Bike Analog Pollution Meter

by rabbitcreek

When I was growing up it was taken for granted that smokers ran the world and as kids you could just shut up and breath their exhaust. Amazing what a few years have done. The smokers from then died miserable deaths and took (and will take) a fair number of us nonsmokers with them. Car interiors filled with their brown crenulated residue, airplane's gas-chambered horrors and restaurants filled with their special "spice". We lived with it because just like the fish in David Foster Wallace graduation speech (https://www.youtube.com/watch?v=8CrOL-ydFMI) ... we didn't know what water (clean air) is. We still don't know exactly what causes cancer from cigarette smoking but most bets are placed on the PM 2.5 pollution levels that increase with smoking and a million other things. Our ability to measure these small knives that penetrate deep into our tissues is getting better. The EPA operates a number of specialized towers that are expensive and provide intermittent information to nearby locals. Satellites swing overhead delivering the broad picture of a downwind toxic facility (or country) that may be the reason all your children die young of anything from depression to heart disease.

The only way to really get a measure of your minute by minute exposure is to meter it yourself. This bicycle mount analog device sniffs the air as you go through your morning commute analyzing the PM 2.5 content of the air your breathing. It delivers the news in a graphical format that tells your breathing equivalent in cigarettes smoked per day. It is surprising what an idling truck, chirping weedwacker or worse a screaming leaf blower will deliver not so silently to your lungs. Be the fish who knows what water is.

Step 1: Gather Your Materials

I am using the Honeywell sensor as in a previous project (https://www.instructables.com/id/Solar-Particle-Analyzer/) It has worked very well and the software is easy to use.

1. HONEYWELL HPMA115S0-TIR PM2.5 Particle Sensor laser pm2.5 air quality detection sensor module Super dust sensor PMS5003 $18

2.ESP32 MINI KIT Module WiFi+Bluetooth Internet Development Board D1 MINI Upgraded based ESP8266 Fully functional $6 (AliExpress)

3. MH-ET LIVE Battery Shield for ESP32 MINI KIT D1 MINI single lithium battery charging & boost $1 (AliExpress)

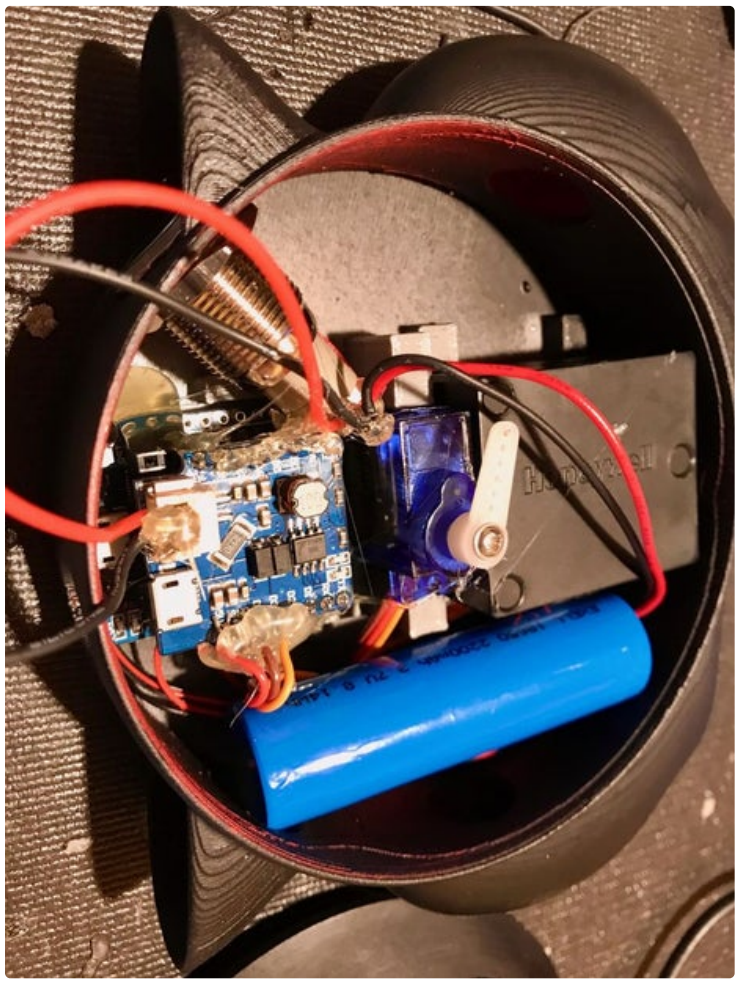
4. HIINST 1pcs 100% NEW SG90 9G Micro Servo Motor For Robot 6CH RC Helicopter Air $1

5. 18650 Battery with wires $4

6. Rugged Metal On/Off Switch with Green LED Ring - 16mm Green On/Off $5 (Adafruit)

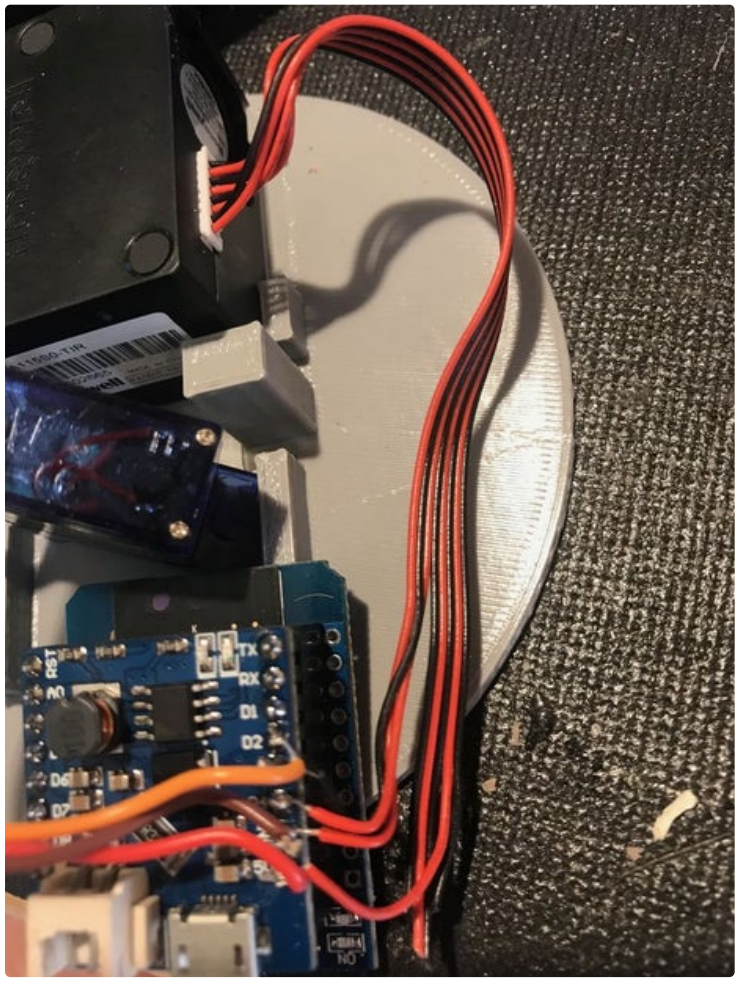
7. Generic 3D printer (Ender 3)

8. Plexiglass



Step 2: Wire It

The wiring for this sensor set-up is based loosely on the CAN-AirIO **https://www.hackster.io/canairio-guide-team/canairio-citizen-network-for-air-quality-monitoring-bbf647#toc-materials-0** write-upwhich uses the stacked power supply/Battery Charger and the small size ESP 32 that mates with it nicely. Neglect the addition of the screen as presented in their video and add the three wires of the stock small servo to the board attaching the control wire to pin 21 and the power(5V) and Ground. The wiring of the Honeywell serial port is to 16/17 on the ESP32. The wiring of the switch and battery is done to the battery board which turns on power to the computer and the Honeywell sensor. The charging circuit is activated whenever the micro usb on the booster is plugged in but you must have the machine running (button ON) to expose the battery to charge.

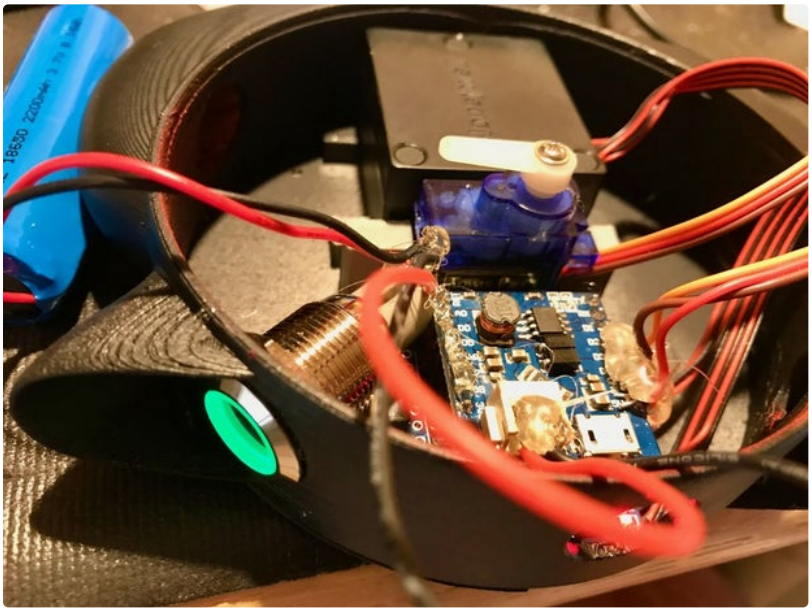


Step 3: Build It

All STL files for the parts can be found here: https://www.thingiverse.com/thing:4202380

The parts are all easily printed with PLA at 0.2mm and 40% infill. I used an Ender 3 -- a wonderful printer. The primary unit has three pieces. The base includes all the mounts for the electronics. The body includes all the air scoops and the openings for the charger port and the ON/OFF switch and the top includes the window for the plexiglass and the opening that the servo head pops through. The photo has to be printed as a 3 inch circle -- this magic is easily done by Walgreens. I had trouble finding a metal printer that would do it exactly this size but you may find one for better obsolescence. All the wired components are hot glued into position according to the photos included above. The tolerances are rather close and you have to make the opening for the charger port appear in its correct slot. The ultimate battery size is up to you --the 18650 battery will last up to six hours.

After the base electronics are glued in the middle case is set into position and glued to the base with Loctite super glue. The photo is carefully trimmed into a 3 inch circle. A 8 mm hole is punched into the photo where it overlays the servo output shaft and it is squeezed into the upper chamber until flat. All adjustments to the servo output have to be done by this point as you will be making any final adjustments before gluing the needle on and sealing up the unit. Setting the zero point of your servo is easily done and you must test out the maximum range of the servo in the software. When everything is set seal the the needle to the shaft and seal the upper chamber on with superglue. A piece of plexiglass is easily cut with a saber saw and sanded to the correct dimensions of the upper portal. This is sealed with a couple spots of hot glue which will allow future removal of the dial if the picture fades.



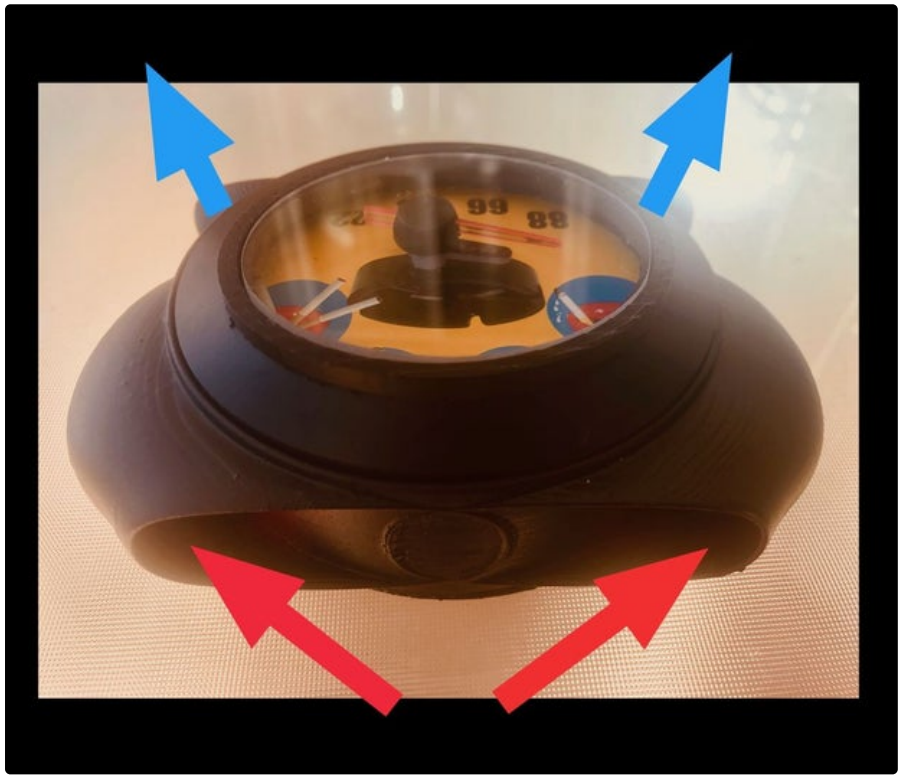
Step 4: Program It

Most of the code work for getting the serial data out of the Honeywell sensor came from this nice piece: **https://medium.com/@boonsanti/esp32-air-quality-measurement-pm2-5-pm10-with-honeywell-hpma115s0-55f411d08fca** The rest of the code just is just for setting up the servo with ESP32 -- sometimes difficult and then setting up the limits for the servo movement with a couple constraints and mapping functions. The sensor is queried about once a second and seems very robust in terms of its response to stimuli.

Step 5: How It Works

Your Analog sensor works by using strategic air vents that capture and samples the air as you are biking through it. The forward vents funnel air to the motorized fan located in the air inlet housing of the Honeywell sensor. Air enters a collection chamber where a laser impinges on the particulate matter floating in the airstream. A lot of algorithms later a serial stream of data is collected once per second and sent to the servo which is calibrated to the cigarette graphics.

Why have an Analog output anymore? Not sure really. It seems the urgency of increasing speed or RPM in a car is still a thing to the brain, but certainly analog clocks are going away. The pure flood of numbers to our new digital brains will probably soon be interpreted with the same urgency as spacial tensions created by a near hit or miss of an arrow in our visual cortex.



Step 6: Using It

So the main question from reading so far is how is your particle measurement can be turned into a quantifiable number of cigarettes smoked per day? Good question--and here is where you should read the answer: **http://berkeleyearth.org/air-pollution-and-cigaret...**It is a very detailed analysis of how they came up with this number. Basically they know the number of cigarettes that are responsible for a certain number of deaths in this country and they know the excess deaths from PM2.5 in china and they developed the equivalency from this data.

SuperGlue the bike mount to the unit (included in the 3D print files) and put it on your bike. Or put it next to your toaster! Ride through the city and find out what you are breathing and who is responsible. It is only with more knowledge of our environment and how it works that we can make educated changes in how we live. "This is Water!"