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The Making of a Contactless Sanitation System out of Arduino Interface and Ion Generators

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Abstract:- As indoor air pollution and poor sanitation remain a public concern worldwide, the main objective of this study was to create a contactless sanitation system out of Arduino interface and ion generators. For the purpose of detecting air pollutants, Arduino interface, an open-source electronics platform based on simple hardware and software, was used in the air quality indicator. Ion generators, which release negative ions, were used to make the air purifier improve indoor air quality by removing small particles from the air. To trigger the disinfecting machine, a sensor was used for automatic activation. Thus, the system had three main components. The results of the study proved the effectiveness of the air quality indicator in terms of accuracy and real-time speed, the effectiveness of the voice-activated air purifier in terms of response time and the number of negative ions produced on a quarter-hourly basis, and the swiftness of the sensor of the disinfecting machine in terms of detection time.

Keywords:- *Air Purifier; Air Quality Indicator; Arduino Interface; Disinfecting Machine; Indoor Air Pollution; Ion Generators.*

I. INTRODUCTION

Coronavirus disease has prevailed across the world since 2019. Known as severe acute respiratory syndrome coronavirus 2, it demonstrated how quickly an infectious disease can push health systems to the brink and hugely affect the lives of families, workers, children, the government, and the community, including Filipino frontliners (Real et al., 2022). Additionally, most people who become sick of Coronavirus have mild-to-moderate symptoms such as coughing, fever, and fatigue, and recover without any special treatment. Some, however, become severely ill and require medical attention (European Centre for Disease Prevention and Control, 2021).

The lack of hygiene also leads to infection with the aforementioned virus. COVID-19 can transmit through a person's nose and mouth via air droplets emitted when they cough, sneeze, speak, sing, or breathe. Consequently, people get infected by staying in poorly ventilated areas and touching their faces without cleaning their hands. Ascariasis, Trachoma, Giardiasis, and many other globally important infections are associated with poor sanitation as well (World Health Organization, 2021).

Indoor air pollution also remains a public concern worldwide. Even if there is no visible dust, one cannot assume that the house is clean and pollutant-free. Indoor air pollution causes four million deaths every year and affects African and Asian nations, where polluting fuels and technologies are used daily, mainly for cooking, heating, and lighting at home (Ritchie & Roser, 2019). Additionally, outdoor pollution has a significant impact on indoor air quality due to the likelihood of transportation of contaminants from outdoors to indoors (Tran et al., 2020).

Leading to respiratory-related illnesses, dust, dirt, or gasses inside buildings are potentially harmful if inhaled. Lung diseases such as asthma and lung cancer have been associated with poor indoor air quality. Soot inhalation from indoor air pollution has been responsible for approximately half of all pneumonia fatalities in children under the age of five (British Lung Foundation, 2021).

With the detrimental effects of indoor air pollution, surveillance and monitoring are essential measures to take. Thus, the use of air quality indicators, ionizers, and purifiers has been encouraged, benefiting people suffering from hay fever and other seasonal allergies. These devices can even eliminate up to 99% of airborne bacteria, including dust, cigarette smoke, molds, soot, pollen, and household odors (Rosone, 2020). Furthermore, they absorb dust before it settles, preventing build-up and leaving people with less to clean.

Costly contactless and automated technology has become vital in ensuring cleanliness and safety during the pandemic as its sensors detect the presence of pollutants in the air. As cases rise, the demand for such devices for sanitation also increases (Taylor, 2020). Specifically, infrared-type and obstacle sensors help minimize the spread of the virus by limiting direct contact from simple hand sanitizers to automated doors.

Arduino is an open-source electronics platform based on simple hardware and software where its inputs of sensors such as lighting are converted into outputs like motors. It has advanced technology that has guided people in their daily activities. With its help, most control systems with programmable timings were created, such as traffic lights and pedestrian lighting (Kaswan et al., 2020).

Ion generators are used to improve indoor air quality by removing small particles from the air. Furthermore, negative ions released from an ion generator interact with tiny particles in the air, causing particles to clump together and land on surfaces (Nunez, 2021). Negative ions from ion generators have improved the lifestyle of many, especially disabled people who are unable to leave their homes. They can kill or inhibit the growth of harmful bacteria, viruses, and molds that cause respiratory-related illnesses like Tuberculosis (Jewell, 2019). Hence, the creation of a contactless sanitation system through Arduino aids in preventing the spread of diseases as sensors measure the distance and ion generators cleanse the air.

This study benefits the Philippine School Doha (PSD), the Qatari and Filipino communities, and future researchers. The outcomes of this study will help the Philippine School Doha community of students, teachers, and non-teaching staff by informing them of the dangers of indoor air pollution. PSD students and staff must be aware of the health implications as Qatar residents. Additionally, this research informs the PSD community that waste materials can be used to create environmentally friendly solutions like a contactless sanitation system.

This study could also assist Qatar by encouraging better measures to avoid indoor air pollution. As a result, Qataris will be less likely to have to breathe dirty air that is harmful to their health. Besides, because it employs the Arduino interface and ion generators to create a contactless sanitation system, this research will assure a better and more sustainable everyday living for Qatar's population. In rural parts of the Philippines, the contactless sanitation system provides a cheap and reliable source of cleanliness. This study would also enable Filipinos to become more conscious of indoor air pollution and the necessity of breathing clean air.

Moreover, future researchers can use the results, data, and information presented in this study as references while doing their research on contactless sanitation systems. They can utilize this study to check the accuracy of other research in the field. Issues in their investigations will be reduced as a result of this research, as will the usage of similar factors and procedures to make better-quality systems.

II. RESEARCH QUESTIONS

The main objective of this study is to create a contactless sanitation system out of Arduino interface and ion generators. Specifically, this study aims to answer the following questions:

➢ How effective is the air quality indicator out of the Arduino interface in terms of:
- accuracy and
- real-time speed?

➢ How effective is the voice-activated air purifier out of ion generators in terms of:
- response time and
- number of negative ions produced on a quarter-hourly basis?

➢ How long is the detection time of the sensor of the disinfecting machine?

III. METHODOLOGY

This study utilized the experimental design of research. Experimental research design is defined as being applied when the study seeks to determine the cause-and-effect relationships between the dependent and independent variables (Tanner, 2018). In this study, the Arduino interface and ion generators were the independent variables, and the contactless sanitation system was the dependent variable. Moreover, the quantitative method was used to properly organize the experiment and acquire the appropriate type of data (Babbie, 2012). It is essential to use this method as it provides a high level of control over the variables that demonstrate an outcome and is advantageous in obtaining accurate, consistent, and precise results.

A. *Research Locale*

The research study was conducted at Philippine School Doha in Doha, State of Qatar, specifically in the Mesaimeer Area (Zone 56), Al Khulaifat Al Jadeeda Street (St. 1011), as the researchers were not only students of this school but also required facilities present in the school that enabled them to make their product.

B. *Data Gathering Procedure*

The procedure shows the step-by-step process of how to make a contactless sanitation system out of Arduino interface and ion generators and how its effectiveness is tested.

In order to determine the effectiveness of the air quality indicator, its accuracy and real-time speed were compared to those commercially available in terms of percentage of accuracy and delay in seconds respectively. The percentage of accuracy was calculated by dividing the observed value from the improvised air quality indicator by the true value from a commercialized one and multiplying the quotient by 100. Using a stopwatch, the delay in real-time speed was calculated by subtracting the time it takes for the LCD of the air quality indicator to display the data from that of the commercialized air quality indicator.

Furthermore, to determine the effectiveness of the voice-activated air purifier, the response time and the number of negative ions produced on a quarter-hourly basis were tested. Once the air purifier received the command to activate and deactivate, the delay in response was recorded using a stopwatch. The number of negative ions was verified using an air ion counter. Other air conditioning units in the room had been switched off before the testing procedure.

Likewise, a stopwatch was used in determining the detection time of the sensor of the disinfecting machine. For reliable results, each test had three trials and the average was calculated by dividing the sum of all values by the number of trials.

IV. RESULTS

This section presents the results and interpretations of the data that were collected during the testing procedure in relation to the research questions.

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A. *Effectiveness of the air quality indicator out of the Arduino interface in terms of :*

➢ *Accuracy*

Table 1 Accuracy of the Air Quality Indicator

Trial	1st	2nd	3rd	Average
Photos				(98+94+100)÷3 97.3333333333
Percentage of Accuracy	98%	94%	100%	97.33%

Table 1 shows the accuracy of the air quality indicator, in comparison with one sold commercially, in terms of percentage. The percentage of accuracy was calculated by dividing the observed value from the improvised air quality indicator by the true value from a commercialized one and multiplying the quotient by 100. For reliable results, a total of three trials were conducted and the average was taken by dividing the summation of percentages by three. In the first trial, the air quality indicator detected 50 µg/m3, whereas the commercialized one detected 51 µg/m3, meaning the air quality indicator was 98% accurate. In the second trial, the air quality indicator detected 51 µg/m3, while the commercialized one detected 48 µg/m3, making it 94% accurate. In the third trial, both the improvised and the commercialized air quality indicator detected 49 µg/m3, exhibiting 100% accuracy.

Analyzing the results, the air quality indicator was 97.33% accurate on average. The trials show that the air quality indicator can detect atmospheric particulate matter accurately, in comparison to those sold commercially, with little to no error. Given in micrograms (one-millionth of a gram) per cubic meter of air (µg/m3), the concentration of an air pollutant is considered healthy at or below 12 µg/m3 since the level did not go to or above 35 µg/m3 for commercial air quality indicators like KKmoon Air Quality Tester Monitor (Indoor Air Hygiene Institute, 2021).

➢ *Real-time speed*

Table 2 Real-time Speed of the Air Quality Indicator

Trial	1	2	3	Average
Photos				(3.35+0.95+3.44)÷3 2.58
Delay (in seconds)	3.35	0.95	3.44	2.58

Table 2 illustrates the real-time speed of the air quality indicator based on its delay time in seconds. The delay in real-time speed was calculated by subtracting the time it takes for the LCD of the air quality indicator to display the data from that of the commercialized air quality indicator. For consistency, three trials were conducted and the average was computed by adding the results of each trial and dividing it by three. In trial 1, the air quality indicator took 4.95 seconds to display the data, while the commercialized one only took 1.60 seconds, resulting in a delay time of 3.35 seconds. In trial 2, the air quality indicator took 2.93 seconds to display the data, whereas the commercialized one only took 1.98 seconds, having a delay time of 0.95 seconds. In trial 3, the air quality indicator took 5.05 seconds to display the data in contrast to the commercialized one displaying the data in 1.61 seconds, exhibiting a delay time of 3.44 seconds.

Evaluating the results of the trials, the average delay time of the air quality indicator compared to one sold commercially was 2.58 seconds. The results show that the air quality indicator had a minimal delay in comparison to a commercial-grade air quality indicator. Moreover, findings from a similar study showed that their air quality indicator varied significantly slower than the actual sensing value which was changing quickly. The study's findings show that the ambient air quality indicator was still effective in representing real-time air quality (Kang & Hwang, 2016).

B. *Effectiveness of the voice-activated air purifier out of ion generators in terms of:*

➢ *Response Time*

Table 3 Response Time of the Voice-Activated Air Purifier

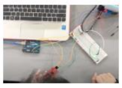
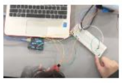
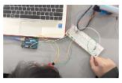
Trial	1	2	3	Average
Photos				(0.9+0.78+0.8)÷3 0.8266666667
Time (in seconds)	0.9	0.78	0.8	0.83

Table 3 displays the response time of the voice-activated air purifier in seconds. Once the air purifier received the voice command to activate and deactivate, the delay in response was recorded using a stopwatch. Three trials were conducted for the credibility of data and the average was taken by dividing the summation of all values by three. In the first trial, it took an average of 0.9 seconds for the air purifier to respond. In the second trial, it took an average of 0.78 seconds for the air purifier to respond. In the third trial, it took an average of 0.8 seconds for the air purifier to respond.

Analyzing the results, it took an average of 0.83 seconds for the voice-activated air purifier to operate after receiving the commands. The trials indicate that the voice-activated air purifier has the slightest delay in response. With the concern of infections through contact after the emergence of COVID-19, voice-recognition-based home automation and its application to patient rooms through Arduino have proven to process voice commands within 3 seconds. The speed can be improved up to 85% by changing the voice command into two syllables with variations of vowels and identical intonation. A higher speed of up to 95% can be reached by recording all the subject's voices; however, the average 3 seconds response time is considered to be essential (Agustin et al., 2019).

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➢ *Number of Negative Ions Produced on a Quarter-Hourly Basis*

Table 4 Negative Ions Produced by the Voice-Activated Air Purifier on a Quarter-Hourly Basis

Minutes	15	30	45
Photos			
Number of negative ions produced (ions/cm^3)	$-1x10^4$ (converted: 10000)	$-1x10^4$ (converted: 10000)	$-1x10^4$ (converted: 10000)

Table 4 indicates the number of negative ions produced (ions/cm3) by the voice-activated air purifier every fifteen minutes. Through the use of an ion counter, the average number of negative ions produced in a quarter-hourly basis was determined by dividing the total of values by three. After 15 minutes, the air purifier produced -1x104 ions/cm3 or 10,000 ions/cm3 when converted. At 30 minutes, the air purifier produced the same result of -1x104 ions/cm3 or 10,000 ions/cm3 when converted. Up until the 45-minute mark, the number of negative ions produced by the air purifier was -1x104 ions/cm3 or 10,000 ions/cm3 when converted.

After the assessment, the results denote that the air purifier consistently produced -1x104 ions/cm3 or 10,000 ions/cm3 throughout different time periods. Likewise, the threshold for fresh air was established to be the negative ion concentration over 1000 ions/cm3 as compared to commercial air purifiers like the KT401 Mini Air Ion Tester (Jiang et al., 2018).

C. Detection time of the sensor of the disinfecting machine

Table 5 Detection Time of the Sensor of the Disinfecting Machine

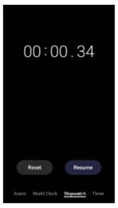
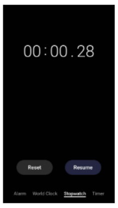
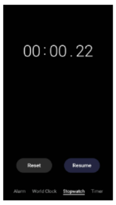
Trial	1	2	3	Average
Photos				
Time (in seconds)	0.34	0.28	0.22	0.28

Table 5 shows the three different trials in obtaining the detection time of the sensor of the disinfecting machine using a stopwatch. For accuracy, the average was computed by summing all results and dividing them by the number of trials. In the first trial, the sensor was able to detect the hand and activate the disinfecting machine with a delay of 0.34 seconds. In the second trial, the sensor was able to detect the hand and activate the disinfecting machine with a delay of 0.28 seconds. In the third trial, the sensor was able to detect the hand and activate the disinfecting machine with a delay of 0.22 seconds.

Evaluating the results, the average time it took for the sensor to detect an object and set off the disinfecting machine was 0.28 seconds. The trials show the fast detection time of the sensor with minimal delay. In another experiment, an obstacle detection system out of ultrasonic and infrared sensors showed great detection for various obstacle materials, including those made of wood, plastic, mirror, plywood, and concrete (Mustapha et al., 2013). Moreover, demonstrating the usefulness of the system within 3 seconds proves that the Arduino interface is well-suited for a wide variety of applications related to environmental monitoring (Real et al., 2021).

V. CONCLUSIONS

Based on the results, the air quality indicator can detect atmospheric particulate matter accurately as it displayed data close to those sold commercially with an average of 97.33% accuracy and displayed it fairly quickly with a minimal delay of 2.58 seconds on average in comparison to commercialized ones. Additionally, the voice-activated air purifier is time efficient as it is activated and deactivated according to the voice commands with the slightest delay of 0.83 seconds on average and consistently generates fresh air, given that it constantly produced 10,000 ions/cm3 throughout different periods. Moreover, the disinfecting machine demonstrated its swiftness in detection time as its sensor detected quickly with an average minimum delay of 0.28 seconds.

This study can assist the community in adhering to the school's mission of being pro-environment. Moreover, the students and school staff are advised to make use of higher-grade materials to improve durability, detection time, and response time, and further investigate to enhance the performance of the contactless sanitation system.

The Qatar and Philippine communities are encouraged to similarly use readily-available materials in making a cost-effective contactless sanitation and air purifying system that is all-in-one, environmentally friendly, and easy to use. The researchers advise the communities to find alternative materials in upgrading the system's capabilities and features. With dust storms being the largest contributor to air pollution in Qatar and vehicle emissions in the Philippines, outdoor air pollution can greatly affect indoor air quality due to the transportation of contaminants. Hence, even though visiting locations with clean air is ideal, it is also necessary that such threshold values are performed at home as well to ensure wellness.

Furthermore, future researchers may use this study as a guide in creating projects that have similarities in functions or components. Future researchers may incorporate more sensors and spray nozzles in making a wider-scale disinfecting machine that can be used for sanitizing larger items. The researchers suggest utilizing a microphone with a low sensitivity level so that the voice-activated air purifier can pick up voice commands even in noisy environments. Its ability and limit in picking up commands from far distances can be further tested. Future researchers are also urged to eliminate the manual switches and program the remaining two components, the disinfecting machine, and air quality indicator, to operate through voice commands.

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