Wireless Functional Electrical Stimulation

Joint Master's Program in Biomedical Engineering, University of Bern and Bern University of Applied Sciences
Subject: Rehabilitation
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For Functional Electrical Stimulation (FES) in mobile and dynamic applications, powerful, portable devices of small size are required which allow patients to move freely and without disruption by electrode wires. The stimulation units of the newly developed wireless-controlled FES system can be mounted locally on a patient's body. They provide functionality for cycling applications and fulfil performance requirements for the activation of large human muscles.

Introduction

The loss of voluntary function in limbs and other body parts, also known as paralysis, is caused by disease or injury to the neuromuscular system. However, in an upper motor neurone lesion, the muscles themselves retain their ability to contract and produce force. By applying appropriate electrical fields to the lower motor neurons, action potentials are provoked artificially. FES is used to restore body functions by coordinated activation of specific muscles.

Methods

The proposed FES system consists of three major sub-units. The first one is the coordination unit, which serves as a user interface and manages the overall process. It interacts wirelessly with stimulation units, which form the second major sub-unit. Each stimulation unit generates electrical pulses on four channels simultaneously. In cycling applications two stimulators are required – one per leg. A sensor system, including a data transmitter, is placed directly on a recumbent tricycle and forms the third sub-unit of the system. Depending on the pedal position, measured by an encoder, specific leg muscles are triggered phase-wise in order to obtain cyclic motion of the legs. Using a throttle, the user can change the stimulation intensity, resulting in changing cycling speed. The hardware and software for the stimulators and the data transmitter, as well as the application code for the coordinator (Android), were developed within this thesis.

Results

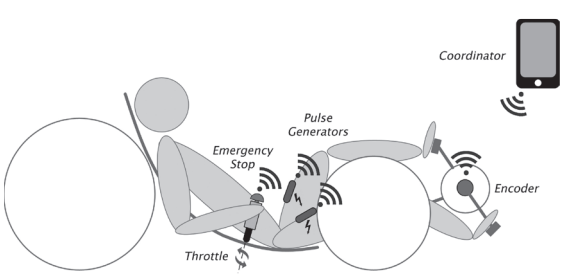
The described system has been implemented and tested. Stimulation parameters can be set individually for each channel on each unit (current amplitude: 10–150 mA, pulse width: 15–500 µs, frequency: 5–100 Hz). The accuracy of stimulation pulse modulation is of the order of 1 µs with regard to timing and 0.5 mA in amplitude.

Textile leg pockets allow installation of the stimulation units directly on a patient's legs approaching minimal wire length. In order to set up a flexible and low power network ANT technology was selected. Its determined range is ~30 m.

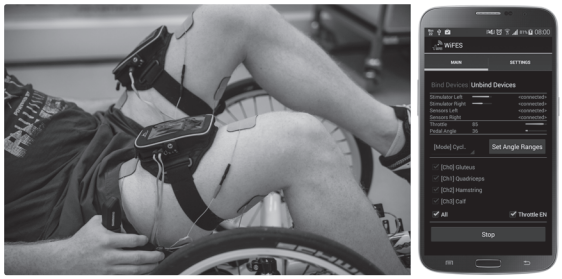
Discussion

Tests have shown that all specifications were met, and performance requirements were fulfilled. Pulse modulation can be rated as very accurate. The wireless range is sufficient for the proposed applications. Due to its aspect ratio, minimal wire length and ease of operation, this novel system has substantially improved functionality when compared to existing FES devices.

Manuel Bracher



Concept for wireless controlled FES-cycling.



Newly developed FES-system in cycling use.