Classification of attention deficit/hyperactivity disorder (ADHD) by extracting non-linear features of children's EEG

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Abstract: ADHD is the most frequent disorder in children. According to researchers, it is the most common disorder of childhood and detection of that is very important. In this study, database includes totally 30 subjects, of which 12 are the ADHD and the other 18 are healthy subjects. Using non-linear features, that selected by Wilcoxon test, we address the classification of both groups (healthy and hyperactive). In this paper, the support victor machine (SVM) classifier with 4 kernel function (Polynomial kernel_3, Multilayer perceptron(mlp), Radial basis function(rbf), and quadratic) is used.

Keywords: Attention deficit/hyperactivity disorder (ADHD), Entropy, Empirical mode decomposition (EMD), Wilcoxon test, Support victor machine(SVM).

1. Introduction

Typically, 3-5% of children in the school ages have ADHD [1], and man-woman ratio of it is 9:1[2]. There are various tests for evaluating both cognitive abilities and motor-mental functions of child, including Wender Utah Rating measurement [3,4], parent Karnes' questionnaire [3], and teacher Karnes'. Because of the variety of ADHD criteria, in which behavior reports are required from parents and teachers, patients will refer to a physician and she/he recognize this disorder. Using analysis of EEG signal to obtain those features being helpful scientifically and medically is a way to reach ADHD recognition.

In this study, using both non-linear features (EMD, entropy) and Wilcoxon test, significant relationships between two groups will be investigated. Then given features will be applied for classification task.

2. Methodology

In this paper, database includes totally 28 subjects, of which 12 are the ADHD and the other 18 are healthy subjects[5-8]. Our aim is classifying ADHD subjects from healthy by extracting non-linear features of EEG signals. For this purpose, we use support victor machine, SVM classifier with kernel functions as follows: Polynomial, mlp, rbf, and quadratic. Also, feature selection is based on Wilcoxon test. Four category of nonlinear features are extracted from EEG signals: signal entropy[9-14], EMD-IMF4[15] (entropy of intrinsic mode function in 4 level of empirical Mode Decomposition), EMD-IMF5, EMD-IMF6. Figure 1 demonestrates our proposed algorithm. As shown in Table 1, based on our proposed algorithm, the best achieved accuracy with polynomial-3 kernel for signal entropy, EMD-IMF4, EMD-IMF5 and EMD-IMF6 is 81%, 80.5%, 91% and 90.5%, respectively.

3. Results

The obtained results show that accuracy of the algorithm increases from signal entropy to EMD-IMF6. Due to the nature of EMD, IMFs would be ordered from highest frequency to lowest one. We could find some differences in entropy of two groups (healthy and ADHD) at low frequencies. Thus, the extracted features from low frequency components of signal will be so effective. Also, from Wilcoxon test, we could find that the significant differences between two groups is more high based on Shannon entropy at Channel T5 as well as sample entropy at Channel F4 (Table 2). Therefore, the disorder will affect more on this brain's area.

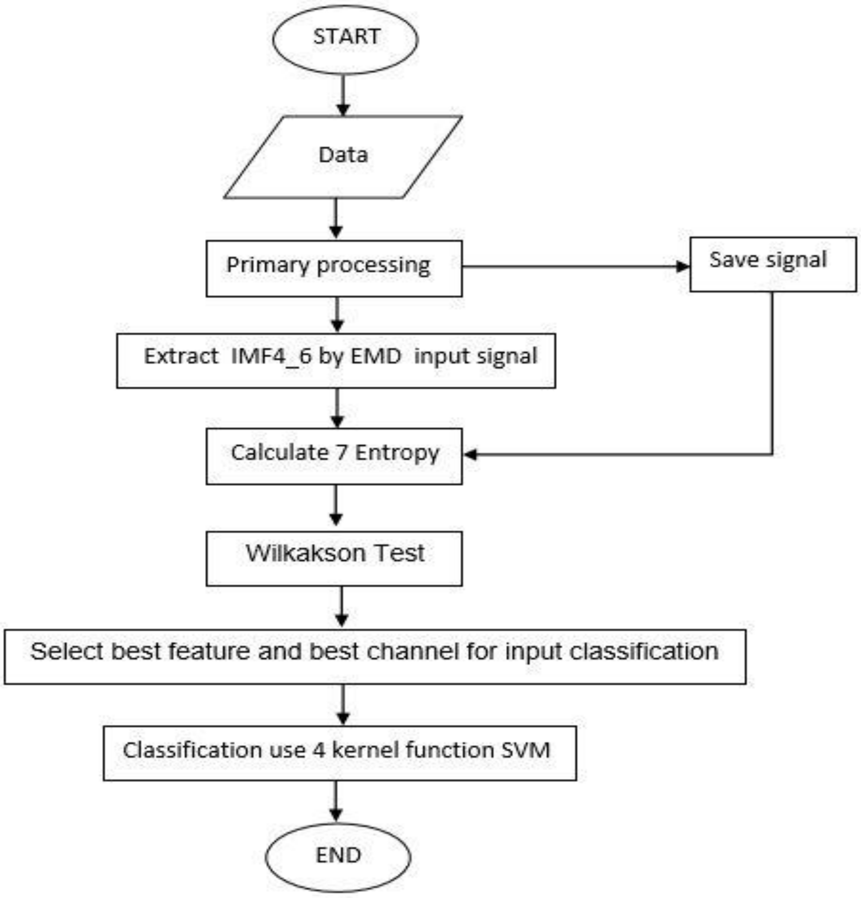

Figure 1: The Proposed algorithm.

Table 1: SVM classifier results based on 4 different categories of features and kernel functions.

Kernel Function	Signal Entropy	Entropy EMD-IMF4	Entropy EMD-IMF5	Entropy EMD-IMF6
Polynomial-3	81	80.5	91	90.5
RBF	76.7	81.2	90	93.2
MLP	75.45	81.6	83.5	91
Quadratic	77.6	80.01	85.7	90.3

Table 2: The best selected channels based on Wilcoxon test with threshold equals 0.02 (p_value).

		Channel
Entropy EMD-IMF5	Shannon Entropy	T5, F8
	Sample Entropy	F4,O1,Fz,C3,T3
Entropy EMD-IMF4	Shannon Entropy	Cz,T4,T5,F4,O1,F7,Fz,Fp2
	Sample Entropy	C3,T3,F4,P3,Fp2,Cz,F3,T5,T6,F7

4. Discussion

With due attention to various articles, we could find the correctness of our results about significant area for both groups. The common property of these area are their role to cause impairment in the brain, and appearing other significant is itself as a reason for the way of signal record (at rest time) and performance of both sample and Shannon entropy. For example, in [16], Swartwood at al. Through studying 46 healthy and ADHD subjects with evaluation test of attention (To Vo) calculated that in subjects with ADHD at area O2, T 6, T 5 in open eyes mode, much more alpha will be observed. Also, alpha production encoding condition at T5 is different from two groups.

In this study, Sohen at al. [17] imposed EEG signal approximate entropy of healthy and ADHD subjects, and found that average approximate entropy in patients with ADHD at FP2 and FP8 is much less than that of healthy ones; thus, we could conclude that there is a highest significant relationship between these entropy and these area.

5. Conclusion

Using non-linear features obtained from EEG signals of both healthy and ADHD children's brain, classification was done, and average hundred bar of training and random experiment for rbf kernel function (92.2%) was obtained, that with due attention to the classification results, we found the most differences between two groups at low frequencies.

6. References

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