Abstract (revised version 2)

Treatment and restoration of motor abilities to individuals with spinal cord injury (SCI) is possible with neuro-rehabilitative systems for unsupported upright stance, also known as quiet stance. The aim of this research project is to develop a controller that will regulate active ankle torque during electrical stimulation for quiet stance. This study uses a novel technique of applying an optimal robust servomechanism controller to bring the human’s centre of mass (COM) to a specified reference position independent of external disturbances. The robust controller obtained was able to track quiet stance within 1 second, and highly attenuate both constant and Gaussian noise disturbances intensity. The robust controller presented can be considered as a step forward in neuro-rehabilitative systems for quiet stance, as previous controllers have not considered dealing with the servomechanism control problem in the regulation of ankle torque.

Abstract (revised version 1)

Spinal cord injury (SCI) causes reduced quality of life for individuals with SCI and their families, and considerable financial impact on the health care system. Neuro-rehabilitative systems such as neuroprosthesis for unsupported upright stance (quiet stance) allow for possibility of treatment and restoration of motor abilities through electrically stimulating the paralyzed muscles of individuals with SCI. The aim here is to develop a controller to regulate active ankle torque during electrical stimulation for quiet stance by using a novel technique of applying an optimal robust servomechanism controller to bring the human’s centre of mass (COM) to a specified reference position. The robust controller obtained was able to track a constant ankle reference angle of 0.1 rad (~ 5°) within 0.6 seconds. The controller also attenuated
constant and Gaussian noise disturbances intensity by three orders of magnitude. The controller presented in this project can be considered as a step forward in neuro-rehabilitative systems for quiet stance, as previous controllers have not considered dealing with the servomechanism control problem in the regulation of ankle torque.

Abstract (original version)

Spinal cord injury (SCI) not only causes immobility and overall reduction in quality of life for individuals with SCI and their families, but it also has considerable financial impact on the individual, his/her family and the health care system. Neuro-rehabilitative systems allow for possibility of treatment and restoration of motor abilities to individuals with SCI. One of the emerging neuro-rehabilitative interventions is a neuroprosthesis for unsupported upright stance. This device, by means of electrical stimulation that is delivered to the paralysed muscles in the legs, generates sufficient forces in the leg joints to enable upright stance. The aim of this research project is to develop a controller that will regulate active ankle torque during electrical stimulation for quiet stance, where the hands of the individual are free to move and are not involved in the stabilization process. This study uses a novel technique of applying an optimal robust servomechanism controller to bring the human’s centre of mass (COM) to a specified reference position independent of external disturbances. The controller obtained was able to track a constant ankle reference angle (the angle between the vertical placed through the ankle joint and the line that connects COM with the ankle) of 0.1 rad (~5°) within 0.6 seconds. The controller also only took approximately 6 seconds to regulate the system when a constant disturbance of 0.244 rad (~14°) was applied and was able to attenuate constant and Gaussian noise disturbances intensity by three orders of magnitude. The controller is also robust, i.e., for
any constant non-stabilizing perturbations in the plant, it provides exact tracking and exact disturbance regulation. The controller presented in this project can be considered as a step forward in neuro-rehabilitative systems for quiet stance, as previous controllers have not considered dealing with the servomechanism control problem in the regulation of ankle torque.