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Assist-as-needed control strategy for upper-limb rehabilitation based on subject's functional ability

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Abstract

The assist-as-needed technique in robotic rehabilitation is a popular technique that encourages patients' active participation to promote motor recovery. It has been proven beneficial for patients with functional motor disability. However, its application in robotic therapy has been hindered by a poor estimation method of subjects' functional or movement ability which is required for setting the appropriate robotic assistance. Moreover, there is also the need for consistency and repeatability of the functional ability estimation in line with the clinical procedure to facilitate a wider clinical adoption. In this study, we propose a new technique of estimation of subject's functional ability based on the Wolf Motor Function Test. We called this estimation the functional ability index. The functional ability index enables the modulation of robotic assistance and gives a more consistent indication of subjects' upper-limb movement ability during therapy session. Our baseline controller is an adaptive inertia-related controller, which is integrated with the functional ability index algorithm to provide movement assistance as when needed. Experimental studies are conducted on three hemiplegic patients with different levels of upper-limb impairments. Each patient is requested to perform reaching task of lifting a can from table-to-mouth according to the guidelines stipulated in the Wolf Motor Function Test. Data were collected using two inertial measurement unit sensors installed at the flexion/extension joints, and the functional ability score of each patient was rated by an experienced therapist. Results showed that the proposed functional ability index algorithm can estimate patients' functional ability level consistently with clinical procedure and can modify generated robotic assistance in accordance with patients' functional movement ability.

Keywords

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