Feature Extraction Using Wavelet Scattering Transform Coefficients for EMG Pattern Classification

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Background : Wavelet transforms analysis is one of the several methods utilised for feature extraction with EMG biomedical signals in the time-frequency domain (TFD). Wavelet analysis-based feature extraction methods can be primarily categorised into three categories: wavelet transform (WT), wavelet packet transform (WPT), and the recently proposed deep wavelet scattering transform (WST). While many researchers utilised the WST methods to extract features from other biomedical signals, the WST has not been investigated for feature extraction with EMG pattern recognition. This paper examines the potential benefits associated with the use of deep WST as a feature extraction method for the EMG signal and compares it with other wavelet methods. We used three well-known different EMG datasets collected with laboratory and wearable armbands hardware to provide a comprehensive performance evaluation under different settings. The new method demonstrates significant improvements in the myoelectric pattern recognition performance compared to WT and WPT, with accuracy reaching up to 96%.

Methodology

One of the efficient tools for data descriptions and feature extractions is the WST, which is considered more advantageous than convolutional neural networks (CNN). Compared to CNN, WST can overcome the need for many model parameters, high computational costs, hyperparameters tuning, and difficulty understanding and interpreting the extracted features. WST can be considered as a deep scattering network, as it also employs convolutions, non-linearity, and pooling, just like CNN. However, unlike CNN, wavelet scattering requires no training and works perfectly with small data sizes, which is a major bottleneck for all deep neural network models. In addition, the WST can deliver reliable locally stable features to small deformations that can be combined with a deep neural network.

In WST, the time-series input of the EMG signal passes through several layers; the output of one layer is an input for the next layer. Each layer consists of three steps to perform wavelet scattering transform: convolution, non-linearity, and averaging, as shown in Figure 1.

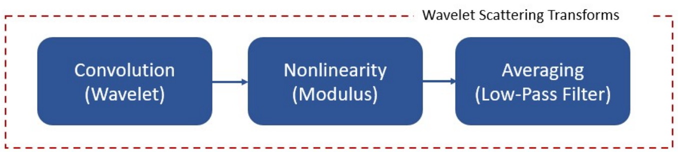

Figure 1

Results

The extracted features were examined via the Wavelet scattering transform method to show the superiority of the proposed technique while using a support vector machine (SVM) classifier to get classification error rates.

Results of BioPatrec-database

The classification errors comparison between the proposed method, WT and WPT features averaged across the 17 participants of the BioPatrec database are shown in Figure 2. It shows, the WST features have better performance than other methods, with p-value of < 0.001 using the Wilcoxon signed rank test of significance.

Results of Force-database

For the transradial amputee's dataset, the results were calculated for each force level, as shown in Figure 3. Across these results, the proposed method achieved a lower classification error with $p < 0.001$ for all tests.

Results of 3DC-database

Figure. 4 shows the averaged classification error results across all the 22 subjects of the EMG 3DC database, following a similar trend displayed with the other two datasets.

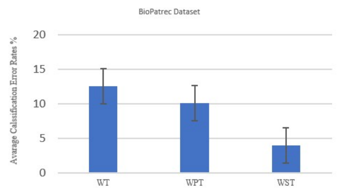

Figure 2

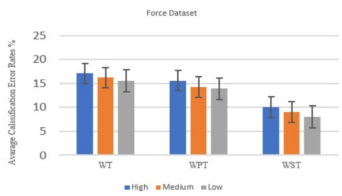

Figure 3

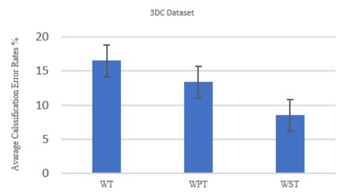

Figure 4