Design of E-Nose for the Detection of Tuberculosis (TB) and Chronic Obstructive Pulmonary Disease (COPD) using the Method Artificial Neural Network (ANN)

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***Abstract*—Design research (E-Nose) has been carried out for the detection of Tuberculosis (TBC) and Chronic Obstructive Pulmonary Disease (COPD) using the Artificial Neural Network (ANN) method. Purpose of this study is the first to determine the function of E-Nose in detecting Tuberculosis and COPD, the second to find out how sensor response in the design of E-Nose based on Arduino ATmega in detecting disease. The method used is to input data form of waves in the form of image acquisition then data is analyzed in a quantitative form. After data were analyzed, the process of testing the artificial neural network was carried out to compare COPD and TBC based on the pattern graph. So that TBC disease has pila (2 2 1 1 0 1) and COPD has a pattern (2 1 1 1 0 1).**

Keywords—electronic nose, volatile organic compound, pattern based on disease, backpropagation ANN, TBC, COPD

I. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a disease that can block air flow and make it difficult for a person to breathe. This disease is characterized by symptoms in the form of shortness of breath or wheezing, besides COPD caused by exposure to harmful gases and particles [1]. Other causes are also due exposure to cigarette smoke and also hereditary traits [2]. Apart from COPD, there are other diseases that cause people to have difficulty breathing, including Tuberculosis (TB).

Tuberculosis is a disease caused by the bacteria Mycobacterium Tuberculosis is highly contagious so it has serious potential, especially affecting the lungs more than other organs (lymph nodes, skin, brain, bones, intestines and kidneys). TB bacteria spread in the air through sputum or fluids from the patient's respiratory tract, for example when coughing or sneezing [3]. The method of identifying TB and COPD is usually done by using a questionnaire, the method of collecting data by interviewing then using the Chi-Square statistical test, and also by using the TCM (Molecular Rapid Test) and methods Microscopic [4].

The method above will certainly take a long time, so an idea emerged to take advantage of a rapidly growing instrument called Machine Learning [5]. This learning machine can program data through a learning algorithm [6]. Once the algorithm learns what to do with the data, it can do its job automatically [7].

Machine Learning has an Artificial Intelligence, namely E-Nose. The E-Nose functions like a human nose [8], which will analyze it through smell or smell using the response from the sensor [9]. Previous research has used E-Nose to detect breast cancer [10].The purpose of this tool is designed first, namely to determine the function of E-Nose which has been designed in detecting Tuberculosis and COPD and secondly to find out how the sensor response in the design of E-Nose based on Arduino Atmega in detecting disease.

II. METHODS

The method used is the Artificial Neural Network (ANN) method which includes input, hidden layer and output [11]. Backpropagation Artificial Neural Network has advantages because the learning is repeated so that it can create a system that is resistant to damage and consistently works well [12], ANN information can be seen from the layer, where the signal from the input layer will be forwarde to another layer and produce many layers (multilayer) [13]. Figure 1 is a simple image form of ANN neurons [14].

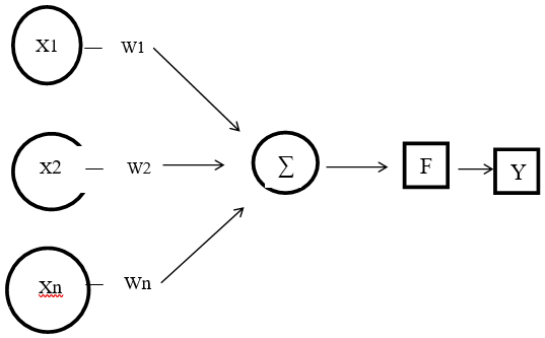

Fig. 1. Simple artificial neurons.

There are several steps or stages in designing an E-Nose system for detecting Tuberculosis and COPD based on Arduino ATmega, namely:

A. *Sensor Circuit Stage*

There are several sensors used, namely MQ2, MQ4, MQ5, MQ7, MQ9 AND MQ135. Inside each sensor are GND, VCC AND A0. The following is a series of design stages.

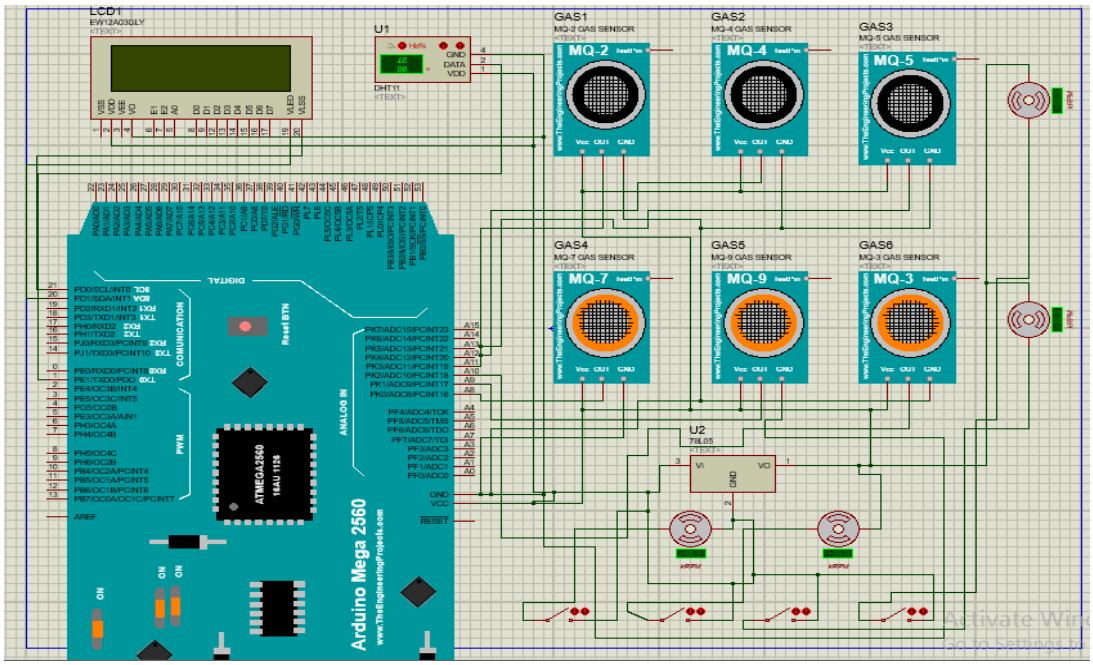

Fig. 2. E-nose gas sensor circuit.

From the above circuit (Figure 2) it can be explained that GND will be connected to GND, VCC will be connected to VCC, and A0 will be connected to each pin on the Arduino ATmega 2560. Then after the tool is designed, it will enter the data collection stage.

Then after all the VCCs are connected, then one current is connected to 5 V. In addition, the temperature sensor has data legs, GND and VCC. Where the data leg is connected to pin 2 on Arduino. In the circuit there are also switch and fan components, where the fan has positive and negative currents, each fan cable will be connected to the positive and negative switch cables so that the fan turns on when the tool is used and connected to a voltage of 220 V.

B. *Data Retrieval Stage*

The following is a flowchart of the E-Nose system for detecting tuberculosis and COPD (Figure 3).

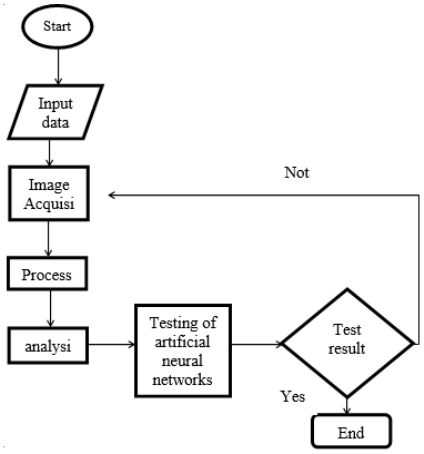

Fig. 3. Backpropagation ANN flowchart identification results.

The flowchart above explains the stages or steps of data collection. First start which is then followed by data input, the inputted data is in the form of breath from a patient suffering from Tuberculosis and COPD which is taken through an oxygen mask, where this oxygen mask has been connected to E-Nose, the breath that is inputted is in the form of a wave called acquisition. imagery. After the breath has entered the E-Nose, the data analysis process will be carried out. The analyzed data will form a pattern. After the pattern is obtained, the neural network testing is carried out, if the test results are successful it will be completed, meaning that it will be displayed in text form in the MATLAB software. If it is not successful, it will return to image acquisition until it forms a TBC or COPD pattern or if it does not form, the meaning is not detected.

III. Results and Discussion

A. The Work of the Designed Electronic Nose (E-Nose)

The current instrument which is very rapidly developing is called the Electronic Nose (E-Nose) which has a working principle like the smell of a human nose. This is because in it there are six sensors that are useful for responding to every aroma that E-Nose enters or receives and can then identify the disease that a person experiences. The sensor has its own function, such as the MQ2 sensor which can respond to the presence of gases in the air, for example cigarette smoke, the MQ4 sensor responds to natural gas levels, for example methane gas, the MQ5 sensor can respond to content CH_4 for example dirt, the MQ7 sensor responds to carbon monoxide gas (CO), the MQ9 sensor responds to the air content in the room and then the MQ135 sensor can detect the gas content of the ammonia sample, CO, CO_2 and O_2.

B. Display Result from Nose (E-Nose)

The method working of the tool begins with the design of the hardware, namely the circuit of the sensor components and the circuit of the switch for the fan. After the tool has been designed, it will enter the data collection stage. The way E-Nose works starts with starting and checking the device first, then continuing with data input in the form of someone's breathing. The breath that is inputted will be in the form of a wave or it is called an image acquisition, then it will be processed in the form of data analysis and will be displayed as shown below (Figure 4).

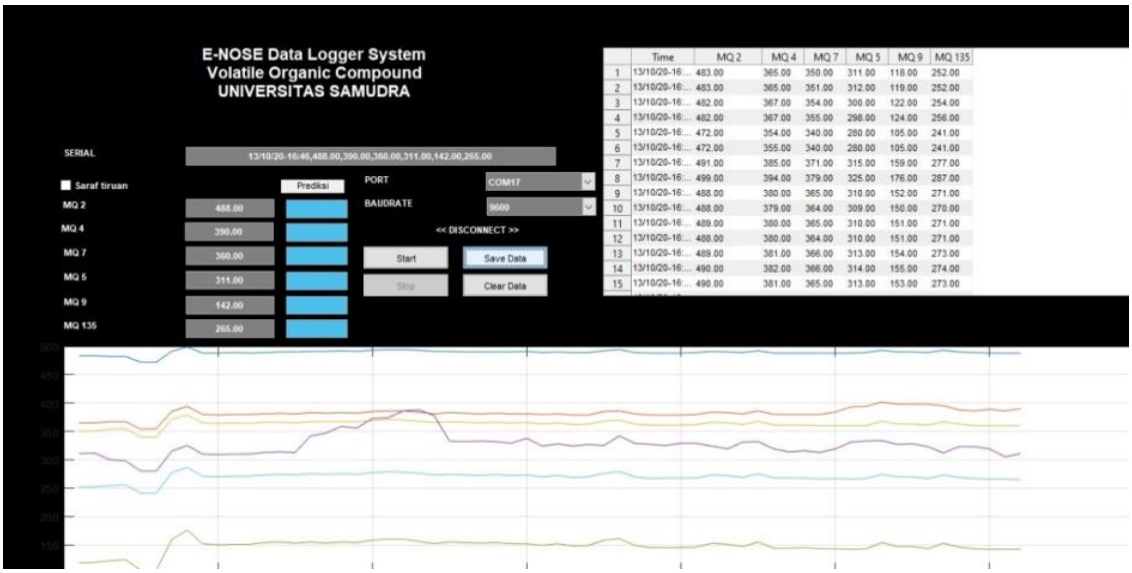

Fig. 4. Electronic nose (e-nose) display.

C. Process Results from Use from Nose (E-Nose)

The use of the Electronic Nose (E-Nose) instrument begins by sterilizing the tool before use, in order to remove the aroma from the instrument so that it is not mixed with the aroma that will be taken later. The way to sterilize it is by turning on the switch that has been connected to the four fans, so that the fan will provide sterility in the room when the fan is on. After the tool is sterile, fans 1, 3 and 4 are turned off but fan 2 is turned on so that when someone is breathing the fan can push someone's breath closer to the sensor so that it is easy to respond. Collecting data on a patient or patient using an oxygen mask that has been connected to the part of the instrument to the room, a person can breathe freely while taking a breath sample so that the sensor can receive it properly.

D. Results of Data Analysis Techniques

Artificial neural networks (ANN) can be used in the Backpropagation algorithm process where the ANN consists of many layers so that data can be obtained as shown in the following table. The following data is a sample of patients suffering from tuberculosis and COPD.

TABLE I. SAMPLES OF PATIENTS WITH TUBERCULOSIS (TBC)

MQ2	MQ4	MQ7	MQ5	MQ9	MQ135
548	465	342	394	124	362
547	465	342	394	124	362
547	465	342	393	123	362
547	465	342	394	124	362
550	467	345	396	125	368

TABLE II. SAMPLE OF PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

MQ2	MQ4	MQ7	MQ5	MQ9	MQ135
443	417	338	405	103	317
434	410	332	398	102	311
442	417	338	406	104	316
442	417	339	406	104	316
455	428	345	415	105	323

The sample above is only a form of response (Table 1 and Table 2), meaning that the E-Nose sensor is very good so that it can display data as above on the computer part.

E. Test Result

The data from the test results will be analyzed by means of quantitative processing (calculations), every data obtained must be known the minimum and maximum values because these values will be used for data programming in the Matlab software. The data processing process can use the following equation:

$$\frac{5}{1023} \text{ x sensor voltage value} \quad (1)$$

Information:

5 = value of grace

1023 = Arduino reference voltage value

From data processing in excel, different patterns of tuberculosis, COPD and asthma have been formed as shown in the table 3.

TABLE III. CLASSIFICATION OF TB, COPD AND ASTHMA

SENSOR	TB	COPD	Asthma
MQ2	2	2	3
MQ4	2	1	2
MQ5	1	1	2
MQ7	1	1	2
MQ9	0	0	0
MQ2135	1	1	1

From the data above, it can be seen that tuberculosis, COPD and asthma have different classification patterns so that it can be seen in more detail in the Figure 5.

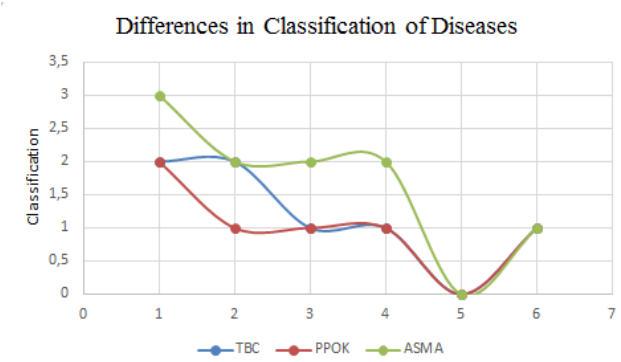

Fig. 5. Differences in classification of diseases.

The graph above explains that in TB disease has a pattern (2 2 1 1 0 1), COPD has a pattern (2 1 1 1 0 1) while in asthma has a pattern (3 2 2 2 0 1). It can be concluded that the E-Nose tool can perform well in differentiating the classification of disease patterns. The pattern of asthma, which was obtained from samples at reference that had been tested, was associated with asthma because it wanted to show that the three patterns were different and not all diseases had the same pattern. After getting the pattern from the data, then enter the testing phase of the ANN through the MATLAB software, the following is a picture of the ANN testing process.

IV. CONCLUSION

The research results have succeeded in making a prototype which shows that the Electronic Nose olfactory system can be an efficient method to identify Tuberculosis and COPD. The method applied in the Electronic Nose olfactory system shows that the sensor response is very good in classifying each disease.

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