Selected Topics in Biomedical Signal Processing

Author 1 Author 2

Date

1 Data-driven filter design for biomedical sensor arrays

Unsupervised artifact removal using CCA

The raw EEG data is shown in Figure.1. In Figure.2, the eye-blink artifacts can be seen at $t = 0s, 2.5s, 4.8s, 7.2s$.

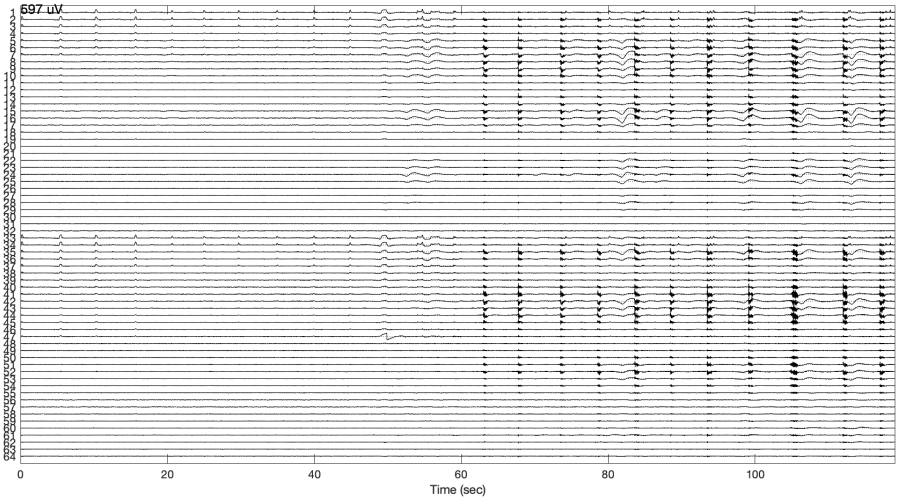


Figure 1: Raw EEG data

The magnitude of the eye-blink artifacts differs from channel to channel. This is cause by the different locations of the electrodes.

The reconstruction can be done by setting the sources with lower autocorrelation to 0.

Supervised artifact removal using MWF

By introducing the delay, the performance.

Filter design in threshold-based spike sorting

Figure.6 shows

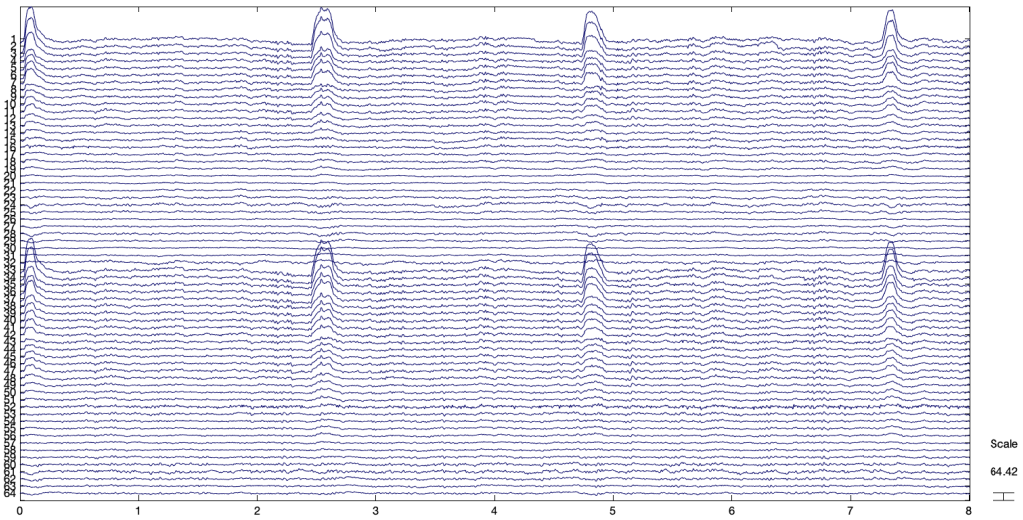
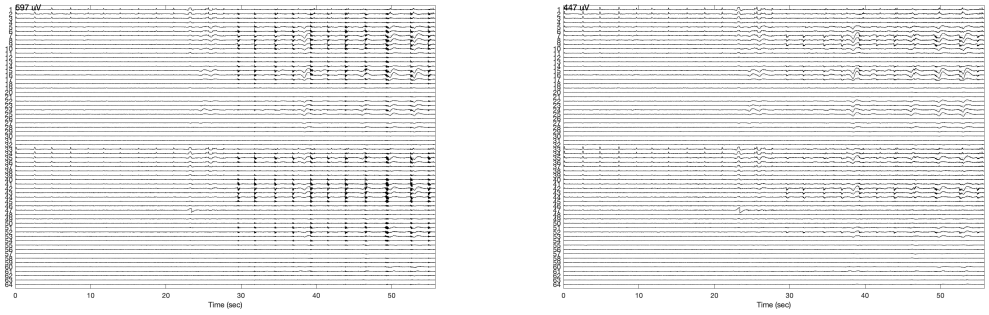


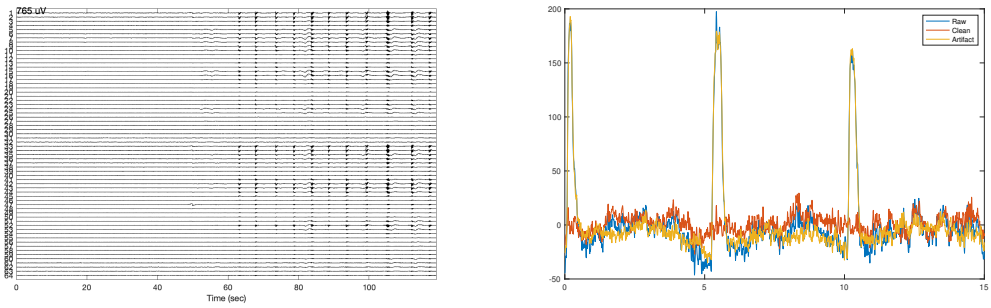
Figure 2: Eye-blink artifacts



(a) Raw EEG data

(b) Muscle artifact removed

Figure 3: Artifact removel with CCA



(a) Eye-blink artifact removal

(b) Artifacts removal on Ch3, zoomed in

Figure 4: Eye-blink artifacts removal with MWF

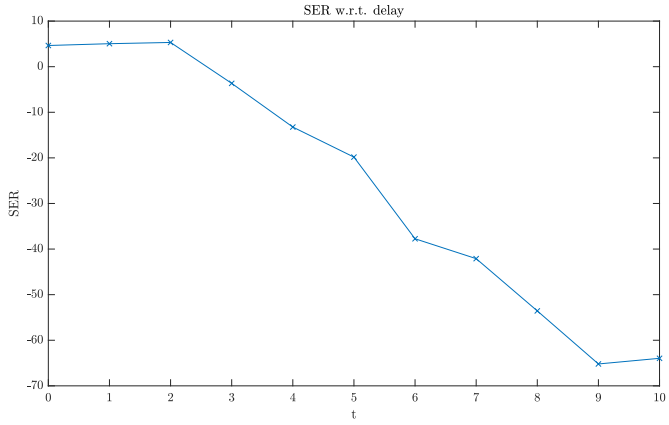


Figure 5: SER under different time delay

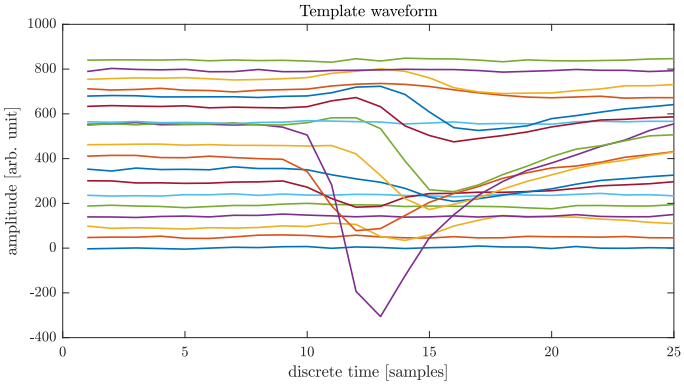


Figure 6: Spatio-temporal template of the target neuron

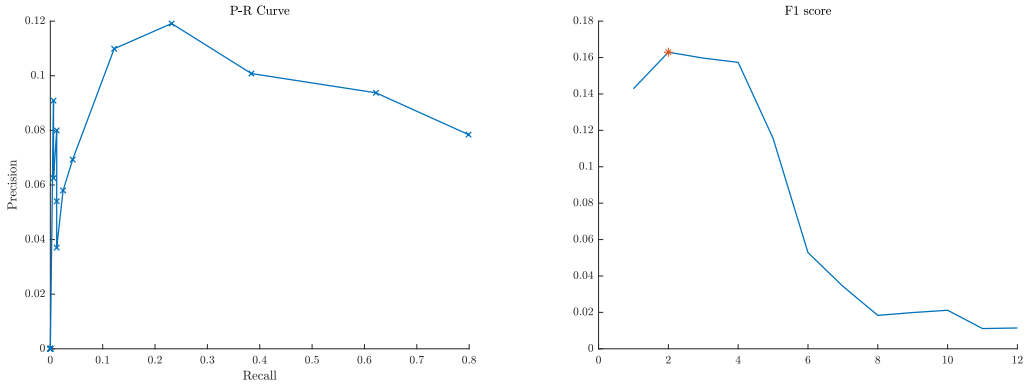


Figure 7: P-R curve and F1 score of the matched filter

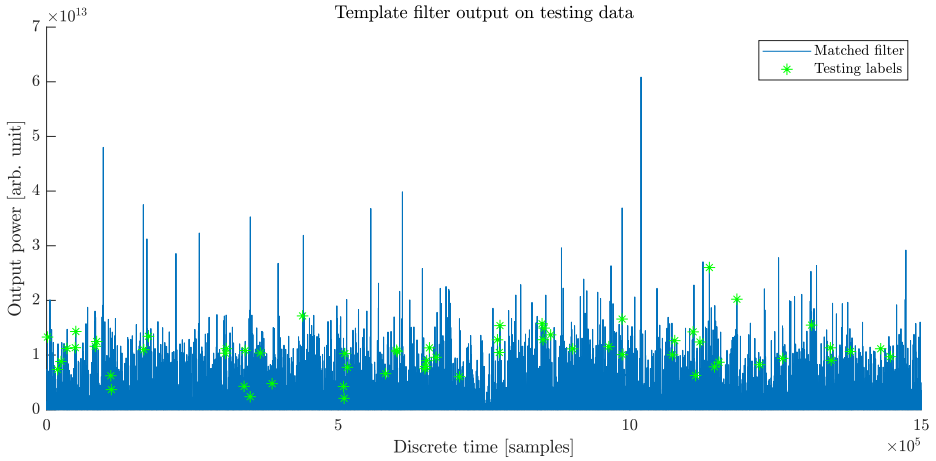


Figure 8: Template filter output

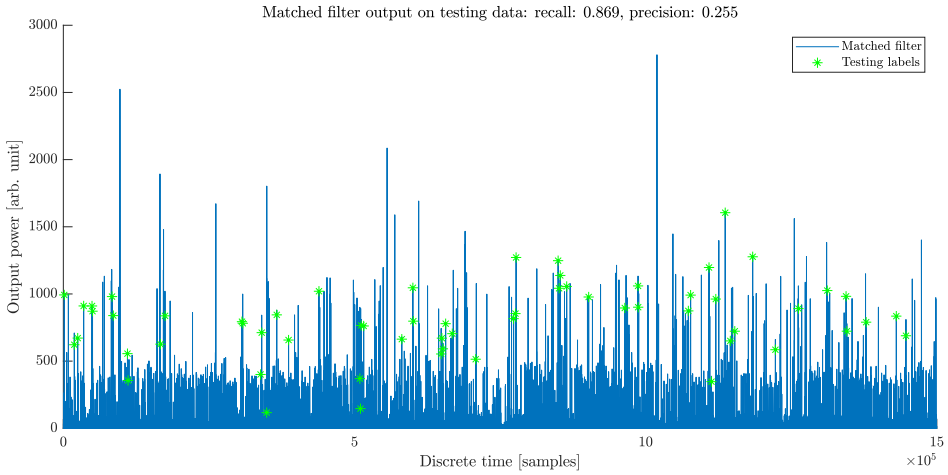


Figure 9: Matched filter output

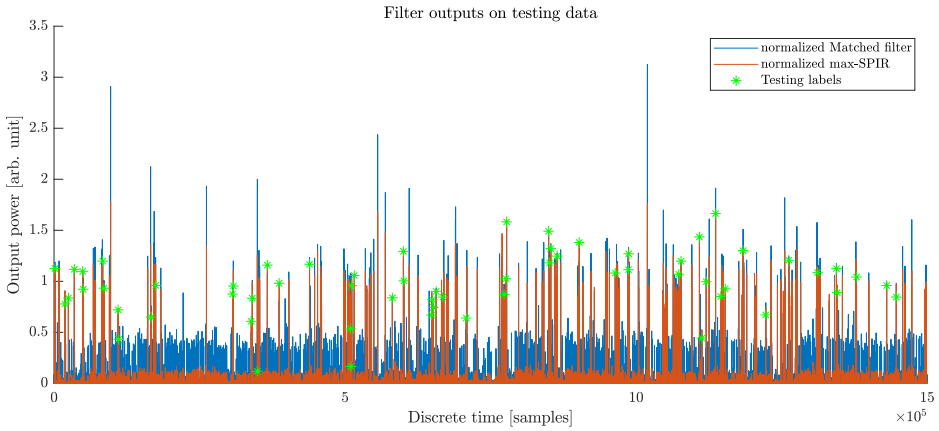


Figure 10: Max-SPIR filter output v.s. matched filter output

Stimulation artifact removal

The neural spikes can be found in Figure.11 at $t = 2.461s$ and $t = 2.468s$

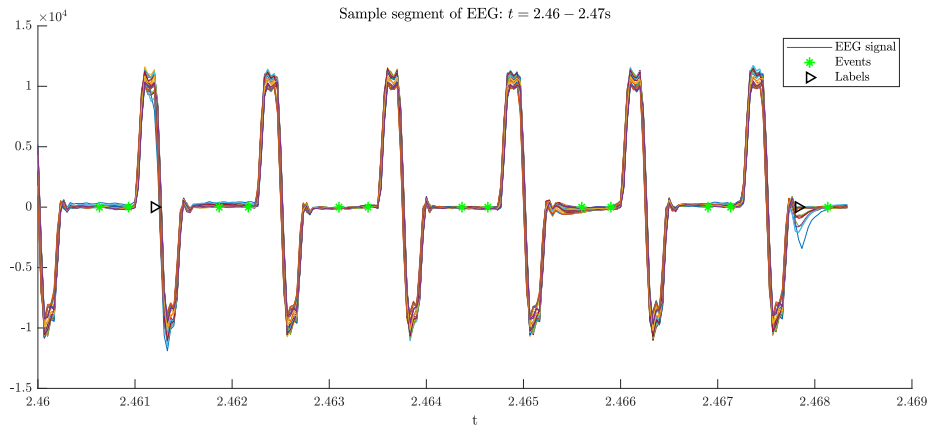


Figure 11: A sample segment of raw EEG signal around neural spike

2 Blind Signal Separation

Denoising using low multilinear rank approximation

As shown in Figure.12,

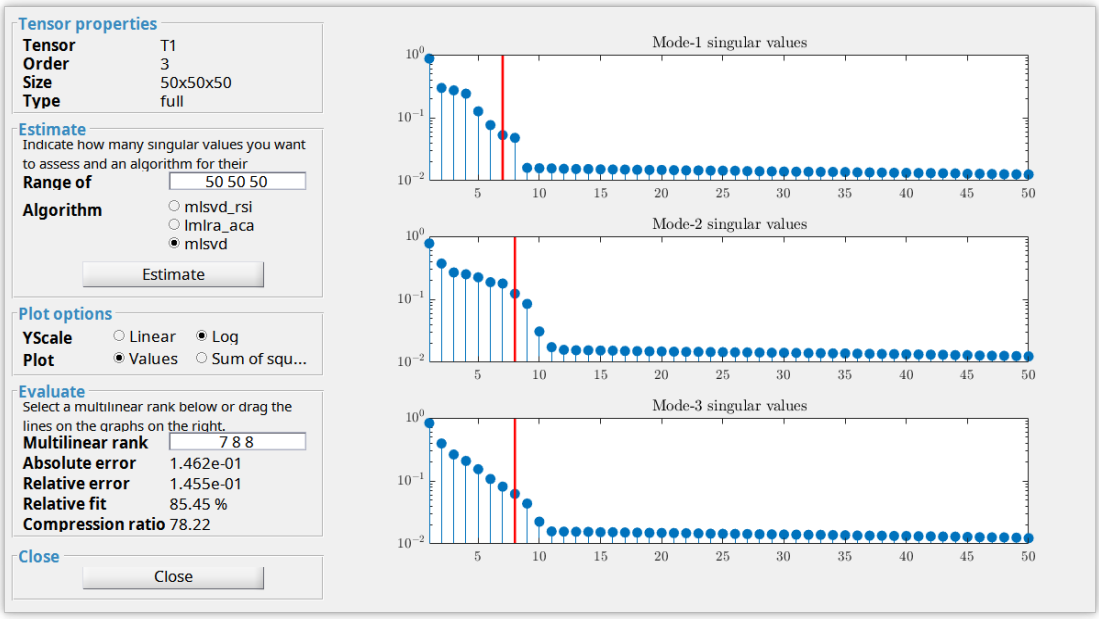


Figure 12: Multilinear low rank approximation

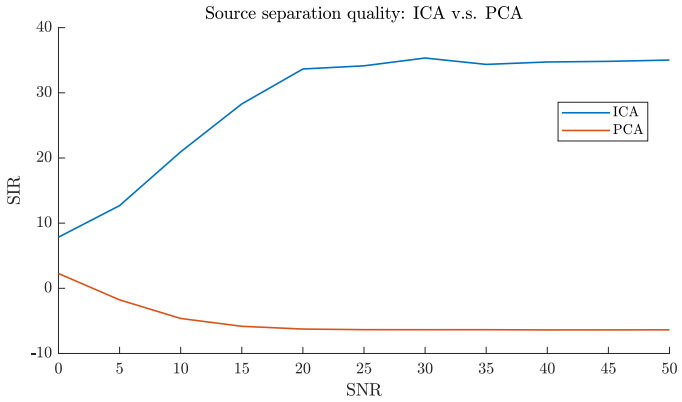


Figure 13: Source separation with ICA and PCA

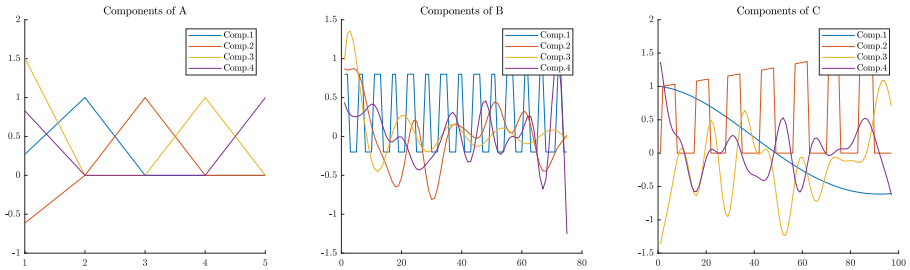


Figure 14: Components in matrix A, B, C

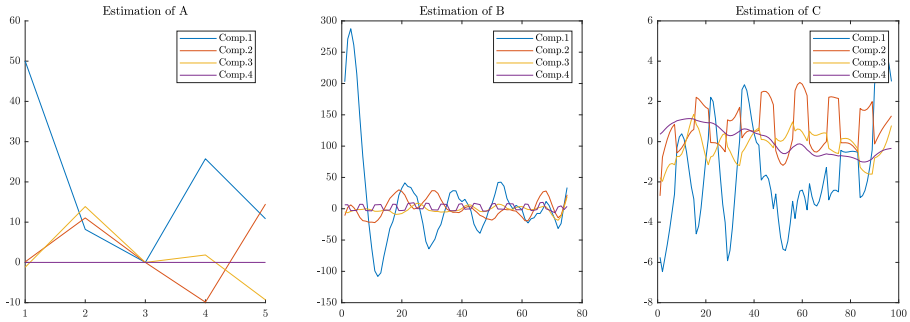


Figure 15: Estimation of components in tensor T_3 using PCA

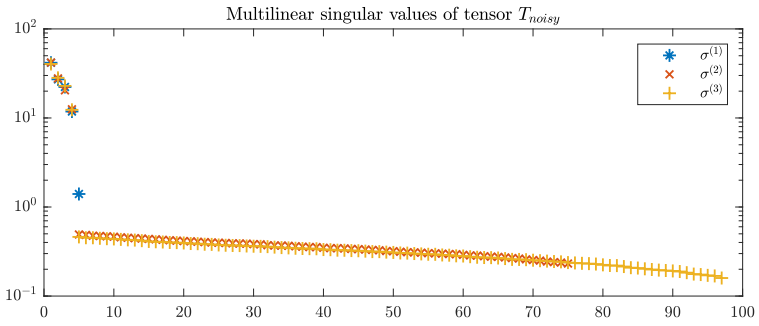


Figure 16: Multiliear singular values of T_3 with additive noise

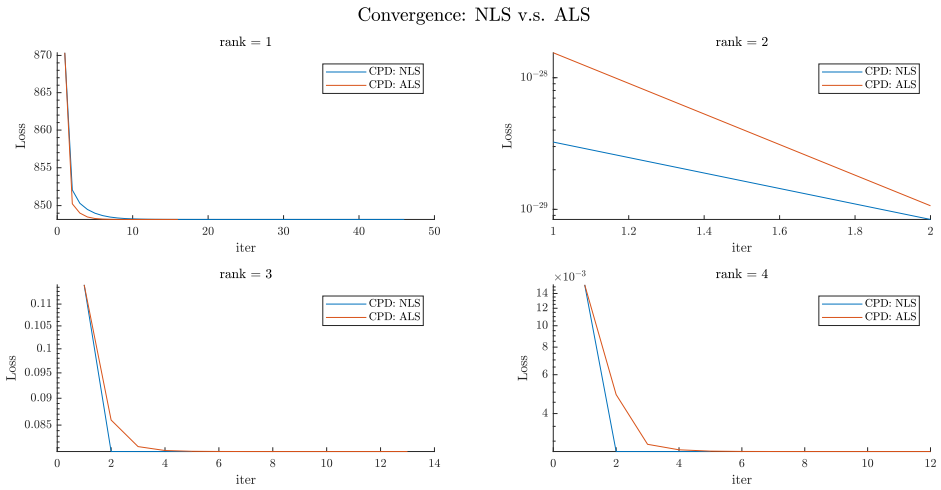


Figure 17: Convergence rate under different rank

Source separation with ICA and PCA

Synthetic CP

Harmonic retrieval

To estimate the number of poles of the signal, we can inspect the multilinear SVD of the Hankel matrix constructed by the signal. From Figure.18 we can assume that the system has 6 poles because there are 6 dominant singular values.

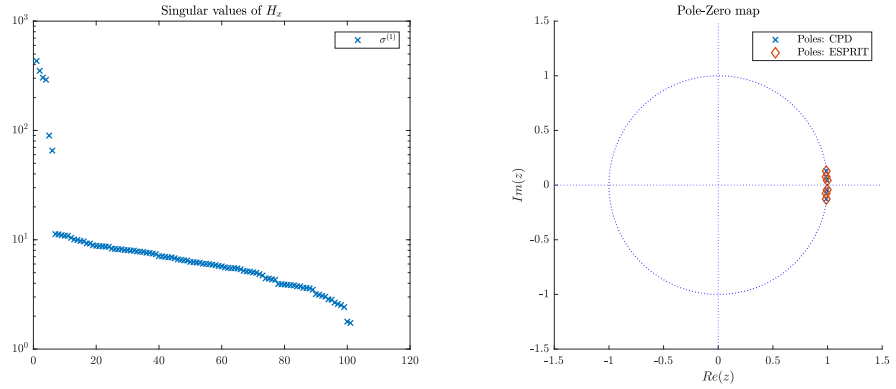


Figure 18: Singular values of H_x and the estimation of poles

3 Nonlinear Signal Processing

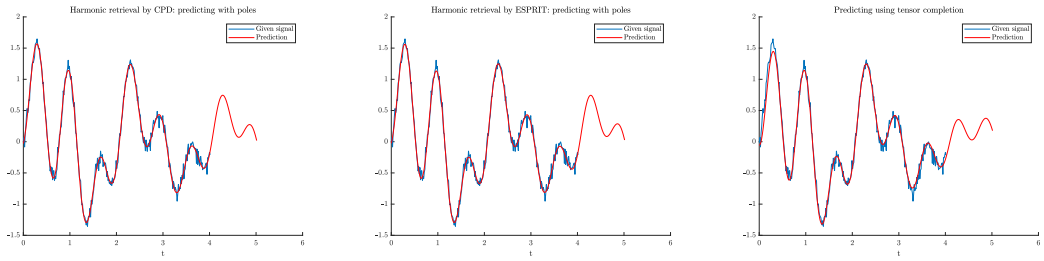


Figure 19: Predicting the signal using poles & tensor completion method