Abstract

Traditionally, physical human-robot interaction (pHRI) research has elaborately explored and documented the effectiveness of constant impedance control strategies. This research explores user adaptive impedance control technique that exploits the agility-stability trade-off which is a limitation of constant impedance control. The aforementioned controller is composed of two parts namely, Variable Damping Controller (VDC) and Variable Stiffness Controller (VSC). The experiments are conducted using an in-house constructed Active Ankle Foot Orthosis (AFO) that provides torque to assist or resist ankle motion. This torque is determined by the user’s intent of motion in VDC and is observed to be predominant during the terminal stance phase and early swing phase. VSC dominates mainly the stance phase of a gait cycle and is used to correct the altered ankle gait due to the mass of the robot by providing torque proportional to deviation of altered gait from nominal gait. The experiments are conducted on healthy subjects of age group 20 - 30 years, male and female, using the AFO on an instrumented treadmill running at 1.25 m/s for 5 minutes each. Test cases like nominal walking, walking with inactive AFO, positive damping, variable damping and variable stiffness are studied. To study the effectiveness of the proposed control strategies, electromyography (EMG) sensors are placed on tibialis anterior (TA), soleus (SOL) and gastrocnemius (GAS) muscle. Muscle exertions in each experiment are compared to nominal walking muscle activity. The validity of the proposed controllers (VDC and VSC) as improved control schemes is thus measured using a combined inspection of muscle activity and ankle trajectory deviation compared to nominal gait.