AI-driven robot-assisted neurorehabilitation: from experimental trials towards a safe, reliable and effective human-robot interaction

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Abstract

In last three decades a better understanding of neurophysiological mechanisms underlying upper limb movements and gait together with the investigation of neural substrates that underlie motor recovery after neurological impairments (such as stroke and spinal cord injury) has led to the development of robotic systems for rehabilitation that incorporate key elements of motor re-learning such as intensive training involving goal-oriented repeated movements.

Robotic devices for the upper limb and gait are increasingly used in neurorehabilitation: several studies have demonstrated the effectiveness of these devices in reducing motor impairments, but only a limited evidence has been found on the improvement of upper limb and gait function so far.

Other studies have investigated the effects of combined approaches that target muscle function (e.g., functional electrical stimulation), modulate neural activity (e.g., non-invasive brain stimulation) and enhance motivation (e.g., Virtual Reality) to enhance the benefits of robot-assisted training.

Recent developments in multimodal human-robot interaction and artificial intelligence are offering significant insights for improving safety, reliability and effectiveness of robot-assisted rehabilitation treatments, in particular in terms of control strategies and prediction of recovery trends (e.g., DSSs).

During the talk, these aspects will be critically reviewed and an overview of the status of robot-assisted therapies and combined treatments will be discussed together with an analysis of the rationale behind them. Recent applications of machine learning algorithms applied to cognitive rehabilitation for stroke patients during upper limb robot-assisted rehabilitation will be presented as well.

Finally, the scientific, technological, ethical, legal and social challenges of robot-assisted rehabilitation of the next decade will be presented.

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