

# Comparison Analysis of Data Groupings of Fluctuation Patterns based on the Amplitude Representation Value (ARV)

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**Abstract**— In this study, we developed an analysis of the data grouping application based on the amplitude representation values (ARV). We use MSCS (multi spectral capacitive sensor) to facilitate the data acquisition process. Furthermore, we compared the 3 objects study in the initial process, such as: H<sub>2</sub>O, H<sub>2</sub>O mixed with NaOH and H<sub>2</sub>O mixed HCl. Here, we apply the quite new method of Tamsir statistical transformation (TST) approach for data processing, which produces 3 fluctuation patterns for each material, namely: MF (Mean Fluctuation), HF (High Fluctuation) and HHF (High High Fluctuation). In the next step, we use the data grouping method at a later stage with the approach of the ARV that are close together at the data processing stage. Hereafter, at the analysis stage, we try to compare the three patterns of fluctuations with several numbers of data sets based on the ARV. Whereas, the results show the value of a small ARV that is found in the 100 data set for each object. While the large ARV value is in the grouping of 200 data set on each object. Hence, we expect this study to be a potential fluctuations reference condition of the material based on the data grouping.

**Keywords**— *Fluctuation pattern; Data Set; Amplitude Representative Value.*

## I. INTRODUCTION

In the result analysis of the data acquisition process, data clustering is one of the steps that need to be done. This occurs because by grouping the data, then the analysis of the results obtained from a study will be more easily understood and compared. Moreover, the results can be analyzed more advanced so that it can get the sophisticated results.

Amplitude value is one of the results placed at a point with a certain value. It has been widely used by researchers to know the state of the data processing. One example is the signal representation can apply the amplitude sampling technique on the frequency domain [1].

There are several studies that have been done by scholars who use the results of the amplitude value for analyzing. For instance, the noise prediction from the sine wave, which was the amplitude after processing the quantization and it used the normal distribution technique. This technique has been proven

to eliminate the bias by applying the LSE (Least Squares Estimator) application [2]. The use of the sine wave amplitude estimations in some measurement implementations was also used as an experimental ADC (Analog to Digital Converter) [3]-[4], and also obtained the characteristics result of a digitizer [5].

Furthermore, this amplitude estimation technique was once used in the analytical measurement of the impedance results at low frequency [6]. Subsequent research shows a detection system on RF Signal measurements at low frequencies to see the amplitude and phase accuracy. Thus, it produced an expectation value with some frequency ranges [7].

This study is a data analysis development from the previous study, which has successfully classified data from fluctuation pattern using H<sub>2</sub>O and H<sub>2</sub>O mixed with NaOH [8]. Therefore, in this study, we compare several ingredients other than the previous ingredients by still using H<sub>2</sub>O as the basis, namely H<sub>2</sub>O mixed with HCl. Both materials have different properties, where NaOH is alkaline, while HCl is acidic. The thing that is quite different from the previous study on the data grouping is that the previous study used the statistical parameters such as the mean value for analyzing [8].

The data grouping employs a new approach method by applying the amplitude representation value (ARV). Also, it used the output data from MSCS (multi spectral capacitive sensors) and applied several statistical analysis parameters from data groupings such as mean value and standard deviation value [9]. Also, the use of MSCS in the data acquisition process had also been used on several previous studies [9] [10] [11]. After going through some pre-processing process of data, then the data processing applied the new approach of transformation statistical Tamsir (TST) [10]. Moreover, the next step is to group the results in several fluctuation patterns, i.e: MF (Mean Fluctuation), HF (High Fluctuation) and HHF (High High Fluctuation).

The analysis process uses an amplitude representation value that can be used to represent a value from a data set (DS). Here, one data set has a lot of data, so it takes a value that symbolizes the amount of data. Data set grouping can be done by seeking

to adjacent the ARV, and then grouped them manually. The aim of this study is to create the useful of the data groupings for analyzing the characteristics of the ingredients and also to see the consistency level. These conditions will be obtained from several comparisons of the several fluctuations results.

This study consists of backgrounds, followed by contributions earned. Then, it shows the experimental data used as the proposed object and method for analyzing the results. The next section shows the results and analysis of the study, then it reveals a conclusion of some essential points after being analyzed.

## II. DATA AND METHODOLOGY

### A. Data Collection

As aforementioned before, this study is a development of the previous research [8]. But, the object in this study is not only focused on H<sub>2</sub>O material alone, but there are two other ingredients that are mixed by a chemical process that are: H<sub>2</sub>O mixed with NaOH and H<sub>2</sub>O mixed HCl. We have tested and mixed the three ingredients in the chemistry laboratory of the Chemical Engineering Department of the Universitas Indonesia to obtain results that are in accordance with the standards. For the data acquisition process, we use MSCS (multi spectral capacitive sensor), which had previously been applied by previous research [9].

After going through some process of preprocessing data, then data processing apply the new method approach of TST [10]. So, in this study, we obtain some results that are divided into several types of fluctuation patterns, namely: Mean Fluctuation (MF), High Fluctuation (HF) and High High Fluctuation (HHF). Here, we also implement the pre-processing procedure that refers to a study done by previous researchers [10]. For each material used, we obtain 600 sets of data for each one and the data processing will be presented next.

### B. Method Proposed

This study uses several approaches to analyze the data obtained. The method has been applied earlier in the study [8]. For more details, the following fig.1 illustrates the scheme of the analysis method proposed in this study.

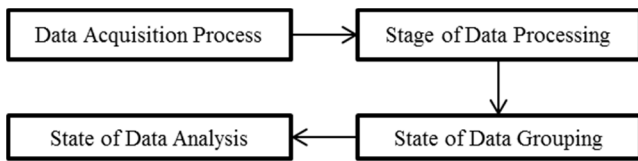


Fig 1. Analysis Method Proposed

#### 1). Data Acquisition Process

The data acquisition process in this study uses MSCS which refers to the study [9]. The MSCS mechanism is a tool that we build to detect changes in a material at a molecular scale and has referred to previous studies [9]. This sensor works based on the principle of impedance spectroscopy, so it

has properties not to damage the molecule / material detected. For more details, the MSCS architecture can be seen in fig. 2 as follows:

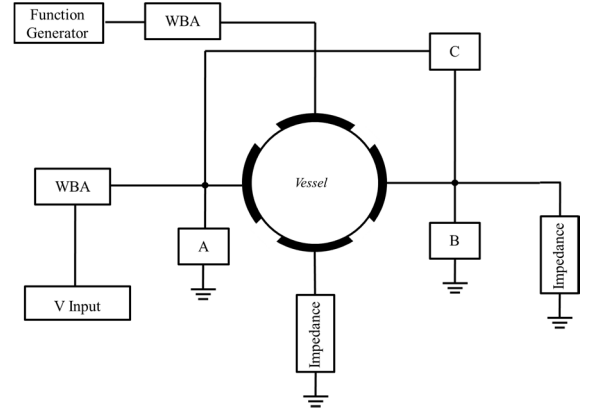


Fig 2. Setting of MSCS (multi spectral capacitive sensor) [9].

Also, the process of retrieving and storing data is controlled by a PC. Here, the output is grouped into the data sets with the amount of data for each material that are 600 data sets.

#### 2). Stage of Data Processing

The data processing process uses the TST approach method, which is divided into several stages as follows [10]:

##### a). Stage-1

In this stage, each data set (DS) is searched for the average value ( $\mu$ ) and standard deviation ( $\sigma$ ) at each tested frequency point, and then the data will be stored with a result known as the fluctuation pattern:

$$MF = \mu \quad (1)$$

$$HF = \mu \cdot \sigma \quad (2)$$

MF (mean fluctuation) describes the average voltage fluctuations read by the sensor. HF (High Fluctuation) is the result of MF multiplied by the standard deviation. Thus, the objective is to be able to see more clearly the change of fluctuation point.

##### b). Stage-2

Furthermore, we do stage-2 after stage-1. The average value of multiplied HF is multiplied by the standard deviation which shows a more significant fluctuation value and the formula of the HHF (High High Fluctuation) pattern as follows:

$$HHF = \mu_{(HF)} \cdot \sigma_{(HF)} \quad (3)$$

The results of the three patterns of MF, HF and HHF fluctuations are in the form of matrix contained in the folder for each DS.

#### 3). State of Data Grouping

In this study, we collect 600 DS for H<sub>2</sub>O, 600 DS for H<sub>2</sub>O mixed with NaOH and 300 DS for H<sub>2</sub>O mixed with HCl. For H<sub>2</sub>O mixed with HCl, we just can collect around 300 data set because the experiment have not completed yet. Stages of the

data grouping process are done by referring to previous research [8]. As known, the ARV is used to represent a value in one DS. This is really fruitful to facilitate the analysis and the grouping of the data set [8].

$$ARV1 = \frac{1}{m \cdot n} \sum_{i=1}^m \sum_{j=1}^n A_{ij} \quad (4)$$

$$ARV2 = \frac{\sum_{i=1}^m \sum_{j=1}^n A_{ij} \cdot f_i \cdot f_j}{\sum_{i=1}^m \sum_{j=1}^n 1 \cdot f_i \cdot f_j} \quad (5)$$

$$ARV = ARV1 \cdot ARV2 \quad (6)$$

Where :

A : Amplitude value

m : Matrix m (8192)

n : Matrix n (31)

$f_i$  : Frequency for m

$f_j$  : Frequency for n

Based on (4), ARV1 is a representation of the fluctuating amplitude graph without involving the frequency in it. Whereas ARV2 on (5), besides involving amplitude, it also enters the frequency for each matrix that will form a fluctuating graph.

Then, we plot the ARV of the 600 DS and also apply to all objects in this study. The next step is to divide the graph into several groupings that start from the division per-100 DS, 150-DS, 200-DS and 300-DS. The purpose of this grouping is to see how much data is needed so that it can get a representation pattern of objects without requiring too many data.

Furthermore, fig. 3 shows the ARV result from the previous study [8]. Figure 3 shows the ARV of H<sub>2</sub>O that is started from the first data set to the 600 data set. Based on the ARV obtained by applying (6), we get ARV results from a range of value from 30 to less than 40. The phenomenon shown in the fig. 3 is also not so smooth but rather slightly up and down on the 500 to 600 of data set.

#### 4). Stage of Data Analysis

The analysis focus on this study is to analyze how the consistency level of a material by using approach of the ARV. It is useful to know the pattern of a material and also to store as the database that we use to compare with other materials. The analysis uses a new TST method approach for the signal processing, and the result is a representation of the amplitude values for each data set, which is the difference value of each data grouping.

Furthermore, we perform the analysis of the output and make a group of the closer value together. Moreover, we try to compare the three types of fluctuation patterns: MF, HF and HHF. Then, they determine the fluctuation pattern and present how many data sets have the difference value that meets the standard. Thus, the smaller of the comparison value, the better result is obtained.

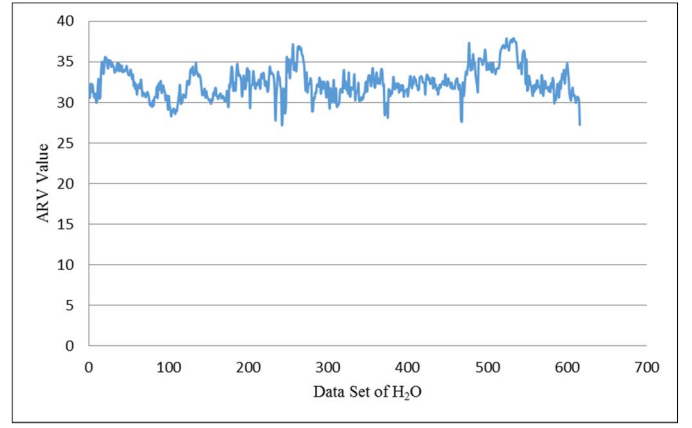


Fig 3. ARV value of H<sub>2</sub>O for 600 Data Set [8].

### III. RESULT AND DISCUSSION

This section discusses some of the results obtained by implementing the analytical step approach as described in the previous section. Furthermore, we analyze the three materials used by using the three fluctuation patterns of MF, HF and HHF. Here, we need to compare the three fluctuation patterns (MF, HF and HHF) because in a more advanced process we will be able to determine which fluctuation patterns are more potential to show the appearance of the material identification with desired reference of the ARV.

However, as previously explained, this study shows a comparison of the ARV application for fluctuations condition. The previous study classified the data grouping based on the amplitude value but only analyzed the mean value of each data group and was implemented on H<sub>2</sub>O mixed with NaOH [8].

#### A. Analysis Result of the ARV for H<sub>2</sub>O

In the H<sub>2</sub>O material, we conduct 600 DS trials and divide them into 4 distribution groups, which are grouping per 100 DSs by 6 groups, per 150 DSs by 4 groups, per 200 DS as many as 3 groups, and per -300 DS as much as 2 groups, as shown in the Tabel 1.

As presented in the Table 1, it can be seen that the values of ARV consist of 3 parts, namely: MF, HF and HHF, as previously explained in (1-3). Furthermore, in the comparison result of 100 DS, it appears that the smallest HHF values are in the second, third, fifth and sixth groupings. They have the smallest fluctuation comparison rate, which are 26.51, 70.30, 7.03 and 5.15, respectively. As explained before, the value of HHF is influenced by the standard deviation or the data variety. In addition, in the comparison result of 150 DS, the smallest HHF values are in the second and third groupings, which are 88.22 and 7.16. Here, we obtain the comparison results for both HHF ARV are quite greater that indicate the occurrences of fluctuation ratios are large.

Moving on to the result of 200 DS, we find the smallest HHF ARV in the second grouping, which is 1.50. However, in the first comparison, we obtain ARV of 125.49 and also ARV

around of 717.18. It means that we get quite large of ARV comparison in the third comparison. It can be said that this indicates the comparison of fluctuations that occurred in the third grouping is very large. Moreover, in the ARV comparison result of 300 DS, we gain the smallest HHF ARV is in the second grouping, which is 1.55.

TABLE 1. THE RESULT OF THE ARV FOR H<sub>2</sub>O

Type of Data Set Comparison	The Result of the ARV		
	MF	HF	HHF
100 DS-1	5.37	38.00	268.90
100 DS-2	2.51	42.64	26.51
100 DS-3	4.55	43.02	70.30
100 DS-4	5.89	38.86	629.38
100 DS-5	2.69	42.17	7.03
100 DS-6	3.71	44.41	5.15
150 DS-1	4.49	48.46	282.57
150 DS-2	4.14	52.91	88.22
150 DS-3	5.50	37.62	7.16
150 DS-4	5.26	48.79	172.81
200 DS-1	4.38	50.17	125.49
200 DS-2	6.17	47.03	1.50
200 DS-3	6.00	50.44	717.84
300 DS-1	5.58	53.68	401.18
300 DS-2	6.36	51.53	1.55

#### B. Analysis Result of the ARV for H<sub>2</sub>O mixed with NaOH

Obviously, we do the same trial with H<sub>2</sub>O for analysis result of the ARV for H<sub>2</sub>O mixed with NaOH. We obtain the 600 DS, which is divided into 4 distribution groups. We can find clearly the ARV result for this material in the Table 2.

As shown in Table 2, it can be seen that in the per-100 DS of the ARV comparison, the smallest HHF ARV are in the second, third, fifth and sixth groupings that are 9.78, 3.15, 28.44, and 28.00, respectively. Interestingly, in this grouping, we find the smaller comparison of ARV result compare to other grouping.

Turning to ratio of 150 DS, the smallest HHF values are in the third and fourth groupings, which are 6.06 and 17.85. Whereas, the occurrence of fluctuation of the ARV results are quite smaller in this group. Furthermore, in the comparison of ARV of 200 DS, we obtain the smallest value of HHF ARV is 104.28 in the second grouping. This indicates that the fluctuation comparison value tends to be large in this condition. Then, in the ARV result ratio of 300 DS, we gain

the smallest HHF ARV is in the first grouping, which is 3.36. It is noticeable to say that the occurrence result of fluctuation comparison value is quite smaller in this group.

TABLE 2. THE RESULT OF THE ARV FOR H<sub>2</sub>O MIXED WITH NaOH

Type of Data Set Comparison	The Result of the ARV		
	MF	HF	HHF
100 DS-1	5.84	54.49	264.02
100 DS-2	5.95	54.91	9.78
100 DS-3	2.84	53.07	3.15
100 DS-4	5.01	32.88	417.87
100 DS-5	2.55	53.95	28.44
100 DS-6	5.13	39.63	28.00
150 DS-1	5.43	57.53	126.10
150 DS-2	4.71	54.08	90.25
150 DS-3	2.67	53.89	6.06
150 DS-4	5.68	40.20	17.85
200 DS-1	6.28	62.77	643.82
200 DS-2	4.54	71.59	104.28
200 DS-3	5.77	5.77	329.87
300 DS-1	7.51	67.02	3.36
300 DS-2	5.77	54.94	323.27

#### C. Analysis Result of the ARV for H<sub>2</sub>O mixed HCl

There is something a bit different on the division of the group for the analysis results of the ARV for H<sub>2</sub>O mixed with HCl. The experiment was carried out by 300 DS, and then we divide into 4 distribution groups, which are: grouping per-100 DS by three groups, per 150 DS as much as two groups, per 200 DS as one group, and 300 DS by one group. We can see it clearly in the Tabel 3.

TABLE 3. THE RESULT OF THE ARV FOR H<sub>2</sub>O MIXED WITH HCL

Type of Data Set Comparison	The Result of the ARV		
	MF	HF	HHF
100 DS-1	5.97	40.01	15.70
100 DS-2	2.64	44.56	6.43
100 DS-3	4.53	39.18	9.39
150 DS-1	3.90	44.74	51.31
150 DS-2	4.60	53.30	298.95
200 DS-1	6.52	48.69	1.52
300 DS-1	7.19	56.43	3.06

As highlighted from Table 3, it can be seen that in the comparison value of ARV for 100 DS for all three groups, we obtain the HHF ARV results tend to be small, ie 15.70, 6.43, and 9.43, respectively. Significantly, the comparison of fluctuation condition tends to be small as well.

In addition, in the ARV result of 150 DS, we acquire the smallest HHF ARV in the first grouping, which amounted to 51.31, while in the second grouping, the comparison of fluctuations is greater, ie 298.95. Hereinafter, in the ARV comparison result of 200 DS and 300 DS, we receive quite small of the HHF ARV, which are 1.52 and 3.06. These two groupings exhibit a small fluctuation ratio.

#### IV. CONCLUSION

In this study, we have compared the ARV from the three object materials, namely: H<sub>2</sub>O, H<sub>2</sub>O mixed with NaOH and H<sub>2</sub>O mixed HCl. We conclude that based on the results analysis, the MF fluctuation pattern for all ingredients shows a small ARV for all the data set groups.

However, very volatile and large amounts of ARVs are shown in the HHF fluctuation pattern for all ingredients. It is noticeable to say that the HHF fluctuations pattern can display a significant fluctuation phenomenon of an ingredient because the results show a significant change for each material. Unlike the HF pattern, it only shows a value that is not so large and not so volatile as well.

Lastly, we can make the group as a reference or description of how the characteristic results of a material using this MSCS for the future work. So the development of sensor research results can be more widespread by trying more materials, and have more database characteristics of material.

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