Rehabilitation Sleeve – A Functional Electrical Stimulation (FES) and Robotic Hybrid System for Stroke Rehabilitation

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The Grand Challenge

- Stroke is a leading cause of adult disability.

### References:
1. WHO statistic report 2013
3. Hong Kong Hospital Authority statistic report 2013
The Grand Challenge

• Long-term rehabilitation is needed after stroke to help the patients regain the independency in their daily life.

• Professional manpower is lacking in the rehabilitation industry due to the expansion of stroke populations.

• Neurehabilitation has been identified as the grand challenge in the coming decades (2010).

References:
Effective Neurorehabilitation after Stroke

- Physical intervention as early as possible
- Repeated and intensive physical training
- Practices with voluntary effort

MIT MANUS 1998
Armeo 2011
PolyJBot 2009
Hand of Hope 2010
Rehabilitation Sleeve 2014

From Passive Motion to Voluntary Intention Control
RehSleeve 復康袖: Intention-driven Multi-joint Training Device

Wearable design

Separable modules for different joints

Wrist/hand

Elbow
Biosignals as Indicators of the Voluntary Intention

Advantages of Electromyography (EMG) $^{1,2}$:

• Higher amplitude
• Focalized resolution of individual muscles
• Non-invasive detection from the skin surface
• Suitable for mild to moderate disabilities

Reference:

More effective rehabilitation after stroke:

• Reduction of compensatory motions by using correct muscles

Besides the muscle weakness and spasticity, discoordination of muscles is the main impairment after stroke. - Dewald J. et al. (1995) ¹

Reference:
¹ Dewald JP, Pope PS, Given JD, Buchanan TS, Rymer WZ. Abnormal muscle coactivation patterns during isometric torque generation at the elbow and shoulder in hemiparetic subjects. Brain 1995;118(Pt 2):495-510
The combined assistance from the NMES and robot

- **Robot**: Improves the accuracy of limb motions
- **FES**: Improves the muscle coordination patterns
- Robot and FES can work together to achieve the optimized assistance.

Reference:

Electrical stimulation can reduce the compensatory muscle activities immediately.

Reference:
The motor improvement achieved by FES-robot is higher than the pure robot.

The recovery progress by NMES-robot is faster than the pure robot.

Rehabilitation is interesting.
Rehabilitation is comfortable!

- The bracing system manages the pressure and moisture levels of the skin during training.
Introduction of RehSleeve 復康袖 to the Public

43rd International Exhibition of Inventions of Geneva

Hong Kong International Medical Devices and Supplies Fair 2014, 2015
RehSleeve 復康袖：EMG-driven NMES and Robot Hybrid System

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