ELECTROMYOGRAPHY GAIT TEST FOR PARKINSON DISEASE RECOGNITION USING ARTIFICIAL NEURAL NETWORK CLASSIFICATION IN INDONESIA

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Abstrak

Diagnosa Parkinson Disease (PD) di Indonesia dilakukan secara klinis. Analisa langkah jalan dengan menggunakan sensor electromyography (EMG) menawarkan alternatif deteksi untuk PD. Sinyal EMG umumnya sulit dimengerti secara klinis. Penelitian ini menggunakan metode pengenalan pola sebagai alat untuk analisa sinyal EMG bagi subjek sehat dan subjek dengan PD. Sinyal EMG direkam dari 15 pasien dengan PD dan 8 subjek sehatdengan usia yang relatif muda saat subjek melakukan langkah jalan. Pengambilan data langkah jalan dilakukan di Rumah Sakit dr Kariadi Semarang, Jawa Tengah Indonesia. Dua belas buah fitur EMG digunakan untuk feature calculation pada sinyal EMG, delapan fitur adalah fitur yang berdasarkan domain waktu dan empat fitur berdasarkan domain frekuensi. Penelitian ini bertujuan untuk mengklasifikasikan dua kelas yaitu kelas untuk subjek sehat dan kelas untuk subjek PD menggunakan metode klasifikasi Artificial Neural Network (ANN) dengan jaringan feed forward dua layer. Jaringan menggunakan metode fungsi transfer log-sigmoid untuk hidden layer dan transfer fungsi softmax untuk output layer. ANN menggunakan 20 neuron pada hidden layer dan 2 neuron pada output layer. Metode training ANN menggunakan algoritma Levenberg-Marquardt dan penentuan nilai eror akurasi menggunakan metode mean square error (MSE). Berdasarkan hasil penghitungan, akurasi klasifikasi dua kelas untuk membedakan anatar subjek sehat dengan subjek PD sebesar 88.4%.

Kata kunci: *Artificial Neural Network (ANN), electromyography (EMG), gait test, Parkinson's Disease.*

Abstract

Diagnosis for Parkinson's Disease (PD) is mainly on clinical examination. Gait test using electromyography (EMG) offer an alternative diagnosis for PD. EMG signals are often difficult to understand clinically. This paper uses pattern recognition method as tool for better understanding EMG signal for healthy control and People with Parkinson (PWP). EMG signals were recorded from 15 patients and 8 young healthy control subject, while doing gait test. Gait test measurement take place in dr. Kariadi general hospital Semarang, Central Java, Indonesia. Twelve EMG features are used for EMG's signal feature calculation, eight features based on time domain feature and four features based on frequency domain feature. This paper proposes two class classification for healthy and PWP using artificial neural network (ANN) with two layer feed forward network. The network utilizes a log-sigmoid transfer function in hidden layer and a softmax transfer function in the output layer. The ANN uses 20 neurons in hidden layer and 2 neurons in output layer. The training of ANN pattern recognition uses Levenberg-Marquardt training algorithm and the performance utilizes mean square error (MSE). Based on the resulted overall confusion matrix, the accuracy of two class classification to discriminate healthy and PWP is 88.4%.

Keyword: *Artificial Neural Network (ANN), electromyography (EMG), gait test, Parkinson's Disease.*

INTRODUCTION

Parkinson's Disease first describe by Dr James Parkinson in his paper An Essay on The Shaking Palsy published on 1871 (Golbe, et al., 2010). PD is one of the top ten most common illnesses in the rumah sakit Ciptomangunkusumo (RSCM) (Caesarendra, et al., 2014). PD is clinically detected by motoric symptom such as tremor, bradykinesia, rigidity and postural instability (Golbe, L. et al., 2010).

To provide alternative diagnose for PD this study presents pattern recognition method for EMG signal. Raw EMG signals are analized using pattern recognition method with steps: (1) preprocessing data, (2) Feature Calculation. Twelve EMG features are used for EMG's signal feature calculation, like integrated EMG, mean absolute value, variance of EMG, RMS (Root Mean Square), Log detector, Waveform length, Kurtosis, Skewness, Mean frequency, Median frequency, Total power and Mean power (Phinyomark, A. et all., 2014). (3) Classification method. ANN (Artificial Neural Network) is used as classification method.

The purpose of the study was to classify between PD patients and healthy subjet based on EMG signal interpretation. The main contribution of this work are as follows : first, give an alternative detection for PD besides clinical examination which easy to use and high accuration. Second, give a better understanding in EMG signal's interpretation for neurology medical staff.

METHODOLOGY

Methodology to distinguish PD patient with healthy subject consist of four steps, (A) Study participants, (B) Measurement system and gait test, (C) Feature calculation and (D) Classification method

Study Participants

Total 23 subjects who have been given their informed consent participated in this study, 15 people with PD and 8 people as young healthy subjects. Table 1 shows participants list for PD and healthy people.

Table 1. ***Participant List***

Subject	Gender	Age (years old)
Parkinson Subject		
S 1	Male	68
S 2	Male	53
S 3	Male	59
S 4	Female	79
S 5	Female	66
S 6	Female	39
S 7	Female	58
S 8	Female	54
S 9	Male	66
S 10	Male	80
S 11	Male	76
S 12	Male	70
S 13	Male	68
S 14	Male	68
S 15	Male	72
Healthy Subject		
Subject	**Gender**	**Age (years old)**
S 16	Male	24
S 17	Male	22
S 18	Male	21
S 19	Male	21
S 20	Male	21
S 21	Female	23
S 22	Female	20
S 23	Male	21

Measurement system and gait test

Surface EMG sensor placed on Tibialis Anterior, gastrocnemius medialis (GM) and gastrocnemius lateralis (GL) muscles according to SENIAM guidelines. BITalino plugged kit connected with OpenSignals open source software used as data acquisiton with sampling frequency 1000 Hz. Gait data measurement follow procedure below (Kugler, et al, 2013) :

1. While sitting, subject tapping heel and toe alternately on the floor for 30 seconds.
2. While sitting, subject lifts leg 5-10 cm above the floor and rotate the ankle joint for 30 seconds.

Feature Calculation

In this study, twelve EMG features are used to interpret EMG raw signals. Definition and equation for each features describe as follows (Ariyanto, et al, 2015) :

1. Integrated EMG (IEMG): IEMG is one of time domain based feature. IEMG often used in clinical application.

$$IEMG = \sum_{i=1}^{N} |x_i| \tag{1}$$

2. Mean absolute value (MAV): MAV is the most used feature in EMG signal interpretation. Similar as IEMG, MAV also used in clinical application.

$$MAV = \frac{1}{N}\sum_{i=1}^{N} |x_i| \tag{2}$$

3. Variance of EMG: variance of EMG is defined as an average of square values of the deviation of that variable.

$$VAR = \frac{1}{N-1}\sum_{i=1}^{N} x_i^2 \quad (3)$$

4. Root mean square (RMS): RMS is modeled as amplitude modulated Gaussian random process whose relates to constant force and non-fatiguing contraction.

$$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x_i^2} \quad (4)$$

5. Log detector (LOG): log is defined as mean of logarithmic value for EMG signals.

$$LOG = e^{\frac{1}{N}\sum_{t=1}^{N}\log(x(i))} \quad (5)$$

6. Waveform length: Waveform length is defined as cumulative length of the EMG waveform over the time segment.

$$WL = \sum_{i=1}^{N-1} \left| x_{i+1} - x_i \right| \quad (6)$$

7. Kurtosis: Kurtosis is defined as measure of data whether peaked or in normal distribution range.
8. Skewness: Skewness is defined as value of asymmetry of the probability distribution of a real-valued random variable about its mean.
9. Mean frequency (MNF): MNF defined as mean value of EMG signal's frequency using Fast Fourier Transform (FFT) method.
10. Median frequency (MF): MNF defined as median value of EMG signal's frequency using Fast Fourier Transform (FFT) method.
11. Total power (TTP): TTP defined as total power of density spectrum for EMG signals.
12. Mean power (MNP): MNP defined as mean power of density spectrum for EMG signals.

a. Classification Method

Classification method used in this paper is the standard artificial neural network as shown in fig. 1. ANN consist of three layer. Feature calculation result illustrated in input layer. Hidden layer consist of log-sigmoid transfer function feedforward network and output layer is a hyperbolic tangent sigmoid transfer function.

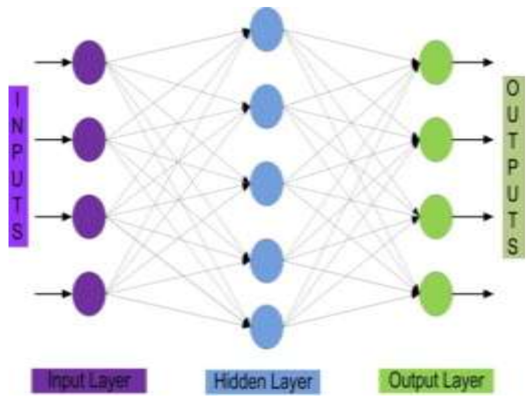

Fig. 1. ANN structure (Ariyanto, et al, 2015)

First output layer of ANN is expressed in Equation (7).

$$\alpha^1 = f^1\left(IWp + b^1\right) \quad (7)$$

Where a^1 is output vector from input layer, input vector length represented by p, IW is input weight matrix, f^1 is transfer function of hidden layer, and b^1 is the bias vector of hidden layer. The first output neuron of the output layer as written in (8).

$$\alpha^2 = f^2\left(LW\left(f^1\left(IWp + b^1\right)\right) + b^2\right) \quad (8)$$

Where a^2 is output vector from output layer, LW is output layer weight matrix, f^2 is transfer function of the output layer, and b^2 is the bias vector of the output layer.

Transfer function for hidden layer and output layer express as in equation (9) and (10). The function of log-sigmoid generates outputs between 0 and 1 while hyperbolic tangent sigmoid function generates ouputs beetwen -1 and 1.

$$f^1(n) = \frac{1}{1+e^{-n}} \quad (9)$$

$$f^2(n) = \frac{2}{1+e^{-2n}} - 1 \quad (10)$$

Training algorithm used The Levenberg-Marquardt as an approach method for second-order training speed without having to determine Hessian matrix. As typical training feedforward networks, the performance function of this training algorithm has the form of a sum of squares, and the Hessian matrix can be approximated using equation (11).

$$H = J^T J \tag{11}$$

and the gradient can be calculated as

$$g = J^T e \tag{12}$$

Where J is the Jacobian matrix that contains first derivatives of the network errors with respect to the weights and biases, and e is a vector of network errors.

The Levenberg-Marquardt training algorithm uses equation (13) to approximate the Hessain matrix.

$$x_{k+1} = x_k - \left[J^T J + \mu I \right]^{-1} J^T e \tag{13}$$

The ANN for classification using Mean Square Error (MSE). The MSE measures the magnitude of the forecast errors as shown in (14). Better model will show the smaller values of MSE.

$$mse_{eror} = \frac{\sum (y_1 - y_2)^2}{m} \tag{14}$$

RESULT

ANN classification result consist of three figures which each representating the data training result, data testing result and total classification result for the data.

Classification result using ANN shows 89.8% of total accuracy for training as can be seen in figure 2. Target class represents input data class and output class represents result of the classification. Class one means healthy control and class two means Parkinson subjects. Output result from healthy class show 75% accuracy and from Parkinson subjects show 97% accuracy.

Table 2. Training result accuracy

Class	True Classification	
	Healthy	Parkinson
Healthy	12	4
Parkinson	1	32
Accuracy (%)	75	97
Overall accuracy (%)	89.8	

Testing accuracy result shows 80% for total classification as can be seen in Table 3. Output accuracy for healthy class training shows 100% accuracy and for Parkinson subjects show 71,4% of accuracy.

Table 3. Testing result accuracy

Class	True Classification	
	Healthy	Parkinson
Healthy	3	2
Parkinson	0	5
Accuracy (%)	100	71.4
Overall accuracy (%)	80	

Total accuracy for ANN classification shows 88,4% as can be seen in figure 4. Total output result classification for healthy control is 83,3% and for people with PD is 91,1%.

Table 4. Total accuracy

Class	True Classification	
	Healthy	Parkinson
Healthy	20	4
Parkinson	4	41
Accuracy (%)	83.3	91.1
Overall accuracy (%)	88.4	

DISCUSSION AND CONCLUSION

Research for EMG signal in people with PD still barely studied in Indonesia. This because Indonesia has only use clinical method to determine PD patient. First contribution of this study is to give an alternative detection method for PD in Indonesia. In further studies PD diagnose can be conducted both clinically and using surface EMG method. Second contribution of this paper is to help better understanding for EMG signals interpretation in PD detection. Feature calculation used in this study balanced between time domain features and frequency domain feature which gives better accuracy and interpretation of EMG signals.

This paper presented a classification method to distinguish PD from younger healthy control using EMG signals for Indonesia case study. As conclusion, the results were able to classified PD from healthy control by above 80% accuracy. Research for age matched participants is on going.

For the further study this research open a path way to distinguish not only PD from healthy control but also PD staging and healthy control. The PD staging tools will be very helpful for both patients and neurological staffs to monitor the progression of disease.

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