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Performance Analysis of various Neural Network functions for Parkinson's disease Classification using EEG and EMG

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Abstract*: Artificial neural network (ANN) is a significant tool for classification of various types of disease using either Biosignals/images or may be any kind of physical parameters. Establishment of appropriate combination of learning, transfer function and training function is a very tedious task. Here, we compared the performance of different training parameters in feed forward neural network for differentiating of Parkinson's disease using human brain (Electroencephalogram) and muscle signals (Electromyogram) features as the input vector. 3 different types of training algorithm with six training functions is used. They are Gradient Descent algorithms (traingd, traingdm), Conjugate Gradient algorithms (trainscg, traincgp) and Quasi-Newton algorithms (trainbfg, trainlm). Proposed work compared the mentioned algorithm in terms of mean square error, classification rate (%),R-value and the elapsed time.

Study showed that trainlm (Levenberg-Marquardt) best fits for larger data set. It showed the highest accuracy rate of 100% with 0 mismatch classification with a best validation mean square error of 0.0040254 in 3 epochs with a elapsed time of 1.12 seconds. The R-value found was 0.9998 which is in nearly equals to 1. Hence, Levenberg-Marquardt can be used as a training function for the classification of any brain disorder

Keywords* : *Artificial neural network (ANN), Electroencephalogram (EEG), Electromyogram (EMG), Parkinson's disease (PD), Neural Network Classification.

I. INTRODUCTION

Parkinson's disease is a brain impairment which is affected due to insufficient and low formation of dopamine in the human brain. It initially starts with tremor of the hands and slowly increases to the other limbs (1) (2). One suffering from PD losses its control of limb movements. They suffer from muscle rigidity and does not have a proper standing, walking or sitting prosture (3). They also come across Sleep disturbances, and many other neuropsychiatric problems (3). PD also results due to continuous contact with toxic drugs like MPTP which is mostly affected in people working in mines. Also the fields workers working in farming sector get exposed to different types chemicals have risk of PD. Many types gene studies are been carried out by researchers to find the genetic causes of PD (4).

Diagnosis of PD brain and muscle signal is a very much essential parameter to find the functional neuronal changes of PD (5). During Parkinson's disease a person muscle and brain coordination gets disturbed. Hence, study of EEG and EMG patterns is a effective tool (6).

Artificial neural network classification is technique to classify various types of system. Most of the disease diagnostic systems are nowadays modeled and designed using neural network classification. ANN is same as that of the biological neurons of our body which consists of inputs, transfer and training functions and the desired output. ANN can be of single-layer or multiple layer neurons. Most of the disease detection system, which is complex dataset, multilayer perceptron (MLP) is used. In MLP network, back propagation (BP) learning algorithm is used (7).

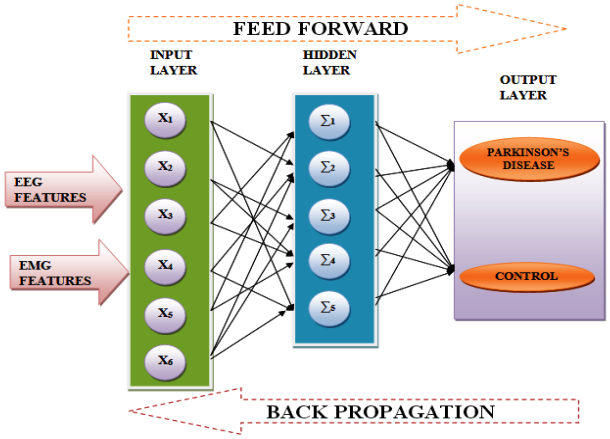

Fig I: ANN Architecture

Some work done in this field is:

Loconsole et al (8) designed a model to classify the PD from healthy subjects on the basis of handwriting on computer vision and sEMG processing. The classification was done using ANN and SVM tools and found that various features on handwriting patterns and classification tools with the sEMG signals acts as effective technique for neurodegenerative disease classification.Berus et. al (9) worked on the classification of PD, using multiple feed-forward ANNs.

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Features were extracted from 26 voice recordings from each individual. Kendall's correlation coefficient based feature selection technique outperformed among all others which recognized the most effective and accurate voice.
Multiple ANNs showed higher accuracy of 86.47% during the classification without use of the feature selection.
Srinivasan et. al (10) studied different pre-processing techniques that can be used to classify PD. Classification was done using ANN using PD datasets collected online database. They concluded that combination of different types of processing techniques like Discretization, Resampling, and SMOTE can be effective for classification of the disease.
Orhan et. al (11) compared some techniques such as artificial immune system, feed forward, learning vector quantization and probabilistic neural network algorithms for detection of PD. 10-fold cross validation method was employed for disease detection. The accuracy was 95.6% from artificial immune system, 95.4% from feed forward, 91.4% from learning vector quantization and 96.5% from probabilistic neural networks where probabilistic neural networks showed the highest accuracy rate.
Training Algorithm
Some of the training algorithm used to evaluate for classification of Parkinson's disease from the control subjects are as follows: (12).

Gradient Descent algorithms

This technique updates weights and biases in negative gradient direction of the performance function. Some of them used are: Gradient Descent back propagation algorithm (traingd) and Gradient Descent with Momentum (traingdm) algorithm(13).

Conjugate Gradient algorithms

It mostly adjusts the weights where the performance function is decreasing quickly (14). Some are: Scaled Conjugate Gradient (trainscg) (15) and Conjugate Gradient back propagation with Polak-Riebre (16).

Quasi-Newton algorithms

The initiation of this technique is finding of the second derivatives of the performance index at the present values of the weights and biases. They are: BFGS (Broyden– Fletcher – Goldfarb– Shanno) (trainbfg) algorithm and Levenberg– Marquardt back propagation (trainlm) algorithm (17)

II. METHODOLOGY

EEG and EMG was acquired from a signal acquisition system designed by AD instruments, Australia loaded with the Lab Chart software for the signal amplification and filtration. 200 subjects participated in the study from health centers around Meghalaya and Assam. Among the participants, 100 subjects were in the initial illness (1 and 1.5 Stage) of PD and 100 subjects were control (no symptoms of PD). The participants were between the age of 50-70 years. Study was initiated by taking written consent from each subject or their guardian. Signals were acquired for a period of 30 minutes in the morning session of the hospital OPD. The exclusion parameters of the PD patients were:

- Later stages (stage 2-5) of the disease
- Age<50 years and > 70 years
- Patients with major surgeries and having any implants (metallic) on their body

Placement of electrodes was as follows (Table no 1):

Table 1: Placement of Electrodes

Parameter	Channel 1	Channel 2	Ground
EEG	Frontal brain	Temporal brain	Forehead bone
EMG	Extension carpis ulnaris	Flexor digitorum superficialis	Elbow bone

Features analyzed from EEG are (18) (19): Lyapunov Exponent and Inverse Lyapunov Exponent, Shannon Entropy and EMG were (20): Power, Standard deviation, Root mean square, Variance, Waveform length, Modified median and mean frequency.
The flowchart of the methodology carried out is given in Fig II.

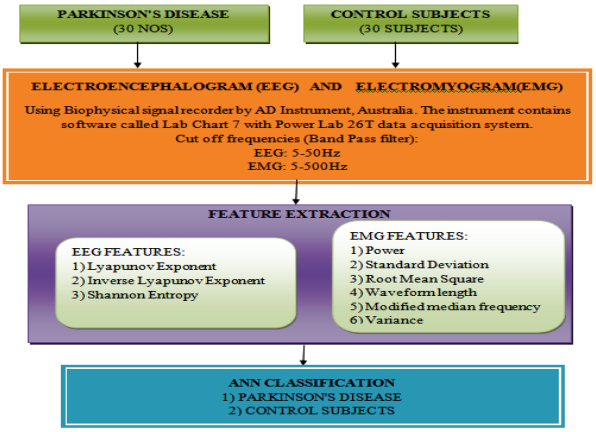

Fig II: Flowchart of Methodology

III. RESULTS AND DISCUSSION

ANN classification and training were carried out in MATLAB 2015(a) using sigmoid function in the hidden layer. The input datasets were the features of EEG (Lyapunov Exponent, Inverse Lyapunov Exponent, Shannon Entropy) and EMG(Power, Standard deviation, Waveform length, Modified median Frequency, Variance and Root Mean Square)extracted from 200 individuals (100 PD and 100 control subjects) and the output datasets were two different classes (PD and Control subjects). During learning, all the inputs were categorized as training (70%), validation (15%) and for testing (15%) sets.
Some of the fixed parameters used are: max_epochs=10000, show=50, performance goal=0.02. The system is compared in terms of elapsed time, no of epoch,
Classification percentage, R on validation. Hidden neurons depend on the size of the input and the output layer. Here we have 9 inputs and 2 outputs. So number of neurons was checked for 5, 7, and 9,10,20,30.
The network is trained till the mean squared error was found to be less than 0.0. It was found that trainscg and trainlm are almost the fastest which outperformed among all other training functions. Table 1 below shows the overall classification percentage and all other parameters for each training function.

Trainlm showed the highest classification rate of 100% and also an R value of 0.9998 which signifies a accurate network response with an epoch time of 1.12 seconds.

Table 1: Overall classification percentage

ALGORITHM	TRAINING FUNCTION	NEURONS	BEST VALIDATION MSE	EPOCH	CLASSIFICATION	ELAPSED TIME	MISMATCH	R VALUE
Gradient Descent	traingd	5	0.098733	387	62	120.54	38	0.349
		7	0.028972	29	55	23.98	45	0.9872
		9	0.984022	80	66	9867	34	0.5768
		10	0.016814	49746	65	140.59	35	0.3385
		20	0.038248	615	59	2.43	41	0.3451
		30	0.11569	27	62	1.803	38	0.4563
	traingdm	5	0.30489	34	70	1.879	30	0.8799
		7	0.67392	98	65	23.97	35	0.5647
		9	0.45729	109	50	45.92	50	0.3987
		10	0.023574	1339	81	3.97	19	0.5643
		20	0.063293	10	62	1.582	38	0.3452
		30	0.21658	39	79.31	1.62	20.68	0.35214
Conjugate Gradient	trainscg	5	0.45922	67	77.7	3.45	22.3	0.9874
		7	0.76845	56	79	5.45	21	0.786
		9	0.67368	89	80	4.56	20	0.8675
		10	0.05474	31	80	0.797	20	0.8976
		20	0.009897	37	78	0.703	22	0.8776
		30	0.85889	34	83	0.859	17	0.6578
	traincgp	5	0.98679	45	56	0.879	44	0.9876
		7	0.34562	67	65	0.987	33	0.8758
		9	0.45638	1200	70	2.99	30	0.9864
		10	0.10601	7	79	2.979	21	0.79643
		20	0.33333	10	50	1.737	50	0.57735
		30	0.045124	4	76	1.727	24	-0.4563
Quasi Newton	trainbfg	5	0.93839	5	55	2.678	45	0.7863
		7	0.85639	25	69	1.77	31	0.7689
		9	0.76835	89	75	0.99	25	0.98753
		10	0.012399	5	78	2.28	22	0.5637
		20	0.010487	5	56	1.88	44	0.6574
		30	0.27778	4	50	1.911	50	0.57733
	trainlm	**5**	**0.000234**	**6**	**96**	**1.88**	**4**	**0.1259**
		7	**0.000215**	**10**	**98**	**0.78**	**2**	**0.9856**
		9	**0.000012**	**15**	**100**	**0.02**	**0**	**0.9879**
		10	**0.0040254**	**3**	**100**	**1.12**	**0**	**0.9998**
		20	**0.027757**	**30**	**89**	**1.928**	**11**	**0.9968**
		30	**0.0048949**	**25**	**90**	**1.14**	**10**	**0.9876**

IV. CONCLUSION

Feed-forward back propagation neural network is a significant tool for classification of neurodegenerative disorders like PD, Alzheimer's disease etc. with effective combination of training , transfer and learning functions.

In our study, it was found that there was no differences between the recognition rates for trainscg and trainlm. On the other hand, it was seen that the training speed of trainlm is much greater. If we see the overall network performance considering all the parameters, trainlm outperforms as compared to other training functions with respect to classification of brain disorders using EEG and EMG.

Hence, it can be concluded that trainlm is the effective function for the classification of any kind of neurodegenerative disorders with respect to both less time for execution with more number of input data.

CONFLICT OF INTEREST

Authors confirm that there is no conflict of interest.

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Ethically approved by:

a) Institutional Ethical Committee (NEHU), Sanction order no: IECHSP/2017/42 and NEIGR/IEC/M6/F13/18.

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