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Title EEG filtering with Quantum Neural Networks for a Brain-Computer Interface (BCI)

INTRODUCTION

Electroencephalogram (EEG) recorded during motor imagery (MI) based communication using a Brain-computer interface (BCI) is inherently embedded with non-Gaussian noise while the actual noise-free EEG has so far been elusive. This paper presents a novel neural information processing architecture which involves deploying the Schrodinger Wave Equation (SWE) to filter noise from EEG.

METHOD

The proposed Recurrent Quantum Neural Network (RQNN) (cf. Figure 1) represents a non-stationary stochastic signal as time varying wave packets [1]. The basic approach is to ensure that the statistical behaviour of the input signal $y(t)$ is properly transferred to the wave packet associated with the response of the quantum dynamics of the network. At every computational sampling instant, the EEG signal is encoded as a wave packet which can be interpreted as the probability density function *(pdf)* of the signal at that instant. The features in the form of Hjorth parameters and band-power are then extracted from the RQNN filtered EEG $\hat{y}(t)$. These features are classified using linear discriminant analysis (LDA).

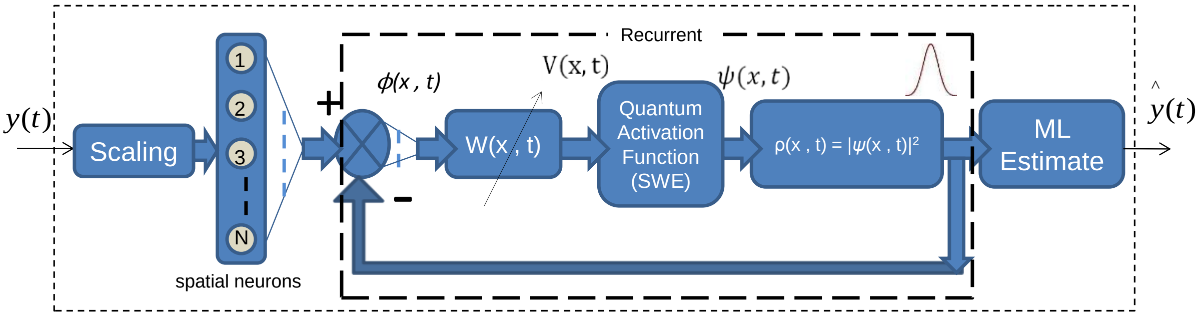

Figure 1: RQNN model

RESULTS

The RQNN is demonstrated to effectively filter noise from simple signals such as DC, staircase DC and sinusoidal with model parameters optimized using particle swarm optimization (PSO). The RQNN is significantly better than the Kalman model while filtering the DC signal. A two-step inner-outer 5-fold cross-validation approach is utilized for selecting the RQNN model parameters to suit individual subjects. The filtered signals from the subject specific RQNN model during the training and the evaluation stages are shown to be more separable than the raw EEG, Savitzky-Golay filtered EEG or raw EEG with the power spectral density or the Bispectrum based features for the BCI competition IV 2b dataset.

REFERENCES

[1] V. Gandhi, V. Arora, L. Behera, G. Prasad, D. Coyle and T. McGinnity, "EEG denoising with a recurrent quantum neural network for a brain-computer interface," in The 2011 International Joint Conference on Neural Networks (IJCNN), pp. 1583-1590, 2011.