Food Freshness Detection Using Smart Machine Learning Classification

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DOI: 10.47750/pnr.2022.13.S09.868

Abstract

Food is considered to be fresh when it is safe to be consumed. In this project, the test subject is chicken meat. Chicken meat can be spoiled by a variety of factors, i.e. microorganisms, environment, and improper freezing techniques. Although many factors may contribute to chicken spoilage, the most common factor of meat spoilage is caused by microorganisms such as bacteria, yeasts and molds. There are many techniques, conventional and using devices to detect the freshness of food. The classical way to classify the condition of the food is by using human olfactory system such as smell and taste. The problem of this method is different people will classify the freshness of food differently according to their experiences and sensitivity. Hence, devices was developed, to improve the way of freshness detection. Examples of a modern way to detect the food freshness is laser test. The freshness of packaged food can be measured by using laser to detect the gas composition present. Other than that, there are freshness indicator produced by GSP Chemical Industries to detect the freshness of fruits and vegetables. Electronic nose that contains a number of gas sensors is one of the promising method in detecting food freshness. In this research, electronic nose is developed to detect gases produced by chicken to determine the freshness through machine learning classification. Through a series of testing, the developed E-nose produced significant result and classified the gases with accuracy 96.6667%.

Keywords: Food, e-nose, freshness detection, machine learning, classification.

1. Introduction

It is important to ensure that the food to be consumed are clean and safe. So, it is essential to prepare meals in a safe, hygienic way. If germs such as harmful micro-organisms and parasites get into the foods and drinks, it may result in diarrhea, vomiting or other symptoms of food poisoning. It could also worsen the health condition of those with illness. Food such as chicken meat plays an important role in a healthy balanced diet as they have a high nutrient density. Chicken is a source of protein that contain less cholesterol and saturated fat as compared to other source of protein such as red meat. With less cholesterol and saturated fat, it would be a better choice for those with heart disease to consume [1]. The presence of vitamin B6 in chicken helps prevent heart attack by lowering the levels of homocysteine [2], the key component that contributes to the increased risk of heart attack. The niacin in chicken also helps to lower cholesterol. Besides that, chicken contains large amount of protein. Every 100g of serving of roasted chicken for example, will provide 31g of protein which is great for those who wants to bulk up and build muscles. Chicken also have a lot of other minerals such as phosphorus, selenium, calcium, tryptophan and vitamin B5. The phosphorus and calcium in chicken can help to keep bones in mint condition while selenium can prevent arthritis. There is also tryptophan and vitamin B5 that is very good as stress relief agents [3]. However if the food consumed are not fresh, those nutrients might not be present, hence it would not be beneficial. There are many techniques and devices to detect the freshness of food such as the classic way of smelling and tasting, or a more refined tests such as laser tests that could measure the gas composition in a packet of food [4]. Other than that, there are freshness indicator produced by GSP Chemical Industries to detect the freshness of fruits and vegetables [5] and last but not least, the most popular method now is electronic nose (e-nose).

Electronic nose (e-nose) is a device that identifies the specific components of an odour and analyses its chemical makeup to identify type of gases. An e-nose mechanism consists of a chemical detection, such as an array of electronic sensors and a mechanism for pattern recognition, such as an artificial neural network. An odour is composed of molecules, each with a specific size and shape. Each of these molecules has a corresponding receptor in the human nose. When a specific receptor receives a molecule, it sends a signal to the brain and the brain identifies the smell associated with that molecule. E-nose is based on the biological model work in a similar manner, substituting sensors for the receptors, and transmitting the signal to a program for processing, rather than to the brain. E-nose is an example of a growing research area called biomimetic, or biomimicry, which involves human-made applications patterned on natural phenomena [6].

In most e-noses, each sensor is sensitive to all volatile molecules but each in their specific way. Most electronic noses use sensor arrays that react to volatile compounds on contact: the adsorption of volatile compounds on the sensor surface causes a physical change of the sensor. A specific response is recorded by the electronic interface transforming the signal into a digital value. Recorded data are then computed based on statistical models [7]. Then classification is done by using one or combinations of machine learning algorithm. For this research, it will just focus on developing an e-nose and its algorithm to classify food freshness. However, if the scope is expanded it can be very useful in controlling air pollution and other application that is related to the chemical reaction in the air.

Most people would not be able to identify correctly whether the food to be consumed are fresh. This is because they identify the freshness of food by their senses such as touch, smell and taste. Different people will have different kind of decision in identifying the condition of the food depending on their experiences. The problem worsens when people lost their sense of smell and taste. When people eat food that is not fresh, the chances for them to get food poisoning is very high. To overcome the problem, e-nose is the best solution to determine the condition of the food. When people know about the condition of the food, it will prevent them from having food poisoning caused by the bad condition of the food. However, e-nose in the market are too expensive, not affordable, and generally used for lab or food industries. It is because it has a lot of function and uses a lot of machine learning algorithm. Countless types of sensors also make the e-nose that is currently available in the market expensive. Hence in this research, only one type of machine learning is used to lower the production cost and to provide the accurate result to classify the condition of the food (raw materials such as poultry and red meat are used).

2. Food Freshness Detection

An e-nose is a device that identify the specific component of an odour. An example of e-nose function is to identify and analyze the chemical that exists in the air or odour. E-nose comprises of two main components, sensor and classification. The sensor part is using a gas sensor to detect an odour that can be executed by using a market ready product such as MOS transistors, QMB, CP, piezoelectric crystal, and QCM. Some researchers developed their own gas sensors for their research [8]. Whereas the classification part is to identify and distinguish types of gases in order to determine the quality of food. For now, the most popular algorithm that is being used in e-nose is backpropagation algorithm (BP) – one of the artificial neural network (ANN) algorithm. It is used to determine gas contained in a few sample of teas and coffees. ANN's ability to classify odour has been proved by combining ANN algorithm with General algorithm (GA) to improve the selectivity of the gas sensor arrays which has been tested on decayed and fresh meat and fish [7].

2.1 Freshness Classification

Most of the meat in the supermarket is packed. Vacuum packed is the most popular type of packaging in the market to pack the raw meat products. If the meat is spoiled, these are the gases that are produced in the package:

1) Mostly ammonia and the volume will be small, but on opening one can get the smell of unclean smell to putrid smell, predominantly due to the growth of Psychotropic gram-negative bacteria.

2) Large volume of Gas, that smells like rotten egg and rotten meat, due to growth of Psychrophilic Clostridium Laramie; it can cause spoilage even at 0 ℃.

In vacuum packaged processed meats products (including fermented products):

a) Mostly carbon dioxide, but can have hydrogen, produced by psychotropic Heterofermentative lactic acid bacteria, predominantly, a few Leuconostoc and a few Lactobacillus species [9].

b) Rarely some psychotropic Gram-negative bacteria can also contaminate and produce ammonia.

c) Very rarely, one can encounter hydrogen sulphide in the pack, produced by some psychotropic Lactobacillus species [10].

Those information are the types of information that needs to be collected in this project. All the gases produced by the samples of food, both in good and spoiled condition is needed to be measured and recorded to be used in training and testing of the data. In this project, the volume of different types of gases produced by the food (in voltage) [11] is measured and recorded.

In the classification task, the activities involved separating data into training and testing set. Each instance in the training set contains one target value such as class label and several attributes (the features or observed variable). The goal of the classification method is to produce a model based on training data which predicts the target values of the test data.

Before the data is being used for training, scaling process needs to be done. The aim of the scaling process is to avoid attributes in greater numeric range dominating those in smaller numeric range. It also avoids numerical difficulties during calculation - kernel values usually depend on the inner products of feature vectors; large attribute values might cause numerical problems. So scaling of attribute to range [-1, +1] or [0.1] needs to be done. This scaling process needs to be done on both training and testing by using the same method [12].

2.2 Type of Classification Method Used

The classification method is another main part of the e-nose. Its function is to identify and distinguish types of gas to determine the quality of food. For now, the most popular algorithm that is used in e-nose is backpropagation algorithm (BP) – one of the artificial neural network (ANN) algorithm. It is used to determine gas contained in a few sample of teas and coffees. ANN's ability to classify odour has been proved by combining ANN algorithm with General algorithm (GA) to improve the selectivity of the gas sensor arrays which has been tested on decayed and fresh meat and fish [7].

There are several weaknesses of backpropagation. The main weakness of this ANN algorithm is its learning time is very slow. Even on simple benchmark problems, a BP network may require thousands of epochs to learn the desired behaviour from examples. The two major problems that contribute to the slowness of BP are step-size problem and the moving target problem. There may, of course, be other contributing factors that we have not yet identified [8]. So to overcome this weakness, Support Vector Machine (SVM) is proposed in food freshness detection using e-nose.

SVM is a machine learning method developed based on statistical learning theory. The SVM classification method needs to solve quadratic programming problem repeatedly, so training time complexity and space complexity are O(n3) and O(n2), where n represents number of training samples. Reducing overall training set size can effectively improve training efficiency. With support for the training set vector machine, support vector only valid sample, before training the classifier, support vector extract can effectively improve the time and space efficiency [13]. Only by using this method, SVM can be fast and good enough to be used as classification method.

3. Research Development

3.1 Hardware and software development

In this project, the e-nose needs to be constructed based on certain sensors. The sensors needs to be relevant to the gases produced by chicken meat. The examples of hardware needed in construction of e-nose in this research are voltage regulator, liquid crystal display (LCD), printed circuit board (PCB) and a number of sensors. Voltage regulator is one of the most common electronic components needed for the sensor as it includes supply of 5V for sensors. LCD is needed for display purposes so that value of gases and freshness determination can be displayed for user's reference.

3.1.1 Sensor

Three types of sensor which are MQ4, MQ135 and MG811 have been selected, as these sensors are able to detect gases emitted by chicken, i.e. carbon dioxide, methane and ammonia.

The sensitivity of the sensor is defined by the connection among the gas application changes and sensor resistance changes. This connection is created on algorithmic function. The sensitivity of the sensors are exposed in Figure 1. In this figure, the sensor resistance values (Rs) remain normalized allowing to the sensor resistance conditions (Ro) for each model, and the Y-axis is indicated as sensor resistance ratio: Rs/Ro. In total, the specific sensor represents typical characteristics.

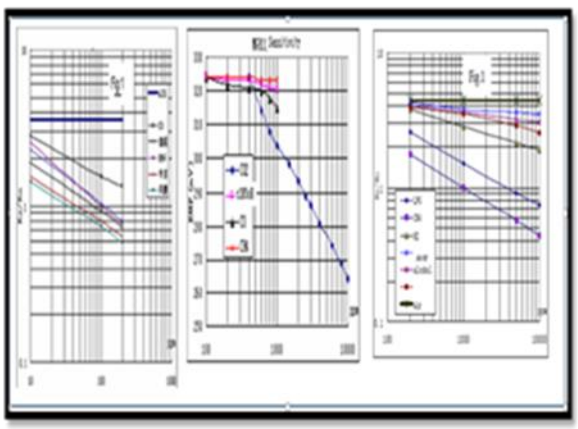

Figure 1. Sensitivity Characteristics of sensor MQ 135, MG811 and MQ4.

3.1.2 Arduino Deumilanove Board

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is an open-source circuit board with a microprocessor and input/output (I/O) pins for communication and controlling physical objects (LED, servos, buttons, etc.). The board will typically be powered via USB or an external power supply which in turn allows it to power other hardware and sensors.

In this project, we are using Arduino Deumilanove. The Arduino Deumilanove is a microcontroller board based on the ATmega328. All the sensors are combined and controlled by using Arduino board.

3.2 Device Testing

The constructed e-nose device in this project have been tested for its functionality. The sensors can react with present gases that are emitted from the chicken.

4. Implementation

4.1 Data Input Analysis for MQ-4

To be able to use the SVM classification method, a set of input data needs to be determined. In this project, hardware has given the data read from the sensors MQ-4, MQ-135 and MG-811. From the data, three sets of inputs or features will be recorded. The data is given by testing two classes of poultry freshness which are Fresh poultry and Rotten poultry. Each of the freshness is tested by comparing their condition.

Table 1 below shows the data for poultry testing for sensor MQ4. The maximum value for the test is 3.85 while the minimum value is 0.35. From the table, the voltage of sensor MQ-4 varies by the freshness of the meat. The fresher the meat, the lower the voltage will be. The more rotten the meat, the higher voltage will be detected by the sensors.

Table 1. Data of Poultry for sensor MQ-4

MQ-4 SENSOR				
NO	TIME TAKEN	DAY 1	DAY 2	DAY 3
1	1.00 PM	0.35	1.01	3.66
2	2.00 PM	0.35	1.01	3.67
3	3.00 PM	0.35	1.03	3.71
4	4.00 PM	0.35	1.03	3.77
5	5.00 PM	0.35	1.06	3.78
6	6.00 PM	0.35	1.07	3.77
7	7.00 PM	0.46	1.19	3.76
8	8.00 PM	0.46	1.26	3.78
9	9.00 PM	0.46	1.36	3.79
10	10.00 PM	0.54	1.43	3.79
11	11.00 PM	0.76	1.48	3.81
12	12.00 AM	0.78	1.5	3.75
13	1.00 AM	0.78	1.67	3.74
14	2.00 AM	0.93	1.73	3.74
15	3.00 AM	0.93	1.79	3.76
16	4.00 AM	0.93	1.93	3.78
17	5.00 AM	0.93	2.05	3.81
18	6.00 AM	0.95	2.36	3.81
19	7.00 AM	0.95	2.79	3.78
20	8.00 AM	0.95	2.83	3.82
21	9.00 AM	0.95	2.86	3.85
22	10.00 AM	0.98	2.96	3.86
23	11.00 AM	0.98	3.2	3.86
24	12.00 PM	0.99	3.56	3.85
MINIMUM VALUE		0.35	1.01	3.66
MAXIMUM VALUE		0.99	3.56	3.85

4.2 Data Input Analysis for MQ-135

Table 2 below shows the data for Poultry testing for sensor MQ-135. The maximum value for the test is 1.70 while the minimum value is 0.26. From the table, the voltage of sensor MQ-135 varies by the freshness of the meat. The fresh meat will have lower voltage detected from the sensor while the rotten meat will have high voltage detected from sensor.

Table 2. Data of Poultry for sensor MQ-135

MQ-135				
c	TIME TAKEN	DAY 1	DAY 2	DAY 3
1	1.00 PM	0.26	0.52	0.81
2	2.00 PM	0.28	0.53	0.83
3	3.00 PM	0.28	0.54	0.83
4	4.00 PM	0.29	0.54	1.0
5	5.00 PM	0.3	0.55	1.21
6	6.00 PM	0.32	0.56	1.25
7	7.00 PM	0.33	0.57	1.31
8	8.00 PM	0.34	0.58	1.32
9	9.00 PM	0.36	0.59	1.34
10	10.00 PM	0.38	0.6	1.36
11	11.00 PM	0.39	0.61	1.37
12	12.00 AM	0.41	0.63	1.44
13	1.00 AM	0.42	0.64	1.50
14	2.00 AM	0.43	0.65	1.52
15	3.00 AM	0.44	0.66	1.54
16	4.00 AM	0.46	0.67	1.55
17	5.00 AM	0.47	0.68	1.57
18	6.00 AM	0.48	0.7	1.57
19	7.00 AM	0.49	0.72	1.59
20	8.00 AM	0.49	0.73	1.63
21	9.00 AM	0.5	0.74	1.66
22	10.00 AM	0.5	0.76	1.70
23	11.00 AM	0.51	0.77	1.70
24	12.00 PM	0.51	0.88	1.70
MINIMUM VALUE		0.26	0.52	0.81
MAXIMUM VALUE		0.51	0.88	1.70

4.3 Data Input Analysis for MG-811

Table 3 below shows the data for Poultry testing for sensor MG-811. The maximum value for Poultry is 1.55 volt while the minimum value is 0.23 volt. From the table, the voltage of sensor MG-811varies by the freshness of the meat. The fresh meat will have lower voltage detected from the sensor while the rotten meat will have higher voltage detected from sensor.

Table 3. Data of Poultry for sensor MG-811

MG-811				
NO	TIME TAKEN	DAY 1	DAY 2	DAY 3
1	1.00 PM	0.23	0.29	1.43
2	2.00 PM	0.23	0.29	1.44
3	3.00 PM	0.23	0.29	1.44
4	4.00 PM	0.23	0.29	1.44
5	5.00 PM	0.23	0.29	1.45
6	6.00 PM	0.24	0.29	1.44
7	7.00 PM	0.24	0.29	1.43
8	8.00 PM	0.24	0.31	1.44
9	9.00 PM	0.24	0.31	1.45
10	10.00 PM	0.26	0.31	1.45
11	11.00 PM	0.26	0.31	1.45
12	12.00 AM	0.26	0.31	1.47
13	1.00 AM	0.26	0.31	1.47
14	2.00 AM	0.26	0.31	1.45
15	3.00 AM	0.26	0.31	1.44
16	4.00 AM	0.26	0.33	1.44
17	5.00 AM	0.27	0.4	1.44
18	6.00 AM	0.27	0.43	1.45
19	7.00 AM	0.27	0.48	1.46
20	8.00 AM	0.27	0.76	1.47
21	9.00 AM	0.27	0.78	1.48
22	10.00 AM	0.28	1.03	1.55
23	11.00 AM	0.28	1.23	1.55
24	12.00 PM	0.29	1.33	1.55
MINIMUM VALUE		0.23	0.29	1.43
MAXIMUM VALUE		0.29	1.33	1.55

4.4 Data Collection

All the data recorded in SVM data file is in numerical form. The reading of all the sensors is combined in a file by using notepad. In figure 2, it shows a sample of data detected by the gas sensors.

Figure 2. Example of display showed by the e-nose.

4.5 SVM Data Creation

To use SVM classification method, a special file needed to be made. In this project, there will be 2 classes which is fresh and rotten and each class is represented by 0 and 1 respectively. The '1:', '2:' and '3:' in subsequent column are representing the chemical compound found in the gases. The '1:' will represent methane which is a reading from MQ4, '2:' represents ammonia which will be detected by MQ135 and '3:' represents carbon dioxide which will be detected by MG811.

1) Training Data File

Figure 3 shows the screen capture of some of the data needed to be trained.

```
data.train - Notepad
File Edit Format View Help
0 1:0.35 2:0.33 3:0.24
0 1:0.46 2:0.34 3:0.26
0 1:0.46 2:0.36 3:0.26
0 1:0.46 2:0.38 3:0.26
0 1:0.54 2:0.39 3:0.25
0 1:0.76 2:0.41 3:0.27
0 1:0.78 2:0.42 3:0.27
0 1:0.78 2:0.43 3:0.27
0 1:0.93 2:0.44 3:0.27
0 1:0.93 2:0.46 3:0.28
0 1:0.93 2:0.47 3:0.28
0 1:0.95 2:0.48 3:0.28
0 1:0.95 2:0.49 3:0.28
0 1:0.95 2:0.49 3:0.29
0 1:0.95 2:0.50 3:0.29
0 1:0.98 2:0.50 3:0.30
0 1:0.98 2:0.51 3:0.29
0 1:0.99 2:0.51 3:0.30
0 1:1.01 2:0.52 3:0.30
0 1:1.01 2:0.53 3:0.31
0 1:1.03 2:0.54 3:0.31
0 1:1.03 2:0.54 3:0.32
0 1:1.06 2:0.55 3:0.31
0 1:1.07 2:0.56 3:0.32
0 1:1.19 2:0.57 3:0.33
0 1:1.26 2:0.58 3:0.35
0 1:1.36 2:0.59 3:0.34
0 1:1.43 2:0.60 3:0.37
0 1:1.48 2:0.61 3:0.36
0 1:1.50 2:0.63 3:0.38
0 1:1.67 2:0.64 3:0.38
0 1:1.73 2:0.65 3:0.40
0 1:1.79 2:0.66 3:0.41
0 1:1.93 2:0.67 3:0.43
1 1:2.05 2:0.68 3:0.46
1 1:2.36 2:0.70 3:0.47
1 1:2.79 2:0.72 3:0.48
```

Figure 3. Some of the data that is used to for the training purposes.

2) Test Data File

For the purpose of prediction, the test data file is created. After the SVM is trained, the SVM will go through all the data in this file and classify them into classes which are fresh and rotten(0 or 1) based on the SVM model that has been created during training phase. After finish processing all the data, svm-predict.exe will give the accuracy rate of its classification. Figure 4 shows the screen capture of some portion of the data in test data file.

```
data.test - Notepad
File  Edit  Format  View  Help
0 1:0.33 2:0.26 3:0.24
0 1:0.35 2:0.30 3:0.25
0 1:0.40 2:0.34 3:0.23
0 1:0.35 2:0.29 3:0.24
0 1:0.54 2:0.39 3:0.25
0 1:0.77 2:0.45 3:0.26
0 1:0.95 2:0.46 3:0.25
0 1:1.00 2:0.56 3:0.31
0 1:1.26 2:0.55 3:0.30
0 1:1.19 2:0.55 3:0.33
0 1:1.55 2:0.66 3:0.40
0 1:1.65 2:0.60 3:0.40
0 1:1.77 2:0.63 3:0.39
0 1:1.90 2:0.65 3:0.38
0 1:1.86 2:0.59 3:0.48
1 1:2.06 2:0.68 3:0.44
1 1:2.66 2:0.70 3:0.48
1 1:2.86 2:0.77 3:0.53
1 1:2.94 2:0.76 3:0.50
1 1:2.98 2:0.76 3:0.55
1 1:3.09 2:0.71 3:0.49
1 1:3.19 2:0.77 3:0.55
1 1:3.35 2:0.80 3:0.60
1 1:3.42 2:0.82 3:0.63
1 1:3.50 2:0.84 3:0.55
1 1:3.70 2:0.88 3:0.60
1 1:3.79 2:0.98 3:0.79
1 1:3.84 2:1.54 3:1.40
1 1:3.85 2:1.50 3:1.39
1 1:3.88 2:1.63 3:1.51
```

Figure 4. Data in Test data file

3) Scaling the Training and Test Data File

Scaling is the process to change a large range of number into a smaller range number. The idea behind this is to make the usage of memory lesser and make the mathematical calculation less complex. In this project the lower boundary of data is set to 0 and upper boundary is 1. Figure 5 below shows the scaling process towards train data file and test data file by using svm-scale.exe program. Table 5 shows the difference between normal trained data and scaled data.

```
Select C:\WINDOWS\system32\cmd.exe
Microsoft Windows [Version 10.0.16299.192]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\Syahin Ahmad>cd C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows

C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows>svm-scale.exe -l 0 -u 1 -s range
data.train>data.train.scale

C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows>svm-scale.exe -r range data.test>
data.test.scale

C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows>
```

Figure 5. The scaling process being done to train and test data file.

Table 5. Difference between normal trained data and scaled data

Train Data File Before Scaling	Train Data File After Being Scale
0 1:1.01 2:0.53 3:0.31	0 1:0.188034 2:0.195652 3:0.0606061
0 1:1.03 2:0.54 3:0.31	0 1:0.193732 2:0.202899 3:0.0606061
0 1:1.03 2:0.54 3:0.32	0 1:0.193732 2:0.202899 3:0.0681818
0 1:1.06 2:0.55 3:0.31	0 1:0.202279 2:0.210145 3:0.0606061
0 1:1.07 2:0.56 3:0.32	0 1:0.205128 2:0.217391 3:0.0681818
0 1:1.19 2:0.57 3:0.33	0 1:0.239316 2:0.224638 3:0.0757576
0 1:1.26 2:0.58 3:0.35	0 1:0.259259 2:0.231884 3:0.0909091
0 1:1.36 2:0.59 3:0.34	0 1:0.287749 2:0.23913 3:0.0833333
0 1:1.43 2:0.60 3:0.37	0 1:0.307692 2:0.246377 3:0.106061
0 1:1.48 2:0.61 3:0.36	0 1:0.321937 2:0.253623 3:0.0984848
0 1:1.50 2:0.63 3:0.38	0 1:0.327635 2:0.268116 3:0.113636
0 1:1.67 2:0.64 3:0.38	0 1:0.376068 2:0.275362 3:0.113636
0 1:1.73 2:0.65 3:0.40	0 1:0.393162 2:0.282609 3:0.128788
0 1:1.79 2:0.66 3:0.41	0 1:0.410256 2:0.289855 3:0.136364
0 1:1.93 2:0.67 3:0.43	0 1:0.450142 2:0.297101 3:0.151515
1 1:2.05 2:0.68 3:0.46	1 1:0.48433 2:0.304348 3:0.174242
1 1:2.36 2:0.70 3:0.47	1 1:0.57265 2:0.318841 3:0.181818
1 1:2.79 2:0.72 3:0.48	1 1:0.695157 2:0.333333 3:0.189394
1 1:2.83 2:0.73 3:0.50	1 1:0.706553 2:0.34058 3:0.204545

4) Training Process by using svm-training.exe

SVM needs to be trained before it can classify the data into their specific classes. In Figure 6, it shows command to train the SVM by using scaled train data file. For training, radial basis function (RBF) kernel is used by using 1 as its c and 0.33 as its gamma. After training process is done, a SVM model is produced. This model will be referred by the SVM to do classification. Figure 7 shows data found in model produced after training process being done.

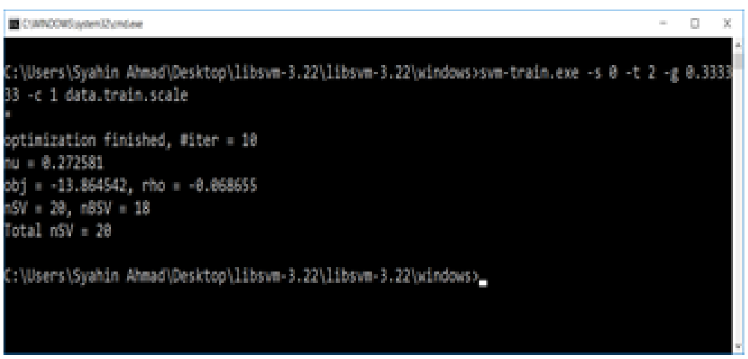

Figure 6. The training process is being done by using command prompt, svm-train.exe program and scaled train data file.

```
svm_type c_svc
kernel_type rbf
gamma 0.333333
nr_class 2
total_sv 20
rho -0.0686554
label 0 1
nr_sv 10 10
SV
0.8129329063457934 1:0.239316 2:0.224638 3:0.0757576
1 1:0.259259 2:0.231884 3:0.0909091
1 1:0.287749 2:0.23913 3:0.0833333
1 1:0.307692 2:0.246377 3:0.106061
1 1:0.321937 2:0.253623 3:0.0984848
1 1:0.327635 2:0.268116 3:0.113636
1 1:0.376068 2:0.275362 3:0.113636
1 1:0.393162 2:0.282609 3:0.128788
1 1:0.410256 2:0.289855 3:0.136364
1 1:0.450142 2:0.297101 3:0.151515
-1 1:0.48433 2:0.304348 3:0.174242
-1 1:0.57265 2:0.318841 3:0.181818
-1 1:0.695157 2:0.333333 3:0.189394
-1 1:0.706553 2:0.34058 3:0.204545
-1 1:0.7151 2:0.347826 3:0.204545
-1 1:0.74359 2:0.362319 3:0.227273
-1 1:0.811966 2:0.369565 3:0.242424
-1 1:0.91453 2:0.427536 3:0.242424
-1 1:0.94302 2:0.398551 3:0.265152
-0.8129329063457934 1:0.945869 2:0.413043 3:0.272727
```

Figure 7. Data found in model produced after training process being done.

5) Predict Process

After SVM has been trained, it is ready to do prediction. In this prediction phase, the SVM will show its percentage of probability of its accuracy on classifying the data in test data file. Figure 8 below shows the prediction process being done by using svm-predict.exe in command prompt.

```
C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows>svm-predict.exe data.test.scale d
ata.train.scale.model data.txt
Accuracy = 96.6667% (29/30) (classification)

C:\Users\Syahin Ahmad\Desktop\libsvm-3.22\libsvm-3.22\windows>
```

Figure 8. Prediction or testing phase is been done.

4.6 Hardware Overview

All the testing process will not be accomplished if there is no hardware to read all the data. Figure 9 shows overview of the e-nose box.

Figure 9. Assembly component except Arduino.

5. Result and Discussion

The accuracy percentage of this project is 96.6667%. SVM is good enough to classify the chicken, meat, fish or any food that release the same three chemical compounds as in this project. This accuracy percentage is obtained from the total correctness of the data in the test file and how many data can be classified by the SVM based on the model produce after training process is being done. In Figure 10, it shows the accuracy of SVM classifying the classes of poultry.

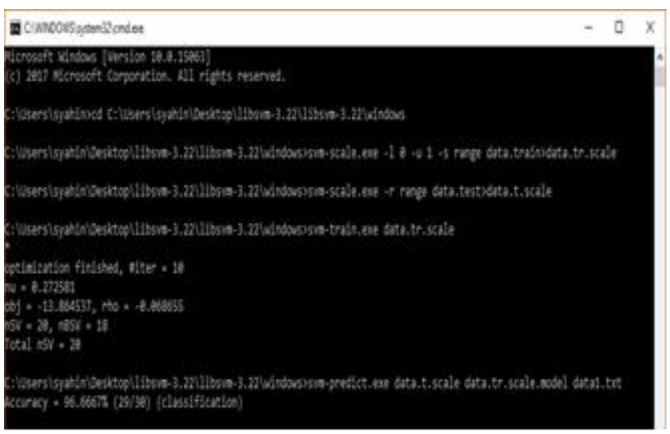

Figure 10. The final result of the research.

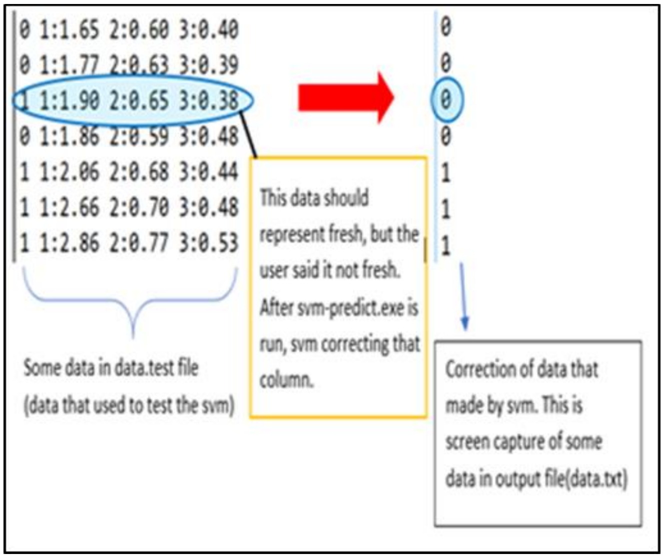

Figure 11. Some of prediction made by SVM towards every row of data in test data file (0 represents fresh and 1 represents rotten)

Figure 11 shows the test data file (data test) and the output file after svm-predict.exe is executed. There is a line that shows the incorrect condition of the food. The collection of gases show that the poultry is still fresh, but the data is recorded as rotten. By using the model that has been produced during the training phase, SVM predicted and changed the data from 1 to 0 (from rotten to fresh) which is the correct state of the food (poultry).

6. Conclusion

The research achieved its objective to progress a prototype based electronic nose to evaluate the possibility of using gases sensor to detect odour. It is an important strategy to build a device including hardware and software that is able to help human to detect a very low level of smell, which can help keep us safe and healthy. This research presents on the design of an Electronic Nose system by using three gas sensors. The development of SVM based electronic nose has been tested to confirm its repeatability, reproducibility and discriminative ability which are significant characteristics of an analytical instrument. Measurements on three gas sensors frequently produced similar patterns with high correlation for the same odour and produced different patterns with lower correlation for different odour accordingly, confirming its repeatability characteristics by using SVM. SVM allows the classification to get optimum result. The developed electronic nose also produces repeatable reactions in the measurement of three odour using different sensor batches, hence confirming its reproducibility characteristics. The developed electronic nose is also able to produce different patterns for different samples. Based on the results, it is decided that the developed electronic nose is a reliable analytical instrument.

For the future development of this research, the ventilation in box used for testing should be considered. All the odour must be cleared up so that the gases from the previous sample will not be mixed up with the new sample. This can increase the accuracy reading of the chemical compound in the gas. After comparing the result of this research with the other researches done previously, It shows this research have more features (in this research's scope; chemical compound produced by the chicken that has been released to the air) and data reading collected to be trained. The higher the number of features and data collected, the higher the precision value you will get during the prediction or test phase. The increase of features also must be paired with the minimalized of class to increase the accuracy when using the SVM.

7. Acknowledgement

This project is funded by FRGS 2018010 1FRGS. Thank you to the Ministry of Education (MOE for the financial supports through FRGS.

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