

Neurorehabilitation and Robotics Laboratory: Brain retraining device with robotics for stroke rehabilitation



Prof. Raymond Tong(2nd Left) and his EEG team, Division of Biomedical Engineering, Department of Electronic Engineering



The EEG and hand exoskeleton robot system for stroke rehabilitation

Stroke has been a major cause of disability worldwide. One of the most common, yet probably also the most devastating, effect of stroke is hemiplegia. Individuals with stroke usually lose the motor functions on one side of their body, which subsequently lead to their dependence on their family members in doing their activities of daily living (ADL). The impact of stroke, hence, is not only suffered by its survivors but also their family members. Improving their motor functions, therefore, becomes the key to help them regain their independence and reduce the burden of their family members.

Throughout their history, the team in the Neurorehabilitation and Robotics Laboratory, led by Prof. Raymond K.Y. Tong, has dedicated their research to tackle those issues with stroke and its induced long-term disability using multiple approaches. Prof. Tong and his team conduct different kinds of research, starting from the more basic research with its animal studies to the more applied one with its development of robotic rehabilitation devices, brain computer interface (BCI), and software for home rehabilitation; all with one ultimate objective: to help individuals with stroke to regain their motor functions and their independency as much as possible.

In one of its animal studies with Sprague-Dawley (SD) rats, they investigated three different kinds of stroke rehabilitation: voluntary, involuntary, and forced rehabilitation training. Through this study, it was revealed that, among the three, voluntary training is most effective to facilitate motor recovery; highlighting the importance of the patient's voluntary intention in stroke rehabilitation.

This finding then contributed to the development of robotic rehabilitation devices in the laboratory. Prof. Tong's team began to develop different rehabilitation robots, both for upper limb and lower limb, which takes into account the voluntary intention of the user. Instead of just applying the then more commonly-used continuous passive motion (CPM) algorithm, the team implemented active control algorithms that require voluntary input from the user indicating their intention to drive the device. These inputs can be in the forms of muscle activities electromyography (EMG) signal, brainwave electroencephalography (EEG) signal, or even residual force signal.

Their innovative ideas did not stop there. Prof. Tong also came up with the idea to use both neuromuscular electrical stimulation (NMES) and robot assistance simultaneously for stroke rehabilitation. The technical difficulties due to the artifact from the NMES that may contaminate the EMG signal recorded was solved using simple tricks in the electrodes placement and signal processing. This leads to further advances in stroke rehabilitation with the results suggesting that the introduction of NMES to the robot-assisted rehabilitation further improve hand, wrist, and elbow functions; indicated by around 52% improvement in upper limb Fugl-Meyer Assessment (FMA) score and 38% improvement in action research arm test (ARAT) score for the NMES-robot group participants three months after training, as reported in one of their recent research articles published in *Neurorehabilitation and Neural Repair* journal (ranked 1st for Rehabilitation journals in 2013 Journal Citation Report).

The lack of improvement in distal joints, i.e. hand and fingers, functions compared to shoulder and elbow functions also motivated Prof. Tong and his team to come up with a solution. They then further developed the hand exoskeleton robot they invented previously. They equipped it with the capability of detecting each individual finger's intention via force sensors and selectively assisting several fingers only; enabling the device to train finer motor control such as two- and three-finger pinching, as opposed to only gross motor control like hand grasping. Their results of a pilot clinical trial using this device then suggested that their robot-assisted finger gestures training helped to better maintain the improvement in the longer term, compared to conventional hand rehabilitation therapy without robot assistance, with 56% and 67% of the participants who completed the robot-assisted training maintained improvement exceeding the minimal clinically important difference (MCID) of the FMA and ARAT scores, respectively, even 6 months after the training ended. In average, these participants also maintained around 60% improvement in their ARAT score 6 months after training.

Prof. Tong and his team in the Neurorehabilitation and Robotics Laboratory here in the Chinese University of Hong Kong are now still working on multi-disciplinary projects related to stroke rehabilitation. Individuals with stroke who are interested in participating in their studies can directly contact Prof. Raymond Tong via email at kytong@cuhk.edu.hk.