EEG-EMG based Hybrid Brain Computer Interface for Triggering Hand Exoskeleton for Neuro-Rehabilitation

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Stroke Rehabilitation

• World Wide Scenario
  ✓ 15 million new cases each year world wide.
  ✓ 50 million living with the consequences of stroke
  ✓ 50% of them have some form of permanently disability

• Key Challenges
  ✓ Lack of trained professionals who can provide stroke rehabilitation.
  ✓ The existing therapies are not effective as they are passive in nature and fail to engage patient’s attention with the therapeutic task.
Motivation and Objective

• Motivation
  ✓ Robots can provide intense repetitive rehabilitation therapy with less or no intervention from a human therapist
  ✓ Robotic therapy can give quantitative measurement of patient’s involvement with the task
  ✓ Robotic therapy can employ different biological signals (such as EEG, EMG etc.) to enhance patient’s active involvement to promote neuroplasticity.

• Objective:
  The objective is to build a hand exoskeleton based rehabilitation system which can be trigged by an functional interaction between brain (EEG) and muscle (EMG) signal.
System Overview

Fig. 1 Basic block diagram of a Hybrid BCI system using EEG and EMG signals

Fig. 2 Experimental environment.

Fig. 3 Timing diagram of a trial.

Fig. 4 CAD model of the developed hand exoskeleton.
Feature Extraction: EEG-EMG Spectral Power Correlation (SPC)

Fig. 5 The block diagram of the SPC Index calculation process

\[ SPC_i = |\rho(smEEG_i, smEMG_i)| \]

Fig. 6 The signal transformation of EEG and EMG during the SPC index calculation steps
Experimental Paradigm

Figure 7. Signal processing flow chart showing the difference between (a)EEG-CSP and (b)EEG-EMG SPC
Results

Table 1. Classification Accuracy Comparison

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<th>Sub ID</th>
<th>EEG-CSP</th>
<th>EEG-EMG SPC</th>
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<tr>
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<td>10CV_Tr_Acc (%)</td>
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p-value (Between Feedback Acc of EEG-CSP and EEG-EMG SPC) = 0.002

Fig. 8 Classification accuracy comparison of the methods in feedback phase

Fig. 9 SPC index distribution of different channel combinations in rest (R) and grasp-attempt (G) classes in feedback phase
Conclusion

• A new combined EEG-EMG feature (SPC) has been introduced.

• All the participants were able to successfully triggered the hand exoskeleton with high accuracy, indicating its potential to be used for patients also.

• The proposed method out performed the conventional only EEG based CSP method.

• The SPC index also gives insight into the level cortico-muscular interaction.

• Future works are in progress to use the EEG-EMG SPC feature to get rehabilitative outcomes, by carrying out clinical trials on hemiparetic patients.
Acknowledgement

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