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Research

Dr. Landry

Research with Air Quality Eggs

**Introduction:**

Air Quality Eggs (AQEs) are atmospheric sensors that can detect levels of temperature, humidity, and greenhouse gases in the air. This project began by student Lisa Soulé under the advisement of Dr. James Landry. Lisa worked with the first version of AQEs. The first version tested levels for temperature, humidity, ozone, dust, volatile organic compounds, carbon monoxide, and nitrogen dioxide. The research she conducted was based off of analytical methods testing precision and accuracy of the AQEs. She concluded that the precision and accuracy testing of both the temperature and humidity sensors seemed to align. This was not the case for the other AQE sensors, however. All the other sensors showed completely different levels of each of the gases in the atmosphere. The AQEs that were placed outdoors did not match each other, and neither did the AQEs that were placed indoors match each other. This was seen as a huge problem within her research, because it was concluded that temperature and humidity readings were the only reading that remain consistent. This would stunt further testing, such as the future testing in LAUSD schools to map the air quality of Los Angeles.

Another problem Lisa was encountering that had was not connected to the problem of preciseness and accuracy of the sensors is that the AQEs had problems remaining continuously connected the Wi-Fi. This is important because it needs it stay connected to continue receiving raw data. This problem did not occur in a private residence, however. Either way, this is still a problem, because it would interfere with the future plans of placing the AQEs in schools.

Wicked Device, the company that created the AQEs, recognized the connectivity problem with most of its costumers, which is why they created version 2 of the AQE. For version 2 of AQE, there were few sensors placed in the AQE for to offset the problems that were occurring with the first egg. The four sensors that are in the instrument are Temperature, Relative Humidity, Carbon Monoxide (CO) and Nitrogen Dioxide (NO2). The AQEs can be very useful in use of experiments that need a time-based collection of data in these four sensors. It is imperative that the AQEs are first tested for the accuracy and precision using analytical experiment design. The objective of using these air quality sensors is to map the air quality of Los Angeles. A way in which this could be put in place is by putting AQEs in schools all around the Los Angeles area. Once the AQE is connected to the school Wi-Fi, the AQE can begin to retrieve raw data of Temperature, Relative Humidity, Carbon Monoxide (CO) and Nitrogen Dioxide (NO2). Data can be collected as often as you set it for the time frame.

Although these AQEs are extremely useful, the process of getting them online took some time. In the interest of the next student who will need to employ the AQEs for further research, I will explain the process by which to successfully use these sensors. Some of the steps that I write may not have an explanation attached to why it is needed for the AQE to work, but will need to be followed anyway.

**Methods:**

Preparatory Phase:

1. Download CodeBender
2. Download the Arduino Software
3. Download these USB drivers (in accordance with the operating system on the computer)
   1. <http://www.ftdichip.com/Drivers/VCP.htm>
4. Add each of the AQEs serial number found in the pamphlet given in packaging per egg on airqulaityegg.com. This can be done by inputting the egg serial number at the top right of that website.

Connecting Phase:

1. Plug in the USB of the AQE into the computer. Wait 1 minute for the computer to register the egg as a device. Then open the Arduino software. Go to Tools🡪Port🡪Select the one that is not “Select Port”, “Incoming Device” or “Modem”. The last one in the list will be the AQE device that should be selected.
2. Then press the magnifying glass icon on the top right corner of the Arduino software page, which will open the Serial Monitor.
3. Set the speed at the bottom right of the Serial monitor to 115200.
4. Once the Serial Monitor is open, type “aqe”. Then hit Enter.
5. Then wait for the welcome page to show
6. Type “ssid “ the name of the Wifi Network. Then hit Enter.
   1. Note: the Wifi needs to be as specific to the region the egg is in as much as possible. If it is in Lab Room 373 of LSB, the Wi-Fi is LMU\_WPA\_Labs. The ssid Student(Secure) will not work.
   2. If this is placed in schools around the LA area, make sure to receive the most geographically specific Wi-Fi for the AQE.
7. Type “pwd ­­­­ “ the password of the Wi-Fi chosen.
   1. If you are not aware of the password of the Wi-Fi chosen, ITS can help you in this area as well.
8. Type “get settings” to receive the MAC addresses (aka the IP addresses) to the AQEs and write them in your notebook. Contact ITS to add the eggs as devices to the school’s Wi-Fi network. It is similar to gaming devices in that way.
   1. Note: This step does not need to occur every time the air quality egg is plugged into the computer.
   2. If new AQEs will be ordered, make sure you ask the company to configure it. For example, if you do not want your Temperature reading to read in Celsius, than ask them to configure it to Fahrenheit.
9. Type “exit” and hit Enter.

The Serial Monitor could be exited out then, as the AQE goes from operational mode to Configuration Mode. If the Serial Monitor is not exited out, the writing seen on it will reflect if the AQE is succeeding in connecting to the Wi-Fi. Everything should check out as “OK” in the Serial Monitor. After you disconnect the USB from the computer, it can be plugged into the power source and plugged into the wall. After a few minutes, readings should be displayed on the screen of the AQE. If the screen lights up and shows readings on the screen, it is a very good indication that the AQE has connected to the Wi-Fi and is receiving data.

For the purpose of future experiments, raw data retrieval is extremely important to show the time and the relative concentrations of each of the sensors. The way to retrieve the raw data is to go to <https://airqualityegg.wickeddevice.com/download>. On that page, write the egg serial number, and follow the directions written on the bottom. If the zip file created does not open, it means that the egg has not collected any data. If it does open, it will open to an Excel page with a time stamp and all the data.

**Data:**

**Figure 1:** This figureshows the temperature readings on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs. Some differences are seen between the readings of these two eggs.

**Figure 2:** This figure shows the readings of relative humidity (%) on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs.

**Figure 3:**  This figure shows the readings for nitrogen dioxide (ppb) on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs.

Note: No figure was made for the values comparison for Carbon Monoxide because the value for both AQE data remained at 0.

**Results/Discussion**:

As soon as the sensors began working, data was collected to test for simple accuracy and precision testing. The three figures that were made were for temperature, relative humidity and nitrogen dioxide. A figure was not made for carbon monoxide because all data points showed that the value was 0. These AQEs were placed right next to each other to ensure accuracy and precision. They were also placed in an indoor lab, even though the AQEs can also be used for outdoor data collection purposes.

In Figure 1, the temperature readings were to compare both LMU-nj5 and LMU-nj6 AQEs between April 28, 2016 from 12:38pm-12:47pm. The readings were only taken for a 10-minute time period due to the volume of readings taken per minute. For the temperature reading, it shows that LMU-nj5 had lower readings that LMU-nj6. Although the values seem to be different, statistical testing needs to be done to show if there is any statistical difference between the two AQEs. A test that can be done is a t-test.

Figure 2 shows the reading for figure shows the readings of relative humidity (%) on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs. The values recorded between 12:40pm and 12:41pm were very close to each other, to indicate that the accuracy and precision of these eggs was good during that time. Statistical testing, such as the t-test, can be used to test between these two AQEs.

Figure 3 shows the readings of nitrogen dioxide (ppb) on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs. There seem to be common trends within these two AQEs. There are general inclines and declines seen at the same time, even if the data points are different from each other. There are multiple overlaps of the data between the two eggs, which are promising for the accuracy of the sensors. However, no conclusions can be made without further statistical testing.

The process of getting these eggs running required a lot of time. There are two things that are needed to move forward with this project. The first is about analytical testing. The analytical testing will show how important or unimportant differences in value are from two different AQEs. If these eggs are going to be placed in schools in the Los Angeles area, the statistical tests have to be done for the AQEs beforehand so that the values collected can be reliable. The second is about data collection. There is about 15 data points collected per minute. The problem is that each of the 15 points collected per minute does not contain data points of all four sensors. Therefore, even if a graph were made of one sensor, there would always be numerous data points going to 0, even if that were not true. The most important piece of data collection is to collect less data per minute of how frequently it is preferred. One data point per minute that contains values of all four sensors would be of great use for graphical representation and statistical testing. Communication with Wicked Device, the company that made the AQEs, or Dick Swart, the founder of Air Quality Egg may shed light into how this can be changed.

**Conclusion**:

Air quality eggs (AQEs) are devices that contain atmospheric sensors that can connect to Wi-Fi and collect raw data according to its different sensors. Version 1 of the AQE had sensors for temperature, humidity, ozone, dust, volatile organic compounds, carbon monoxide, and nitrogen dioxide. Due to multiple complications, Wicked Device created a Version 2 of this egg, which is the current version of the egg that is being used for research and data selection. After the many complications encountered in getting the AQEs started, the data eggs were connected to the Wi-Fi, which began the process for data collection. The Wi-Fi that was used successfully was not the regular Wi-Fi for LMU, but rather a more geographically specific Wi-Fi. The temperature, relative humidity, and nitrogen dioxide data was collected from the sensors in the version 2 eggs. This figures show the readings on April 28, 2016 from 12:38pm-12:47pm for both LMU-nj5 and LMU-nj6 AQEs. Ten minutes was a workable amount of time for data point collection, which can further be used to test for analytical purposes of precision and accuracy. All three figures showed differences in the values between the two AQEs. Statistical analysis will show whether the differences are significant or not. The important step to take next is to ensure that the differences in the AQE data collected is not completely statistically different, because that will prove whether the sensors in the AQEs are reliable for further use or not. Next would be to communicate with Wicked Device, the company that made the AQEs, or Dick Swart, the founder of Air Quality Egg to figure out how to control the number of data points collected per minute. With these steps taken, the further use for AQEs in schools in the LA area can become a possibility. The success in these areas can set forth the eventual mapping of time-relevant air quality traveling through Los Angeles each day.