

Wavelet Transformation Approach to Identify Several Fluctuation Patterns by Applying The Amplitude Representative Value Scheme

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Abstract— Our research is a development study of data grouping analysis based on the value of representative amplitude (ARV) with the implementation of the FFT transformation. Then, we use MSCS (Multi-Spectral Capacitive Sensor) to facilitate the data acquisition process. Furthermore, in this study, we also compared three research objects: H₂O, H₂O mixed with NaOH, and H₂O mixed HCl. Here, we propose a comparative analysis of ARVs using the Fourier transform in previous research with the wavelet transform method that we recommend. Preliminary research data using Fast Fourier Transform (FFT) has produced 3 (three) fluctuation patterns for each material, namely: MF (Mean Fluctuation), HF (High Fluctuation), and HHF (High High Fluctuation). However, in this study, we only used HF and HHF patterns. The next step we are working on is applying the data grouping method to the ARV approach close to the data processing stage. Every research object that we use will get every ARV value for each fluctuation pattern. Next, in the analysis phase, we compare two fluctuation models (HF and HHF) that apply Fourier and Wavelet transformations for several data sets. In the end, we hope that the results we get can be a reference whose changes have better ARV values to analyze fluctuation patterns to facilitate the process of identifying material characteristics later.

Keywords— Data Grouping, Representative Amplitude, Fluctuation pattern, data processing

I. INTRODUCTION

Amplitude value analysis studies have been conducted. One example is to determine the state of data processing that can represent a signal by applying amplitude sampling techniques in the frequency domain [1]

Many researchers previously used the results of the amplitude values to be analyzed. The following are some previous studies that used amplitude values for their analysis. Estimation of the amplitude of sine waves that have noise after quantification by applying a uniform distribution technique of the signal phase has been carried out by [2]. The results

showed that this technique could eliminate bias by using LSE (Least Square Estimator). Furthermore, a detection system for amplitude with high accuracy and phase measurements on RF signals has been carried out by Zheng [3]. Where the results obtained, indicate that the detection system can meet predetermined standards.

Research on the analysis of the amplitude value has also been carried out by Dong Y, by showing the amplitude of the microwave and phase measurements have been developed and built with the implementation of hardware logic algorithms [4]. Also, this amplitude estimation technique has been used in analytical analyses of the results of impedance at low frequencies [5]. Calculation of time variance and amplitude of SNR (Signal to noise ratio) has been shown in research conducted by [6] by comparing previous results.

Research on identifying patterns of fluctuation has been developed in recent years. Starting from the analysis of the level of consistency of fluctuation patterns with new increases [7] Then proceed with a review of the application of the segmentation method for fluctuation patterns, which can provide more detailed results for each segment of the pattern [8]. Also, the grouping of data from the effects of fluctuation patterns has been carried out using the output data from the MSCS (multi-spectral capacitive sensor) and applying some statistical analysis parameters from the grouping of data such as average values and standard deviation values [9].

Based on the previous results, we concluded that the value of the representative value of the amplitude (ARV) is a representation of the value of the Data Set (DS). Since 1 DS itself has a lot of data, we need a value that represents the amount of data. Thus, DS grouping can be done to determine ARV values, which are adjacent to each other, then grouped manually. This grouping is useful for analyzing the characteristics of materials to see the level of consistency [10].

Our study is a continuation of previous studies [10]. Here, the data approach method for fluctuation patterns has been carried out by applying the Fourier transform. Grouping is done on several data groups, namely, per 100 data, 200 data, and 300 data. The object of research used in previous studies

is H₂O, H₂O mixed with NaOH and H₂O mixed with HCl only, while the fluctuation pattern applied consists of three types, namely: MF (Mean Fluctuation), HF (High Fluctuation) and HHF (High High Fluctuation). The results obtained show a comparative analysis of ARV values for MF fluctuations for all materials with the smallest amount. Whereas the HHF pattern shows remarkable ARV results in big grouping data as well.

Based on the findings of this study, we strive to find new processes that can make a better contribution to classifying data from fluctuating material patterns. We propose to use the Fourier transform method in the process of processing signal fluctuations, and then the results will still apply the method of grouping data with ARVs. But the data we use here is higher than the previous research data. In addition, the fluctuation patterns used are only HF and HHF, which have large fluctuations. The hope is that it will make it easier to see the characteristic model of material fluctuation patterns by applying wavelet transforms.

Furthermore, based on the theory, wavelet transform has several advantages in the identification method, namely: (i). It can show more precise characteristics of fluctuation patterns, which show striking differences from the point and distribution of unique designs. (ii). It can reduce, suppress, and minimize noise results in fluctuations. Also, Wavelet transforms have been widely used in signal processing, which is the result of sensors, as has been investigated by Lee [11]. He uses the wavelet transform method to detect ceramic equipment, which is the result of sensors and get good results. Then, Wavelet is also implemented in damage monitoring equipment with a detection algorithm to produce a real-time monitoring system [12]

It can be added about the application of wavelet transforms to the processing of sensor results by several other researchers. Soung has used Fourier and wavelet transforms to measure signal pressure, which can prove that both of these methods are useful for analyzing fluctuating pressure signals [13]. Then, Jun applies the Modified Empirical Wavelet Transform (MEWT) method through data-based adaptive Fourier spectrum segments to get performance in signal composition [14]. In addition, Liang has developed an effective way to analyze the signal results from the echo test by combining the Fourier spectrum and the marginal wavelet spectrum to determine the peak of the echo signal [15]. The application of wavelet transform for signal processing turns out to be quite effective in processing the signal, which is the result of data acquisition of a tool, as has been done by [16], [17]. However, the object under study is an output signal from EEG signal processing.

The type of mother wavelet used in this study is type 1 coiflet. The use of wavelet coiflets for signal processing has been done before by several researchers, especially signal processing resulting from sensor data acquisition. In [18], non-stationary signals are analyzed using CWT and FFT to predict harmonic and inter harmonic states in the wrong and normal conditions. Then, Coiflet along with wavelet transform symlet is also used by [19] to remove noise from the partial discharge signal.

The study consisted of background, followed by contributions made. Then, the next part is the study of literature. The research method comprises of data used as research objects along with several parameters used and also

the proposed research method. The next section shows the results and analysis of this study and concludes with several important points after the analysis.

II. METHODOLOGY

A. Data Acquisition Process

This study uses several approaches to analyze the data that has been obtained. This method has been applied before in research [10]. For more details, Fig. 1 describes the schematic method of analysis proposed in this study.

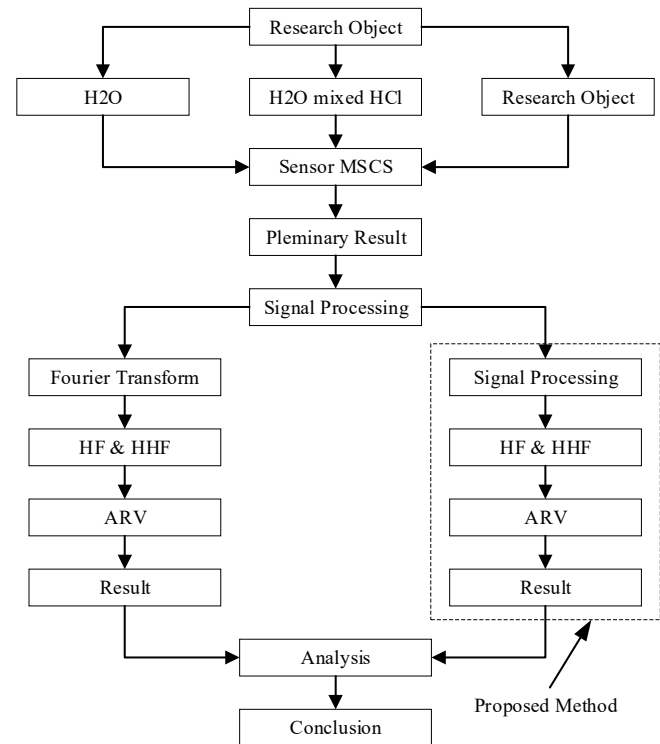


Fig. 1. Scheme of method proposed.

The data acquisition process in this study uses MSCS, which refers to research [20]. Multi-Spectral Capacitive Sensor (MSCS) is a sensor formed based on the concept of white noise impedance spectroscopy. The idea uses spectral frequencies or noise that approximates the frequency domain signal that results from the influence of the field on the dielectric. This sensor works based on the principle of impedance spectroscopy so that it has the property of not damaging the material or molecules detected [21].

Fig. 2 shows the MSCS work system used in previous studies and is a reference in this study. Based on Fig. 1, it can be seen that data processing is automatically done using Personal Computer (PC) using Matlab software to form 2D (dimensional) graphics. Based on the results of 2D graphics, changes in H₂O material can be investigated.

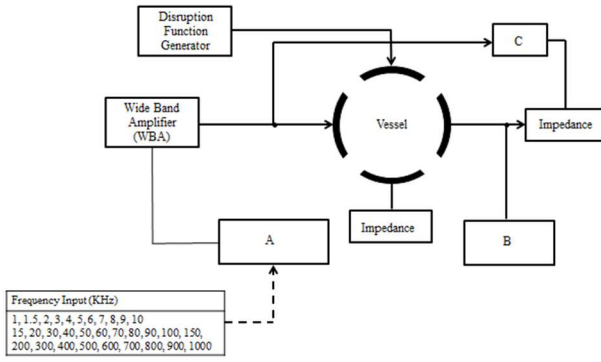


Fig. 2. Scheme of multi-spectral capacitive sensor (MSCS)[19].

In addition, the process of taking and storing data are controlled by a PC. Where output is grouped into data sets with the amount of data for each material, there are 600 data sets.

B. Signal Processing Stage

The signal processing stage refers to the proposed research method that we propose in Fig. 1. For more details, see Fig. 3.

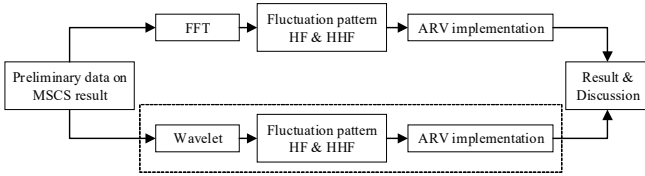


Fig. 3. Scheme of Signal Processing Stage.

As shown in Fig. 3, the first step we took was to obtain preliminary results from the data acquisition process with the MSCS system, as previously done [10]. But the number of data sets we got was not the same as before [10]. Furthermore, the data will be processed using a Fourier transform. As shown in Fig. 3, the dashed line section is the part that we propose, namely by applying wavelet transforms for processing fluctuation patterns.

Data processing using TST approach, which is divided into several stages, as follows [7]:

• First Stage

In this section, each Data Set (DS) looks for the average value (μ), and standard deviation (σ) at each frequency point tested, then the data becomes:

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

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

Here, we proposed to apply Wavelet coiflet Transform. So, the first stage are going to be the new MF and HF, which is as follow:

$$MF(WT) = \mu(WT) \quad (3)$$

$$HF(WT) = \mu \cdot \sigma(WT) \quad (4)$$

Equation (3) and (4) are the result of MF and HF fluctuation patterns by applying the Transform Wavelet coiflet.

• Second Stage

Pattern of HHF (High High Fluctuation) is obtained by employ the equation as follow:

$$HHF = \mu_{(HF)} \cdot \sigma_{(HF)} \quad (5)$$

The same thing is also done in the second stage by applying Wavelet coiflet transform based on equation (5), so that it gets:

$$HHF(WT) = \mu_{(HF)(WT)} \cdot \sigma_{(HF)(WT)} \quad (6)$$

Based on the results (6), the HHF results are obtained with the proposed method of the Transform Wavelet coiflet.

From Equation (1) to (3), then the data will be stored for each data set in the form of a matrix. Then, the process of grouping the data is done by referring to previous studies [10]. As is known, ARV is used to show the amplitude value in a data set. It is known to be very useful to facilitate the grouping and analysis of data sets [10].

$$ARV1 = \frac{1}{m \cdot n} \sum_{i=1}^m \sum_{j=1}^n A_{ij} \quad (7)$$

$$ARV2 = \frac{\sum_{i=1}^m \sum_{j=1}^n A_{ij} \cdot f_i \cdot f_j}{\sum_{i=1}^m \sum_{j=1}^n 1 \cdot f_i \cdot f_j} \quad (8)$$

$$ARV(Total) = ARV1 \cdot ARV2 \quad (9)$$

Where A is amplitude value, m is matrix m (8192), n is matrix n (31), f_i is frequency for m and f_j is frequency for n .

Based on equation (9), the same thing is also done for the method we propose, so we get the ARV equation with the implementation of the Transform Wavelet Coiflet, which is as follows:

$$ARV(Total)(WT) = ARV1(WT) \cdot ARV2(WT) \quad (10)$$

Then, we will plot each ARV value per unit of data set, and this applies to all objects in this study. The application of ARV is also carried out for signal processing using Fourier transform and wavelet transform. The purpose of this grouping is to see how much data is needed so that it can get an object representation pattern without requiring a lot of information [10]. ARV results will be carried out for the results of HF, and HHF fluctuation patterns with signal processing methods with Fourier and wavelet transforms.

• Stage of Data Analysis

In the analysis phase, we carried out a comparative analysis of the results of the application of ARVs for HF and HHF fluctuation patterns with two signal processing methods, namely: Fourier and Wavelet transforms. The results are shown in a comparison graph for each pattern of fluctuation. Fig. 4 is the initial results obtained for H₂O material.

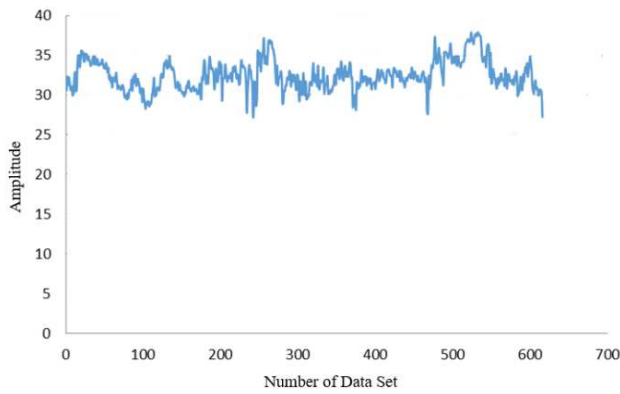


Fig. 4. The ARV Results of HF patterns of H_2O for all 600 data sets with FFT [10].

III. RESULTS AND DISCUSSION

This section will discuss some of the results that have been obtained by applying the stage analysis approach, as explained in the previous section. We analyzed three materials used (600 data sets of H_2O material, 600 data sets for H_2O material mixed with NaOH, and 300 data sets for H_2O material mixed with HCl). Data processing is performed using Matlab software.

The results obtained from the analysis of data grouping using Amplitude Representative Value (ARV) from Equation (8). Then, the results consist of several parts by applying the Fourier transform and Wavelet transformation, as shown in Fig. 3. Fluctuation patterns are used only in the HF and HHF patterns.

As shown, Fig. 5 is the Representative Value Result of H_2O Material for 600 Data Sets for (a) HF-Fourier patterns, (b) HHF-Fourier patterns, (c) HF-wavelet patterns, and (d) HHF-wave patterns. The trend of ARV results for this material is different for each of the fluctuation and processing transformation models used. For the Fourier transform method, with a data set of 600, the HHF ARV yield is not much higher than the HF pattern, which ranges from 30 to 35 for, whereas for HHF, ARV results range from 25 to 30. Different things are shown in processing with transformation Wavelet For HF results ranging from 14 to 18, while for HHF patterns, ARV results are far below. However, ARV results for the HHF pattern appear to be still slightly fluctuating but not as much as the HF pattern.

Then, Fig. 6 shows ARVs from H_2O material mixed with HCl for 600 Data Sets for (a) HF-Fourier Pattern, (b) HHF-Fourier Pattern, (c) HF-wavelet Pattern, and (d) HHF-wavelet patterns. The data set we got for this material is 300 data sets. The ARV results show a slightly similar trend in Fig. 5. However, the initial trend of ARV results rises somewhat sharper from point 25 to point 35 in the HF pattern with Fourier transforms. HF pattern for ARV results in Fig. 6 also has higher ARVs than all of them, as well as ARVs that use Wavelet transforms. The state of ARVs tends to fluctuate up to 300 data. However, for HHF patterns with Wavelet transforms, fluctuations are not very visible and have a fairly low ARV result, which is below 5.

Finally, Fig. 7 represents the results of representative values of H_2O material mixed with NaOH for 600 Data Sets for (a) HF-Fourier patterns, (b) HHF-Fourier patterns, (c) HF-wavelet patterns, and (d) HHF-Wavelet patterns. Trends in Fig. 7 almost resembles Fig. 6, with an increase in ARV values, which is much higher than Fig. 6. But the ARV results dropped slightly on the data to 300 and 600, which is about 30 ARVs. Then the results are seen rising back to point ARV 35 and showing ARV results, which fluctuate slightly until the data set becomes 600. Interesting things can be seen in the HHF pattern with Wavelet transforms, and ARV results are at point 0. This clearly shows that there is no fluctuating activity in this pattern.

Based on the three materials used in this study, several important points can be drawn. First, the trend of NRA results for the three ingredients has a similar pattern, especially for H_2O mixed with HCl and H_2O mixed with NaOH. Then, ARV that uses Wavelet transforms can reduce fluctuations compared to ARV results that use Fourier transforms. However, for processing fluctuations, HF patterns with Wavelet transforms are better used, because the HHF pattern has dramatically reduced the effects of ARV and the possibility of fluctuations is no longer the case.

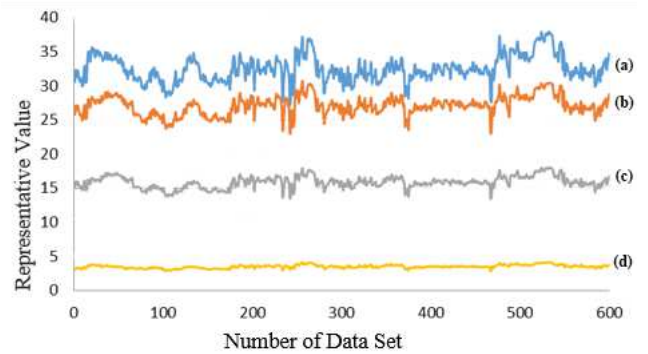


Fig. 5. The Results of ARV of H_2O Material for the 600 Data Sets for (a) HF-Fourier patterns, (b) HHF-Fourier patterns, (c) HF-wavelet patterns and (d) HHF-wavelet patterns.

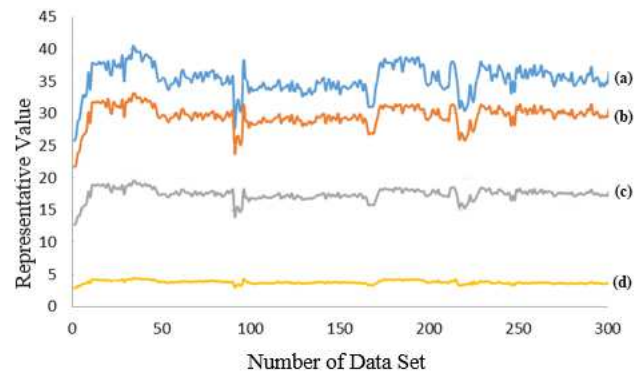


Fig. 6. The ARV Results of H_2O material mixed with HCl for all 300 Data Sets for (a) HF-Fourier Pattern, (b) HHF-Fourier Pattern, (c) HF-Wavelet Pattern and (d) HHF-Wavelet Pattern.

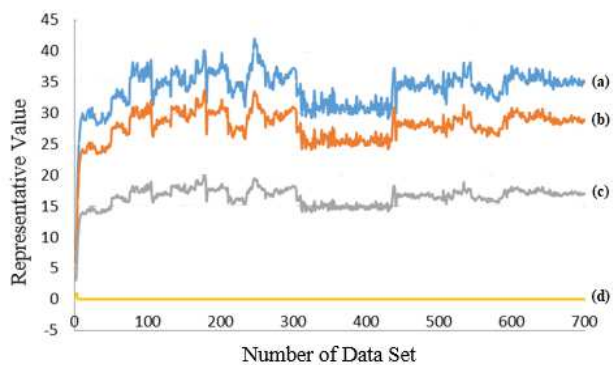


Fig. 7. The ARV Results of H₂O material mixed with NaOH for the 600 Data Sets for (a) HF-Fourier patterns, (b) HHF-Fourier patterns, (c) HF-Wavelet patterns and (d) HHF-Wavelet patterns.

IV. CONCLUSION

This research has succeeded in comparing the analysis of the implementation of ARV (representative value of amplitude) on the HF and HHF fluctuation patterns using Fourier and Wavelet transforms. Our results show that the fluctuations pattern by applying Wavelet can reduce or decrease the ARV results, so the changes look more stable than the application of Fourier transforms. However, HF fluctuation patterns with Wavelet transforms show fluctuations that show more material characteristics when compared to HHF patterns, which are very heavy pressure fluctuations.

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