CLASSIFICATION OF ARABICA AND ROBUSTA COFFEE USING ELECTRONIC NOSE

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Abstract— **The ability of nose as the sense of smell, causing high sensitivity to the aroma of coffee. The electronic nose can be applied to recognize the aroma of coffee as an objective measure of coffee gas. The detection of Arabica and Robusta coffee was diluted for 20 minutes and resulted in 288 gas data. From the data displayed on the Arduino produces different signal values. From the results of sensor data displayed on the Arduino will be made aroma classification based signal data. Classification of Arabica coffee aroma and Robusta coffee aroma is done with Support Vector Machine (SVM) and Perceptron method. Accuracy results obtained with the SVM method is 71% and Perceptron 57%. Based on the accuracy value obtained, SVM method can recognize Arabica Coffee and Robusta with better results.**

Keywords — Electronic Nose, Support Vector Machine, Perceptron, Arabica and Robusta

I. INTRODUCTION

Coffee is one of the top commodities in Indonesia. As a tropical region, Indonesia has a wide sector of coffees agriculture. There are two types of coffee that produced by Indonesian farmers, that is arabica and robusta. From Sabang to Merauke, coffee has a distinctive aroma some areas. This what makes coffee lovers have sensitivity for each served coffee aroma. Besides that, coffee already become a part of lifestyles among youngster these days. With so many coffee aromas in Indonesia, we can recognize typical Indonesian coffee aroma with the smell.

The coffee aroma can be detected by measuring the gas contained in coffee. When detecting the coffee aroma, we will use a sensor medium. The sensor has characteristics in identifying gas. The MQ 135 sensor is capable of detecting the gas in ground coffee.Coffee will release its strong aroma after going through the roasting process, then in the process of roasting occurs an organic chemical process. As temperatures are rising during coffee roasting, physical and chemical reactions continue to occur and form new compounds, creating the chemical composition of coffee beans and then the formed compounds evaporate.

The nose ability as a sense of smell could differentiate complex smell, causing a high sensitivity to the aroma of coffee. The smell of coffee that has been through the roasting process and then ground into coffee powder is very easy for a nose to recognize it, especially for coffee lovers. In order to recognize the coffee aroma, we can apply an *electronic nose* as an objective measure in detecting gas of powdered coffee. Electronic nose technology has also been applied in some areas such as fisheries, pharmaceuticals product and pharmacy itself, helping in representing the results they want to obtain.

Artificial Neural Network (ANN) is a method of calcification that can be applied. Development of Artificial Neural Network (ANN) includes various methods, such as vector machine support (SVM) and perceptron, so in this research, we will analyze aroma of Arabica coffee and Robusta coffee classification by using extraction and pattern recognition system. Artificial neural networks, to classify arabica and robusta coffee based on their aroma.

II. PRELIMINARIES

2.1 Coffee Aroma

Roasting is a process of coffee preparation to emits an aroma that can be smelled by humans. The process of roasting itself consists of several phases, including: [1]

1. Drying, which aims to secrete the water in coffee beans
2. Yellowing, at this stage the thin skin of coffee beans/chaff will peel off
3. First Crack, the process of opening the coffee beans and formed the familiar character and taste of coffee beans
4. Roast Development, forming the color of coffee beans based on the temperature used by roasting process
5. The second Crack, in this process the coffee beans reach the phase of producing its natural oils and reduced its acid character that binds to the beans

2.2 Electronic Nose

The electronic nose known as the artificial nose is a model to mimic the function of a biological olfactory system. The electronic nose is a device designed to detect, differentiate and recognize odors inspired by the principles of a biological olfactory system. The electronic nose is a set of tools consisting of electronic chemical arrays and pattern-measuring systems that have the ability to detect simple or complex odors. The process from the work of the electronic nose occurs when the aroma is presented in the sensor circuit. with the principle that electronic noses can be one device that can be applied and developed in the field of food and beverage industry, as a benchmark in delivering a consistent product in terms of aroma. [2]

This study will be using the MQ135 sensor as a medium that will detect the aroma that binds to coffee. The MQ135 sensor has a sensitivity to gas; CO 2, O2, NH3, NOx, alcohol, Benzene, and smoke. This sensitivity can be seen in figure 1 below:

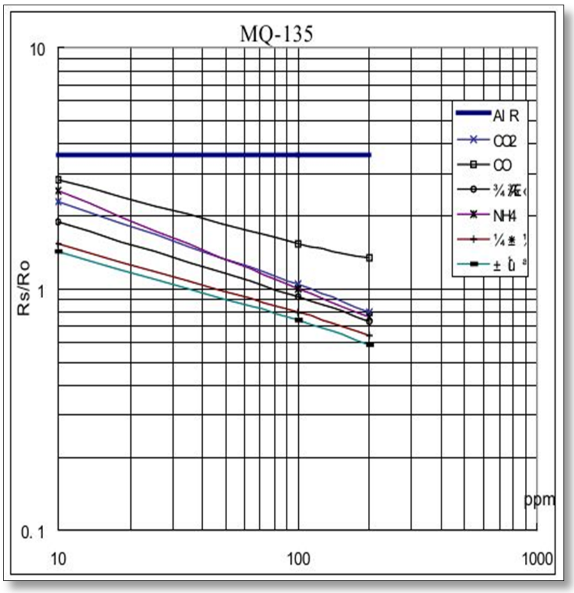

Figure 1. Sensitivity of MQ135

Each type of gas that can be detected by MQ135 has a value of each slope that has the x and y-axes. Electronic nose with the MQ135 sensor is a portable sensor with a relatively cheap price, connected with *Arduino* as a microcontroller, as an output of sensor reader to make it easier.

2.3 Support Vector Machine (SVM)

SVM is a learning method that works based on the Structural Risk Minimization (SRM) procedure in determining the best hyper-location that separates between the two classes in the input. SVM can be applied to linear or non-linear data. For the classification case, when the data is not linear we can use the Kernel method. [3]

The optimization problem using SVM for classification cases, with two classes where data cannot be grouped. The SVM classification uses SVM series results in classifying vector *x*, which is formulated by this equation:

$$c = \sum_i a_i k(s_i, x) + b \quad (1)$$

In the above equation, so is the supporting vector, a_i is the weight, *b* is the bias, and *k* is the kernel function. In a linear kernel, *k* is the deciding point. If $c \geq 0$, then *x* will be classified as part of the first group member. If it does not find a match for the first group member, it will be the second group.

2.4 Perceptron

Perceptron is one of Artificial Neural Network methods with guided learning method. Perceptron uses a training algorithm procedure consisting of single neurons with synaptic weights that are set using the hard limit activation function. Perceptron runs on the appropriate assumption that the procedure can be proved by convergent into the correct weight, weights that allow the network to produce the correct output value for each training input pattern. in figure 2 below perceptron concept in pattern control: [4]

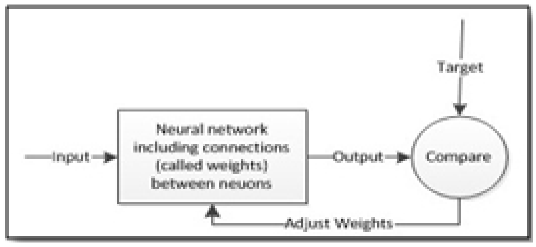

Figure 2. Compare Process

When comparing process is running, if there is still a difference then the weight will be adjusted to produce an output value close to the target

2.5 Earlier Research And Problem Limits

Here are some studies that have been done previously used as a reference in doing this research:

1. **Study on Electronic Nose Based Quality Monitoring System for Coffee Under Roasting** [5]
Conducted in this study is to monitor the quality of coffee beans by applying the timing of roasting parameters, roasting temperatures, and the color of grilled coffee beans, with roasting techniques applied is the usual coffee in roasting techniques. In the quality monitoring of electronic nose applications.

2. **Electronic Nose Application for Fruit Identification, Ripeness and Quality Grading** [6]
Instrumentation research conducted to identify the best quality fresh fruit based on gas released by the fruit, they will be identified by the sensor. By identifying the fruit aroma
will produce a wide range of volatile organic compounds that give a distinctive aroma to the distinctive brand and contribute to the unique flavor characteristics. With the application of potential and up-to-date electronic devices (with special sensors), a highly effective instrument for distinguishing volatile fruit, as a new effective tool for fruit flavor analysis is more efficient to replace the conventional expensive methods used in fruit. The evaluation of the scent evaluates the volatile nature of the fruit chemicals during all stages of the agro-fruit production process, explaining some important applications that e-nose technology has marked the aroma of fruit, and summarizes the latest research that provides e-noses. With this research can be found a new step in fruit identification, cultivar discrimination, with graduation assessment and fruit assessment to ensure fruit quality in the commercial market.

3. **E-nose application to food industry production** [7]

In this study, the electro nose is used as a medium for measuring the aroma. In the food business, manufacturers will make new innovations in creating the latest products. The results achieved in this study are measuring the scent of products with electronic noses, to develop new products in meeting market needs and new innovations in creating scents. This is considered important in conducting business development. An electronic nose can be a useful tool for achieving this goal. E-nose is a combination of various sensors used to detect gas by generating signals for the analysis system.

4. **What happens at the aroma of coffee beans after roasting** [8]
   The smell of coffee is one of the most important quality evaluation criteria used for coffee commercialization and consumption. Nanowires show exceptional and outstanding crystal quality. The ratio is high to wide, resulting in increased sensing ability and long-term material stability for long operation.Various methods of a roasting process will give you a different Aroma coffee will add to the flexibility that exists has a matrix due to different origins.Test this work and describe a broad potential spectrum use of EN techniques in food quality control.

5. **Electronic Nose for coffee quality control** [9]
   In the research conducted, with the application of phase extraction algorithm new (phase space integral) aims to improve the performance of classification system. The electronic nose works to evaluate the quality of Italian espresso coffee produced by Jolly Caffe S.p.A for the best timing of packing according to pre-packaged packaging.

Based on the study that has been done above, researchers are interested to conduct research that focuses on aroma level in coffee powder. In conducting this study, an object of pelleting is arabica coffee aroma that loved by Indonesian society, especially among youngster.

III. RESULTS AND DISCUSSION

The aroma detection is done by E-Nose, with the gas present in the coffee. Results aroma arabica and robusta coffee, is illustrated by the results of signal gas as follows:

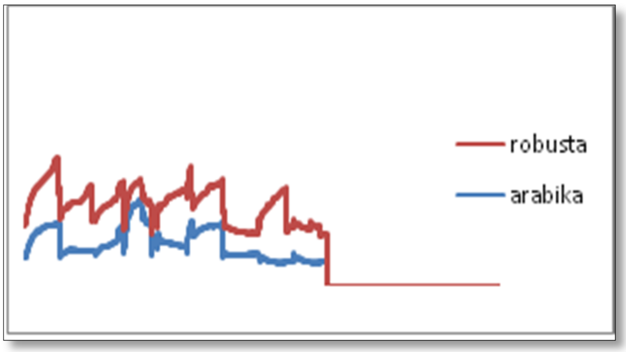

Figure 5. Coffee Aroma Signal

Measured in this study are CO_2 gas contained in arabica and robusta coffee. Organic compounds present in coffee will change after going through the roasting process. The compounds are formed by a chemical process comprising a carbon atom associated with a hydrogen atom and double-bonded with an oxygen atom. The change is transformed into a gas formed through a roasting process done to the coffee beans, so the scent of the coffee can be measured. The strong scent stored in coffee detected in this study is the CO_2 gas content. Proven in the study of gas measurements in coffee with E-nose CO_2 values that dominate in signal Arduino displayed.

Measurements of CO_2 gas in arabica coffee and robusta coffee are carried out for 20 minutes, and the value of the Arduino-displayed gas signal from the electro-nose can be seen as in table 1 below:

Table 1
Arabica Sensor Results 1

No	Arabica 1		
1	458,76	450,85	452,96
2	465,11	454,58	455,99
3	461,93	454,58	459,03
4	461,93	458,30	462,06
5	468,29	462,03	465,10
6	446,08	462,03	468,15
7	471,19	619,99	551,06
8	474,24	638,96	556,42
9	427,13	469,48	477,29
10	433,44	469,48	480,35
11	433,44	476,94	483,4
...	...	...	...
288	914,22	532,83	895,24

Table 1 Results of the gas sensor (ppm) in arabica 1 coffee, with the amount of data generated 288 data.

Table 2
Arabica Sensor Results 2

No	Robusta 2		
1	509,51	482,87	507,76
2	528,38	500,95	533,32
3	550,46	519,24	558,94
4	569,41	524,5	574,96
5	585,21	535,08	590,99
6	601,02	540,39	603,81
7	619,83	469,75	478,56
8	635,83	469,75	483,47
9	651,59	556,42	651,82

10	670,52	559,10	670,98
11	686,27	578	683,73
...	...	...	...
288	905,74	613,57	902,22

Table 2 Results of the gas sensor (ppm) in arabica coffee 2, with the amount of data generated 288 data.

Table 3
Arabica Sensor Results 3

No	Arabica 3		
1	450,84	458,87	458,87
2	455,57	463,8	463,8
3	455,57	468,72	468,72
4	460,3	468,72	468,72
5	460,3	468,72	468,72
6	465,03	473,64	473,72
7	478,56	471,19	619,99
8	483,47	474,24	638,96
9	469,75	483,47	483,47
10	474,48	483,47	483,47
11	474,48	488,38	488,38
...	...	...	...
288	474,48	359,97	359,97

Table 3 Results of the gas sensor (ppm) in arabica coffee 2, with the amount of data generated 288 data.

From the detection of arabica coffee obtained data as much as 288 on every one detection is done, the detection of coffee aroma on the type of arabica coffee is done 3 times for each kind of coffee, and there are 3 kinds of coffee this research is used, namely arabica gayo, arabica Malabar and arabica Lintong.

From the result of the gas signal displayed on the Arduino, for each coffee presents different values for each time the experiment. The above data is the value of gas detection which is the aroma signal in ppm unit. Likewise for the type of robusta coffee, following the results of the detection of Robusta coffee:

Table 4
Robusta Sensor Results 1

No	Robusta 1		
1	465,32	452,3	292,96
2	469,04	457,34	288,08
3	476,5	457,34	283,2
4	480,23	462,37	283,2
5	483,95	467,4	283,2
6	487,68	487,68	467,4
7	491,41	491,41	472,42
8	498,86	498,86	472,42
9	502,59	502,59	472,42
10	506,31	506,31	477,44
11	506,31	502,29	477,44
...	...	...	...
288	823,63	657,87	317,53

Table 4 Result of the gas sensor (ppm) in Robusta 2 coffee, with the amount of data generated 288 data.

Table 5
Robusta Sensor Results 2

No	Robusta 2		
1	450,26	453,49	422,47
2	450,26	446,39	422,47
3	450,26	442,84	410,38
4	455,38	439,29	404,33
5	455,38	435,74	398,27
6	455,38	432,2	392,21
7	455,38	425,12	416,43
8	460,49	428,66	416,43
9	460,49	425,12	422,47
10	465,59	425,12	416,43
11	465,60	425,12	416,43
...	...	...	...
288	822,47	645,08	331,59

Table 5 Result of gas sensor (ppm) in Robusta 2 coffee, with the amount of data generated 288 data.

Table 6
Robusta Sensor Results 3

No	Robusta 3		
1	449,75	422,82	457,03
2	453,84	410,43	461,95
3	453,84	416,63	466,87
4	457,93	416,63	466,87
5	466,11	416,63	466,87
6	470,2	422,82	486,49
7	470,2	416,63	486,49
8	474,29	422,82	491,38
9	490,64	422,82	501,15
10	494,72	422,82	501,15
11	494,72	422,82	501,15
...	...	...	...
288	555,69	338,89	319,10

Table 6 Result of the gas sensor (ppm) in Robusta 2 coffee, with the amount of data generated 288 data.

From the results of gas detected on arabica and robusta coffee will be classified, by applying two methods of classification of Support Vector Machine (SVM) and Perceptron method, with the purpose of both methods can present the value of accuracy and error of the results of classification performed. The steps taken in this classification are as follows:

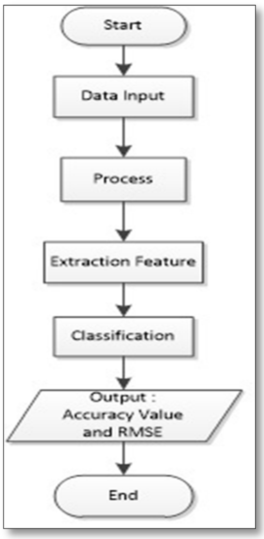

Figure 4. Flow Chart

The first step is data input. In this step, there is two kind of data which is Arabica Coffee and Robusta Coffee. The next step is reducing data noise using discrete wavelet transforms. After completing the process stages, the data will go through the feature extraction stage, this stage is done with the aim to normalize the data, by using kurtosis and skewness in tidying the data structure, after the extraction stage is done, the next step is to do the classification by using two methods, namely Support Vector Machine and Perceptron, from both methods will look the highest accuracy value and the lowest error in arabica coffee and robusta coffee aroma.

From the classification of arabica and robusta coffee with Support Vector Machine (SVM) and Perceptron method, we get Accuracy and Root Mean Square Error (RMSE) as follows:

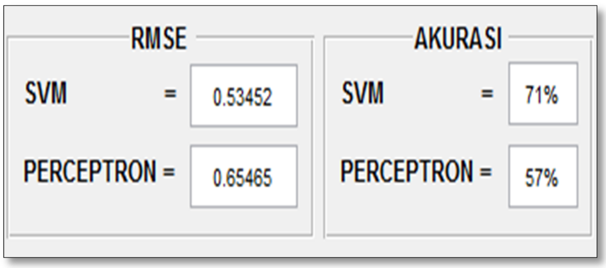

Figure 5. Image of RMSE Results and Accuracy

From the results of the classification performed, the higher accuracy value is generated from the Support Vector Machine (SVM) method. In this grouping, the Support Vector Machine (SVM) is able to group the types of arabica and robusta coffee with an accuracy value of 71% and the error value is 0.53452.And for the results of the method Perceptron get an accuracy of 57% with an error value of 0.65465.If seen from the results of the classification graph is done as follows:

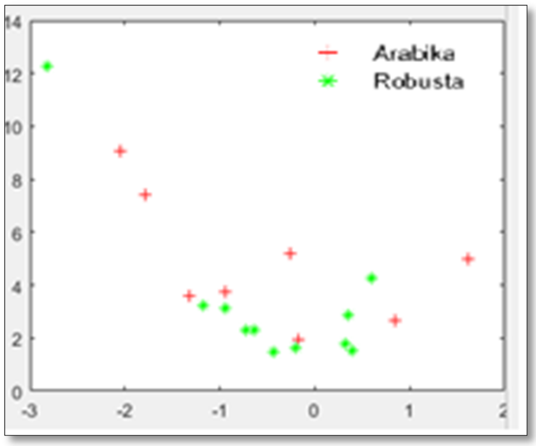

Figure 6. Graph of SVM Results

In the graph above shows the classification results with the SVM method. This graphic display illustrates the classification pattern that the SVM method executes.

Introduction of arabica coffee aroma and Robusta coffee aroma by detecting CO2 gas with E-Nose and classification with SVM.From the results of experiments conducted with coffee powder samples, and detection of CO2 gas carried out for 20 minutes. In this study using a coffee powder that has been through a grill with a temperature of 180 ° done for 12 to 16 minutes for / 2 Kg in a roasting process.

IV. CONCLUSION

The detection of the aroma of coffee with E-Nose can be applied in determining the type of arabica and robusta coffee based on the sensor signal displayed on the Arduino. In the detection of the aroma of coffee, many factors can be seen, especially the distance of the sensor and the coffee to detect, this is very influential on the signal results obtained, as well as the conditions around both inside and outside the container of the coffee censor. During the detection process carried out for 20 minutes, the signal generated from as many as 288, experiments conducted on similar coffee there are three times detections, and on each type of coffee, there are 3 kinds of coffee that are detected.

In the detection of arabica coffee aroma and robusta coffee aroma done with E-Nose, the classification by the SVM and Perceptron methods performed obtains the best accuracy value using the SVM method, with an accuracy of 71%.In previous research, researchers have not included the accuracy of the use of E-Nose in detecting the aroma of coffee, In previous research, researchers have not included the accuracy of the use of E-Nose in detecting the aroma of coffee, so that with this research can provide new innovations in the detection and classification of coffee aroma.

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