IoT based wearable personal air monitoring for sinusitis

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Abstract. Sinusitis is inflammation of the cavities around the nose, caused by viruses or allergic reactions of bacteria, fungi, and ARI. Other influential factors are polluting the environment, cold air, and dry. There is no specific device that can help sinusitis sufferers in monitoring air condition. This research was developed to be easy to use for people with sinusitis to be able to display temperature and humidity in real-time using a BME280 sensor and providing action in the form of a humidifier when the humidity is below the set point. The trial results show that the data sent has been successfully received by the output and can turn on the humidifier. From the measurement data obtained, 2.571% error for temperature measurement and 5.898% for humidity measurement. The results of interviews with participants found that this device can help sufferers of sinusitis as a preventive measure if the air condition is not good.

1. Introduction
According to the Indonesian Ministry of Health, sinusitis ranks 25th out of 50 major ranking disease patterns or around 102,817 outpatients in hospitals. This proves that there are still many people who suffer from sinusitis to this day [1]. The prevalence of sinusitis in Indonesia is quite high. The results of research from the sub-section of the Department of ENT Rhinology FKUI-RSCM, of 496 outpatients found 50% of patients with crony sinusitis [2].

Sinusitis is inflammation of the cavities around the nose, caused by viruses or allergic reactions of bacteria, fungi, and ARI. Other influential factors are polluting the environment, cold and dry air, and smoking habit. Dry humidity and cold temperatures can irritate sinusitis and trigger nasal congestion. So that in patients with sinusitis, symptoms more easily appear [3]. The treatment for acute sinusitis is antibiotic therapy, whereas for those who are chronic antibiotic therapy is not enough [4]. Therefore, in order not to become chronic sinusitis, it is better to take preventive measures.

Research on personal water monitoring is carried out [5] to produce large-sized devices with the use of complex sensors. It is generally used to monitor the condition of the surrounding air by focusing on the condition of a particulate meter (PM), which affects the work of the brain and has not been specific to sufferers of certain diseases that are affected by air conditions. Esquiagola et al. [6] by using the same sensor displaying the results of air conditions in the room, not paying attention to the appearance of a wearable device for users and more emphasis as IoT Platform Monitoring Indoor Environments. By using the same sensor research Baca Gómez et al. also focuses on Air Monitoring as a whole with the use of several types of sensors [7]. Research Tastan using a DHT22 sensor produces a fairly large device with the addition of other sensors [8].

According to this issue, IoT Based Wearable Personal Air Monitoring for Sinusitis with Humidifier has been developed. Air condition monitoring equipment specifically for people with sinusitis equipped
with a humidifier. The design of this device takes focus on two factors, i.e., cold and dry air, because the air temperature is too low, and the humidity of the dry air can increase sinusitis pain [3]. As a preventive measure, when the condition of the surrounding air is not in good condition, which will notify the user and activate the humidifier to moisturize the air.

2. Methods
This research was preceded by a literature study on sinusitis and its causal factors. Determine which sensors will be used and design what stages will be carried out during the study. The design starts with writing a program script, then designing the PCB layout, soldering, and hardware integration. In designing the program, there are two types of microcontrollers used. For the first program, the device is devoted to monitoring surrounding air conditions by publishing data using the MQTT protocol. The second program design as an output that gives action when the humidity is below the set point by subscribing data that has been previously published by the first program.

The next stage is the hardware design, which includes two types of hardware. The first hardware function is to send data temperature, humidity, air pressure, and altitude to the cloud that comes from the BME280 sensor readings [9]. ESP32WROOM microcontroller will display the measurement results on the OLED display and the FlexIoT platform Dashboard. The second hardware humidifier functions to receive humidity data from the cloud using the ESP32 microcontroller and provides water vapor spray output to the air to restore humidity above the set point. Figure 1 is a block diagram for the workings of the designed device.

![Figure 1. Design of the system.](image)

Determination of the setpoint is taken from the book Goldstein [10] and research Wolkoff [3] where the good air condition approaches relative humidity, the more humidity, the higher the relative humidity. When the air temperature is low, the humidity will increase if the air temperature is high, the humidity will decrease. In general, when the relative humidity of a room rises above 70%, mites and dust will quickly develop [10]. While on research Wolkoff [3] states that dry humidity and cold temperatures can trigger nasal congestion and cause irritation to sinusitis. Ideal air humidity so that allergies do not recur is 45% - 65%. So when the humidity is below 45%, the humidifier will turn on and restore the dry air to the ideal air condition.

After successful hardware and software design, testing is done by integrating hardware and software. The sensor measurement data is successfully sent to the cloud and received by the other hardware to turn on the humidifier.

How the user uses the developed system, interviews were conducted. The first participant was an ENT specialist Dr. C, and other participants were three people with sinusitis. Interviews were conducted
by presenting the designed device and giving space for participants to express their opinions about this device, what should be added, and suggestions for further development of the device.

3. Result and discussion

3.1. System design

3.1.1. Hardware. The first hardware consists of ESP32WROOM as a microcontroller, BME280 as a sensor, Oled Display, MMBT2222A for automatic reset when the program is uploaded, and the supply is taken from a 3.7V LiPo 1s battery. The second hardware consists of a humidifier that will spray water vapor into the air if the humidity is below the set point. ESP32 as a microcontroller, transistor as a switch, and supply comes from the power bank. When the humidity is below 45%, the transistor will work as a switch that will turn on the humidifier until the humidity returns above 45%.

3.1.2. Software. The program is created using Arduino IDE software and data transmission format using JSON. The first program publishes data to the cloud using the MQTT protocol. The data sent is in the form of temperature, humidity, air pressure, and altitude data. The second program will subscribe to only one measurement result data, namely humidity from FlexIoT. Figure 2 is a display of data on the FlexIoT Platform with four measurement parameters.

![Figure 2. FlexIoT data.](image)

When the hardware is turned on, ESP32 will initialize Wi-Fi. Once connected, the measurement data is displayed on an OLED display and published to the cloud. The second hardware subscribes to humidity measurement data coming from the cloud. A humidifier as an output will turn on if the humidity <45%.

3.2. Test

3.2.1. Hardware test. The results of the design of the device that has been made are tested by integrating the first hardware and the second hardware. Figure 3 displays current temperature (T), and humidity (H) data, and the user can see additional features in the form of a digital clock.
Figure 3. The designed hardware.

Figure 4 show the integration of the first and second hardware. Integration between the two hardware is successful when the humidity is below the set point, and the humidifier turns on. Data from FlexIoT has been published by the first hardware was successfully subscribed to the second hardware.

Figure 4. The hardware of personal air monitoring and humidifier

3.2.2. The comparison of hardware measurement.

- Measurements were made in several different rooms with a device that has been designed and make comparisons of measurements using a hygrometer. Temperature measurement error value [9]:

\[
e_T = \frac{T_{Device} - T_{Hygrometer}}{T_{Hygrometer}} \times 100\%
\]  

\(e_T\) = Error of temperature measurement  
\(T_{Device}\) = the value of temperature  
\(T_{Hygrometer}\) = the value of hygrometer temperature
### Table 1. Comparative temperature of device and hygrometer.

| No | Room | Designed Temperature | Hygrometer | Error  |
|----|------|-----------------------|------------|--------|
| 1  | A    | 25.3°C                | 24.8°C     | 2.016 %|
| 2  | B    | 26.2°C                | 25.7°C     | 1.946 %|
| 3  | C    | 27°C                  | 25.9°C     | 4.247 %|
| 4  | D    | 26.1°C                | 25.7°C     | 1.556 %|
| 5  | E    | 26.7°C                | 25.9°C     | 3.089 %|

Error Average: 2.571 %

- Moisture measurement and comparison. Temperature measurement error value [9]:

\[
eH = \left( \frac{H_{Device} - H_{Hygrometer}}{H_{Hygrometer}} \right) \times 100\%
\]  

\(eH\) = Error of humidity measurement  
\(H_{Device}\) = the value of humidity  
\(H_{Hygrometer}\) = the value of hygrometer humidity

### Table 2. Comparative humidity of device and Hygrometer.

| No | Room | Designed Humidity | Hygrometer | Error  |
|----|------|-------------------|------------|--------|
| 1  | A    | 75%               | 80%        | 6.250% |
| 2  | B    | 70%               | 75%        | 6.667% |
| 3  | C    | 68%               | 72%        | 5.556% |
| 4  | D    | 69%               | 73%        | 6.849% |
| 5  | E    | 69%               | 72%        | 4.167% |

Error Average: 5.898%

Through the measurement data in Table 1 and Table 2, the results show that the average error from the temperature measurement is 2.571%, and the average error from the humidity measurement is 5.898%.

#### 3.2.3. Interviews with ENT specialists and sinusitis patients

To find out if this device can help sufferers of sinusitis conducted an interview. From the results of interviews conducted with ENT specialists, Dr. C said that things that must be shunned for people with sinusitis are cold, dust, and smoke. From these explanations, the cold, which is the measured part of this device, has been successfully displayed. For sinusitis sufferers, there were three speakers.

"This device is very useful when sinusitis is cured, but the air condition is not suitable for sufferers, so it is sure to interfere with the activity, while the suggestion is better to add dust conditions in the air, because according to personal interviewee A this dust greatly affects the condition of sinusitis sufferers"  
Participants A, Male, 20 years.

"This device can represent the condition of the surrounding air well" Participants B, Female 22 years.
"This device is very good to use sinusitis sufferers with a form of devices that are easy to use and equipped with a humidifier that can help maintain air condition, while the advice is given would be nice if added with a dust sensor" Participants C, Female 21 years old.

From the results of the interview above, it can be concluded that this device can help sinusitis sufferers to find a suitable air condition so that symptoms do not recur. The advice given tends to add dust sensors that really affect sinusitis sufferers.

4. Conclusion
Based on the results and discussion, it can be concluded that the design of IoT Based Wearable Personal Air Monitoring for Sinusitis was successfully carried out. The result of device test, the data from the sensor are sent to the cloud and successfully received by the second hardware. When the humidity is below the setpoint, the humidifier turns on. From the measurement, 2,571% error for temperature measurement and 5,898% for humidity measurement. The response of the interview results is known that this device can help sufferers of sinusitis as a preventive measure if the air condition is not good.

References
[1] Amelia N L, Zuleika P and Utama D S 2017 Prevalensi Rinosinusitis Kronik di RSUP Dr. Mohammad Hoesin Palembang Maj. Kedokt. Sriwij. 49 75–82
[2] Kurniasih C and Ratnawati L M 2019 Distribusi penderita rinosinusitis kronis yang menjalani pembedahan di RSUP Sanglah Denpasar Medicina (B. Aires). 50 133–7
[3] Wolkoff P 2018 Indoor air humidity, air quality, and health–An overview Int. J. Hyg. Environ. Health 221 376–90
[4] Mustafa M, Patawari P, Iftikhar H M, Shimmi S C, Hussain S S and Sien M M 2015 Acute and chronic rhinosinusitis, pathophysiology and treatment Int. J. Pharm. Sci. Invent. 4 30–6
[5] Zhuang Y, Lin F, Yoo E-H and Xu W 2015 Airsense: A portable context-sensing device for personal air quality monitoring Proceedings of the 2015 Workshop on Pervasive Wireless Healthcare pp 17–22
[6] Esquiagola J, Manini M, Aikawa A, Yoshioka L and Zuffo M 2018 SPIRI: Low Power IoT Solution for Monitoring Indoor Air Quality. IoTBS pp 285–90
[7] Baca Gómez Y R, Estrada Esquivel H, Martínez Rebollar A and Villanueva Vásquez D 2019 A Novel Air Quality Monitoring Unit Using Cloudino and FIWARE Technologies Math. Comput. Appl. 24 15
[8] Taştan M 2018 An IoT Based Air Quality Measurement and Warning System for Ambient Assisted Living Avrupa Bilim ve Teknol. Derg. 960–8
[9] Utama Y A K, Widianto Y, Sardjono T A and Kusuma H 2019 Perbandingan Kualitas Antar Sensor Kelembaban Udara Dengan Menggunakan Arduino Uno Pros. SNST Fak. Tek. 1
[10] Goldstein MF 2017 Understanding Sinusitis and Allergy: The Asthma Center Education and Research Fund Manual Philadelphia: Professional Arts Building Suite 300