Implementation of Segmentation Scheme based on Wavelet Transform in Multi-Spectral Fluctuation Patterns

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***Abstract*—Segmentation is one of signal processing methods that is fruitful to recognize some details of parts contained in a detail pattern before will be further processed. This study proposed a segmentation scheme, which is the input is based on the output of approximation of level two from wavelet transformation of 2D-DWT (Two Dimension Discrete Wavelet Transform). The segmentation scheme and algorithm process are implemented on the fluctuations patterns of HHF (High High-fluctuation) in multi spectral that previously are extracted. The fluctuation patterns of HHF are 2D (Dimensional) graphic that consist of matrix of the average value and standard deviation inside. The method that will be used is to apply the approach of segmentation scheme, which is suitable for treating HHF fluctuation pattern. Moreover, it also employs the approach to acquire the highest amplitude value and also to present the signals in the segments that have the top peak these fluctuations. In addition, there are some parameters that are very prominent in segmentation results to be analyzed, such as: the number of segments, the input frequency, spectral noise, the peak of amplitude value and VMR (variance to mean ratio). Furthermore, the analysis results of these parameters will be compared between the highest top three segments in the pattern fluctuation of HHF. Based on the results, it is noticeable to say that the segmentation scheme can be implemented for HHF pattern. Moreover, there are some segments that have the highest peak of amplitude values and also some parameters show quite striking phenomenon compare to other segments with the same parameters. In addition, the result of VMR is suitable with the statistical approach at VMR <1. It can be said that the proposed segmentation approach can provide the illustration of the segment each of pattern fluctuations HHF clearly.**

***Index Terms*—Segmentation; Fluctuation Pattern; Peak Of Amplitude.**

I. Introduction

In the context of image processing, image segmentation is a fundamental problem that can refer a process of solving image into pieces or slices containing the information of an image [1]. Based on the process, the signal is divided into two sections, stationary and non-stationary. Unlike stationary, for non-stationary signals, changes may take place in the mean and the variance, therefore the signals have broken down into segments that can be further analyzed and processed [2].

The previous scholars have done many studies related to image segmentation by several different methods to overcome the problems and to find out the solution of the image. Here are some of the methods used in the image segmentation, namely: Data-Driven Markov Chain Monte Carlo(DDMCMC)[3], Markov Chain Monte Carlo[4], K-means[5], spectral clustering [6]. In addition, [7] has implemented a watershed algorithm to segment the image processing, but this algorithm has deficiency that the segmentation is incomplete and also over-segmentation.

The motivation of the segmentation process performed in this study is to provide meaningful information, more detailed and easier to analyze than the pattern of fluctuations, which are the result from the 2D-DWT [8]. There are four types of fluctuation patterns that have been obtained, namely: MF (Mean Fluctuation), HF (High Fluctuation), HHF (High High-Fluctuation) and HMF (High Mean-Fluctuation). Fluctuation pattern used in this study is HHF because the pattern of HHF is derived from the patterns of HF. Thus, it shows the results more clearly and accurately than the previous pattern. Feature extraction process for all the four fluctuation patterns have been done before by [8], where the results obtained are the approximation level 2 for the second category fluctuation patterns of MF and HF that exhibit quite close prediction of the original results of fluctuations patterns.

According to [9], the image feature extraction result of the process should be able to accommodate the segmentation process by extracting the notable information and significant characteristics of the signal areas that will be examined later. However, based on the extraction results, it can be said that there are still too difficult to present the phenomenon of the fluctuations patterns in HF and HHF. Therefore, we need an advanced process that can generate them into clear section and quite detail of fluctuation patterns.

Moving on to the parameter analysis, there are several parameters that can be noticed based on the segmentation result: the segment section, peak of amplitude, frequency input and noise spectral. Some parts of these parameter results will be employed as a reference to perform material identification stage through the HF and HHF fluctuation patterns that can characterize dominant view of the material.

The study is divided into several sections, starting from the introduction of the background, and some research that have been done by several researchers on the methods of image segmentation and also the motivations and goals of the segmentation process performed in this study. In the second part, the proposed segmentation and algorithms used in this study will be discussed. Simulation, results and discussion are described clearly in Section 3. Finally, Section 4 explains the conclusion of the study with directions for future work.

II. The Proposed Segmentation Algorithm

Segmentation scheme proposed in this study is related to some previous studies that have been done. Figure 1 shows the proposed scheme that is applied in this study.

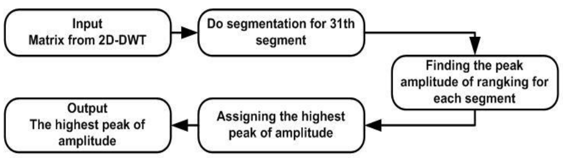

Figure 1: Proposed scheme

Figure 1 shows segmentation process, which is done in this study. Generally, the input comes from the extraction that is the result is in a matrix of HHF fluctuation pattern. Then, the segmentation process performs on the matrix, which provides the peaks of amplitude. Lastly, the highest peak is obtained by sequencing multiple rankings amplitude in the segment. In detail, stages of segmentation will be presented clearly in the next section.

A. Feature Extraction

Feature extraction that is used in this research is a kind of 2D-DWT [8]. There are plentiful studies, which are conducted by previous scholars related to the feature extraction, such as: [10] [11] [12] [13] [14], in which the researchers are using 2D-DWT to show some algorithms of 2D-DWT in accordance with the development in improving the performance of the system design with feature extraction material processed, and they use the image in JPEG format in the form of material tested.

This study is going to continue the previous study that is done by [8]. 2D-DWT is applied in this study by producing approximation level 2 or A2. The algorithms that is used are modified from [15], as follows:

Inilitialization stage

1. Load image HHF with the size of the matrix [31x8192]
2. Transpose matrix

Decomposition stage

3. Obtain the single-level wavelet decomposition
4. Do construction and present approximation detail of each coefficient.
5. Show regeneration with single-level image of the inverse wavelet transform.
6. Do the decomposition of multilevel *wavelet* (level 2)

Extraction stage

7. Present extraction approximation of coefficients

Reconstruction stage

8. Perform reconstruction for at detail and approximation of the level 2
9. Show the results on multilevel decomposition.
10. Run back to the original image reconstruction
11. Compress image and show the results
12. End

Besides, based on the results obtained from the approximation of level 2 of 2D-DWT, it was notable that they indicated quite different results on the values of their matrix. Therefore, the matrix values approximate rate 2 has a greater value than that of level 1. Interestingly, this phenomenon represents a clear and sharp image when compared the results of Approximation of 1. Therefore, the result approximation of level 2 has a unique shape that can determine the results of the original image and can be used as input to the next process in this study. The results of the 2D-DWT can be seen in Figure 2, 3, and 4, which are the results of A2 for MF, HF and HHF fluctuation patterns. Figure 4 is the result of the extraction process of HHF Fluctuation pattern, which is used as a basic input for the process of segmentation in this study.

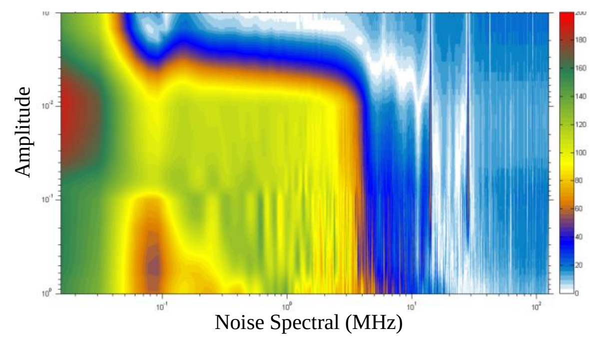

Figure 2: MF Fluctuation pattern of level A2 2D-DWT

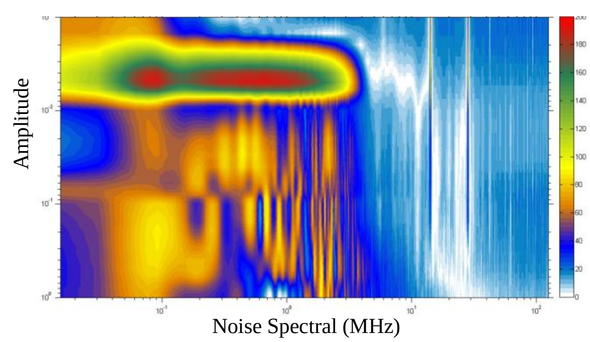

Figure 3: HF Fluctuation pattern of level A2 2D-DWT

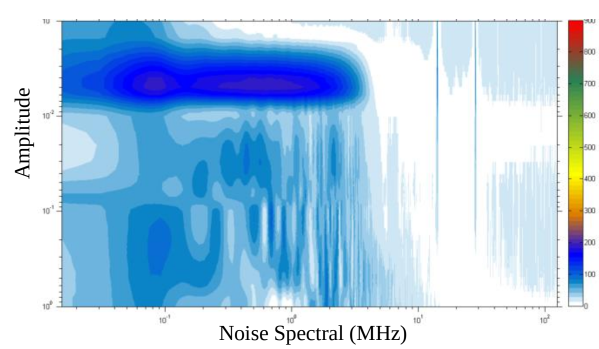

Figure 4: HHF Fluctuation pattern of level A2 2D-DWT

B. Segmentation Stage

As explained previously, the segmentation that will be done is the result of the process of feature extraction by employing the 2D-DWT level two for image fluctuation HHF, which contains of matrix with the size of [8192 x 31]. Usually the image based on spatial-based, but the image will be processed here is an image that is based on the frequency based. Therefore, the approach used is also different.

The segmentation algorithm based on 2D-DWT that is applied in this study is defined as follow:

1. Compute 2D reconstruction of approximation level 2 of the frequency-based image that is obtained in the previous study [6]
2. Do segmentation for the results of the 2D-DWT approximation of level 2 by dividing segmentation into 31 segmented, which is used the results in a matrix of A2. Where, 31 segments are considered as *n*. *n* is the frequency of input or input signal which is a multiplication of the average value and standard deviation. There are 31 numbers *n* with its input frequency starting from 1 Hz to 1 MHz, while *m* is the number of spectral matrices consisting of 8192.
3. Assume the matrix as follow:

$$m\overset{n}{\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}} \quad (1)$$

   Then, for each segment of segmentation, which is obtained by taking the value of each column to the n^{th} and is divided into 31 segments, which means that there will be 31 segments for each input frequency.
4. Calculate each segment by multiplying the first row of the first column of *m* and *n* will be obtained:

$$\text{Segment1 to segment31} = m_{8192} \text{ x } n_1 \ldots m_{8192} \text{ x } n_{31} \quad (2)$$

After performing the segmentation process, the next step is to reach the highest peak amplitude and to find out a segment, which has the highest peak compared to others segments.

The algorithm used to obtain the peak amplitude of the segmentation results will be shown as follows:

Step 1 : Take data matrix per frequencies input that are within 1 vector of matrix segmentation.

Step 2 : The first stage will be generated from the vector with A (1.1: *m*)

Step 3 : Then summed by the vector itself that has been shifted by 1 pixel, it will get a new vector *B* by the equation:

$$B(1,x)=A(1,x)-A(1,x+1) \quad (3)$$

where: B is a vector with the value of *B* (1.1: m-1).
x is the iteration 1
A is an initial matrix

Step 4 : At this stage, it will be carried out iterations to get peak amplitude value iteration, starting from *(1: m-1)*

Step 5 : There are a few steps on this part to seek the highest peak based on the frequency to be filtered, namely:

1. Compute value of *B* if $B(1,x)<0$
   1 is expressed as the lower limit.
2. After doing no.1, Calculate the value of *B* if $(1,x+1)\geq B(1,x)$
3. if the value of $B(1,x+1)<B(1,x)$, so the lower limit becomes to $B=(1,x+1)$
4. If $B(1,x+1)>0$, then the lower limit is equal to $B(1,x+1)$ and $B(1,x)$ is the peak of amplitude
5. The results will be counted repeatedly and is known as a sieve for the first frequency.

Step 6 : Do the same steps, starting from step 1 to 5 to achieve the highest peak, which will become to the second frequency filtering. After that, it will take the value of VMR (variance to mean ratio), where the value is based on a comparison of the average value fluctuations of HF divided by the value fluctuations MF that is the standard deviation.

Step 7 : End

III. SIMULATION, RESULT AND DISCUSSION

A. Simulation Step

Simulations in this study use MATLAB 2013a and some parameters of the study are shown in Table 1. In addition, the data used is data fluctuation patterns that are the result from the study of [8], which use 2D-DWT extraction. Furthermore, fluctuation pattern that is used is the type of HF and HHF because the pattern shows the real situation, where there is a fluctuation of the basic pattern is MF. In addition, the pattern of HF and HHF showed characteristics that were so dominant in material, which have an average value and standard deviation.

Table 1
Specification of segmentation process

Parameter	Capabilities value/Remarks
Number of data	150
Fluctuation type	HF(high fluctuation) HHF(high high fluctuation)
Frequency Perturbation`(KHz)	0.5
Range of Amplitude	0 – 200
Noise Spectral MHz)	10^{-3}, 10^{-2}, 10^{-1}, 10^{0}, 10^{1}, 10^{2}
Input signal (n)(MHz)	31 number of frequency: 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10 15, 20, 30, 40, 50, 60, 70, 80, 90 100, 150, 200, 300, 400, 500 600, 700, 800, 900, 1000

Segmentation in HHF is done by implementing the algorithm described earlier. Based on the algorithm process, the segmentation will be divided into 31th segmentations by the input frequency for each segment in accordance with the parameters in Table 1.

The purpose of the 31th division of segment in the process is to view clearly the changes significant of fluctuations that occur in every segment of its division. In addition, the division of segmentation is based on the frequency input of *n* as many as 31 frequencies as shown in Table 1. In addition, there is also the approach, which is used to gain the segment that has the highest of amplitude peak for each type of fluctuation patterns by applying the proposed algorithm.

B. Result and Discussion

Based on the study that has been done, segmentation will be performed in the fluctuation pattern of HHF, which is the second part of the HF fluctuation pattern that shows the average value and standard deviation of the fluctuation pattern.

Before obtaining the highest amplitude value of each segment, it is necessary to find a sequence of amplitude values as shown in Table 2. Table 2 presents the sequence of the top 20 highest amplitude fluctuations on the type of HHF approximation of level 2 with some parameters contained, such as: the order of ranking, number of segments, the input frequency, spectral noise, the highest amplitude and VMR (variance to mean ratio).

As highlighted in the Table 2, the highest amplitude is in the segment 10 that is in the first position, followed by the segment 9. Then, in the next ranking, there are the segment of 11 and 8, respectively, which the peaks of the order of 1 to 5 are 191, 181, 171, 138 and 122, respectively.

In order to be able to analyze the pattern of fluctuations more clearly, it will have three segments that only have the highest amplitude peak sequence. It can be seen that the amplitude peak in the segment 10 exceeds the amplitude peak in the segment 9 and 11, respectively. In addition VMR value for that segment is below 1, which is: 0.3776, 0.3172, and 0.4010, respectively. This phenomenon indicates that the value of VMR is in a standard statistic with VMR values <1.

Table 2
The highest 20 Amplitude of HHF

No	Number of Segment	Freq. Input (MHz)	Noise Spectral (MHz)	Amplitude	VMR
1	10	0.009	0.0763	192	0.3776
2	9	0.008	0.0763	181	0.3172
3	11	0.010	0.0763	171	0.4010
4	8	0.007	0.0763	138	0.5865
5	31	1	2.3346	122	0.8746
6	12	0.015	0.0763	118	0.0752
7	31	1	0.2136	112	0.6685
8	26	0.5	1.9531	111	0.5059
9	30	0.9	0.2136	108	0.3740
10	25	0.4	1.9531	105	0.4878
11	11	0.01	0.4272	103	0.7752
12	12	0.015	0.4425	103	0.7551
13	27	0.6	1.9531	102	0.8663
14	29	0.8	2.3346	102	0.4014
15	31	1	2.4567	102	0.7365
16	13	0.02	0.4425	101	0.0813
17	29	0.8	0.1984	100	0.6180
18	30	0.9	2.4567	99	0.5940
19	25	0.4	0.8698	98	0.1524
20	27	0.6	2.5940	98	0.0797

Furthermore, as aforementioned in the Table 2, there will be discussed the top 3 of HHF segmentation, which are 10, 9 and 11, respectively. The parameters of segment 10 are referred to the Table 1. Furthermore, Figure 5 shows the results of segmentation 10 with an input frequency of 0.009 MHz Based on Table 2, there is only taken ten highest amplitude sequences in the segmentation 10.

As determined in the Table 3, there is striking peak of amplitude that has the highest peak of amplitude is equal to 192 and 0.0763 MHz of frequency spectral noise. But after that peak amplitude drops dramatically to be in a position of 95 that are the input frequency and spectral noise are 0.009 MHz and 0.4272 MHz, respectively.

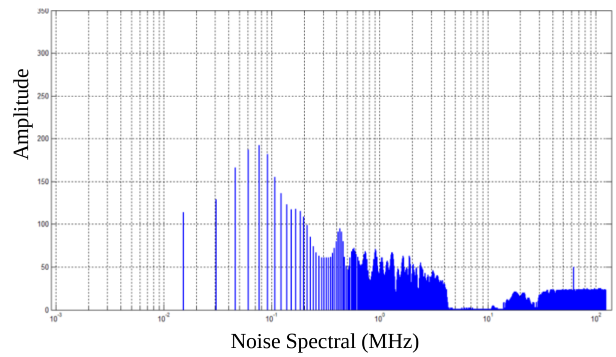

Figure 5: Segment 10 of HHF Approximation of level 2

Table 3
The highest 10 Amplitude segment 10 of HHF

No	Number of Segment	Freq. Input (MHz)	Noise Spectral (MHz)	Amplitude	VMR
1	10	0.009	0.0763	192	0.3776
2	10	0.009	0.4272	95	0.2631
3	10	0.009	0.5798	72	0.2433
4	10	0.009	0.9155	71	0.4939
5	10	0.009	0.7324	68	0.2251
6	10	0.009	1.6479	63	0.1544
7	10	0.009	1.8921	63	0.4285
8	10	0.009	1.0376	61	0.0943
9	10	0.009	1.1749	57	0.0728
10	10	0.009	2.3956	55	0.1156

Table 4
The highest 10 Amplitude segment 9 of HHF

No	Number of Segment	Freq. Input (MHz)	Noise Spectral (MHz)	Amplitude	VMR
1	9	0.008	0.0763	181	0.3172
2	9	0.008	0.4272	78	0.1521
3	9	0.008	0.9155	64	0.0983
4	9	0.008	1.3123	62	0.1686
5	9	0.008	0.5646	60	0.2003
6	9	0.008	0.7324	57	0.2682
7	9	0.008	1.8921	54	0.0213
8	9	0.008	1.6479	53	0.0967
9	9	0.008	1.0376	52	0.2218
10	9	0.008	1.1749	48	0.03

Moreover, the peak values of the amplitude decrease gradually until the last position with their peak amplitude is 55 and spectral noise is 2.3956 MHz Interestingly, the values of VMR to all the segment 10 are at a value of VMR <1. Whereas, the value of the highest VMR is 0.4939 and the lowest is 0.0728.

The phenomenon that occurs in segment 9 and 11 exhibits quite similiar things with the segmentation of 10. By applying the parameters in Table 1, the results obtained in segments 9 and 11 have been obtained.

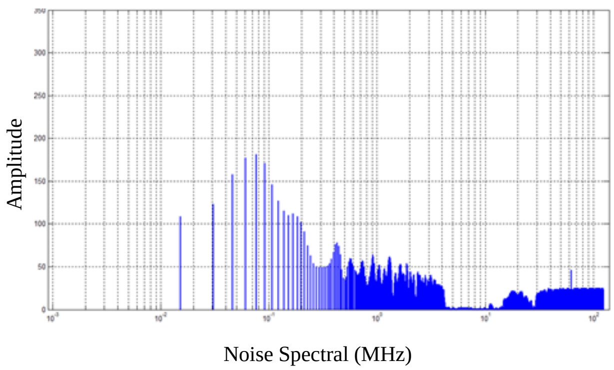

Figure 6: Segment 9 of HHF Approximation of level 2

As illustrated in Figure 6, the amplitude of the highest peak on segment 9 based on Table 4, which is 181 with 0.0763 MHz of spectral noise, and the value of VMR is 0.3172. Furthermore, the amplitude peak value goes down dramatically, it begins with the order of 2 to 10 of rank. However, the value of VMR still resides in appropriate standard of VMR < 1, with the highest value of VMR is 0.2682 at the rank of 6 and the lowest VMR is 0.03 in the order to 10.

The final analysis will be performed on the segment 11 with the results of fluctuation pattern as shown in Figure 7 and the results of processing parameters in Table 5 that has the top of 10.

Not much different from the previous segmentation result of segment 10 and 9, the HHF fluctuation pattern of segment 11 has shown the value of the highest amplitude which is 171 and spectral noise is 0.0763 MHz. Then, the amplitude peaks of value decrease slightly to 103, but on the next position, the peak amplitude values will decline rapidly until the position 7 and after that it will be stable for positions 8, 9, 10, respectively with amplitude peaks is 62.

In addition, based on Table 5, the value of VMR for segment 11 is in the range of VMR < 1, with the highest VMR is 0.9703 that is on spectral noise of 0.5951 MHz and the lowest value of VMR is 0.4010 at 0.0763 MHz of spectral noise.

Table 5
The highest 10 Amplitude segment 11 of HHF

No	Number of Segment	Freq. Input (MHz)	Noise Spectral (MHz)	Amplitude	VMR
1	11	0.01	0.0763	171	0.4010
2	11	0.01	0.4272	103	0.7752
3	11	0.01	0.5951	80	0.9703
4	11	0.01	0.7324	73	0.1340
5	11	0.01	0.9155	68	0.6686
6	11	0.01	1.6479	67	0.1961
7	11	0.01	1.8921	67	0.1635
8	11	0.01	1.1597	62	0.1758
9	11	0.01	1.2970	62	0.1034
10	11	0.01	2.3956	62	0.2847

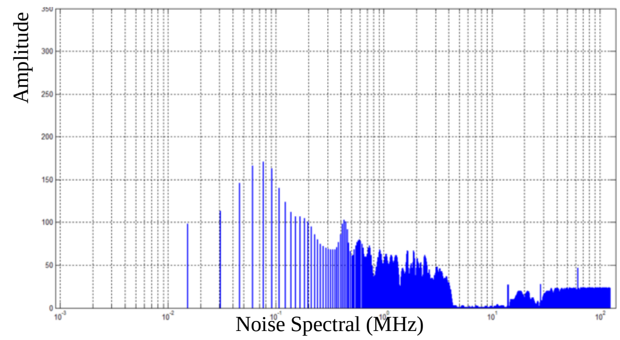

Figure 7: Segment 11 of HHF Approximation of level 2

There is an interesting phenomenon that has been obtained from the analysis, which are the highest peaks of amplitude values for the segments of 10, 9 and 11 have the same spectral noise value of 0.0763 MHz. Moreover, all grades VMR are appropriate statistical standards that are meet at VMR <1. Whereas, the value of the lowest and the highest VMR currently are in the segment 9.

IV. Conclucion

In this study, segmentation scheme based on wavelet transform multi-spectral fluctuation in patterns have been implemented. Based on the results that have been obtained, the method and the proposed segmentation algorithm have been able to effectively address the issues contained in the extraction using 2D-DWT.

Based on the analysis of the results obtained, it can be said that the application of segmentation scheme will help us to be able to see in detail and clearly state the signal that occurs in every segment generated. This segmentation will show the segment that has the highest amplitude value. Thus, it can be a reference for further research.

In addition, the segmentation also obtains the highest amplitude peak value that is found in the fluctuation pattern of HHF. This indicates that the application segmentation scheme is very appropriate and also assists in the signals processing of multi-spectral fluctuation pattern. Furthermore, the results of VMR for all segments are fulfilling the standard of the statistic approach that is VMR < 1.

Acknowledgment

The authors gratefully acknowledge the research grant funded by the Ministry of Research, Technology and Higher Education of Indonesia under grant No. 1140/UN2.R12/HKP.05.00/2016.

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