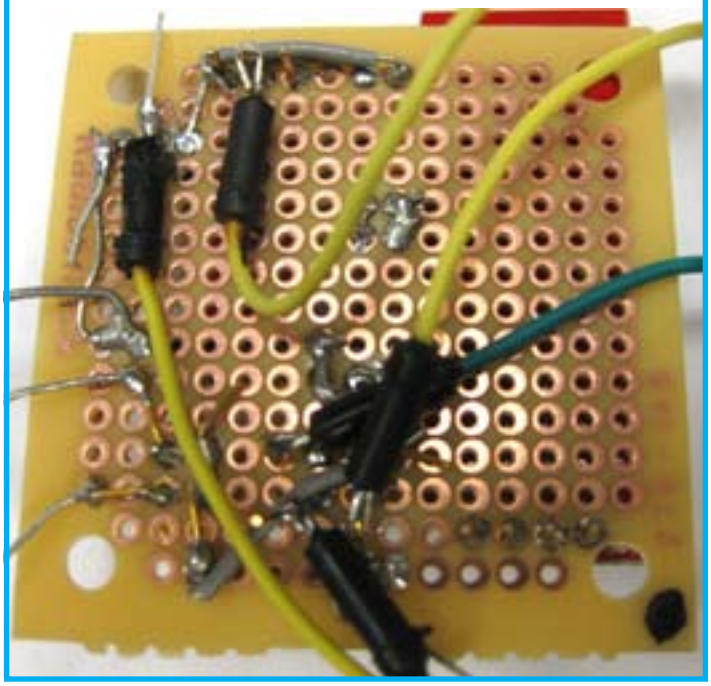
17 Wiggle the wires protruding from the humidity sensor until they break away



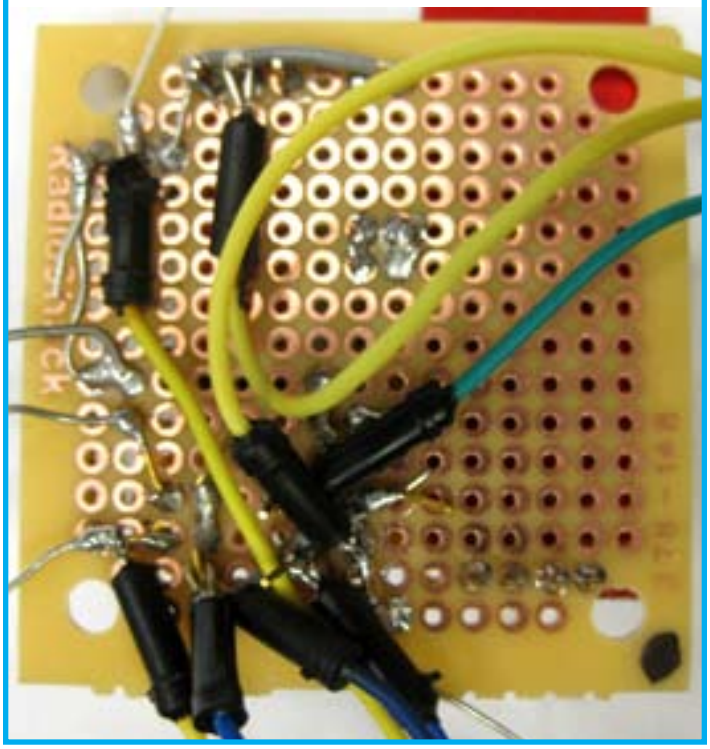
18 Hook and solder a yellow jumper cable to the center leg of the humidity sensor.



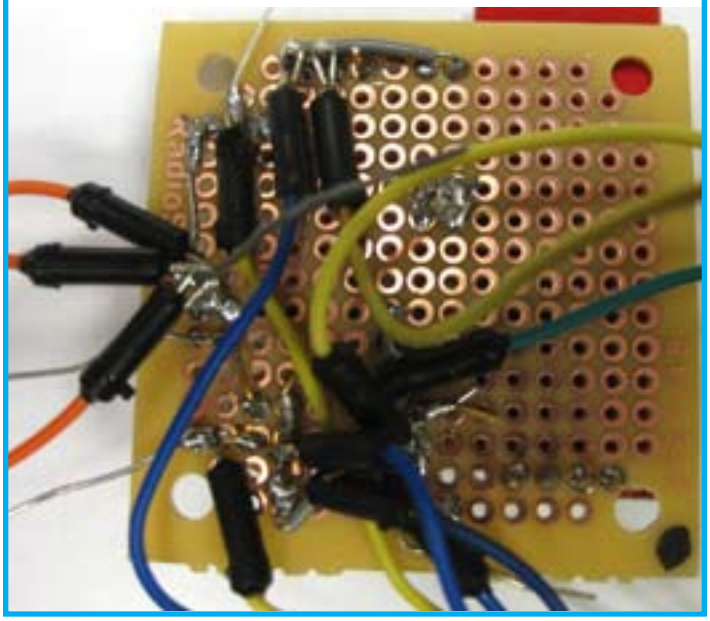
19 Hook and solder a yellow jumper cable to the bottom right leg of the CO sensor



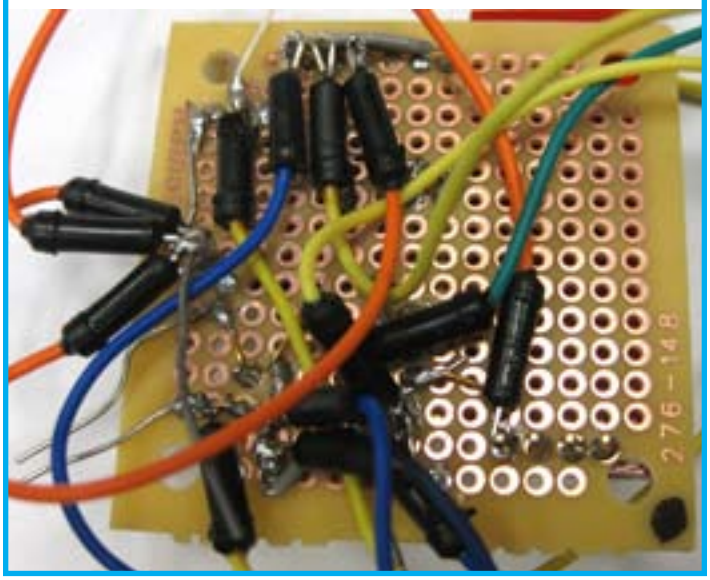
20 Hook and solder a yellow jumper cable to the bottom left leg of the NO2 sensor. Hook and solder two blue jumper cables to the bottom right leg of the NO2 sensor.



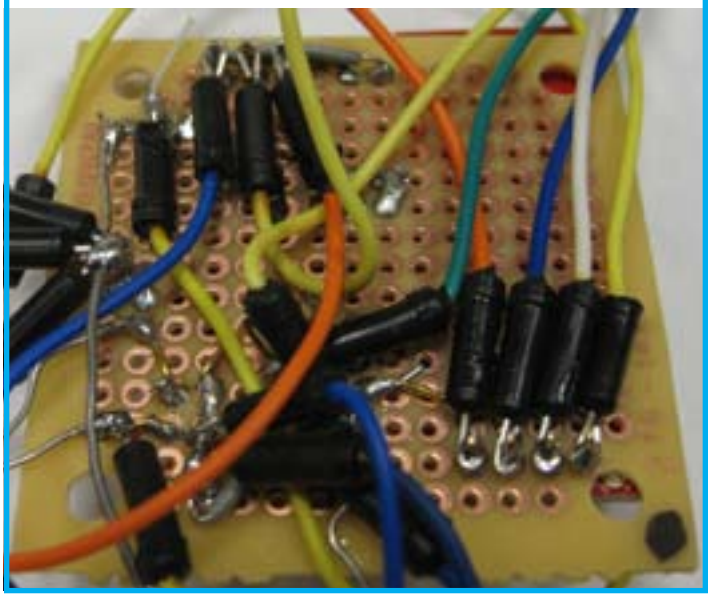
21 Take one of the blue jumper cables from the bottom right leg of the NO2 sensor and hook and solder the opposite end to the left leg of the humidity sensor. Next, hook and solder three orange jumper cables to the remaining wire protruding from the bridged connection between the resistor and the left leg of the temperature sensor.



22 Take one of the orange jumper cables and hook and solder it to the right leg of the humidity sensor. Take the second orange jumper cable and hook and solder it to the left leg of the BT.



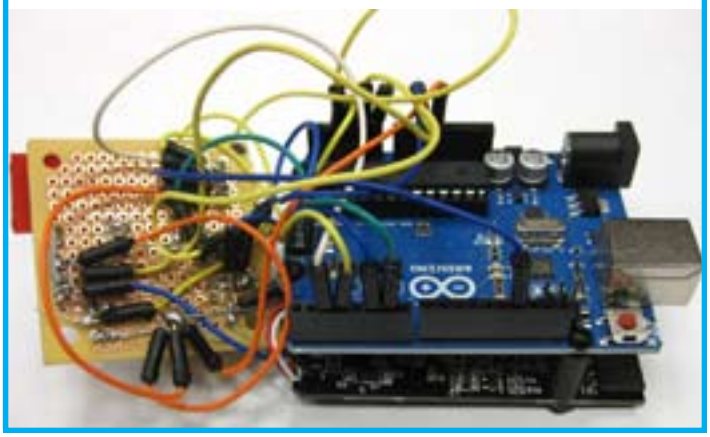
23 Hook and solder a blue jumper cable to the center-left leg of the BT. Hook and solder a white jumper cable to the center-right leg of the BT. Hook and solder a yellow jumper cable to the right leg of the BT.



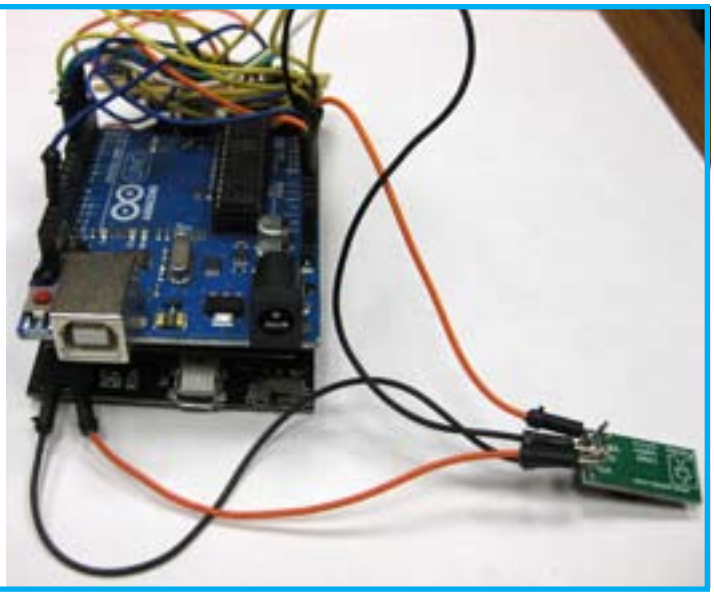
24 Hook and solder two black jumper cables to the center leg of the boost regulator. Hook and solder an orange jumper cable to the left and right legs of the voltage booster.

25 Screw the Lithium Backpack to the Arduino. Following the schematic layout, plug the jumper cables into the Arduino microcontroller pins as listed below.

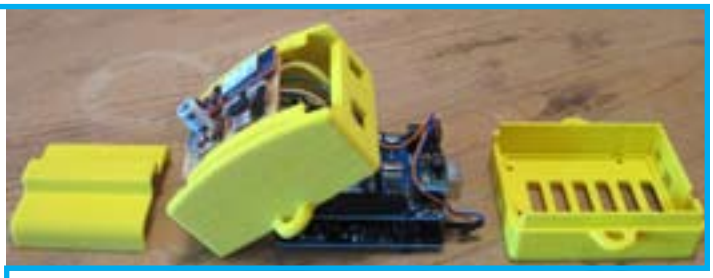
- Pin AO: Humidity
- Pin A1: CO Sensor
- Pin A2: Temp Sensor
- Pin A3: NO2 Sensor
- 5V Pin: Power Sensors + Bluetooth
- GND Pin: Common Ground
- GND Pin: Common Ground
- Pin 2: Rx pin for Bluetooth
- Pin 3: Tx Pin for Bluetooth
- Pin 5: Power cycle for CO Sensor
- Pin 6: Power cycle for CO Sensor



26 Plug one of the black jumper cables running from the center leg of the boost regulator into the Arduino's power GND pin. Plug the second black jumper cable running from the center leg of the boost regulator into the Lithium Backpack's GND pin. Plug the orange jumper cable running from Vin leg of the boost regulator into the 5V pin of the Lithium Backpack. Plug the orange jumper cable running from the VOUT pin of the boost regulator into the Arduino's VIN pin.



27 Print out the casing (www.thingiverse.com/thing:26555) or buy it from Shapeways (www.shapeways.com/shops/AirCasting). Slot the breadboard into the casing cover then insert the Lithium Backpack and Arduino into the base. Finally, slot the sensor cover into place. Note that the slots for the breadboard and sensor cover may need to be filed for a better fit.



28 Now that your Monitor is fully assembled, you can connect it to the AirCasting app and begin mapping and graphing your sensor measurements. First, download and install the Arduino software on your computer, www.arduino.cc/hu/Main/Software. Then connect your Arduino to your computer using a USB a to b cable and run the Arduino software, opening up a new Sketch.

29 Next, copy the AirCasting Arduino INO file from GitHub - https://github.com/LunarLogicPolska/AirCastingAndroidClient/blob/master/arduino/aircasting/aircasting_tmp36.ino - paste it into your Sketch and upload it to your Arduino. Once the upload is complete, disconnect the Arduino from the USB cable.

30 Next, turn on your Monitor by flipping the power switch on the Lithium Backpack. Note that you may need to charge the Lithium Backpack prior to powering up. You'll know the battery is fully charged when the orange charging indicator on the Lithium Backpack turns off. Once the Monitor is on, you should observe a blinking red light on the Bluetooth modem.

31 Now you're ready to connect your Monitor to the AirCasting app over your Android phone's Bluetooth connection. First, open the Play Store app and search for, download, and launch the AirCasting app. Then, press the menu button on your phone, select "Settings", select "External devices", select "pair with new devices", "search for devices", select your Monitor name and MAC address (e.g. R42-C22C 00:06:66:46:C2:2C), enter the pairing code "1234", return to the AirCasting app, select your monitor from the "External devices" dialog, and when prompted to connect press "Yes".

Once the AirCasting app is connected to the Monitor the blinking red light on the Bluetooth modem will be replaced by a solid green light and the AirCasting Sensors Dashboard will appear and begin enumerating the data streams from the sensors.

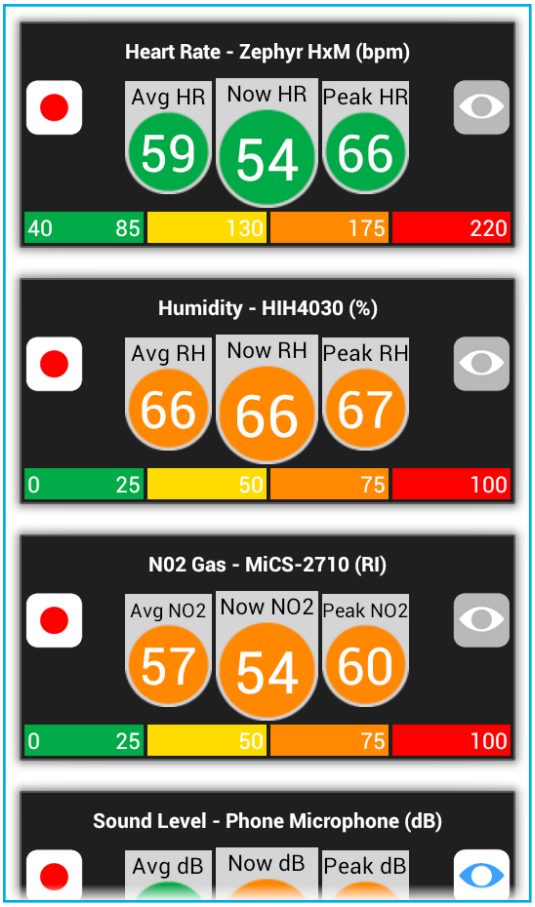
You only need to pair and connect the Monitor to the AirCasting app once. After that, the Monitor should automatically connect to the AirCasting app when it's launched. If the Monitor does not automatically connect after 60 seconds, select "Settings", select "External devices", and connect again.

32 AirCasting provides four ways to view your sensor data: the Route Map, the CrowdMap, the Graph and the Sensors Dashboard. Toggle between the views by tapping the triangular buttons located on the left and right sides of the screen. If you don't see any buttons, tap the screen once to make them appear; tap the screen again to make them disappear.

Toggle to the Route Map or CrowdMap. Make sure your GPS is on and your location on the map is accurate. Without a GPS fix you will not be able to record data. Press the bullseye button to refresh your location and center the map. Once you have confirmed that your location is accurate, press the record button to begin recording data. If you don't see the record button, tap the screen once and it will appear.

Hint: To adjust the relationship between sensor measurements and display colors, tap the "Heat Legend" (the colored bar at the top of the screen). To toggle between sensor streams tap the "Avg" "Now" "Peak" circles at the top of the screen.

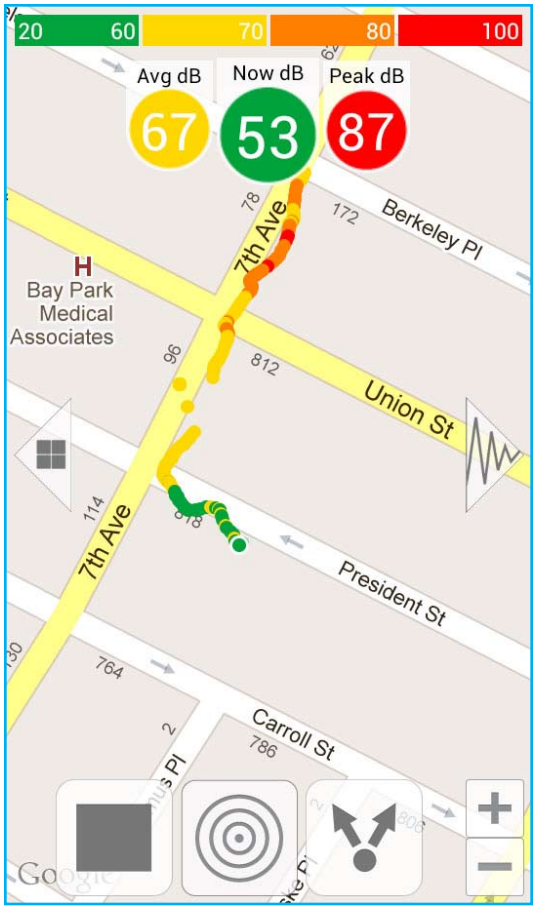
33 When you're done recording your AirCasting session press the stop button. If you don't see the stop button tap the screen once and it will appear. Enter a title, tags, and description and press "Save session". You will then be prompted to contribute your session to the CrowdMap. Sessions added to the CrowdMap are publicly accessible via the website, www.aircasting.org



Sensors Dashboard

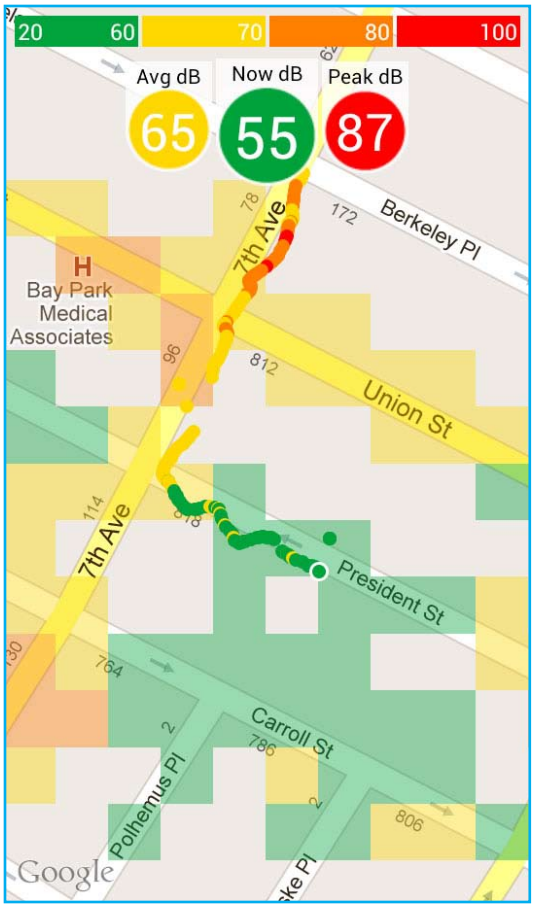
The **Sensors Dashboard** displays the measurements from all your sensor streams simultaneously. Tap the record buttons next to each sensor stream to toggle recording off/on. Tap the eye icon to select that sensor stream for viewing on the Route Map, CrowdMap and Graph.

The **Route Map** displays your current position as a colored dot with a white outline; dots without an outline are past readings. A dot's color corresponds to the reading's intensity at a location. Refer to the "Heat Legend " (the colored bar at the top of the screen) to identify the intensity range for a reading. For example, a yellow dot corresponds to a sound level reading between 61 and 70 decibels.



Route Map

The **CrowdMap** displays AirCasting data from all contributors. Each square's color corresponds to the average intensity of all the readings recorded in that area. Refer to the "Heat Legend " to identify the intensity range for a square. For example, an orange square corresponds to an average sound level between 71 and 80 decibels. If no colors are displayed, there is no data in that area.



CrowdMap

The **Graph** displays your readings over time. Zoom in and out for more or less detail. Swipe to pan through the data.

Graph