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EEG decoding of gait for clinical rehabilitation and assessment

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Introduction: The reconstruction of lower limb movement patterns using non-invasive EEG is a relatively less explored area of neural signal decoding [1]. Accurately and continuously tracking the movement of lower limb joints holds significant clinical potential for advancing the rehabilitation of motor impairments. To achieve a comprehensive and objective assessment of gait performance and functional improvement in stroke survivors, EEG-based decoding can offer a more sophisticated and neurophysiologically sound measure.

Material, Methods and Results:
To address this, our research focuses on predicting gait patterns through deep learning using EEG data. Our team proposed a multi-model attention network (MATN) that utilizes self-attention to adaptively learn the temporal dynamics of spatio-temporal EEG features [2, 3]. The network learns the neural foundations through a two-stage training approach, where a teacher model is first trained and later assists the student model in training on data from separate recording session. The core components of our base model include temporal, spatial, and separable convolution, and a fully connected layer. In the student model, a self-attention block is integrated after the spatial convolution block. We evaluated the proposed network using the mobile brain-body imaging (MoBI) dataset [1]. Our results summarized in Fig.1(c) show that, compared to state-of-the-art methods in EEG regression, MATN achieves the highest Pearson's correlation coefficient of 0.752, surpassing the best baseline model performance by over 18%.

Conclusion: Using the proposed approach with data from healthy subjects, we found a correlation of 0.752 between the recorded and predicted joint angle values. Building on this, we are currently evaluating our proposed method on clinical data and refining our techniques for robust predictions on large-scale healthy participant datasets as well. Currently, a clinical trial is in progress to assess stroke survivors through clinical metrics and EEG predictions at three time points, four weeks apart. The findings indicate that the proposed approach is feasible and that EEG decoding holds promise as an effective tool for rehabilitating and assessing lower limb impairments.

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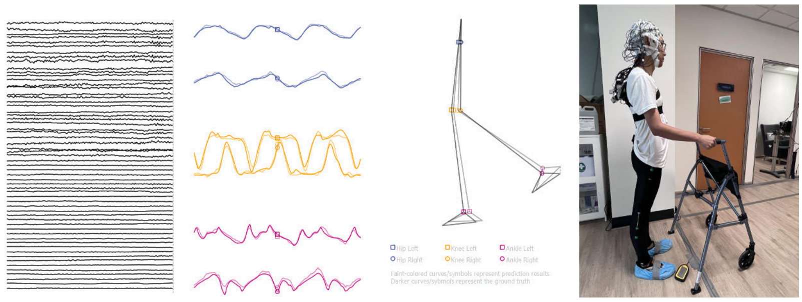

(a) (b)

Algorithm	PCC	Number of Parameters
Linear	0.626±0.127	
CNNLSTM	0.562±0.209 0.58±0.223	54876 14910
LSTM	0.57±0.171 0.586±0.209	7270 20678
TCN	0.527±0.161 0.634±0.184	18486 52326
EEGNet	0.63±0.155 0.625±0.186	2358 11430
SAM	0.641±0.178 0.629±0.236	3446 9446
MMN	0.702±0.165 0.682±0.169	6060 14668
MATN	**0.752** ± 0.172	10796

(c)

Figure 1: *(a) Illustration of reconstructed gait patterns of the participant (b) A subject preparing to walk, wearing EEG and goniometer sensors. The use of walking aids effectively minimized potential confounding effects of upper body movements on EEG signals. (c) Summary of results.*

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