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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

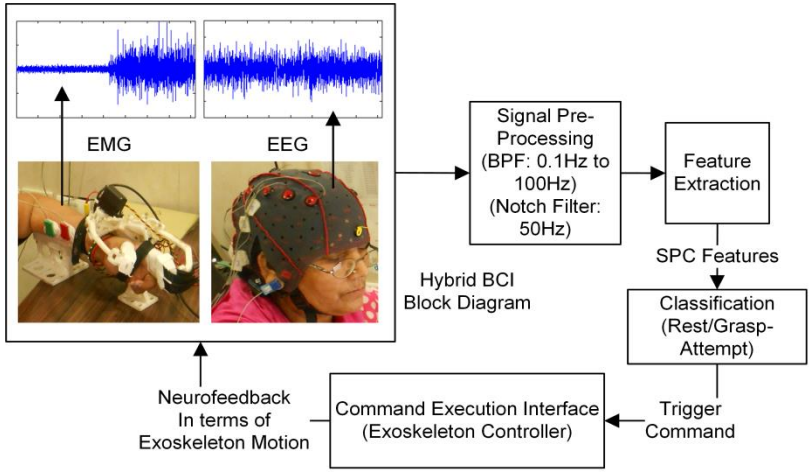

Fig.1 Basic block diagram of a Hybrid BCI system using EEG and EMG signals

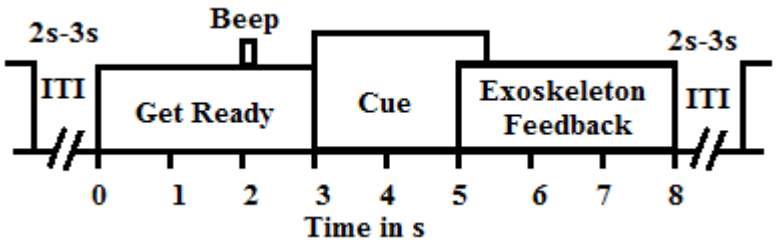

Fig.3 Timing diagram of a trial.

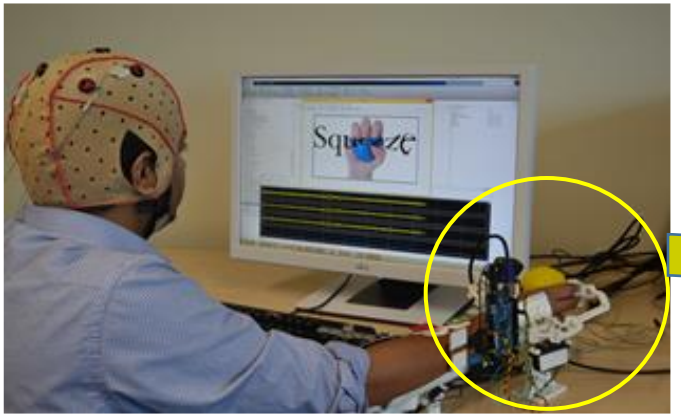

Fig.2 Experimental environment.

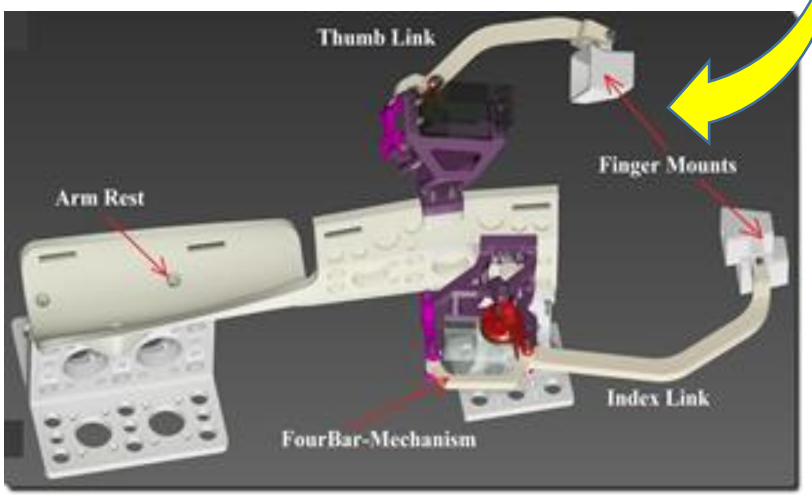

Fig.4 CAD model of the developed hand exoskeleton.

Feature Extraction: EEG-EMG Spectral Power Correlation(SPC)

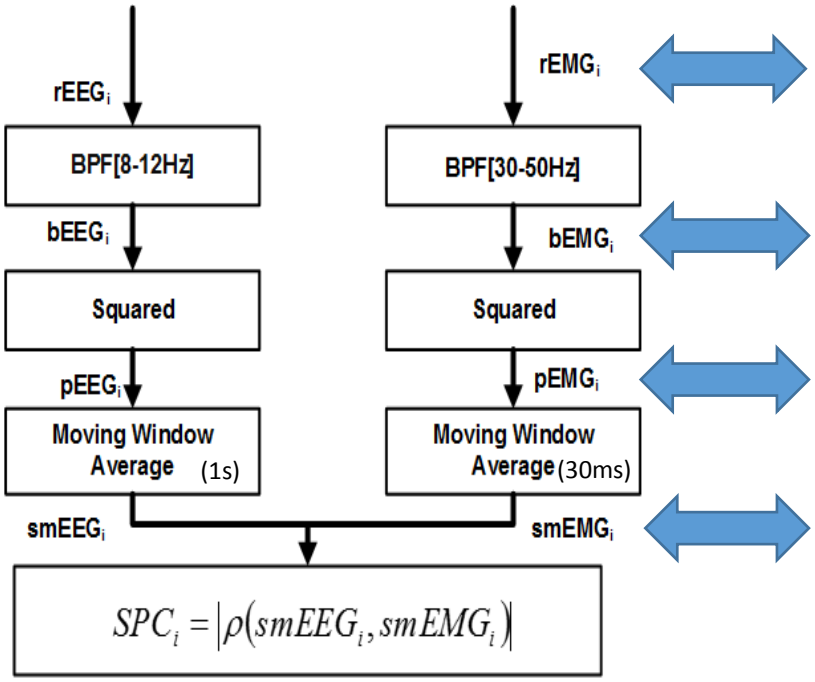

Fig.5 The block diagram of the SPC Index calculation process

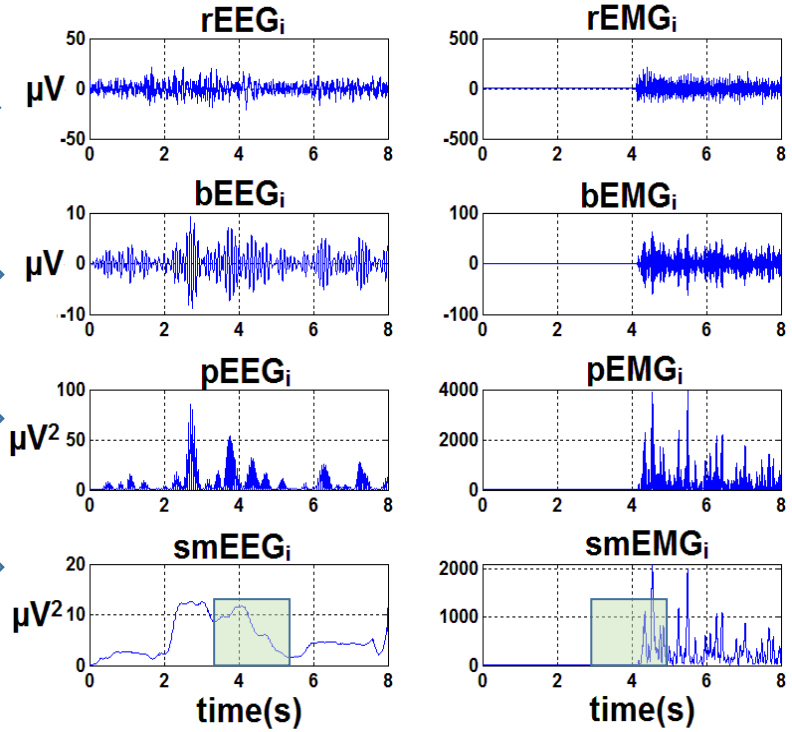

Fig.6 The signal transformation of EEG and EMG during the SPC index calculation steps

Experimental Paradigm

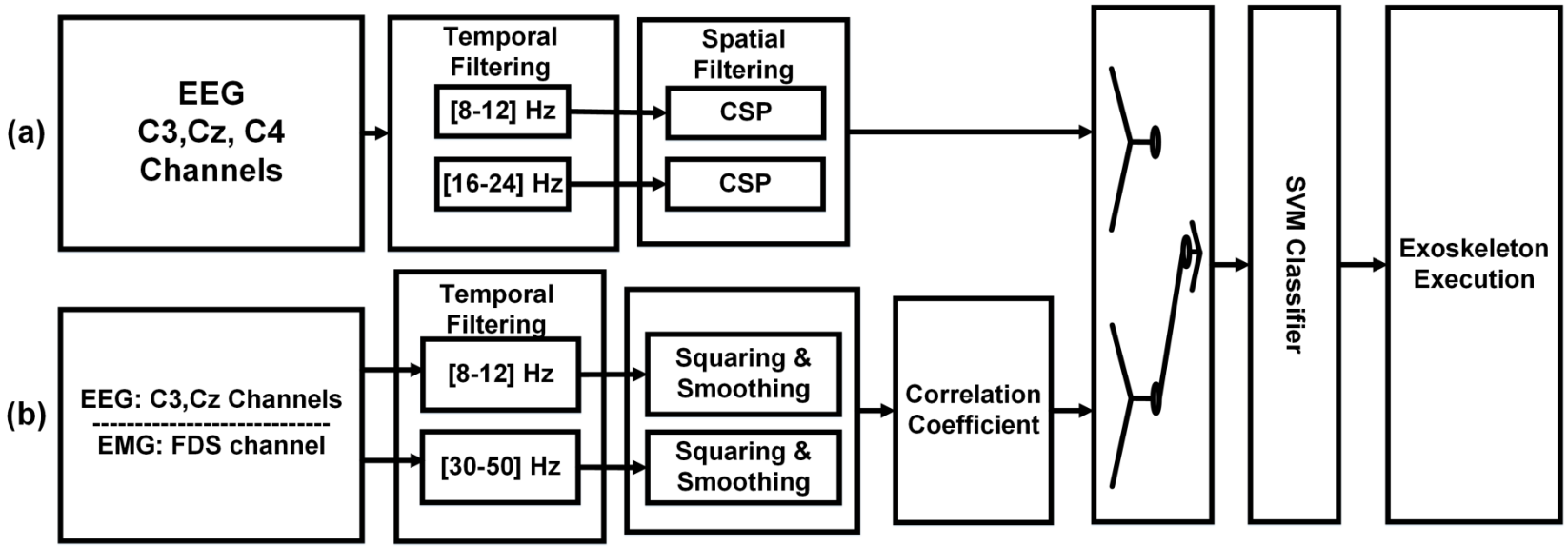

Figure 7. Signal processing flow chart showing the difference between (a)EEG-CSP and (b)EEG-EMG SPC

Results

Table 1. Classification Accuracy Comparison

Sub ID	EEG-CSP		EEG-EMG SPC	
	10CV_Tr_Acc (%)	Feedback_Acc (%)	10CV_Tr_Acc (%)	Feedback_Acc (%)
S01	73.75	80.00	95.00	87.50
S02	73.75	85.00	91.25	87.50
S03	88.75	90.00	97.50	100.00
S04	83.75	75.00	92.50	87.50
S05	73.75	75.00	97.50	90.00
S06	77.50	75.00	90.00	92.50
S07	70.00	82.50	98.75	87.50
S08	66.25	85.00	88.75	95.00
S09	65.00	77.50	93.75	90.00
S10	67.50	72.50	97.50	82.50
MEAN	74.00	79.75	94.25	90.00
STD	7.63	5.71	3.55	4.86
p-value(Between Feedback Acc of EEG-CSP and EEG-EMG SPC				0.002

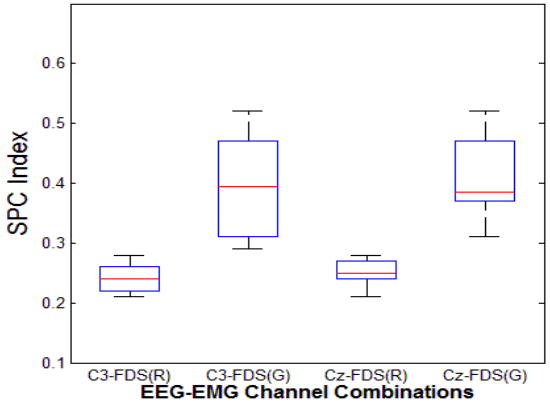

Fig.8 Classification accuracy comparison of the methods in feedback phase

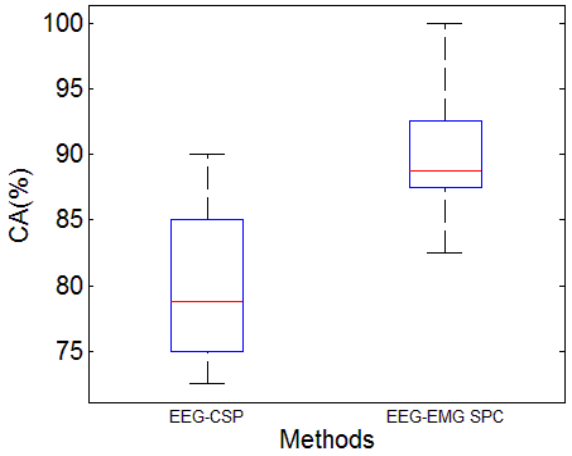

Fig.9 SPC index distribution of different channel combinations in rest(R) and grasp-attempt(G) classes in feedback phase

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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