Abstract

Ankle foot orthosis (AFO) is used to support or restore the complex ankle foot movements of the subjects with neurological or muscular impairments. Neurological impairments are due to stroke, polio, multiple sclerosis, spinal cord injuries, and cerebral palsy. Active ankle position control is one of the most basic functionalities of the human ankle. It allows for foot clearance during the swing phase and maintains a proper landing of the foot during foot strike. The standard AFO is a rigid polypropylene structure that prevents any ankle motion. Emerging technologies provide a vision for light weight, small size, high efficiency and low noise orthosis which can be of daily wear assist devices. In this dissertation, a novel design of active AFO is presented. This AFO design is portable and can be used for rehabilitation outside the clinical therapy. The work is focused on design of an intelligent control system in order to provide proper gait assistance in the following simplified gait phases: (1) motion control at the start of the gait cycle, i.e heel strike. (2) plantarflexor torque assistance during late stance i.e heel off to toe off transition.(3) dorsiflexor position control of the foot during swing. The gait analysis of normal and pathological is done using Electromyography (EMG) signals. After lot of deliberation on the sensors, the portable sensors gyroscope and tactile sensors were selected in the gait analysis and AFO design.

In this work, in order to develop a compact, energetically efficient AFO design, an embedded control system using Ardupio Uno board has been adopted. The tactile sensors are used to find the gait events to give proper triggering for the plantar and dorsiflexion movements. The gait movements are validated by treadmill testing with a constant speed of walk.

In order to generalize the control system, multi body foot model is designed and combined with mathematical modeling of the actuator. The optimum design of the controller is evolved using the Ziegler-Nichols method and Root locus techniques. After the initial parameters of the controller are obtained, the optimization is done to get the desired characteristics and performance of the system.
To summarize, this dissertation is purported to analyze, simulate and control the ankle joint during gait, by means of designing an active AFO to assist individuals having pathologies in the ankle foot complex. The ankle foot pathologies are mainly due to stroke causing hemiparesis. The design methodologies involved in this dissertation are: understanding the biomechanics of locomotor unit, study of muscle activity during normal gait and ankle joint movements and analyzing the different phases in gait. The results obtained in the later stage are used to control the actuation system of AFO.