Design and Development of Electronic Nose (E-Nose) to Detect Gastric Diseases (*Gastritis* and *Dyspepsia*) Through the Respiratory Tract

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***Abstract*—In this study has been designed an E-Nose system that serves as a respiratory aroma or smell detector in gastric patients. The gastric is a digestive organ found in humans that are susceptible to diseases. Gastric disease detection is carried out using Artificial Neural Network (ANN) method. Artificial Neural Network (ANN) is a part of artificial intelligence related to forecasting or prediction that can be described as a simulation of a collection of biological neural models. The design of the E-Nose system uses MQ gas sensors including MQ2, MQ4, MQ5, MQ7, MQ9 and MQ135, which serves to recognize the respiratory air samples of gastric patients. The use of several gas sensors aims to obtain the output of sensors in the form of voltage patterns, where each sensor can recognize the aroma of each respiratory sample of gastric patients namely gastritis and dyspepsia. From the ANN test results showed the accuracy of the output with the target indicated by a correlation coefficient value (R) of 0.94913. The correlation coefficient value (R) value that almost reaches a value of 1 indicates that the ANN processing is running well, with an accuracy value of 99.5%.**

Keywords—E-nose, Artificial Neural Network (ANN), gas sensors, gastritis and dyspepsia

I. INTRODUCTION

Electronic Nose abbreviated as *E-Nose* is an instrument used to detect a smell or aroma similar to the human sense of smell [1]. *E-Nose* has been applied in the field of health used to identify a pulmonary disease through the respiratory tract [2] as well as other internal diseases. One of the internal diseases that can be identified by using *E-Nose* is gastric disease.

The gastic is one of the organs in the digestive system in humans that serves to digest food [3]. The gastric is also a digestive organ that is very susceptible to disease, caused by the wrong diet and can be fatal to the health of the gastric. Breathing air produced by gastric sufferers is directly connected with metabolic activity in the body, breathing air patterns exhaled there are *volatile* gases that are characteristic of biomarkers (biological markers) of gastric diseases. In normal human breathable breathing air has been identified more than 1000 types of volatile organic compounds (VOC) with concentrations in the order ppm to ppb, including nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), water vapor (H_2O) and others [4,5]. Respiratory detection using VOC compounds can provide early diagnosis information for people with gastric diseases detected by sensor responses. Then the sensor response will be analyzed by utilizing the artificial neural network (ANN) method.

Artificial neural networks (ANN) have been widely used in solving various problems, one of these problems is decision making based on the training provided. Artificial neural network (ANN) technique is an information processing technique in which the principle of its work mimics the workings of human neural networks networks [6]. In the study Sulaiman [7] the application of artificial neural networks was used to diagnose early stomach diseases including dyspepsia, ulcers, GERD (Gastroesophageal Reflux Disease) and stomach infections. Continued in the study Dewi et al. [8] namely the detection of disorders in the gastric organs through iris imagery using the method of neural tissue replica backpropagation. In previous studies there are still gaps to be studied and developed, so in this study, e-nose design was carried out to detect gastric diseases (gastritis and dyspepsia) through the respiratory tract.

II. METHODS

Before testing the *E-Nose* system, the training data must be prepared in advance. To obtain the training data is carried out several stages of data retrieval using sensor samples of patients suffering from gastric diseases. The following stages of data collection training using samples of patients suffering from gastric diseases:

- The first step is to retrieve zero data without using samples. Electronic *Nose* is first turned on for 20 minutes to achieve the sensor's working temperature

and sensor outer stable point. After that, data recording is done when the sensor is only exposed to free air, and the data is used as zero data.

- The second step is to retrieve the initial data using the sample. Samples were taken from patients suffering from stomach diseases through their breathing. The breath is channeled to the *Electronic Nose* through an oxygen mask and then the patient's sample is captured by sensors. Samples captured by the sensor in the form of analog signals are then converted into digital signals.
- The third step, then the recovery of sensor response. The room that has been filled with sample aroma is then cleaned by turning on the fans 1, 2 and 3 for 5 minutes or more until the sensor is back in a stable state. furthermore, a reduction is made between the initial data to zero data, to obtain the result value of the training data.

I_1 = n1, n2, n3, n4, n5, n6 (initial data)

I_0 = n1, n2, n3, n4, n5, n6 (zero data)

Result = n1, n2, n3, n4, n5, n6 (original data)

- The fourth step, determine the maximum value of the initial data collection to find out if *Electronic Nose* can recognize the respiratory samples of patients suffering from gastric diseases.

Flowchart research design *Electronic Nose* (*E-Nose)* to detect gastric diseases through the respiratory tract as Figure 1.

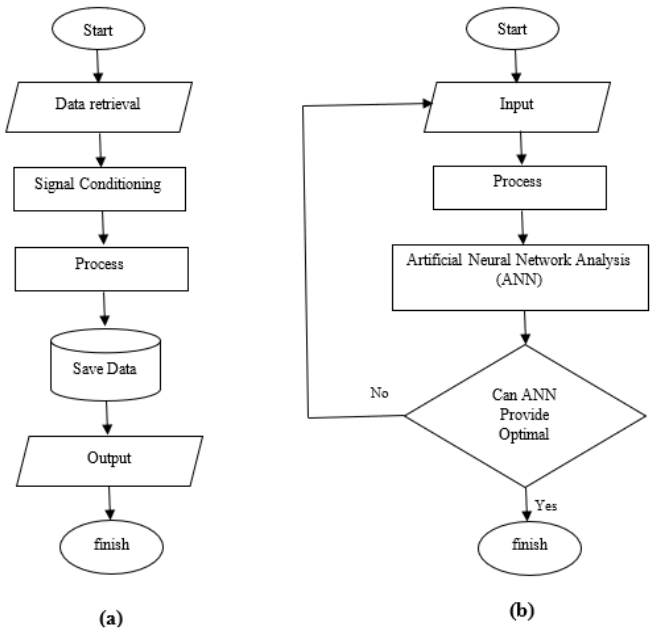


Fig. 1. Flowchart d(a) training, (b) testing.

III. Results and Discussion

A. PCA Analysis

In this study, the results of PCA analysis were presented using minitab software, in the form of spread plot scores and data groupings for gastritis and dyspepsia respiratory samples.

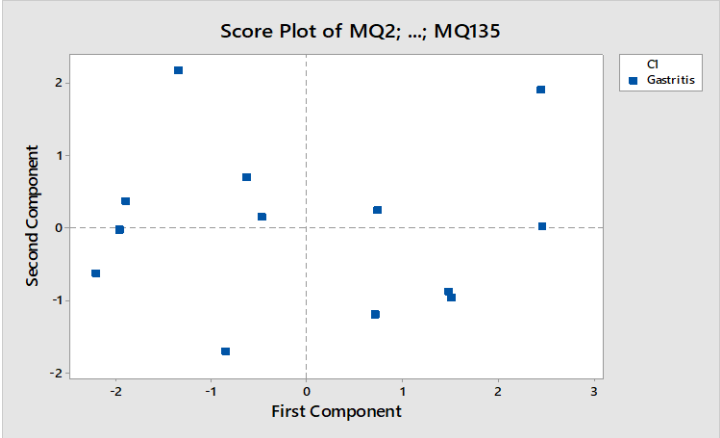


Fig. 2. Gastritis data distribution.

In Figure 2 is a spread of *gastritis* data, it appears that the results of the PCA analysis showed that each sample is not fused, this is due to *the volatile* gas levels exhaled for each sufferer is different, although scattered and not fused but can still be distinguished between each sample of *gastritis* sufferers.

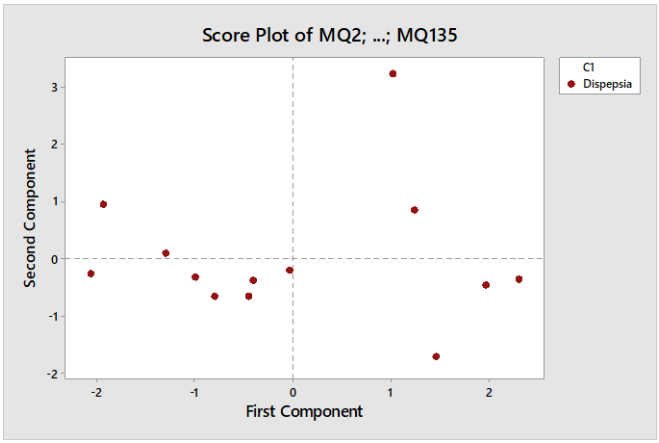


Fig. 3. *Dyspepsia* data distribution.

In Figure 3 is a spread of *dyspepsia* data, it appears that the results of the PCA analysis showed that each sample is not fused, this is due to the *volatile* gas levels exhaled for each sufferer is different, although scattered and not fused but can still be distinguished between each sample of *dyspepsia* sufferers.

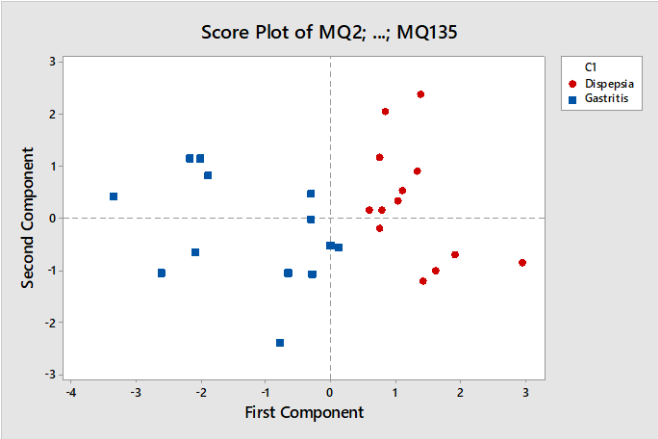


Fig. 4. Data distribution of *gastritis* and *dyspepsia.*

In Figure 4 is a spread of *gastritis* and *dyspepsia* data, it appears that the results of PCA analysis showed that each sample is not fused, this is because there is the same volatile *organic* gas between *gastritis* and *dyspepsia* and *volatile* gas levels exhaled for each sufferer is different, although scattered and not fused but can still be distinguished between each sample of *gastritis* and *dyspepsia.*

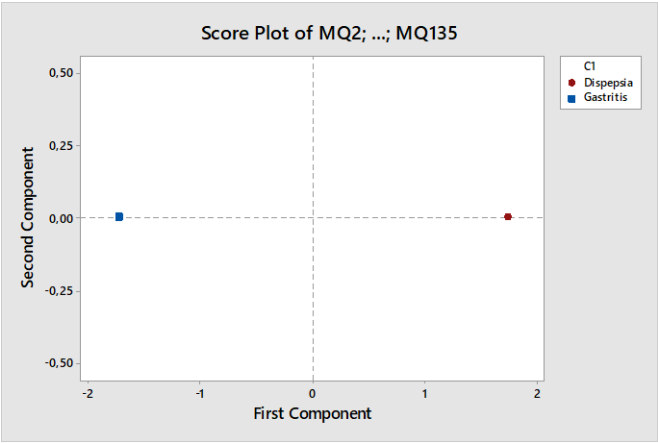
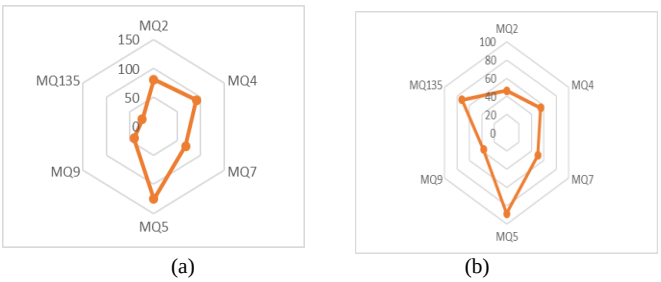


Fig. 5. Grouping gastritis and dyspepsia data.

In Figure 5 is the result of PCA analysis of *gastritis* and *dyspepsia* data grouped. The image shows a sample of *gastritis* sufferers in the left quadrant, while the *dyspepsia* is in the right quadrant. It is noticeable that analysis using PCA can distinguish between *gastritis* and *dyspepsia* samples.

There are certain molecules in the human breath that are used as indicators of a disease. The levels of *volatile* gas exhaled for each person are different. Many trigger factors that affect the occurrence of diseases of the stomach that cause metabolic differences produced by the body. In gastric patients this type of *gastritis* has *volatile* gas NH_3,CO_2, *terpenes*, *trimethylamine* and *ketones* [9]. While *dyspepsia* has *volatile* gas NH_3 and CO_2 [10]. Due to some similarities in *volatile gases* between people with *gastritis* and *dyspepsia*, it causes the samples to be close to each other. In the grouping of *gastritis* and *dyspepsia* data it is clear that each sample is separate. This proves that the sensors used on the *E-Nose* can function well in distinguishing *gastritis* and *dyspepsia* samples.

In this study, radar patterns can also be established to see sensory responses in people with *gastritis* and *dyspepsia.* Here's the radar curve for *gastritis* and *dyspepsia* (Figure 6).



(a) (b)

Fig. 6. Radar, (a) *gastritis*, (b) *dyspepsia*

B. *ANN Analysis*

In Matlab R2014 program by *default* will use 70% data for *training*,15% data for *validation* and 15% data for *testing.* Here is the algorithm resulting from the identification of gastric diseases *(gastritis* and *dyspepsia)* with the number of *input* and *output* data as many as 26 samples.

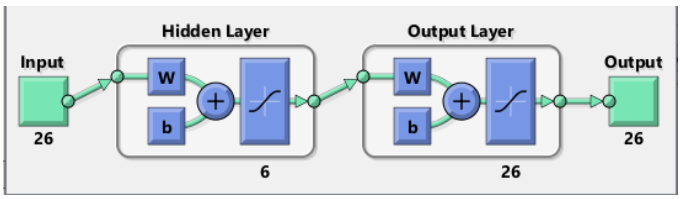


Fig. 7. Artificial neural network architecture.

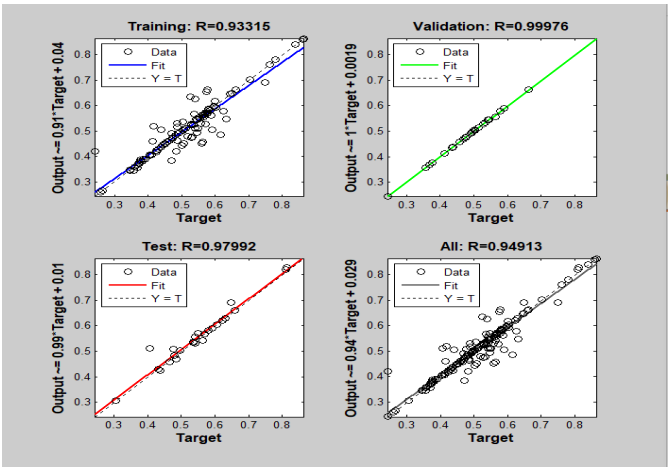


Fig. 8. Graph *of regression* relationship between *gastritis* data sample and *dyspepsia.*

Based on the Figure 7 and Figure 8can be known the results of the ANN process displayed in the form of graphics. The image shows the relationship of the target to the network *output* in the training data. Where the dot lines are predictive

data that has been compared with the original data (fit) which is marked in black in a straight line. In Figure 8 shows the accuracy of the *output* with the target indicated by a correlation coefficient value (R) of 0.94913. The R value that almost reached the value of 1 indicates that the ANN processing process is running well, with an accuracy value of 99.5%. This proves that ANN is very influential in recognizing the patterns of data entered. The smaller the target error generated, the smaller the deviation rate and the higher the determination level of a predicted model.

From the analysis that has been done shows that the classification of using artificial neural networks (ANN) supported by *principal component Analysis* (PCA) for the disease detection process is an effective method in the process of detection of stomach diseases through the respiratory tract.

IV. CONCLUSION

Detection of gastric diseases through the respiratory tract is done using *the E-Nose tool*, where the *E-Nose* serves as a tool to detect the breath smell of gastric patients containing volatile compounds. The *E-Nose* system is able to detect stomach diseases through the respiratory tract and has a good sensory response in testing gastric diseases. Classifying using artificial neural networks (ANN) supported by *principal component Analysis* (PCA) for the process of detecting gastric diseases through the respiratory tract is an effective method used, with a correlation coefficient (R) of 0.94913 and an accuracy of 99.5% of the standard error provision *(MSE)* of 0.005.

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REFERENCES

[1] D. Karakaya, O. Ulucan, and M. Turkan, "Electronic Nose and Its Applications: A Survey," Int. J. Autom. Comput., vol. 17, no. 2, pp. 179–209, 2020.

[2] Muhammad Rivai, S. Hariadi, W. Koesoemoprodjo, H.A. Sujono, and M. Taufiqurrohman, "Sistim Diagnosa Udara Pernapasan Menggunakan Hidung Elektronik," Pros. InSINas, 2012.

[3] M. Rivai, D. Purwanto, H. Juwono, and H.A. Sujono, "Electronic Nose Using Gas Chromatography Column and Quartz Crystal Microbalance," vol. 9, no. 2, pp. 319–326, 2011.

[4] C. Wu, Y. Liu, Y. Yang, P. Zhang, W. Zhong, Y. Wang, Q. Wang, Y. Xu, M. Li, X. Li, M. Zheng, L. Chen, and H. Li, "Analysis of Therapeutic Targets for SARS-CoV-2 and Discovery of Potential Drugs by Computational Methods," Acta Pharm. Sin. B, 2020.

[5] F.J.J. Joseph, "IoT Based Weather Monitoring System for Effective Analytics," Int. J. Eng. Adv. Technol., vol. 8, no. 4, pp. 311–315, 2019.

[6] J. Nugroho, D. Muryani, S. Rahayoe, and N. Bintoro, "Aplikasi Jaringan Syaraf Tiruan Untuk Identifikasi Aroma Teh Menggunakan Electronic Nose," Pros. Semin. Nas. Tek. Pertan., no. 2008, pp. 18–19, 2008.

[7] R.R. Sulaiman, "Penerapan Jaringan Syaraf Tiruan Untuk Mendiagnosa Awal Penyakit Lambung Menggunakan Metode Learning Vector Quantization 2.1 (Lvq 2.1)," Tugas Akhir, P. Universitas Islam Negeri Sultan Syarif Kasim Riau, 2016.

[8] A.K. Dewi, A. Novianty, and T.W. Purboyo, "Deteksi Gangguan Pada Organ Lambung Melalui Citra Iris Mata Dengan Menggunakan Metode Jaringan Syaraf Tiruan Backpropagation," e-Proceeding Eng., vol. 3, no. 1, pp. 681–688, 2016.

[9] U.F. Service and A.D. Wilson, "Future Applications of Electronic-Nose Technologies in Healthcare and Biomedicine."

[10] E. Górska-Horczyczak, D. Guzek, Z. Molęda, I. Wojtasik-Kalinowska, M. Brodowska, And A. Wierzbicka, "Applications of Electronic Noses in Meat Analysis," Food Sci. Technol., vol. 36, no. 3, pp. 389–395, 2016.