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A BCI Robotic Glove System for Hand Motor Rehabilitation

S. Zhang[1], N. Robinson[1], K. P. Thomas[1], Y. Tang[1], H. W. Ng[1], A. A. P. Wai[1], N. Khendry[1], C. W. K. Kuah[2], S. K. Wee[2], K. S. G. Chua[2], C. Guan[1]*

[1]*Nanyang Technological University, Singapore;* [2]*Institute of Rehabilitation Excellence (IREx), Tan Tock Seng Hospital Rehabilitation Centre, Singapore;*

*50 Nanyang Ave, Singapore. E-mail: ctguan@ntu.edu.sg

Introduction: Although several brain-computer interfaces (BCI) have been developed for upper limb rehabilitation, most primarily target gross motor functions and place limited emphasis on the fine motor control of hand [1]. To address this gap, we developed a novel integrated BCI robotic glove rehabilitation system specifically aimed at training hand movements in individuals recovering from a stroke.

Material, Methods and Results:
The clinical study is designed as a three-arm assessor-blinded randomized controlled trial, assessing the efficacy of a combined intervention of BCI robotic glove training and conventional occupational therapy (COTS), compared to COTS alone and robotic glove training with COTS. The proposed BCI detects motor attempts made by the user their affected hand. The system components are illustrated in Fig.1. Accurate detection of attempts to open and close the hand triggers the robotic glove to execute the corresponding movements, thereby providing precise motor training. The system delivers both robotic and visual feedback to promote neuroplasticity. An attention-based temporal convolutional network is employed for the detection of hand open and close attempt by the user. The network utilizes multihead self-attention and temporal convolution layers to efficiently derive relevant EEG features [2, 3]. To evaluate whether the BCI system can identify distinct patterns generated by the user during more precise tasks, we conducted a screening session. Users are required to achieve an accuracy of 70% or higher to qualify to undergo the proposed training. We propose 6 week training in which the users participate in three 45-minute training sessions of BCI training every week. The results obtained from the screening session are summarized in Table 1. Over 73% of the patients achieved over 70% accuracy and were recruited for training. The training of these patients is currently in progress.

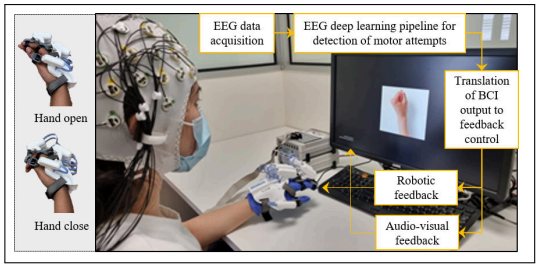

Figure 1: *Schematic of BCI robotic glove rehabilitation system.*

Table 1: Classification accuracies (%) for all participating patients in the screening session.

Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean (±STD)
Open	74.00	80.50	79.50	67.50	85.00	84.00	75.50	92.00	86.00	50.00	89.00	55.50	79.00	95.00	49.00	76.10 (±14.08)
Close	84.00	85.00	83.00	63.00	96.50	90.00	70.50	93.00	81.50	65.00	89.50	54.50	90.50	97.00	69.50	80.83 (±12.75)
Average	79.00	82.75	81.25	65.25	90.75	87.00	73.00	92.50	83.75	57.50	89.25	55.00	84.75	96.00	59.25	78.47 (±12.92)

Conclusion: Preliminary results show the system detects hand opening and closing with an average accuracy of 78.47% (±12.92%), highlighting its potential for upper limb rehabilitation. Future research will investigate its clinical efficacy in fine motor rehabilitation following a stroke.

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