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Detection of Epileptic Spike Patterns on EEG Signal of Epilepsy Patients with Wavelet Transform Method

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***Abstract*– Epilepsy is a disorder that occurs as such excessive not controlled from some or all central nervous system. Epilepsy is characterized by entering transient voltage to wave (spike and sharp wave) that are usually called epileptic spike. Detection and classifying of epileptic spike by using visual screening of EEG record is a work that complex and many time-consuming. This Research detect patterns epileptic spike in EEG signal of patients with epilepsy with the method wavelet transform through detection test result against gold standards using the detectability and selectivity. Types of wavelet that used in this research is Daubhecies 4, Coiflet 4, Mexican hat and Symlet 6. Wavelet Daubechies 4 produces the same value high of detectability and selectivity is 80% and 78.57% on the scale 9, Symlet 6 produces the 86.79% and 80.70% at scale 10, Coiflet 4 produces 83.02% and 78.57 % at scale 8, Mexican Hat produces 89.13% and 71.93% on the scale 3. Wavelet type Symlet 6 at scale 10 produces the detectability and selectivity, that is the best than 3 types of another wavelet.**

***Index Terms*– Epileptic Spike, Wavelet, Detectability and Selectivity**

I. INTRODUCTION

ELECTRIC activity of cell or bio-electric that occurs in the brain can be known by recording of brain through the surface of the scalp. The result of the recording is called electroencephalogram (EEG). The intensity of brain waves on the scalp is about 0 - 200 microvolt and frequency is start from 0 to 50 Hz [5]. The most result of EEG recording is irregular and do not have a common pattern that can be seen clearly. But when the brain has disorder, an epileptic spike will arise with specific pattern is specific.

Part of the brain patients with epilepsy is characterized by excessive activities that are not controlled from highly unfavorable or the whole central nervous system. In the record of EEG, epilepsy is marked with the spike, or often called with epileptic spike is entering transient voltage to signal a sharp and isolated from EEG. Electric charge Spike in appearance as excess of neurons in areas of the brain some or all. At the time to read and detect epileptic spike in the record EEG, the electroencephalographer (EEG) still rely on direct observation in the record EEG that at least have 8 channel measurements. Sure, it needs more energy and thought of readers because much of data and there are many similarities signal EEG like a signal epileptic spike from some patients that must be read.

There are many researches to detect patterns of epileptic spike has been done. Vijayalakshmi et al. (2010) doing research to detect patterns epileptic spike in the record EEG by using this method template matching famous book about method [15]. Juozapavicius et al. (2011) said that in order to detect appearance epileptic spike it needs a method of morphology filter and a database design that be needed to analyze EEG wave easily. It is hoped that this method in the future can provide data that can be accessed for the development data mining algorithms. As is well known that in detecting epileptic spike in signal EEG in a lot of very difficult to be even by the doctor who was trained [10].

Other research done by Buteneers et al. (2009), it is written that Reservoir Computing (RC) has succeed to detect epileptic seizure on record EEG in a more quickly and reliable as a result, even in this research using mice as respondents. Chen, et al (2013), in Empirical research result is rendered use Mode Decomposition (EMD) to help in providing more information with accuracy average 70% - 90 percent. EMD provides an informative in getting the picture EEG associated with epileptic. EEG spike had standard deviation in all higher dimension of EEG normal. EEG spike has a smaller correlation coefficient EEG that normal. Standard deviation EEG spike higher than that in the EEG normal [2].

Problem that will be examined is how detect patterns epileptic spike from a record EEG patients with epilepsy by using methods wavelet transform. The aims of this research are getting a scale of 4 types of wavelet Daubhecies 4, Coiflet 4, Mexican Hat and Symlet 6, which was able to detect patterns epileptic spike with highest the detectability and selectivity value. Hopeful, the result of the research able to facility for doctors to support the diagnosis seizures by EEG recording.

II. FUNDAMENTAL

A) Brain Waves Patients with Epilepsy

Epilepsy is a disorder that occurs as a nerve cell (neurons) in the brain out signals that are not normal. Epilepsy is characterized by excessive activities that are not controlled from some or all central nervous system. The expert in the

central nervous system has classified more than 30 different type's epilepsy. But basically there are two basic types of seizures, namely generalized epilepsy and partial epilepsy. Generalized epilepsy happened in the brain, while partial epilepsy took place in a part of the brain. Generalized epilepsy divided into seizures grand mall and petit mal. Other type of psychomotor epilepsy, renal impairment, seizure that can cause: (1) lost memory (amnesia) in a very short period of time, (2) raged, (3) anxiety or fear all of a sudden, (4) beef (mumbling), (5) attack others without conscious and actions do not understand.

The characteristic epilepsy as seen in EEG record, there are signals that is slow (slow wave), not in order (irregular) and spike. According to Committee on complex terminology of the International Federation of Societies for Encephalography and Clinical Neurophysiology, spike is defined as a wavelength entering transient voltage to that can be clearly differentiated from signal background, as the achievement the culmination and duration of 20 to 70 pp. Spike may happen in itself, but more often is to follow the waves that are slow (which indicates the renal impairment, seizu), took place between 150 - 350 ms, so that they formed a spike and slow wave complex. Detection of spike and spike and slow wave complex requires a separation of such background EEG, mainly mining activities from electromyographic (EMG).

Fig. 1 showing a signal EEG of patients with epilepsy types of grand mall, petit mall and psychomotor.

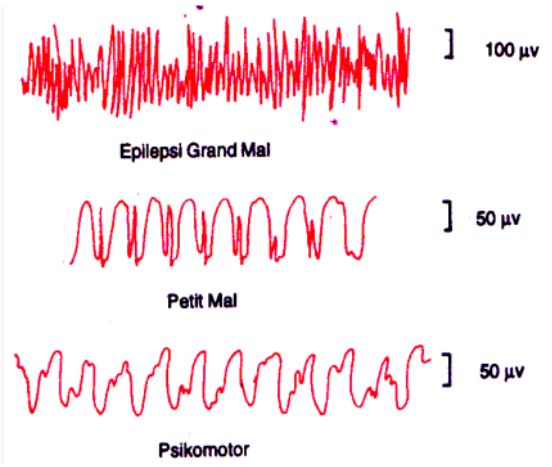

Fig. 1: EEG signal for pathology epilepsy [5]

B) Continous Wavelet Transform

Continous Wavelet Transform is defined as an integral part of all time from signal multiplied by large-scale wavelet function and shift. (scale,position,time):

$$CWT_x^{\psi}(\tau,s) = \Psi_x^{\psi}(\tau,s) = \frac{1}{\sqrt{|s|}} \int x(t)\psi^*(\frac{t-\tau}{s})dt$$

In equation on τ is a shift (translation), s. becomes a (scale), ψ (t) is a function transformation or that are usually called mother wavelet. The mother wavelet can be interpreted from two words that wavelet and mother. Wavelet reflects a small wave. In a small definition explains a condition that function (windows) has a wide are limited. Mother explained that functions that used in transformation process with a different width is obtained from the main function or called with mother wavelet. In other words mother wavelet can be interpreted as prototypes to raise window function. Meanwhile, the word translation or shift to the location of Windows, Windows continued to move as long as signals that will transform. CWT result is many coefficient wavelets C, which is a function scale and the position. Multiply for each coefficient wavelet with large-scale and no longer produce certain elements wavelet of original signal as shown in Fig. 2.

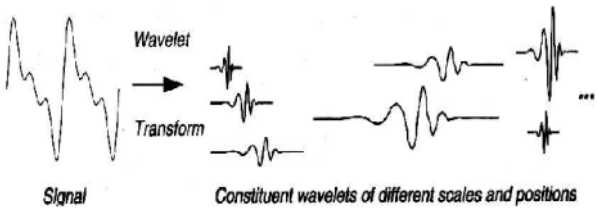

Fig. 2: Decompositions wavelet from a signal [1]

There are many families from basic wavelet, including Haar, Daubechies, Biortogonal, Coiflet, Symlets, Morlet, Mexican Hat and Meyer.

III. METHODOLOGY

The steps of this research are the activities of software-making. It consists of these steps these activities will be explained in flowchart following (Fig. 3):

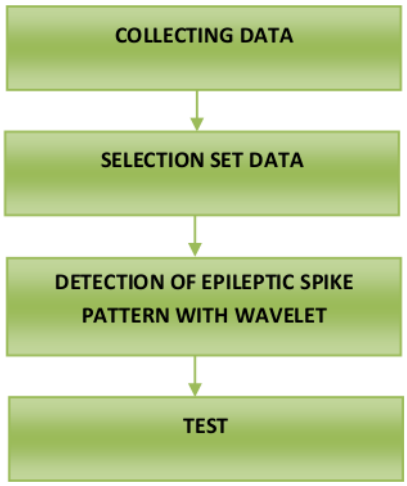

Fig. 3: The framework of research concept

A) Collecting Data

The process for taking data EEG was done in Dr. Soetomo Hospital, Surabaya, East Java, Indonesia. Electroencephalograph equipment is used type EEG 7310B/F/W made by Nihon Kohden Corporation Japan as shown in the Fig. 4. This equipment has maximum sensitivity 1μV / mm on the paper recording EEG. In this research for the installation electrode on the scalp of the patients used "system 10-20".

Recording signal EEG in the patient with epilepsy is often found that record in a normal or not found the pattern epileptic spike because this pattern occurs only when there is an attack. By because it is to raise the attack seizures when done recording signal EEG, patients need to be given a stimulus stimuli and medicines physical. Physical stimuli that can be used to attack has sparked a flash is light at frequency range 10 - 15 Hz or to drugs that can has sparked an attack is anti-inflammatory drugs depression tricyclic antidepressants are, sleep medicines or fenotiazin.

Data EEG that are to be used in this research is a secondary data obtained from patients with epilepsy. The record EEG from the patients' seizures on paper which is obtained from Laboratory EEG Dr. Soetomo Hospital Surabaya after segmentation in a prolonged period of time suspected there was the appearance of the patterns epileptic spike. Data segment EEG suspected there were epileptic spikes then is scanned in a circular way and stored in the form either JPG files.

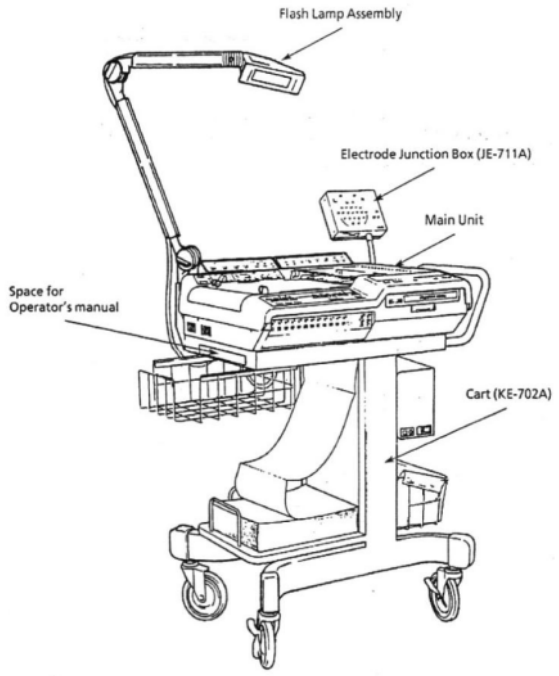

Fig. 4: Electroencephalograph Model EEG 7310B/F/W [14]

B) The Selection Set Data

Selection data set will be done in a way to execute receiving scanning recording EEG from patients suspected of being a pattern spike, then the results are divided in the form until 1024 bit row data. The format advanced data was changed in the form format matlab, consisting of array data value $0 \le hi \le 1$ to be understood high the program, which is a couple of coordinate of x,y.

C) Detection Epileptic Spike Pattern

Pattern epileptic spike will be done by the method wavelet transformation. To analyze the pattern epileptic spike in recording EEG, we use several kind of wavelet that equity of form explicit like spike namely Daubhecies 4, Coiflet 4, Mexican Hat and Symlet 6, 3

D) Test

Test of results are maintained by means compare detection methods wavelet transformation to Gold standards for then sought the Detectability and Selectivity. Gold standards that used is the result analysis of EEG-er, in this case is a Neurolog.

If spike and non-spike is regarded as the positive and negative, and it will be there are several possible combination results with software doctor. Genesis as True Positive (TP) is if the method and the doctor wavelet nerve classify the EEG that analyzed as spike, True Negative (TN if they both said that non-spike. False Positive (FP) if the method wavelet said spike however, the doctors said nerve non-spike, and False Negative (FN) if the method wavelet said non-spike and EEG-er states as spike

Table 1: Combination results Doctors and Computer

		NEUROLOG	
		N	P
Wavelet	N	TN	FP
	P	FN	TP

Advanced defined criteria detectability and selectivity as follows:

$$Detectability = \frac{TP}{(TP+FP)}$$

$$Selectivity = \frac{TP}{(TP+FN)}$$

IV. RESULTS AND DISCUSSION

The signal EEG of patients who are suffering from epilepsy has done segmentation each with a length data is 1024 bit row data. Each segment data with long 1024 bit then analyzed by specialist doctors nerve (EEG-er) to determine forms of signal that is characteristic epilepsy namely epileptic spike. Fig. 5 following is a model some data EEG segmentation that has been analyzed by specialist doctors nerves (Neurolog).

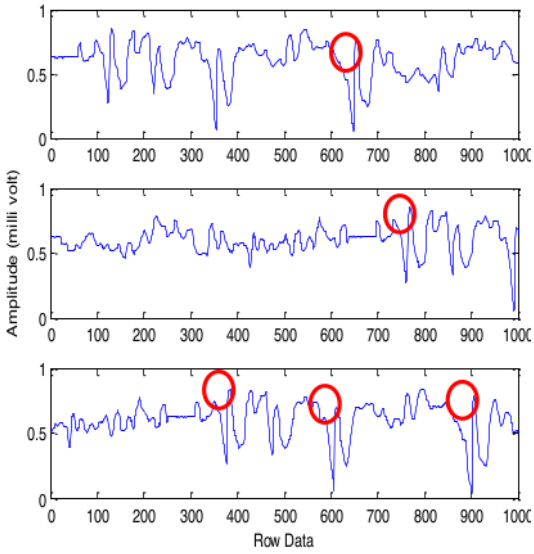

Fig. 5: Data EEG segments with characteristics epileptic spike (red circle is a feature epileptic spike)

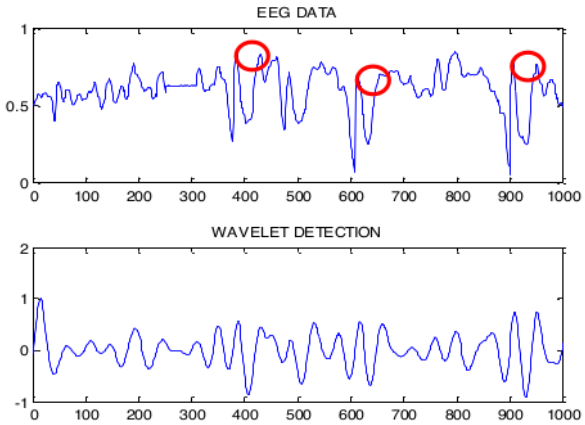

Fig. 6: Pattern detection epileptic spike scale wavelet that is not proper (red circle is a feature epileptic spike)

Wavelet in this research function to detect patterns epileptic spike from data EEG. Wavelet used because this method can alter the domain signals time to signal the domain time-frequency so that it will be known position (time) the emergence epileptic spike from data EEG in the right place. In this research is used some types of wavelet that has many forms, according to the pattern epileptic spike like Daubhecies 4 , Coiflet 4, Mexican hat and Symlet 6.

For getting the result detection wavelet that have detectability and selectivity is good, needed a good time to each kind of wavelet. Fig. 6 and Fig. 7 following is a model pattern detection epileptic spike with wavelet type Coiflet 4.

In the Fig. 6 can be seen that with wavelet becomes that is not proper, Coiflets does not provide a good detection. This can be seen from the coefficient wavelet almost the same across time and even at this point (time) the emergence epileptic spike.

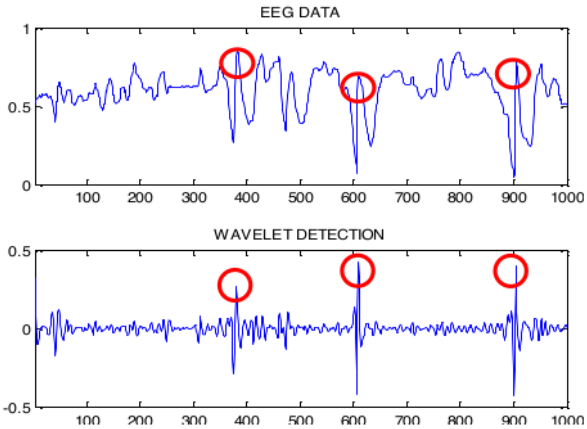

Fig. 7: Detection epileptic pattern spike with proper wavelet scale (red circle is a feature epileptic spike)

In the Fig. 7 can be seen that, with a proper, Coiflets give a better detection. This can be seen at this point (time) the emergence epileptic spike which has an individual value coefficient wavelet be compared to other point.

In this research pattern detection epileptic spike be done with 4 kinds of wavelet which have a form a pattern epileptic spike. Four types of wavelet is Daubhecies 4, Coiflet 4, Mexican hat and Symlet 6. Each kind of wavelet were examined the data EEG that are known point epileptic spike from diagnosis specialist doctors nerves with the scale that becomes the varied from 1 to 10.

Each becomes the 1 to 10 from the four types of wavelet will produce the detectability and selectivity. Scale that will give the exact detectability and selectivity. Table 2 to Table 6 here will display the detectability and selectivity scale from 1 to 10 out of the four types of wavelet.

Table 2: Values detectability and selectivity from wavelet Daubechies 4 from the scale 1 to 10 (in percent)

Scale	10	9	8	7	6	5	4	3	2	1
Detect	75.93	80	75.51	78.72	81.40	82.50	85.29	93.55	96.55	71.43
Select	77.36	78.57	66.07	64.91	63.64	60	51.79	51.79	50	8.93

On The Table 2 demonstrated that on the scale 2 Daubechies 4 produce detectability at least, that is 96.55 percent (blue) but the selectivity low rate that is 50 percent. A right to produce the detectability and selectivity that period. In Daubechies 4 scale 9 becomes produces the detectability and selectivity period, that is 80% and 78.57 percent (yellow). Thus, it can be said that right Daubechies 4 used to detect patterns epileptic spike on the scale 9.

Next Table 3 shows the results of detection of epileptic spikes pattern of wavelet Symlet 6.

Table 3: Values detectability and selectivity from wavelet Symlet 6 from the scale 1 to 10 (in percent)

Scale	10	9	8	7	6	5	4	3	2	1
Detect	86.79	85.71	81.13	80	83.33	84.21	96.77	96.77	82.14	92.86
Select	80.70	73.68	76.79	63.16	53.57	62.75	53.57	53.57	41.07	23.21

Table 3 values detectability and selectivity from Symlet 6 from the scale 1 to 10 (in percent). In Symlet 6 scale 10 produces the detectability and selectivity period than the 86.79 percent and 80.70 percent (yellow). Thus, it can be said that right Symlet 6 used to detect patterns epileptic spike on the scale 10.

Next Table 2 shows the results of detection of epileptic spikes pattern of wavelet Coiflet 4.

Table 4 values detectability and selectivity from Coiflet 4 from the scale 1 to 10 (in percent). In Coiflet 4 scale 8 produces the detectability and selectivity period than the 83,02 percent and 78,57 percent (yellow). Thus, it can be said that right Coiflet 4 used to detect patterns epileptic spike on the scale 80.

Next Table 5 shows the results of detection of epileptic spikes pattern of wavelet Mexican Hat.

Table 4: Values detectability and selectivity from Coiflet4 from the scale 1 to 10 %

Scale	10	9	8	7	6	5	4	3	2	1
Detect	81.82	82	83.02	80	83.33	90.91	96.88	94.59	93.94	96.30
Select	77.59	71.93	78.57	64.29	54.55	53.57	55.36	62.50	55.36	46.43

Table 5: values detectability and selectivity from Mexican Hat from the scale 1 to 10 %

Scale	10	9	8	7	6	5	4	3	2	1
Detect	17.72	19.75	28.24	38.67	47.76	64.52	71.19	89.13	94.87	96.88
Select	25	28.07	42.86	52.73	56.14	72.73	77.78	71.93	64.91	55.36

In Mexican Hat scale 8 produces the detectability and selectivity period than the 89.13 percent and 71.93 percent (yellow). Thus, it can be said that right Mexican Hat used to detect patterns epileptic spike on the scale 3

Four types of wavelet Daubhecies 4, Coiflet 4, Mexican hat and Symlet 6 proved to be used to detect patterns epileptic spike with the scale that is not the same for each type wavelet as shown in the Table 6 below:

Table 6: The detectability and selectivity out of the four types of wavelet right scale

	Daubechies 4	Symlet 6	Coiflet 4	Mexican Hat
Detect	80	86.79	83.02	89.13
Select	78.57	80.70	78.57	71.93

Table 6 shows the detectability and selectivity right scale for the four types of wavelet Daubhecies 4, Coiflet 4, Mexican hat and Symlet 6. But from the four types of wavelet was kind of Symlet becomes 6 with 10 produces the

detectability and selectivity, that is the best that 3 types of wavelet another.

V. CONCLUSION

1. Wavelet type Daubhecies 4, Coiflet 4, Mexican hat and Symlet 6 can be used to detect patterns epileptic spike with a different scale value.
2. Daubechies 4 produces same scale the detectability and selectivity period that is 80% and 78.57 percent on the scale 9.
3. Symlet 6 produces the detectability and selectivity period than the 86.79 percent and 80.70 percent on the scale 10.
4. Coiflet 4 produces the detectability and selectivity period than the 83.02 percent and 78.57 percent at scale from 8.
5. Mexican Hat produces the detectability and selectivity same value on 89.13 percent and 71.93 percent on the scale 3.
6. Symlet 6 with scale 10 produces the detectability and selectivity that is the best that 3 types of other wavelet.

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