An updated point of view about FES in the field of motor rehabilitation.

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Abstract

FES is a method to activate excitable tissues (e.g. Muscles and nerves) with electrical current pulses. The current pulses are applied either through surface (transcutaneous), or implantable (percutaneous and intramuscular) electrodes.

Stimulation above motor or sensory threshold is currently used in motor rehabilitation mainly for functional training and restoration of functional movements. Nerves and muscles can be activated electrically. For eliciting and executing motor functions transcutaneous (surface) electrical stimulation (TES) is the most frequently applied technique in clinical practice despite the huge efforts made to improve implantable technologies and some marginal efforts done in applying magnetic stimulation. Stimulation electrodes play an important role in interfacing the tissue with the stimulation unit. New techniques concentrate on multi-channel approaches and intelligent control for excitation and modulation of neural activity. Nevertheless, the systems need to be properly adapted to specific pathologies and need to take into account remaining neural properties and neuropathological changes that occur after an incidence affecting the motor-sensory system.

Lower extremities

Lower extremity FES is currently mainly applied as augmented stimulation for partially disabled, e.g. with drop foot stimulators, which help lift the foot and by stimulation of the foot lifter muscles and by using a polysynaptic reflex, the flexion reflex, that help to actuate the hip and knee flexor muscles during swing phase. Persons with complete walking impairment can use FES systems for walking as long as their lower motor

neuron is still intact. However, fast occurring muscle fatigue make FES only useful for exercising or short distant walking or standing. Hybrid orthotic FES systems are currently developed by several research groups (e.g. In the Spanish Consolider project Hyper, see http://www.iai.csic.es/hyper)

Upper extremities

With FES the hand and finger movements can be activated functionally for lateral and pinch grasps. Also wrist and in a supportive way elbow function can be activated. Fine finger movements, and shoulder movements are currently only limited possible and are implemented together with orthotic actuators in hybrid systems.

Other applications

Besides applications in lower and upper extremities FES is widely applied for urinary bladder control in spinal cord injury. To a lesser extent applied are other FES applications as FES rowing, FES cycling, FES respiration, and FES low back pain treatments.

The lecture will introduce main changes and effects affecting the functions that currently can be provided by electrical stimulation, provide a brief overview about the used technology and give some insights into new emerging technologies.

Recommended references with the talk

JOURNAL OF AUTOMATIC CONTROL, UNIVERSITY OF BELGRADE, VOL. 18(2):1-92, 2008

Functional electrical stimulation with surface electrodes

Author: Bajd Tadej --- Črt Marinček --- Munih Marko **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 3-9

Central nervous system lesions leading to disability

Author: Popović Dejan B. --- Sinkjær Thomas **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 11-23

Electronic stimulators for surface neural prosthesis

Author: Broderick Barry J. --- Breen Paul P. --- Ólaighin Gearóid **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 25-33

Electrodes for transcutaneous (surface) electrical stimulation
Author: Keller Thierry --- Kuhn Andreas **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 35-45

Additional reading:

Surface electrical stimulation for foot drop: Control aspects and walking performance
Author: Stein Richard B. --- Rolf Robert --- Everaert Dirk G. --- Bobet Jacques --- Chong Suling **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 47-52

Functional electrical stimulation therapy improves grasping in chronic cervical spinal cord injury: Two case studies
Author: Miller Rosalynn C. --- Popović Miloš R. --- Thrasher Adam T. --- Verrier Molly **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 53-61

Neural prostheses for walking restoration
Author: Popović Dejan B. --- Popović Mirjana B. --- Došen Strahinja **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 63-71

Fes cycling
Author: Berkelmans Rik **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 73-76

Rowing with FES
Author: Davoodi Rahman **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 77-84

Abdominal stimulation for respiratory support in tetraplegia: A tutorial review

Author: Gollee H. --- Hunt K.J. --- Fraser M.H. --- Mclean A.N. **Journal:** Journal of Automatic Control **Year:** 2008 **Vol:** 18 **Issue:** 2 **Pages/record No.:** 85-92