Design of an Oscillatory Neural Network with FES to Assist Paraplegic Walking of Patient with Motor Neuron Disease

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Abstract

There are many diseases that affect the motor neurons of the human’s nervous system. One of these diseases is the weakness and inability to control the leg muscles such as the case with foot drop condition. Foot drop usually results from an injury at the peroneal nerve which is responsible to control the lifting muscle of the leg, and as a result the foot and toes drop downward while lifting the leg causing unstable walking gait.

To overcome this problem, many devices were developed to solve the foot drop condition taking in mind the fact that the muscle electrical conductivity is still intact although the nerves are disconnected from the brain. Thus, muscles can be stimulated by external electrical supply. For example, Functional Electrical Stimulation (FES) method replaces the function that has been lost by substituting the brain connection to the muscles. Drop-Foot Stimulator (DFS) is a special portable device designed to stimulate the peroneal nerve using surface electrodes to get rid of the foot drop and improves the walking movement. There are few commercialized devices such as WalkAide and NESS L300. However, these devices are very expensive to afford to Omani patients. In addition, they depend on a threshold value that needs to be tuned for individual condition after period of times to adjust his/her improved muscle condition. Modifying and tuning the device performance requires clinicians’ supervision in hospitals.

This study addresses the control of FES generation in the DFS devices using Neural Oscillators networks which is called Central Pattern Generators (CPG). A CPG network produces a stable cyclic rhythm which can be synchronized with the human walking motion if used with the aid of sensory feedback. The proposed CPG is based on a well known neural oscillator called Matsuoka since it has robust stable output and can be synchronized with the system’s dynamics to produce more natural motions. A proposed CPG controller was tested on a simulation model of a biped robot with foot drop condition to mimic the human motion, since experimenting the FES directly on a real human might be harmful. The simulation results showed that the proposed CPG controller did control the foot drop by synchronizing with the robot walking gait using ZMP as sensory inputs. Finally, a modified Matsuoka oscillator was proposed to be used for the real FES by linking the oscillator parameters to FES properties.