

Asthma Monitoring: Respiratory Monitoring System for Asthma Patients Based on the Internet of Things

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ABSTRACT

Air is one of the most important things in human life. However, the denser the activity that triggers the growth of the air. Asthma is one of the main respiratory problems. Medically, asthma is difficult to cure, it's just that this disease can be controlled so it doesn't interfere with daily activities. This study aims to create a model for monitoring the respiratory rate of asthma patients. The stages in developing an asthma monitoring tool include the stages of knowing component needs, component design, program development, testing and evaluation. The respiratory rate of asthmatic patients can be calculated using the LM35 temperature sensor. The frequency value to be displayed in the web browser uses an Ethernet shield, which is very helpful for doctors to access patient information from anywhere in the hospital. Then by using data mining techniques, to find out the health status of patients without medical professionals helping. With the help of this system, disease detection can be done earlier.

Keywords: Asthma Monitoring, IoT, Arduino ATMEGA 2560, LM35 Sensor

1. INTRODUCTION

The most important moment in the history of the Indonesian nation occurred in 2045, because at that time Indonesia entered the 100th anniversary of its independence. There is a great hope that in 2045 Indonesia will be filled by a generation that has a large number of productive ages (Abi, 2017). In addition, in 2045 Indonesia will also face a good moment called the demographic bonus. Demographic bonus is the condition of a country where the number of productive age population is greater than the population of non-productive age. So that this opportunity needs to be managed properly so that youth can grow into human beings with character, intelligence, and competitiveness.

Air is one of the most important elements in human life. However, in modern times like today, it is in line with physical developments, industrialization activities, and the development of transportation technology that uses fuel which results in air pollution. Air

pollution is a change in one of the compositions of the air from its normal state, namely the entry of pollutant substances (in the form of gas/aerosol) into the air in a certain amount so that it can interfere with the life of living things.

Over the past two decades, Indonesia has experienced dramatic changes in its air quality. From 1998 to 2016, Indonesia went from one of the cleanest countries in the world to one of the twenty most polluting countries, as the concentration of particulate air pollution increased by 171 percent. Pollution more than doubled from 2013 to 2016, with at least some of the increase due to forest fires. Regardless of these causes, 80 percent of Indonesia's 250 million population in 2016 lived in areas where average particulate pollution levels exceed WHO guidelines (Greenstone et al, 2019). The level of pollution is predicted to continue to increase, given the increasingly dense population activity and the rampant open burning of forests.

Asthma is one of the main respiratory problems in both developed and developing countries. The prevalence of asthma according to the World Health Organization (WHO) in 2016 estimates that 235 million people in the world currently suffer from asthma and are underdiagnosed with a mortality rate of more than 80% in developing countries (WHO, 2016). The incidence of asthma in Indonesia based on data from the 2013 Basic Health Research (Riskesdas) reached 4.5%. According to the Indonesian Ministry of Health in 2011, asthma was included in the top ten causes of death in Indonesia. It is estimated that this figure will increase by 20% in the next 10 years, if not controlled properly.

Medically, asthma is difficult to cure, it's just that this disease can be controlled so it doesn't interfere with daily activities. Asthma control is done by avoiding trigger factors, namely all things that cause asthma symptoms. The long-term goals of asthma management are to achieve good symptom control, maintain normal activity levels, to minimize the risk of exacerbations, to improve airflow limitation and medication side effects.

2. LITERATURE REVIEW

2.1 Arduino ATMEGA 2560

Arduino ATMEGA 2560 is a microcontroller on ATMEGA 2560 which has 54 digital inputs/outputs of which 16 pins are used as PWM outputs, 16 analog inputs, and in it there is a 16 MHZ crystal oscillator, USB connection, power, ICSP, and reset button. This Arduino performance requires microcontroller support by connecting it to a computer with a USB cable to turn it on using AC or DC current and it can also use batteries (Oktariawan, 2013).



Figure 1. Arduino ATMEGA 2560

2.2 LM35 Temperature Sensor

The LM35 sensor is a temperature sensor whose output voltage is linear proportional to the Celsius temperature. The LM35 sensor has an accuracy of $\pm 1/4^{\circ}\text{C}$. The temperature sensor range is -55°C to $+150^{\circ}\text{C}$. The output of the sensor provides an analog voltage. The output is directly proportional to the temperature (celcius). Every 10 mV is considered as 1°C . Thus dividing the mV output by 10 gives the temperature value in $^{\circ}\text{C}$. The LM35 temperature sensor is shown in Figure 2.

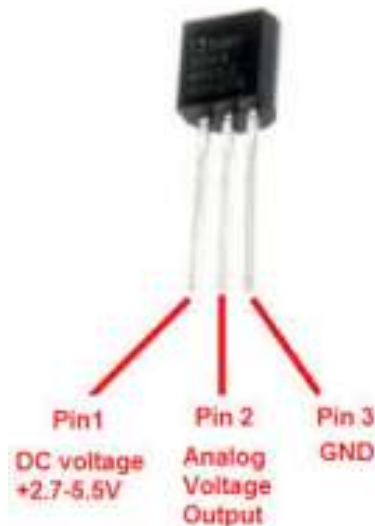


Figure 2. LM35 Temperature Sensor

The LM35 sensor has 54 digital and 16 analog input/output pins. With a voltage value of 6-20 V. It has 256 KB flash memory and has a 10 bit Analog to Digital Converter (ADC). Using the internal ADC, the sensor can convert analog values into digital values. In data acquisition, the raw value of the sensor is also stored in a text file. LM35 (2) temperature sensor changes affect LM35 (1) temperature value. There is a small change in the voltage

value in the LM35(1) that is, the correct trace respiration signal occurs within the LM35(1) temperature value. Then the value of the voltage will be amplified by using a differential amplifier.

2.3 INA122 Differential Amplifier

The INA122 differential amplifier is used in this system which is accurate with low noise. This section consists of two op-amps designed with low current performance and portable. The INA122 differential amplifier is shown in Figure 3.

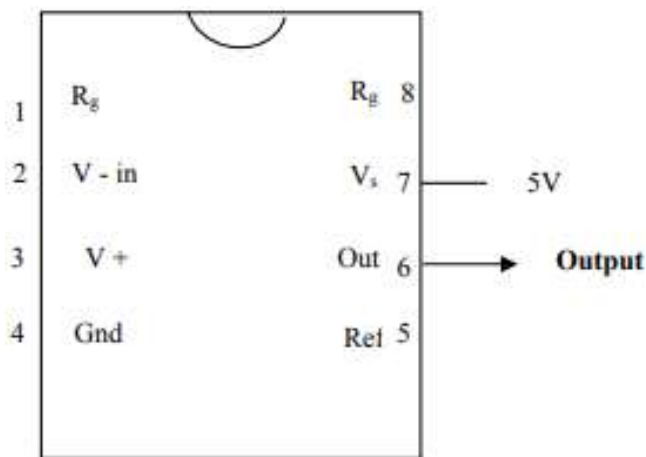


Figure 3. INA122 Differential Amplifier

INA122 consists of 8 pins. A 10k ohm resistor is connected across pin1 and pin8. LM35 (1) temperature sensor output is connected to the inverting input + (pin 3). The LM35 temperature sensor output (2) is connected to reverse the input - (pin 2). Pin 4 is connected to ground. Pin 5 and Pin 7 are connected to external voltage. The amplified voltage output pin 6 is connected to one of the Arduino digital pins which is used for the conversion of analog to digital values.

3. EXPERIMENTAL

The stages in developing an asthma monitoring tool include the stages of identifying component needs, component design, program development, testing and evaluation. The main components needed to develop this system are Arduino ATMEGA 2560, LM35 Temperature Sensor, INA122 Differential Amplifier, NRF24l01 and Ethernet Shield.

The electronic components are then assembled according to the corresponding pins. The series of components so that it can function as an asthma monitoring system tool. The following is a flowchart of the tool shortening system, namely:

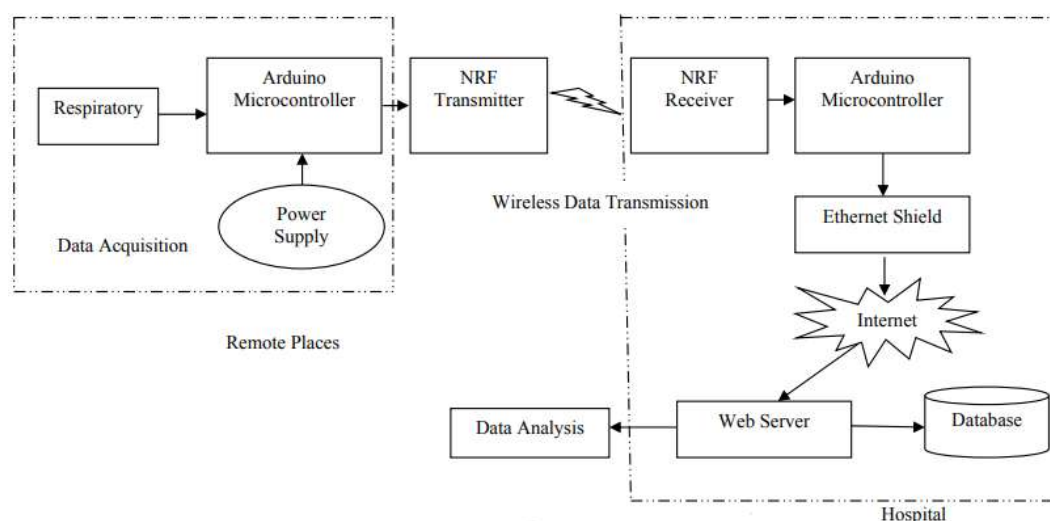


Figure 4. Flowchart of respiratory rate monitoring system

4. RESULTS AND DISCUSSION

At any time, asthma patients will need the help of doctors or medical personnel to monitor their breathing rates. However, the fact is that doctors or medical personnel cannot always monitor it. That is, the patient missed the examination, experienced pain and shortness of breath. Even when the person is in an emergency, without direct external assistance the patient will be in great pain. Based on these problems, the authors are interested in developing a solution called Asthma Monitoring to monitor the breathing of asthma patients.

Through advances in technology in the digital era, the Internet of Things or known as IoT is a concept that aims to expand the benefits of continuously connected internet connectivity. IoT enables users to connect machines, equipment, and other physical objects with network sensors and actuators to acquire data and manage their own performance. IoT can be utilized to monitor a patient's respiratory rate without external assistance. Using medical sensors, asthma patients' breathing is monitored based on the temperature of the inhaled and exhaled air. Then the data is displayed on the web page using Ethernet cable communication. For alarms and warning messages appear after the threshold is reached.

Respiratory system monitoring can be used for both inpatients and outpatients. The respiratory rate is calculated based on the temperature value using the LM35 as a temperature sensor. To calculate the respiratory rate, using two LM35 temperature sensors. Then detect the temperature value in real time using Arduino microcontroller. Next, the value will be displayed in the web browser using an Ethernet cable connection. If any abnormal condition is detected, it will trigger an alarm and generate an alarm message in the web browser. Then,

the data is analyzed using data mining techniques to identify the patient's health status without outside help.

Data Acquisition

The Arduino board can read the sensor values that are placed on the circuit board and converted into the desired output with the help of the open source Arduino IDE software. The Arduino ATMEGA 2560 used has set instructions written in the Java language.

Data Pre-Processing

The data obtained from the sensor may contain some noise. When taking samples from unwanted or irrelevant persons with respiratory data. In the data acquisition step, five samples were taken from each person at a specified time interval. Due to the position of the mask, the output value can exceed 1024 or be less than 0. The noise must be removed from the output by preprocessing the data. So that more accurate results are obtained. After pre-processing the data, a data set test will be carried out for monitoring the patient's respiratory rate.

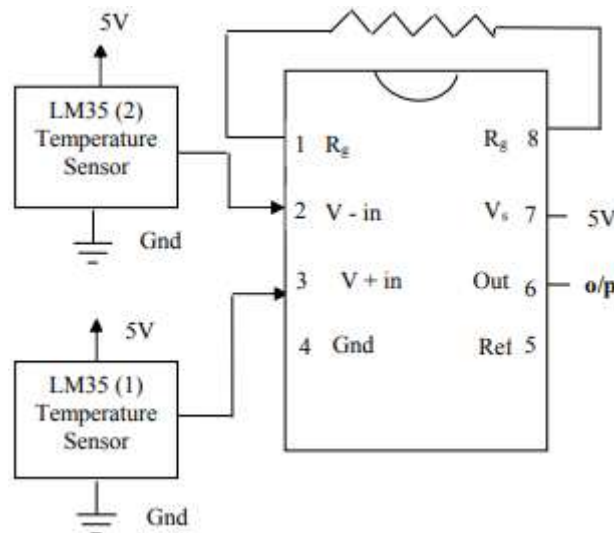


Figure 5. Circuit Diagram

Wireless Data Transmission

NRF24l01 is used to transmit data from one end to the other with some specific range. Consists of MOSI, MISO, SCK, SS pins, CE, CSN, VCC and GND. The NRF24l01 pins are connected to the corresponding digital pins on the Arduino Mega 2560. The CE and CSN pins are connected to the digital pins in the arduino that are assigned to the center of the RF24. MOSI is connected to digital pin 51, MISO is connected to digital pin 50, SCK is connected to digital pin 52 and SS is connected to digital pin 53. The circuit forms an adhoc architecture network. Among many nodes, one node acts as a control and the remaining nodes

as elements. In its setup, control nodes send sensor data to other nodes. Table 1 shows the NRF24l01 specifications.

Criteria	Specification
Standard	IEEE 802.15
Distance	Long distance (>1000 m)
Data transfer speed	250k/ 1M/ 2Mbps
Cost	Low cost

Table 1. NRF24l01 Specifications

Publish data on Web Server

Uses an Ethernet shield to run a web server through a web browser on a computer. An Ethernet shield is installed on top of the Arduino. Figure 6 shows an Ethernet shield that comes with Arduino. To run the web server in a web browser, you will need: Ethernet and Arduino which have the same network address. By using html, it can be read the value from the sensor. Server Ethernet network uses dynamic IP to run the web server and refresh the page by using html code. By using an Ethernet cable to connect to wifi. The data will be accessed wirelessly by IP using a web browser. The data can be viewed by doctors/medical professionals anywhere and once the data reaches the threshold it generates a warning message and the data is stored in the database for future reference. Figure 7 represents the client server architecture.



Figure 6. Ethernet shield installed on Arduino

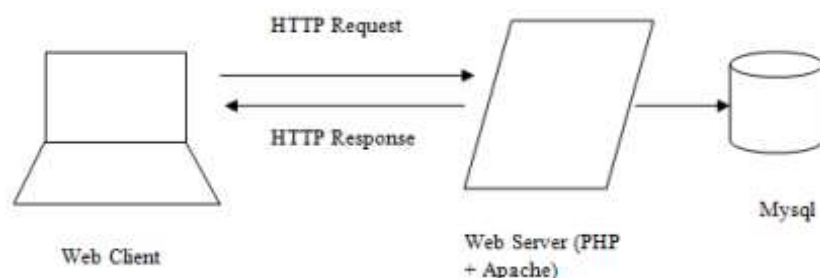


Figure 7. Client server architecture

Furthermore, related to the intermediate results of each system module that provides an evaluation of the performance of the system being run.

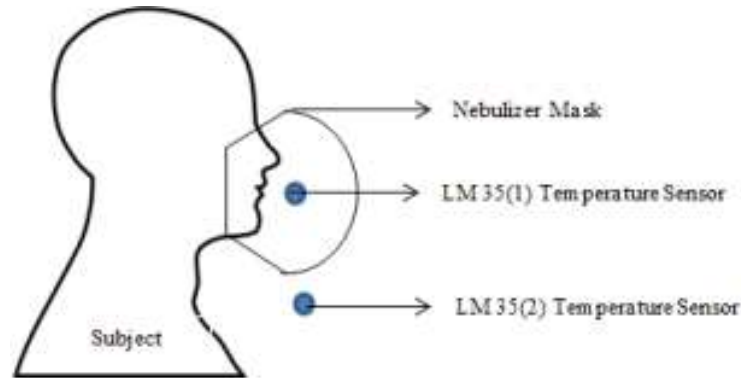


Figure 8. Experimental setup

The LM35 temperature sensor is used to sense the temperature of the inhaled air. First, by fixing the nebulizer mask in the patient's mouth. There are two LM35 temperature sensors needed to monitor the respiratory rate. One LM35 temperature sensor (1) is placed in the nostril. And another LM35 (2) temperature sensor is placed outside the nebulizer mask. The experimental setup is shown in Figure 8. Using a single LM35 temperature value, the system cannot predict the respiration signal correctly. Because the air inhaled depends on the room temperature. So that the other LM35 temperature sensor is placed outside the nebulizer mask. The exhaled air is hotter than the inhaled air. Suppose the room temperature is relatively low, the air that comes out is also low. The blowing air temperature range is 2-3°C which is greater than the inhaled air temperature. The in-breath temperature is about 25°C and the out-breath temperature is about 28°C.

5. CONCLUSION

Therefore, with the author's idea about Asthma Monitoring, this can be used as an initial idea for further laboratory-based research and testing processes. The respiratory rate of asthmatic patients can be calculated using the LM35 temperature sensor. The respiratory rate value will be displayed in the web browser using an Ethernet shield, which is very helpful for doctors to access patient information from anywhere in the hospital. Then by using data mining techniques, to find out the health status of patients without medical professionals helping. With the help of this system, disease detection can be done earlier. Asthma Monitoring's contribution to the field of science and technology is as an IoT-based medical device so that it can realize Golden Indonesia 2045.

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