多用途功能性電刺激系統之研發與應用

Development and Application of a Versatile FES System

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摘要

本研究之目的乃是研發一多用途功能性電刺激系統，並進行中樞癱瘓肢體功能重建之臨床應用測試。功能性電刺激系統核心刺激器研發乃以單元封包法爲基礎，藉由數位訊號處理器直接合成任意波形，並以類比輸出電路提供電壓控制之雙向定電流刺激。波形樣式產生器接受來自患者驅動輸入控制裝置之指令，或來自閉迴路回饋感知器之指令，合成需要之波形以刺激肌肉神經，產生期望之動作功能。在臨床應用方面，研究完成功能性電刺激踩車系統，及由患者自我驅動之手部抓握系統與閉迴路回饋控制系統，和以類神經網路及模糊理論控制器完成之功能性電刺激踝部動作控制系統 之測試。結果顯示研發之核心刺激器可以其波形樣式產生器之任意性及回饋處理之高性能，全面適用於不同功能性電刺激系統之應用，而所進行之應用測試也都達成令人滿意之麻痺肢體功能重建。

Abstract

The purpose of this study was to develop a versatile Functional Electrical Stimulation (FES) system and to perform clinical applications to restore the functions of decentralized and paralyzed limbs. The development of the electrical stimulator, core of the FES system, is based on the element-envelope method. A direct-synthesized arbitrary waveform is generated by a digital signal processor, and bi-phasic, voltage-controlled, constant current stimuli are provided by an analog output circuit. The pattern generators receive the commands, coming from a patient-driven input device or a closed-loop feedback sensing device, to synthesize the required waveforms and elicit the required functions. In clinical application, a pedal cycling FES system, a patient-driven hand grasping FES system with a closed-loop feedback controller and an ankle motion FES system with a neural network and fuzzy controller were tested. The results showed that the proposed stimulator could be considered as a full-featured electrical stimulator for various FES applications with its

flexibility in pattern generation and feedback processing capabilities. All of the clinical applications showed satisfactory results in the restoration and control of some specific functions