Wearable robotics in motion

Prostheses and rehabilitation systems enabled by wearable robotics technologies hold promise for IMPROVING THE LIVES OF PEOPLE WITH DISABILITIES.

Using wearable devices to enhance motion and assist rehabilitation is an increasingly feasible technology for treating physical disabilities. China's ageing population, and rising incidence of strokes and their after-effects, lead to a growing demand for wearable robotics.

The focus of the lab led by Qining Wang, a professor from Peking University's College of Engineering, is designing wearable robots and rehabilitation systems. Bridging neurological, mechanical, and robotics studies, his team conducts theoretical studies on dynamic walking principles and human-robot interfaces. The lab's spin-off, Beijing SpeedSmart, accelerates commercialization of its technologies for lower-limb prostheses and rehabilitation robots.

Optimizing human-machine interfaces

Motion intent recognition is essential for wearer control of prostheses. The conventional electromyography (EMG) approach uses metal electrodes to track electrical signals sent by motor neurons, whose direct contact may break the skin.

Wang's team proposed a non-contact capacitive sensing strategy, which uses capacitors to measure muscle shape changes during motion. The capacitance signals are fused with the mechanical signals on the prosthesis, enabling accurate recognition of motion transition, comparable to the accuracy rate achieved by the EMG-based approach. The method works for patients with varying limb lengths.

The recognition strategy is adaptive to mechanical signal variation over time, enabled by an automatic training algorithm. Furthermore, an integrated system collects and synchronizes sensor signals, and processes data in real time, allowing for intent recognition and robotic control.

Perfecting robotic design

Having studied human movement, Wang's team designed a bioinspired model to control their wearable robot, using central pattern generators (CPGs), the neuronal networks that produce rhythmic activation of muscles. This enables smooth limb coordination and walking pattern transitions.

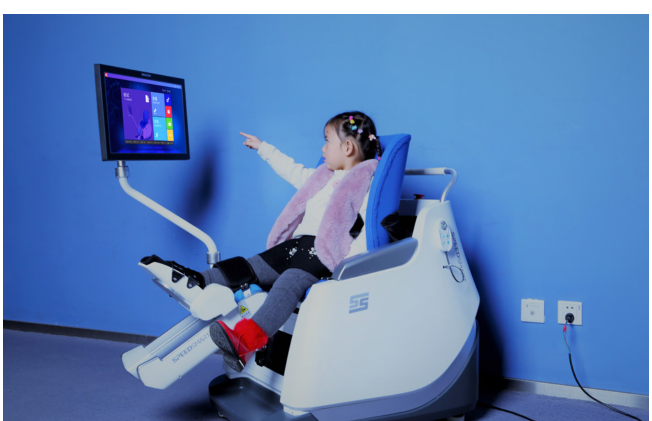
The robotic transtibial prosthesis weighs only 1.3 kg, excluding battery. A damping control strategy allows it to manipulate ankle impedance with little power consumption, capable of adapting to different terrains. The mechanical structure has also been revamped to combine push-off and damping behaviours, further improving gait symmetry and walking stability, while reducing energy use.

Co-controlled by a hydraulic damping system and an electronic actuation system, the transfemoral prosthesis can automatically recognize the wearer's motion intention, and provide damping adaptation to ensure stability. It supports walking on flat ground, up and down stairs, and cycling.

Wang's team also works on rehabilitation robotic systems for neurological disorders. Their robotic ankle–foot rehabilitation systems deliver real-time interventions for adult stroke patients and children with cerebral palsy. The system has an electronically adjustable platform with large degrees of freedom, which can automatically alter to a pre-set position after first use. This design enables an optimal rehabilitation position for patients, and easy, convenient operation for therapists.

Keen to improve control and safety for robotic ankle rehabilitation, Wang's team proposed methods to enhance the range of motion (ROM) measurement and avoid unsafe movement. Their system can stretch the ankle safely to its extreme positions.

The team has also integrated proprioceptive neuromuscular facilitation (PNF), a neurorehabilitation technique widely used by physical therapists. Robot-assisted training provides visual feedback for patients when their limbs dynamically interact with the robot. It has potential as a useful tool for rehabilitation training of gait disorders. ■



Intelligent lower-limb rehabilitation system for children

Robotic lower-limb prosthesis

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