MSEMG: Surface Electromyography Denoising with a Mamba-based Efficient Network

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Abstract

- Surface electromyography (sEMG) recordings can be influenced by electrocardiogram (ECG) signals when the muscle being monitored is close to the heart.
- Distortion can be observed in the denoise result or previous methods such as high-pass filter (HP) , template subtraction (TS) , and fully convolutional network (FCN).
- Diffusion models are effective but computing intensive.
- This study proposed MSEMG, an effective and efficient approach combining CNN and structured Mamba state-space model to reconstruct high-quality sEMG samples from ECG-interference.

Code

Paper

Background

- sEMG and ECG signals share a similar frequency band (0–100 Hz), making it challenging to isolate sEMG signals.
- ECG artifacts would cause distortion to sEMG signals and impact sEMG applications. (i.e. prosthesis control and gesture recognition in virtual reality (VR).

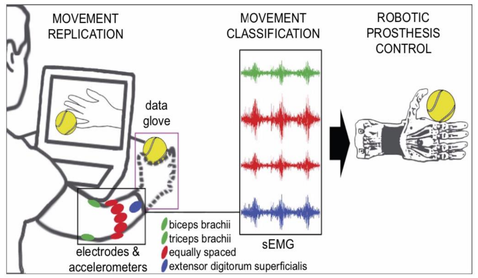
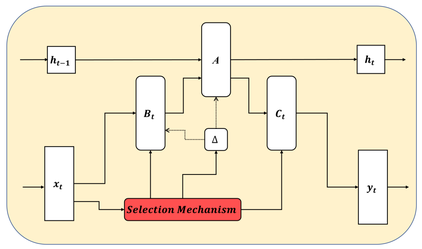


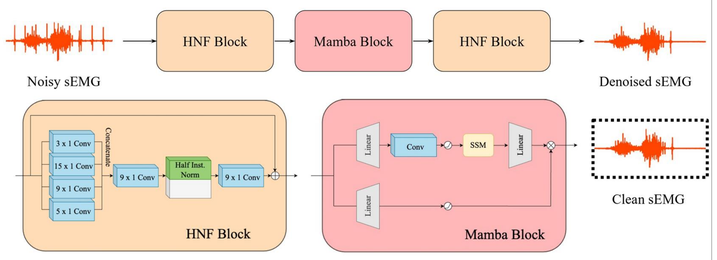
Fig . The setting of sEMG measurement in NINPro database.

State Space Model



- Mamba is designed for efficient sequence modeling featuring linear time complexity.
- Efficient handling of long-range dependencies.
- $h^{\prime}(t)=Ah(t)+Bx(t),\ y(t)=Ch(t)$
- Adaptive matrix updates using a trainable parameter (Δ).

Method



- Input sEMG signals processed with Half Normalized Filters (HNF).
- Convolutional kernels extract features at different resolutions.
- Mamba captures long-range dependencies.
- HNF reconstructs the denoised signal.

Datasets

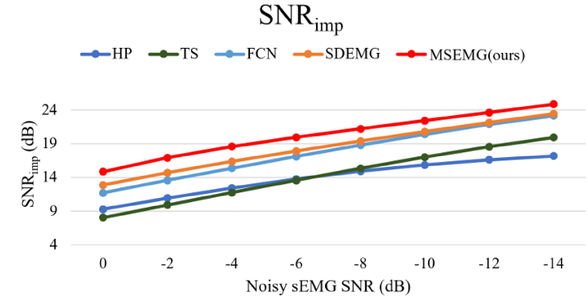
- The 12-channel clean sEMG data of the NINAPro DB2, including sEMG from 40 subjects.
- For ECG artifacts, this study employs the MIT-BIH NSRD from the Physionet data bank.
- Mismatch conditions between training and testing datasets.

Dataset	sEMG	ECG	SNR (dB)
Train	Channel 2, Exercise 1, 30 subjects	14 Subjects	-5, -7, -9, -11, -13, and -15
Test	Channels 9 to 12, Exercise 2, 10 subjects	4 Subjects	-14 - 0 with a step of 2

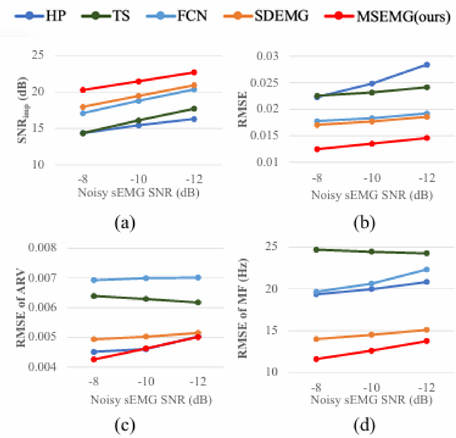
Result

TABLE I
OVERALL PERFORMANCE OF HP, TS, FCN, SDEMG, AND MSEMG.

	SNR_{imp} (dB)	RMSE	$RMSE_{ARV}$	$RMSE_{MF}$ (Hz)
HP	13.885	1.735e-2	3.064e-3	19.471
TS	14.279	1.626e-2	3.859e-3	23.149
FCN	17.758	1.178e-2	3.864e-3	18.038
SDEMG	18.467	1.138e-2	2.809e-3	14.435
MSEMG(Ours)	**20.317**	**8.603e-3**	**2.382e-3**	**11.379**



- Trunk sEMG



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