IoT-based system to impact the poor indoor air quality

(a case study done on vulnerable people)

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ABSTRACT

The quality of the air we breathe has started to gain more and more attention in the last decade, lately following an IoT approach [1], [2], the focus being still mostly on workspaces and outdoor air quality. The EEA (European Environment Agency) has recognized this issue, and it publishes a yearly report on Air quality in Europe [5]. The report contains measurements and the impact of current air quality, proposes new legislation to reduce pollution and reveals a detailed description of the primary pollutants.

The importance of air quality has guided our IoT-based system to be focused on measuring and monitoring the air quality, especially for poor indoor air. This approach shows one more evidence out of many on how IoT shapes the future in helping people to have a better life quality. By two valuable experiments, our project proves explicitly how much a smart system can impact a good air quality level and can help people suffering from a chronic pulmonary disease like COPD (chronic obstructive pulmonary disease).

This year's womENcourage theme, "*Bridging Communities to Foster Innovation*" (September 22-24, 2021), could very well be an adjacent definition of IoT itself. Therefore, our current project supports this idea by considering various documents provided by many fields like chemistry, biology, medicine and consultation with a pulmonologist.

KEYWORDS

smart system, IoT, web interface, JSON, indoor air quality, COPD

1 Framework

The current project started from the observation of what living with COPD means. When there is not enough air reaching the lungs, and real breathing difficulty is a reality, the breathed in air quality makes the difference between breathing and choking.

Even if this disease is for life and there is no current cure, affordable solutions are available. Moreover, they can improve the quality of patient life by monitoring the particulate matters (PM or particle pollution levels) in the air and automatically turning on an air purifier until the air reaches a healthy level of quality.

This project is an extension of existing technology and research however the current market and existing products for indoor home air quality are for general usage. This project's innovation is in recognizing the special and unique needs of COPD patients. Even if the values higher than the recommended level are not noticeable by healthy people, a COPD patient immediately feels this and starts coughing.

The key open research questions should be to set personalized values as threshold triggers for the air purifier to power on. The common applications in this area can turn on the air purifier based on a schedule, not based on current air quality. Based on our personal experience working on this project for over a year with a COPD patient, we may conclude that a specialized doctor could recommend such a smart device, and the application should have the flexibility for the threshold values to be modified based on the severity of the disease.

Our project is hardware-based on (a) two Raspberry Pi boards, one model 4 and one model 400, for measurements validation and comparison [6], (b) a low-cost laser dust sensor SDS011 that measures the PM2.5 and PM10, and (c) a Dyson model DP04 air purifier that is both automatically and web-controlled powered on by the system. Besides the target of combining all these hardware components in a specific prototype to fit the purpose, our main contribution here was to write the appropriate implementation for supporting real-life experiments. Considering two of the people's daily habits, namely smoking and aromatherapy using essential oils, how these affect the indoor air quality and how much time is necessary to reduce the pollution effects of the given habits, were our project main targets. The following figure represents our IoT system architecture.

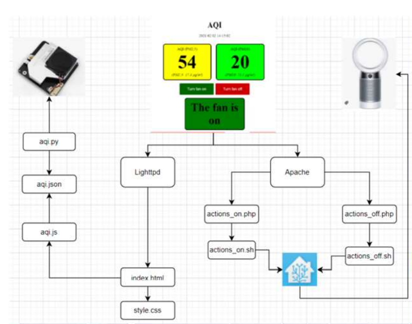
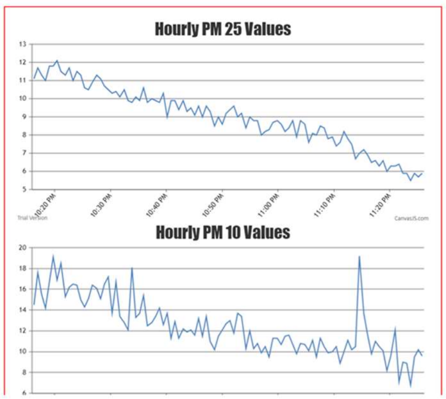


Figure 1: Project architecture

2 Experiments

The first experiment shows the effects of cigarette smoke, which is considered to be a bad habit. The baseline is a good air quality level. One cigarette is smoked on the balcony with the door to the room closed and the balcony window opened. After 10 minutes, the AQI (EPA's air quality index for reporting air quality) values [3] for both PM2.5 and PM10 pointers reached almost hazardous values, and it took 40 minutes with the air purifier on to reduce the values back to normal. A standard data collection for this experiment is represented in Figure 2.



pm25	pm10	time
11.4	18	2021 01 27 22:15:34
11.1	14.5	2021 01 27 22:16:16
11.7	17.6	2021 01 27 22:16:58
11.3	15.5	2021 01 27 22:17:40
11	14.2	2021 01 27 22:18:22
11.8	16.7	2021 01 27 22:19:05
11.8	19.1	2021 01 27 22:19:47
12.1	16.9	2021 01 27 22:20:29
11.5	18.5	2021 01 27 22:21:11
11.3	15.3	2021 01 27 22:21:53
11.7	16.2	2021 01 27 22:22:35
11	16.5	2021 01 27 22:23:18
11.5	16.4	2021 01 27 22:24:00
11.3	15	2021 01 27 22:24:42
10.6	14.3	2021 01 27 22:25:24
10.5	15.1	2021 01 27 22:26:06
10.9	16.4	2021 01 27 22:26:48
11.3	16.1	2021 01 27 22:27:30
11.1	15.1	2021 01 27 22:28:13
10.7	16.5	2021 01 27 22:28:55
10.5	17.2	2021 01 27 22:29:37
10.3	13.7	2021 01 27 22:30:19
10.4	16.7	2021 01 27 22:31:01
10.1	13.4	2021 01 27 22:31:43
10.5	12.8	2021 01 27 22:32:26
9.9	12.1	2021 01 27 22:33:08
9.8	18.1	2021 01 27 22:33:50
10.1	13.3	2021 01 27 22:34:32
9.9	13.7	2021 01 27 22:35:14
10.6	15.4	2021 01 27 22:35:56

Figure 2: ***Graphic representation for a one-hour data collection provided by an aqi.json file***

Our second target experiment shows the effects of aromatherapy with essential oils, which is usually considered a beneficial habit. Again, the baseline is a good air quality level. After 7 minutes, the AQI values for PM2.5 and PM10 went from good to moderate air quality based on EPA's AQI table [3]. Venting the room for only 2 minutes took the values back down to normal levels; however, the effect on a COPD suffering person was extensive coughing for approximately 15 minutes. Therefore, our system proves that even a seemingly beneficial habit could be a pollutant unexpectedly difficult to control in certain circumstances.

These two experiments were enough to come to a conclusion because they produced the same reaction every time they were performed. It does not matter what the particle is from a chemical point of view, but it is good or bad for health if it gets difficult to breathe when there is too much filling in the air. Therefore, the two experiments should cover an example of harmful and not harmful particles that can produce the same breathing difficulties for a COPD patient as they are more sensitive, allowing us to extrapolate a possible conclusion in general also of what the effects of high particulate matter in the air can cause.

3 Conclusions and further work

Following our IoT system-based experiments, one of the most important conclusions is the awareness of how much we can influence the air quality in our homes by giving up bad habits and acquiring innovative technology to improve our everyday life. Specifically, for sensitive people, this approach could extend their life expectancy.

The measured data is saved to a database, which can help doctors treat their patients. Doctors may notice patterns that provide specific actuators that can be used to trigger proactive actions and algorithms for data processing.

An advantageous way to extend this project is by increasing the IoT use to connect an oxygen concentrator with the existing components and adjust the oxygen flow rate based on air quality levels. A further extension would also measure and automatically adjust the oxygen level based on atmospheric pressure, air humidity, SPO2 (blood oxygen level measured by a pulse oximeter), or breathing rate. We already have oxygen concentrators that perform intelligent functions. An example would be the iGO2 product of DeVilbiss [4] with a smart dose function, which automatically adjusts the oxygen dose in response to changes in breathing pattern.

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