Supplementary Files

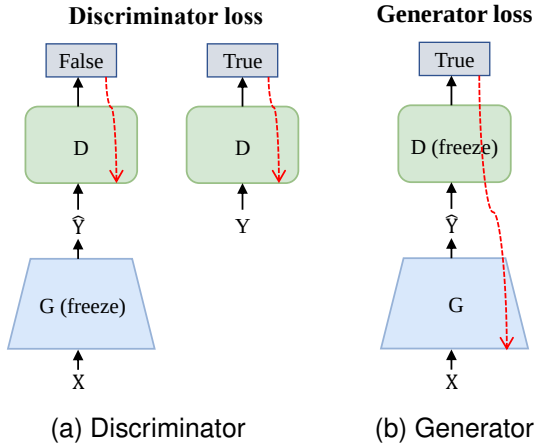


Fig. S1. The training process of the proposed network.

I. Training Process

In the training process, the discriminator and generator are trained alternately, as depicted in Fig. S1.

II. Visualization

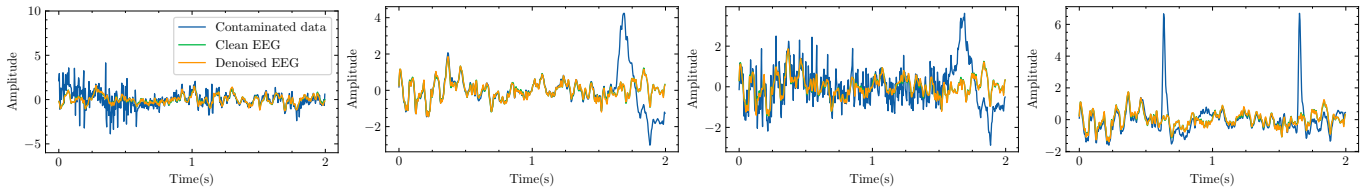
To give a better insight into denoised EEG signals, we also visualize the denoising results of various artifacts using the proposed network. As can be seen from Fig. S2a to Fig. S2c, the denoised EEG signals are very close to the clean EEG signals, which suggests that the proposed network can effectively remove multi-type artifacts and reconstruct artifact-free EEG signals. Fig. S2d displays a visualization example of ECG artifact removal, where the denoised EEG signal exhibits a striking resemblance to the clean EEG, demonstrating well-removed heart activity signals.

III. Ablation Study

We present the results of different network structures under different SNRs, as shown in Fig. S3, and the optimal performance is achieved after fusing each module, indicating the effectiveness of each module.

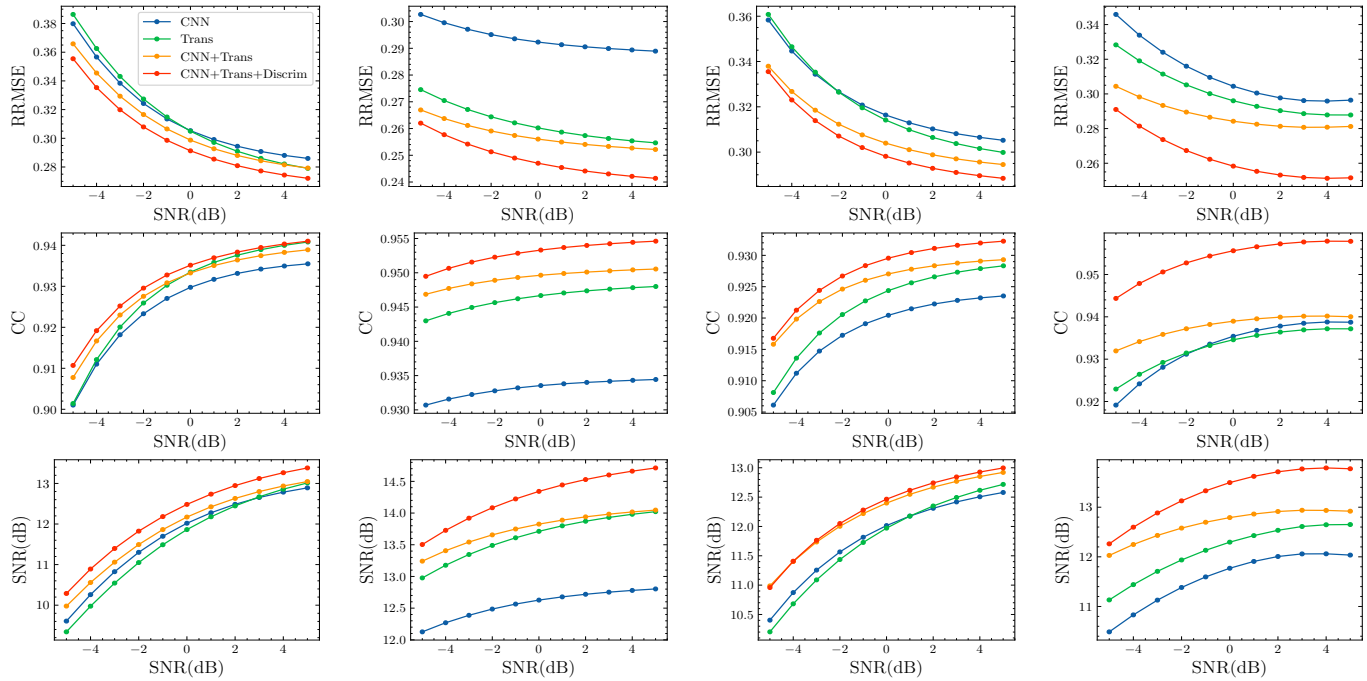
IV. Effects of Feature Loss

In this subsection, we investigate the impact of different feature losses on ECG artifact removal. We defined four feature losses when $\lambda_1 = 0.05$ and $\lambda_2 = 0$: (1) the feature loss of layer 2, (2) the feature loss of layer 4, (3) the feature loss of layer 6, and (4) the average feature loss of layer 2, layer 4, and layer 6. When the generator is used without incorporating any feature loss, the RRMSE is 0.272, CC is 0.948, and SNR is 12.989. Then, incorporating different feature losses can enhance the performance of the denoising network, as depicted in Fig. S4. After comparing the denoising results, we observe that the feature loss of the fourth layer exhibits the best results. Therefore, we adopt the fourth layer of the discriminator to calculate the feature loss.



(a) EMG (b) EOG (c) Mixed (d) ECG

Fig. S2. Denoising results for different artifacts using the proposed netowrk.



(a) EMG (b) EOG (c) Mixed (d) ECG

Fig. S3. Comparative results of ablation experiments at different SNRs. “CNN”, “Trans” and “Discrim” represent CNN brach, transformer branch and discriminator, respectively.

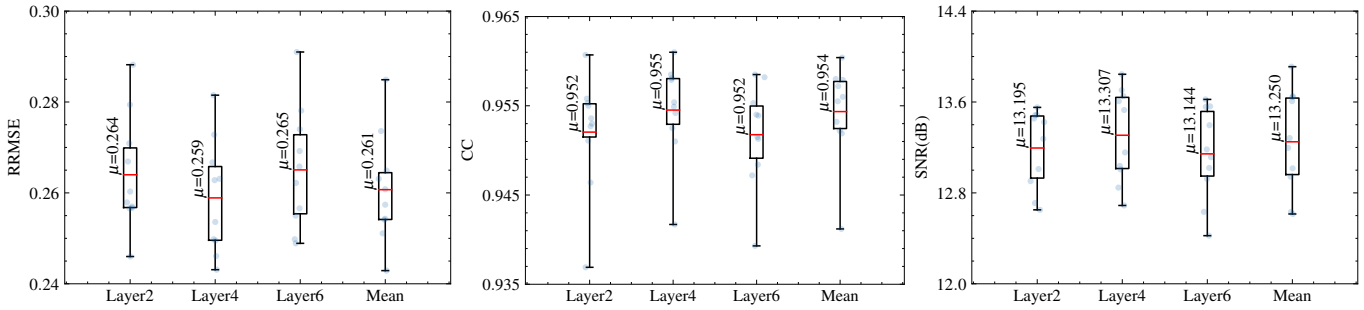


Fig. S4. Denoising results using different layers’ feature loss. “Mean” represents the average loss of layer 2, layer 4, and layer 6.