Detection of Parkinson's Disease Using Automated Tunable Q Wavelet Transform Technique with EEG Signals

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Abstract

Parkinson's disease (PD) is a brain disorder that causes unintended or uncontrollable movements, such as shaking, stiffness, and difficulty with balance and coordination. Electroencephalogram (EEG) signals may faithfully represent the changes that occur during PD in the brain. Therefore, EEG signals are required to decompose into multiple sub-bands (SBs) to get detailed and representative information from it. Hence, An automated tunable Q wavelet transform (A-TQWT) is proposed for automatic decomposition. A-TQWT extracts representative SBs for analysis and provides better reconstruction for the synthesis of EEG signals by automatically selecting the tuning parameters. Five features are extracted from the SBs and classified different machine learning techniques. The proposed method yielded an accuracy of **96.13%** and **97.65%** while the area under the curve of **97%** and **98.56%** for the classification of HC vs PD (OFF medication) and HC vs PD (ON medication) using least square support vector machine, respectively.

Objective

The objectives of the research work are as follows:

- To extract the hidden information from the EEG signal using A-TQWT.
- To obtain high classification performance with minimal margin of error.
- To develop fully automated Parkinson's disease detection method.

Methodology

The proposed framework comprises of the following steps:

- **At first,** A-TQWT adapts the tuning parameter according to the nonstationary and non-linear nature of EEG signals using Jaya optimization algorithm (JOA) and decomposes it into SBs.
- **Secondly,** Hurst exponent (HE), Higuchi fractal dimension (HFD), minima, Hjorth complexity (HJC) and mobility (HM) features are extracted from each SB.
- **Finally,** validity of these features is tested by classifying and evaluating several performance parameters using least square SVM (LSSVM).

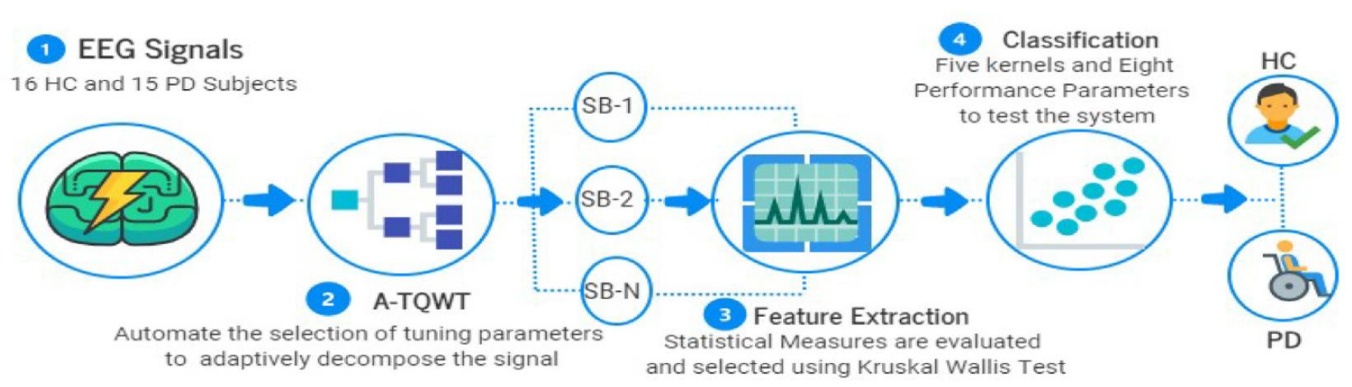


Fig. 1: Flow Chart of the Proposed Method.

Automated TQWT

TQWT decomposes the signals into lowpass (LPS) and high-pass (HPS) SBs with a choice of tuning parameters.

The study of low-frequency content in the signal is analyzed with lowpass scaling (LPS) represented by ψ.

$$U(v) = V(\psi v), |v| \leq \pi$$

The high-pass scaling (HPS) enables the analysis of high frequency components of the signal denoted by n.

$$U(v) = \begin{cases} V(\xi v + (1-\xi)\pi), 0 < v < \pi \\ V(\xi v - (1-\xi)\pi), -\pi < v < 0 \end{cases}$$

TQWT requires tuning parameters called quality factor (Q), redundancy rate (q), and a number of decomposition levels (R) to decompose the signal into sub-bands.

$$\rho = \frac{\xi}{1-\psi} \qquad Q = \frac{2-\xi}{\xi} \qquad R_{max} = \left| \frac{\log\left(\frac{N}{4(Q+1)}\right)}{\log\left(\frac{Q+1}{Q+1-\frac{2}{\rho}}\right)} \right|$$

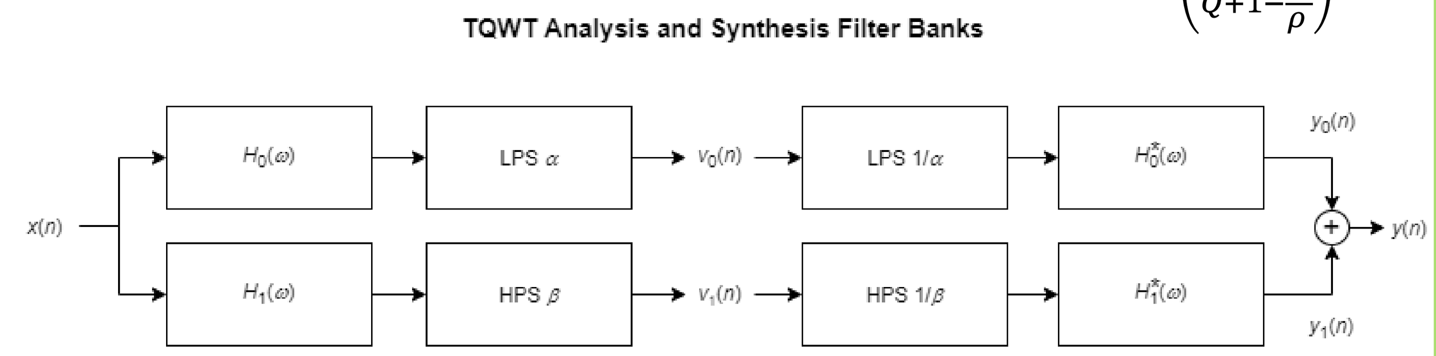


Fig. 2: Tunable Q Factor Wavelet Transform (Filter Bank).

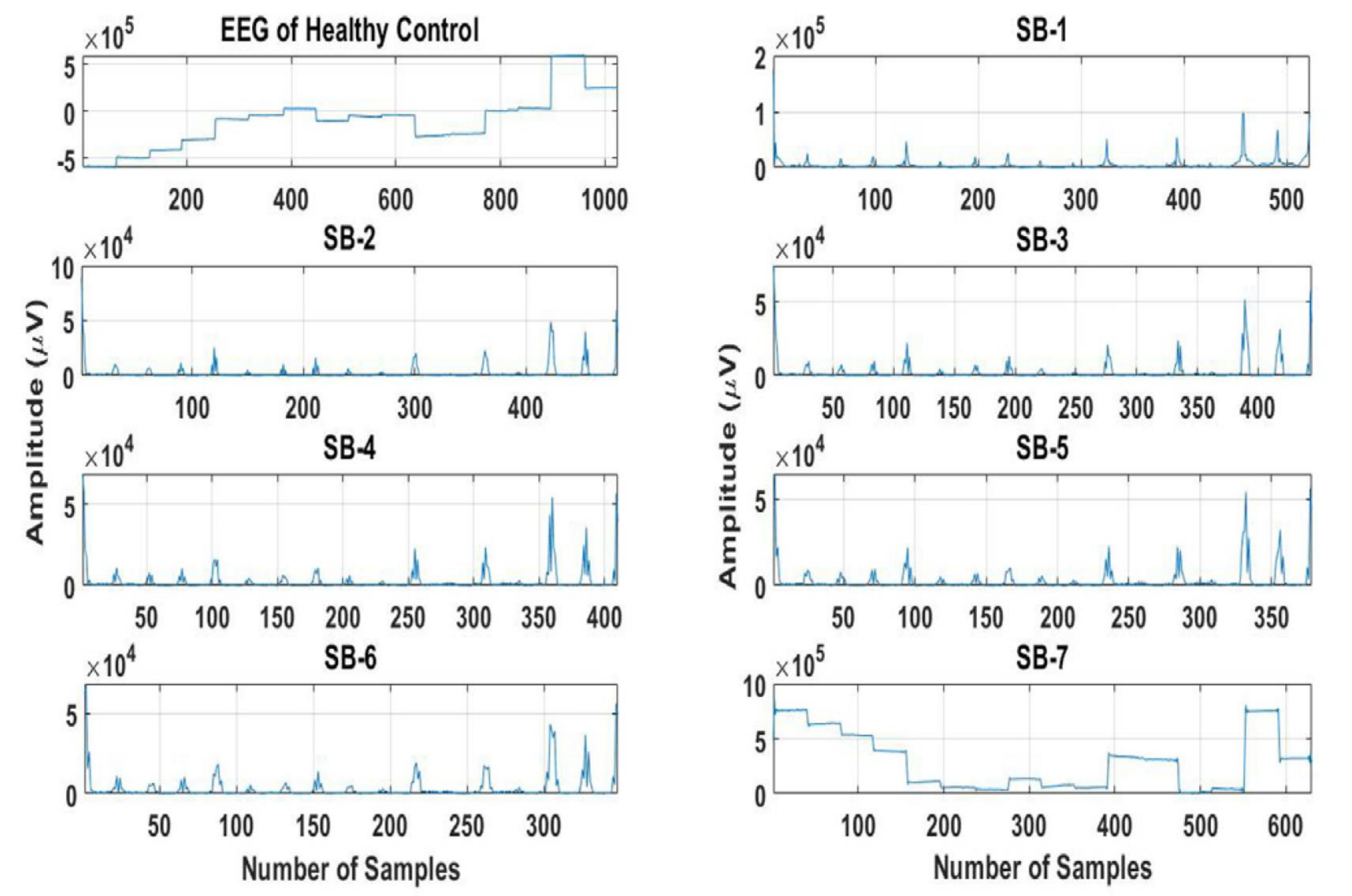


Fig. 3: Typical EEG signals: (a) HC subject, and (b) its ATQWT sub-bands.

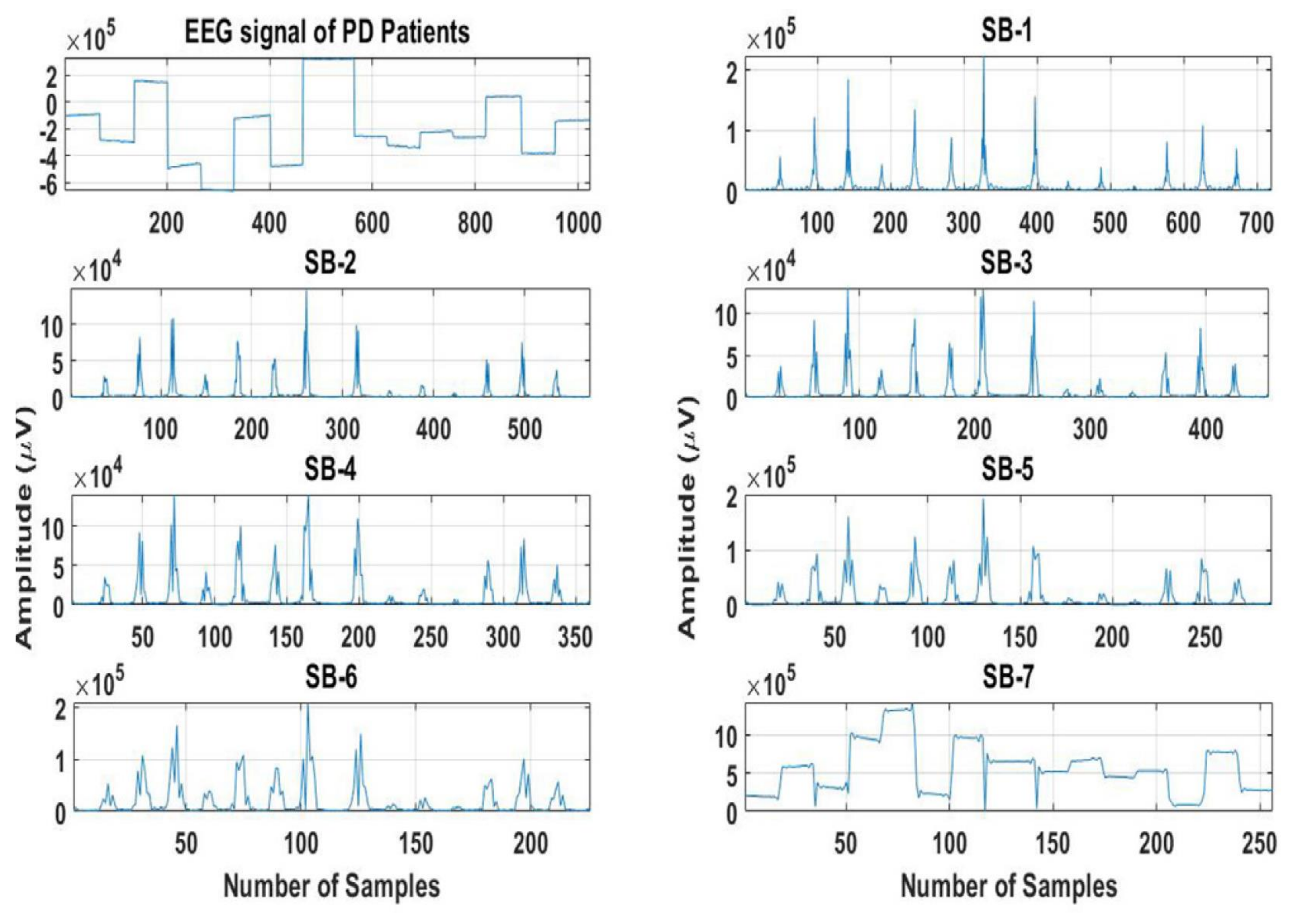
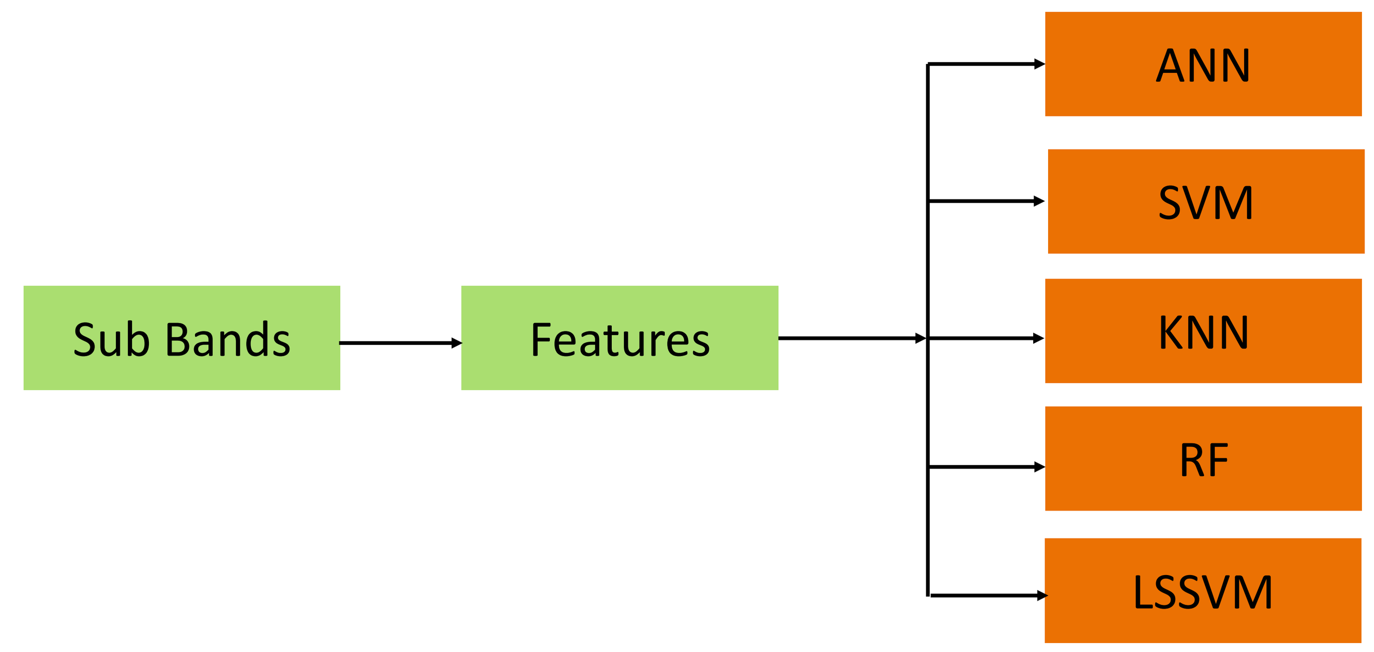


Fig. 4: Typical EEG signals (a) PD subject, and (b) its ATQWT sub-bands

Classification



Results

Table-1: Comparison of average errors obtained due to TQWT and A-TQWT techniques.

Class	TQWT	A-TQWT
HC	0.0491	**3.88 X 10^{-06}**
SF	0.0456	**1.78 X 10^{-05}**
SO	0.08903	**1.10 X 10^{-06}**

Table-2: Summary of comparison for automated detection of PD with state-of-the-art techniques.

Authors	Dataset	Method	Classifier	ACC(%)
[1]	Speech	WT, MFCC	SVM	86.64
[2]	EEG	WT	LDD	79.16
[3]	EEG	FFT	RNN	74
[4]	EEG	TVD	SVM	94.34
Proposed	EEG	A-TQWT	LSSVM	**97.65, 96.13**

Conclusion

This poster presents an effective and automated PD detection method using A-TQWT technique with EEG signals. The proposed A-TQWT provides representative decomposition and reconstruction for signal analysis and synthesis. The proposed combination of A-TQWT and LSSVM is so effective that it outperforms existing speech, motions, and EEG-based state-of-the-art techniques. In future, the proposed method can be used to detect other neurological disorders like autism, Alzheimer's disease, attention deficit hyperactivity disorder and insomnia.

References

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