

Supplementary Materials

Table S1: MIN2Net architecture, where C is the number of channels, T is the number of time points, z is the size of latent vector and N is the number of classes. Noted that the data format of Conv2D is “channels last”

Blocks	Layer	Filter	Size	Stride	Activation	Options	Output
Encoder	Input		(1, T, C)				(1, T, C)
	Conv2D	C	(1, 64)	1	ELU	padding=same	(1, T, C)
	BatchNormalization						(1, T, C)
	AveragePooling2D		(1, $T // 100$)				(1, 100, C)
	Conv2D	10	(1, 32)	1	ELU	padding=same	(1, 100, 10)
Autoencoder	BatchNormalization						(1, 100, 10)
	AveragePooling2D		(1, 4)				(1, 25, 10)
	Flatten						(250)
Decoder	Latent	FC	(z)				(z)
		FC	(250)				(250)
	Reshape		(1, 25, 10)				(1, 25, 10)
	Conv2DTranspose	10	(1, 64)	4	ELU	padding=same	(1, 100, 10)
	Conv2DTranspose	C	(1, 32)	$T // 100$	ELU	padding=same	(1, T, C)
Metric learning	Latent						(z)
Supervised Learning	Latent						(z)
	FC	N			softmax		(N)

z is equal to C and 256 for 2- and 3-class classification, respectively.

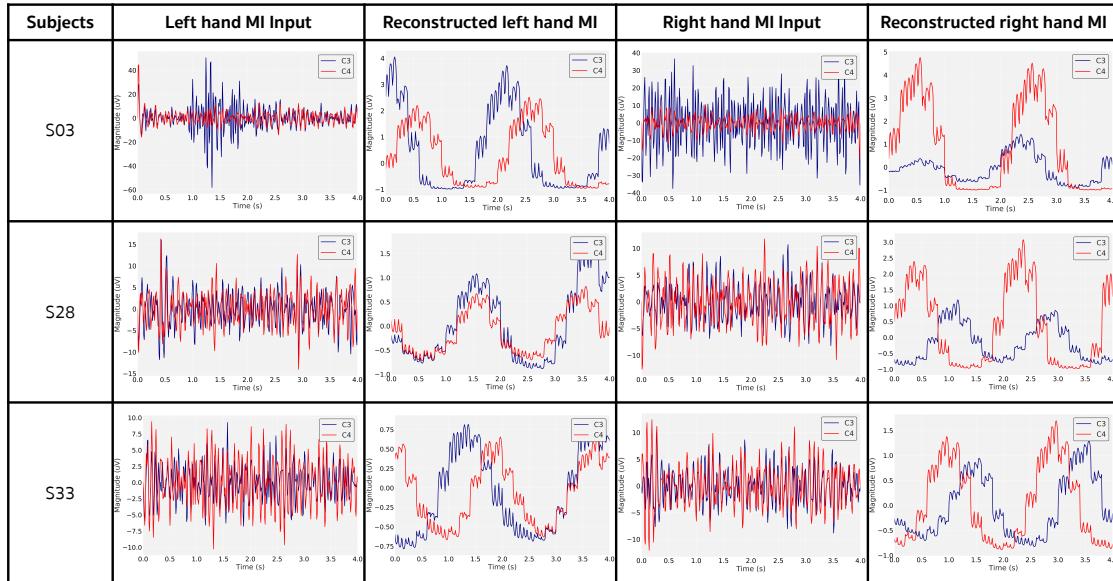


Fig. S1: Visualization of a time series of a single-trial EEG of the OpenBMI dataset on both the input and reconstructed EEG-MI signals in certain channels ($C3$ and $C4$) using the proposed method. The plot illustrated how the reconstructed signals from different classes interact in different patterns.

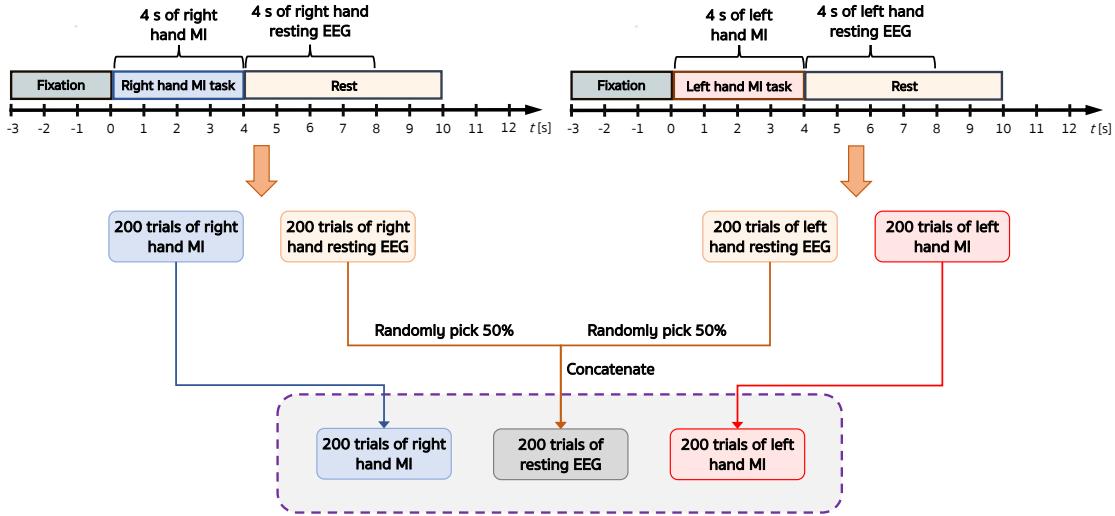


Fig. S2: An experimental procedure demonstrates how the OpenBMI dataset was used to segment a subject's EEG signal into three classes.

Table S2: Classification accuracy and F1-score (in %, \pm SD) on the subject-dependent manner for the two-class classification of MI. Bold denotes the best numerical values.

β_1	β_2	β_3	BCIC IV 2a		SMR BCI		OpenBMI	
			Accuracy	F1-score	Accuracy	F1-score	Accuracy	F1-score
0.1	0.1	0.1	63.23 \pm 12.63	63.17 \pm 13.64	63.83 \pm 15.74	60.04 \pm 18.21	60.71 \pm 13.89	63.16 \pm 13.97
0.1	0.1	0.5	63.04 \pm 14.94	62.93 \pm 16.32	66.10 \pm 15.25	63.23 \pm 17.48	61.16 \pm 15.27	63.57 \pm 15.43
0.1	0.1	1.0	63.40 \pm 15.65	63.45 \pm 16.51	65.90 \pm 16.50	64.13 \pm 17.66	60.53 \pm 15.65	62.91 \pm 16.04
0.1	0.5	0.1	59.60 \pm 11.79	58.75 \pm 13.16	60.95 \pm 16.19	57.25 \pm 18.44	60.24 \pm 14.05	63.13 \pm 13.82
0.1	0.5	0.5	64.54 \pm 14.65	63.97 \pm 15.92	65.45 \pm 16.41	61.32 \pm 19.40	60.96 \pm 14.33	63.36 \pm 14.70
0.1	0.5	1.0	63.67 \pm 14.80	63.42 \pm 16.22	65.79 \pm 15.75	62.74 \pm 17.82	60.71 \pm 14.94	63.38 \pm 15.06
0.1	1.0	0.1	57.69 \pm 11.57	55.90 \pm 13.85	60.12 \pm 16.01	58.03 \pm 17.68	58.21 \pm 13.10	61.18 \pm 13.36
0.1	1.0	0.5	61.36 \pm 13.16	60.24 \pm 14.95	63.38 \pm 18.19	60.30 \pm 20.28	60.63 \pm 14.55	62.98 \pm 14.83
0.1	1.0	1.0	63.18 \pm 14.13	62.20 \pm 16.14	65.81 \pm 16.70	61.88 \pm 19.37	60.93 \pm 14.66	63.37 \pm 14.99
0.5	0.1	0.1	59.34 \pm 10.01	59.29 \pm 10.81	63.31 \pm 15.08	59.94 \pm 17.31	58.98 \pm 13.06	60.73 \pm 13.75
0.5	0.1	0.5	62.81 \pm 13.99	63.40 \pm 15.06	65.38 \pm 15.46	61.25 \pm 18.31	61.12 \pm 14.43	63.38 \pm 14.61
0.5	0.1	1.0	63.50 \pm 14.78	63.64 \pm 16.23	64.67 \pm 16.46	61.81 \pm 18.83	61.22 \pm 15.03	63.46 \pm 15.13
0.5	0.5	0.1	58.35 \pm 10.56	57.67 \pm 11.76	60.55 \pm 15.66	57.52 \pm 18.21	57.68 \pm 12.66	59.85 \pm 13.25
0.5	0.5	0.5	62.61 \pm 12.99	62.59 \pm 14.23	63.71 \pm 15.92	59.56 \pm 18.61	60.49 \pm 13.72	62.98 \pm 13.76
0.5	0.5	1.0	63.77 \pm 13.99	63.62 \pm 15.00	64.17 \pm 16.00	60.29 \pm 18.71	61.03 \pm 14.47	63.59 \pm 14.53
0.5	1.0	0.1	58.44 \pm 10.07	57.32 \pm 11.77	56.00 \pm 14.11	51.71 \pm 17.99	56.35 \pm 11.78	58.50 \pm 12.64
0.5	1.0	0.5	63.06 \pm 12.96	61.82 \pm 14.44	58.76 \pm 13.79	54.93 \pm 17.46	58.68 \pm 13.41	60.98 \pm 14.07
0.5	1.0	1.0	63.87 \pm 13.84	63.11 \pm 15.31	60.14 \pm 14.78	55.52 \pm 18.25	59.28 \pm 13.70	61.75 \pm 14.18
1.0	0.1	0.1	56.81 \pm 8.08	56.93 \pm 10.62	59.98 \pm 13.81	55.51 \pm 17.97	56.69 \pm 12.27	58.15 \pm 13.16
1.0	0.1	0.5	62.21 \pm 12.72	63.10 \pm 14.23	62.81 \pm 14.46	58.12 \pm 18.76	60.31 \pm 13.73	62.50 \pm 14.16
1.0	0.1	1.0	63.46 \pm 14.33	64.28 \pm 15.27	63.12 \pm 15.11	59.10 \pm 18.69	60.61 \pm 14.28	63.13 \pm 14.44
1.0	0.5	0.1	58.40 \pm 10.01	57.88 \pm 11.19	56.05 \pm 13.92	51.75 \pm 17.79	56.36 \pm 12.07	58.29 \pm 13.34
1.0	0.5	0.5	61.23 \pm 10.96	60.86 \pm 12.10	61.02 \pm 13.69	56.11 \pm 17.90	59.40 \pm 13.29	61.31 \pm 14.06
1.0	0.5	1.0	63.94 \pm 13.39	64.14 \pm 13.99	61.83 \pm 13.99	56.93 \pm 18.19	60.18 \pm 13.74	62.41 \pm 14.29
1.0	1.0	0.1	58.30 \pm 10.27	57.63 \pm 11.31	55.98 \pm 13.62	51.69 \pm 17.68	56.16 \pm 11.50	58.02 \pm 12.89
1.0	1.0	0.5	61.88 \pm 11.36	60.51 \pm 12.91	60.00 \pm 13.62	54.71 \pm 18.50	58.36 \pm 13.10	60.38 \pm 13.95
1.0	1.0	1.0	62.39 \pm 12.62	61.94 \pm 13.71	61.19 \pm 13.13	55.91 \pm 17.62	59.78 \pm 13.73	61.90 \pm 14.33

Table S3: Classification accuracy and F1-score (in %, \pm SD) on the subject-independent manner for the two-class classification of MI. Bold denotes the best numerical values.

β_1	β_2	β_3	BCIC IV 2a		SMR BCI		OpenBMI	
			Accuracy	F1-score	Accuracy	F1-score	Accuracy	F1-score
0.1	0.1	0.1	58.81 \pm 8.76	43.39 \pm 23.51	58.07 \pm 11.86	56.10 \pm 24.06	71.59 \pm 13.94	71.95 \pm 14.75
0.1	0.1	0.5	59.17 \pm 8.34	50.28 \pm 18.35	57.64 \pm 12.80	58.07 \pm 23.21	71.45 \pm 14.24	71.97 \pm 14.40
0.1	0.1	1.0	57.62 \pm 8.16	46.87 \pm 20.60	58.71 \pm 12.18	60.82 \pm 20.14	71.40 \pm 14.35	71.94 \pm 14.51
0.1	0.5	0.1	55.09 \pm 7.35	38.30 \pm 24.19	57.76 \pm 11.80	57.09 \pm 24.45	69.79 \pm 14.49	69.36 \pm 15.74
0.1	0.5	0.5	58.02 \pm 9.05	45.10 \pm 22.86	60.00 \pm 13.04	60.58 \pm 22.04	70.02 \pm 14.53	69.40 \pm 16.45
0.1	0.5	1.0	57.78 \pm 8.31	44.05 \pm 22.07	58.71 \pm 12.52	60.72 \pm 20.57	71.13 \pm 13.97	71.51 \pm 14.13
0.1	1.0	0.1	52.89 \pm 7.87	54.16 \pm 18.23	59.79 \pm 13.72	61.10 \pm 23.64	69.54 \pm 14.28	68.83 \pm 15.80
0.1	1.0	0.5	53.49 \pm 7.05	40.93 \pm 26.35	58.07 \pm 11.36	58.40 \pm 21.67	69.86 \pm 14.22	69.32 \pm 15.74
0.1	1.0	1.0	53.87 \pm 7.38	36.79 \pm 23.55	59.50 \pm 13.03	60.57 \pm 22.31	69.95 \pm 14.58	69.35 \pm 16.39
0.5	0.1	0.1	57.89 \pm 8.42	37.33 \pm 25.69	59.38 \pm 12.87	56.70 \pm 26.25	62.43 \pm 14.61	61.88 \pm 15.24
0.5	0.1	0.5	59.10 \pm 8.64	43.27 \pm 23.35	59.10 \pm 13.50	58.32 \pm 24.60	71.85 \pm 14.18	71.35 \pm 15.98
0.5	0.1	1.0	60.03 \pm 9.24	49.09 \pm 23.28	58.52 \pm 12.91	58.82 \pm 22.89	71.83 \pm 13.95	71.25 \pm 15.35
0.5	0.5	0.1	57.65 \pm 8.08	37.54 \pm 25.74	57.90 \pm 11.16	56.79 \pm 23.30	70.89 \pm 14.13	71.46 \pm 14.09
0.5	0.5	0.5	58.21 \pm 8.87	42.65 \pm 23.81	58.86 \pm 12.58	56.13 \pm 25.06	71.30 \pm 14.04	72.15 \pm 13.76
0.5	0.5	1.0	59.14 \pm 8.79	47.03 \pm 21.61	58.81 \pm 14.01	58.18 \pm 23.42	72.03 \pm 14.04	72.62 \pm 14.14
0.5	1.0	0.1	57.69 \pm 7.54	39.64 \pm 23.36	58.21 \pm 11.86	57.68 \pm 22.22	70.47 \pm 13.59	71.07 \pm 13.80
0.5	1.0	0.5	58.02 \pm 7.53	41.43 \pm 23.78	58.88 \pm 11.74	57.75 \pm 23.18	70.45 \pm 13.87	70.77 \pm 14.28
0.5	1.0	1.0	58.40 \pm 8.52	45.02 \pm 21.63	59.60 \pm 12.63	58.46 \pm 22.85	70.83 \pm 13.63	70.99 \pm 13.97
1.0	0.1	0.1	55.91 \pm 6.70	34.63 \pm 24.83	57.26 \pm 10.06	54.40 \pm 23.60	54.52 \pm 11.08	54.17 \pm 11.57
1.0	0.1	0.5	58.18 \pm 8.70	40.77 \pm 25.77	58.00 \pm 11.06	56.38 \pm 24.07	71.12 \pm 14.55	71.42 \pm 15.02
1.0	0.1	1.0	59.20 \pm 8.20	45.32 \pm 23.50	58.50 \pm 11.28	57.52 \pm 23.90	72.20 \pm 14.19	72.40 \pm 14.70
1.0	0.5	0.1	58.27 \pm 8.64	38.16 \pm 26.01	58.05 \pm 11.31	57.61 \pm 21.90	70.50 \pm 13.92	71.27 \pm 14.26
1.0	0.5	0.5	58.84 \pm 8.61	42.66 \pm 23.50	60.12 \pm 12.22	58.41 \pm 23.23	70.66 \pm 13.80	70.98 \pm 14.41
1.0	0.5	1.0	59.10 \pm 9.39	43.13 \pm 25.48	59.40 \pm 11.67	58.41 \pm 23.11	71.19 \pm 13.67	71.50 \pm 14.07
1.0	1.0	0.1	58.26 \pm 8.64	38.33 \pm 25.80	57.74 \pm 10.48	57.56 \pm 21.05	70.26 \pm 13.59	71.05 \pm 13.60
1.0	1.0	0.5	57.95 \pm 7.76	38.65 \pm 24.68	59.14 \pm 11.34	58.22 \pm 22.10	70.56 \pm 13.33	70.86 \pm 13.60
1.0	1.0	1.0	58.55 \pm 8.99	43.96 \pm 22.80	60.69 \pm 13.04	58.25 \pm 25.13	70.86 \pm 13.66	71.14 \pm 14.03