"Classification of EEG Using Wavelet Based -Neural Networks"

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Content

Introduction

Epilepsy is a common brain disorder that affects about 1% of the world population, where 25% of such patients cannot be treated properly by any available therapy [ENG97].

Epileptic seizures:

A sudden abnormal function of the body
Loss of consciousness
Increase muscular activity
Abnormal sensation

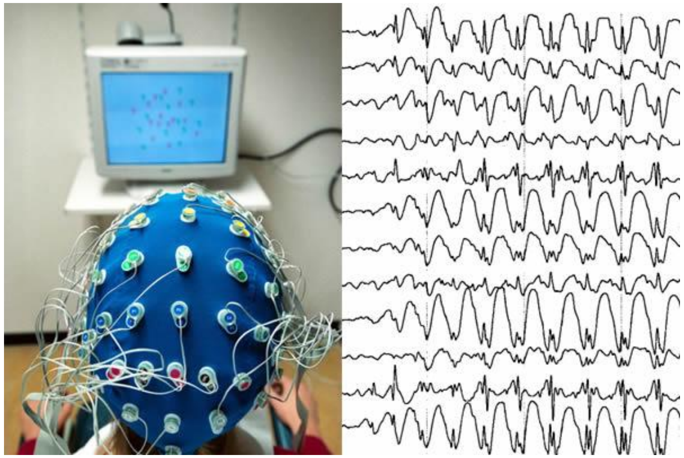


Figure 1. Electroencephalogram (EEG)

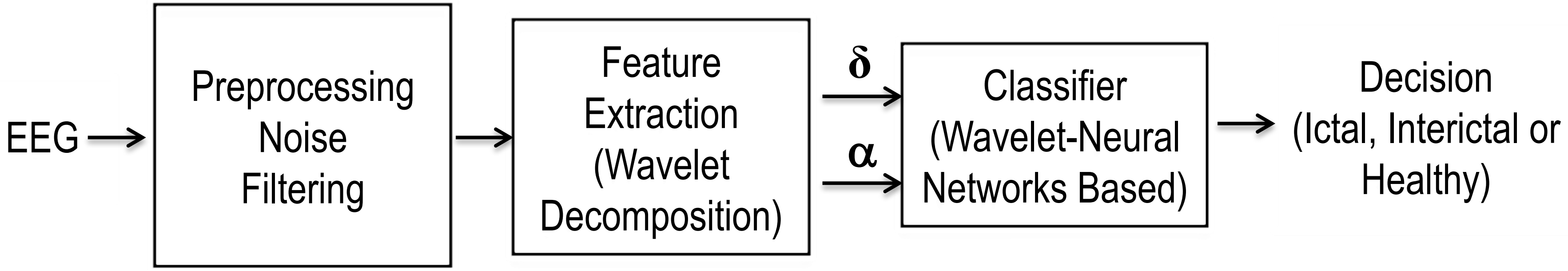
Electroencephalogram (EEG) is a technique non-invasive, is clean, cost effective and safe technique for monitoring brain activity.

Research objective

This research is focused on a study of connectionist models to analyze, detect and classify to identify stages of Epilepsy using EEG.

This work aims to develop new structures of classifiers based on Wavelet Neural Networks to enhance the classification of the EEG signals.

General block diagram



Preprocessing

Some physiological researchers consider that EEG frequencies above 60 Hz are noise and can be neglected [MIR11].

Low-pass filters

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Characteristics

- Cut-off frequency: 64 Hz
- Ripple in the pass-band: 3dB
- Attenuation in the stop-band: 60 dB

↓ ↓

Infinite Impulse Response (IIR)

- Chebyshev II (order 24)
- Elliptic (order 9)

Finite Impulse Response (FIR)

- Equiripple (order 343)
- Least squares (order 350)

Feature extraction

In this work, wavelet analysis was used to decompose the EEG signals into delta (δ), theta (θ), alpha (α), beta (β), and gamma (γ) sub-bands.

Wavelet analysis

Discrete Wavelet Transform (DWT)

- Haar wavelet
- Second order Daubechies (Db2)
- Fourth order Daubechies (Db4)

Maximal Overlap Discrete Wavelet Transform (MODWT)

- Haar wavelet
- Second order Daubechies (Db2)
- Fourth order Daubechies (Db4)

Delta, Theta, **Alpha**, Beta, Gamma
(Mean, Absolute median, Variance)

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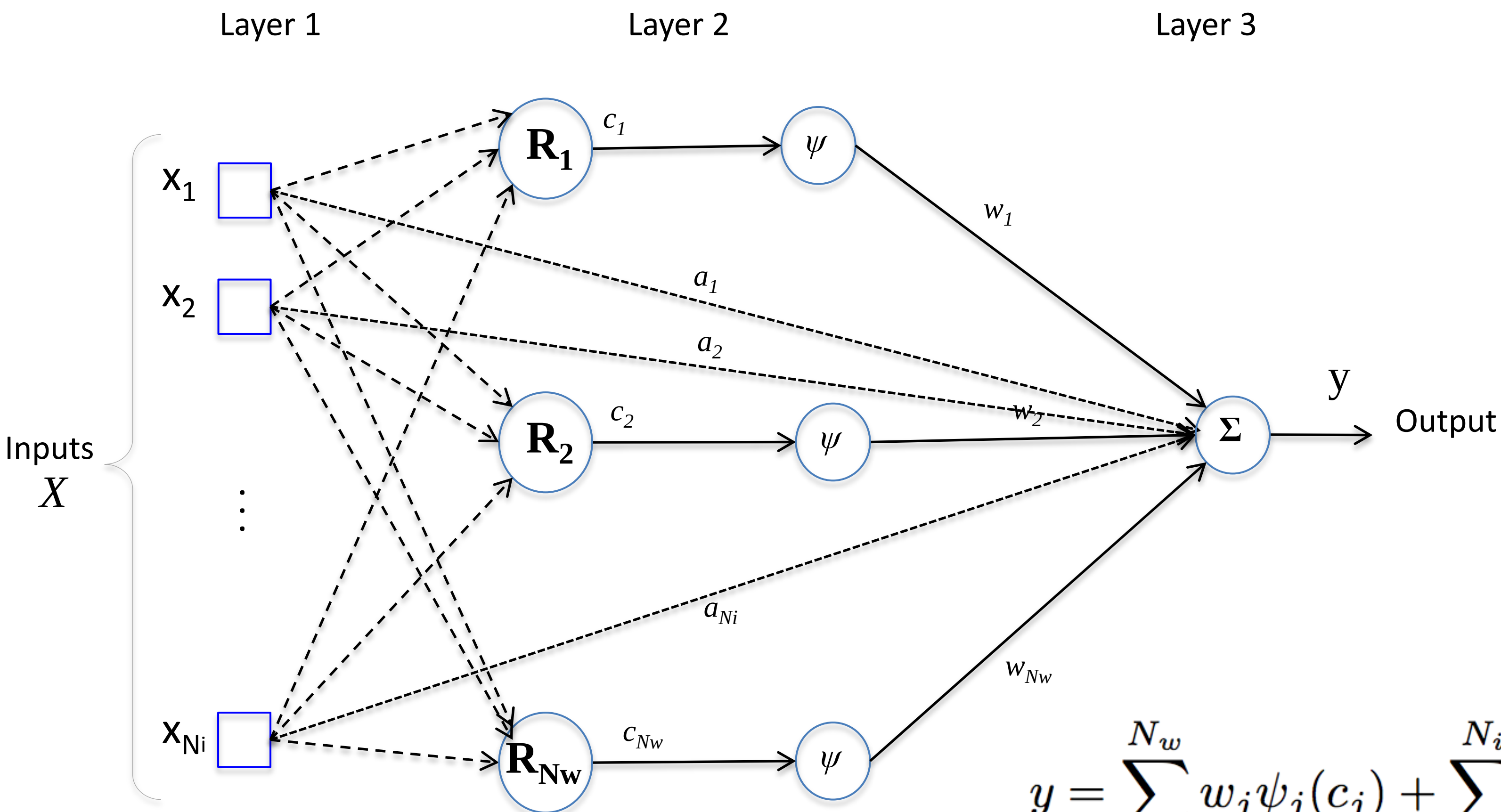
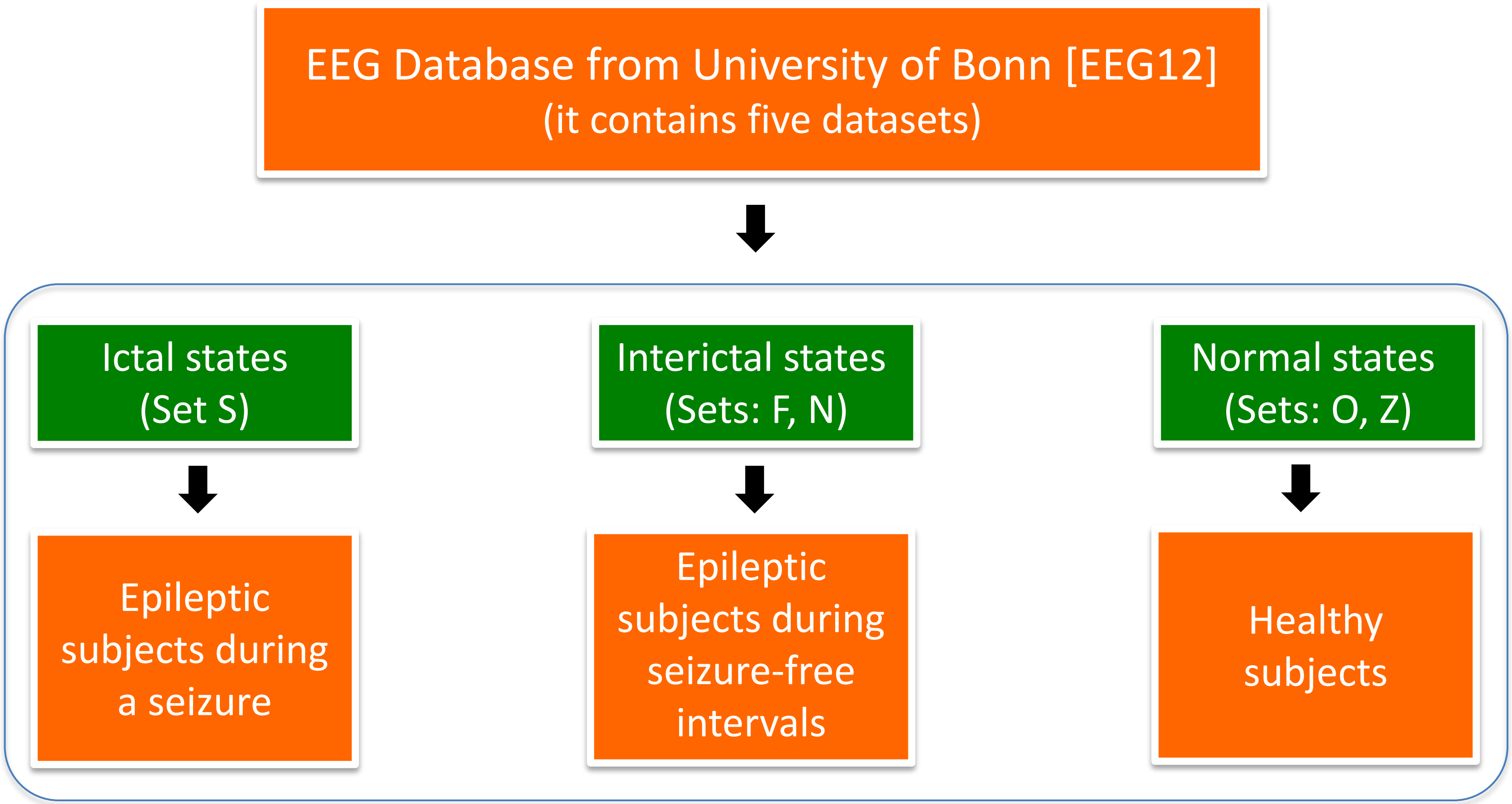
Proposed model: Multidimensional Radial Wavelons – Feed-Forward Wavelet Neural Networks (MRW-FFWNN)



$$y = \sum_{j=1}^{N_w} w_j \psi_j(c_j) + \sum_{k=1}^{N_i} a_k x_k$$

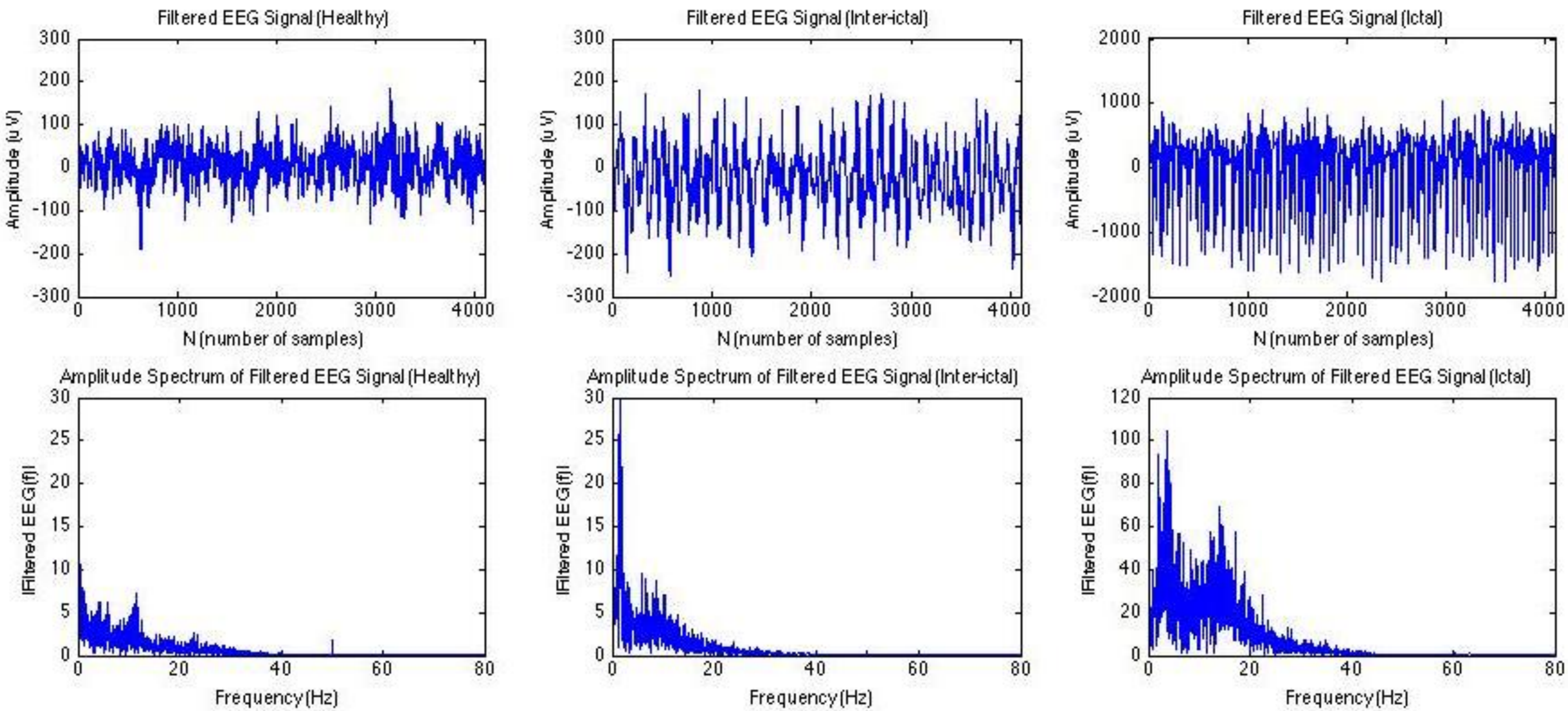
Experimental Data EEG



Each set holds 100 segments of EEG signals of 23.6 seconds. The sampling frequency of these signals was 173.6 Hz, so each segment contains 4,096 samples. Sets Z, F and S were used only for the results reported here.

EEGs states

Healthy | Inter-ictal | Ictal



Results

We present the results of a model based on wavelet analysis and neural networks for identification of seizures events of epilepsy (Ictal, Interictal and Healthy). We tested several filters, wavelets and wavelet transformations and we have used several classifiers to compare the results obtained.

1. FFWNN (Feed Forward Wavelet Neural Network)
2. **MRW-FFWNN (Multidimensional Radial Wavelons FFWNN)***
3. SRWNN (Self-Recurrent Wavelet Neural Network)
4. MRW-SRWNN (Multidimensional Radial Wavelons-SRWNN)

***Proposed model**

Results of classifiers based on WNN (Decision tree: Ictal-Interictal-Healthy)

Best combinations:

Feature Extraction	FFWNN (Accuracy %)					*MRW_FFWNN (Accuracy %)				
	Ictal	Inter	Healthy	Indeter	Total	Ictal	Inter	Healthy	Indeter	Total
Cheby2-SWT-Db2	90.59	46.67	71.56	12.33	**72.11**	92.35	40.00	72.81	13.54	71.44
Ellip-DWT-Db4	73.00	75.00	30.36	14.89	60.44	85.00	**79.06**	52.50	12.05	**72.78**

Feature Extraction	SRWNN (Accuracy %)					MRW_SRWNN (Accuracy %)				
	Ictal	Inter	Healthy	Indeter	Total	Ictal	Inter	Healthy	Indeter	Total
Ellip-DWT-Db2	90.94	34.81	64.84	14.52	**65.11**	85.94	64.81	50.97	14.21	67.56
LeastSquares-DWT-Db1	92.22	33.03	37.67	15.65	52.33	94.07	49.70	79.00	12.05	**72.78**

Characteristics of WNN:
Wavelet: Mexican hat; Iter: 100; Learning rate: 0.1; 10 executions, 40 neurons

* Our proposal

Conclusions

- ✧ We present the results of a model based on MRW-FFWNN as classifier and we tested several filters, wavelets and wavelet transformations in order to find a suitable combination to improve the results reported in the classification of EEG signals.

Thanks