Mechanical Engineering Thesis Defense

Gait Dynamic Stability Analysis with Wearable Assistive Robots

School for Engineering of Matter, Transport and Energy

Seyed Mostafa R. Sorkhabadi

Advisor: Dr. Wenlong Zhang

abstract

Lower-limb wearable assistive robots could alter the users gait kinematics by inputting external power, which can be interpreted as mechanical pertirbation to subject normal gait. The change in kinematics may affect the dynamic stability. This work attempts to understand the effects of different physical assistance from these robots on the gait dynamic stability. A knee exoskeleton and ankle assistive device (Robotic Shoe) are developed and used to provide walking assistance. The knee exoskeleton provides personalized knee joint assistive torque during the stance phase. The robotic shoe can store the potential energy at heel strike and release it by using an active locking mechanism at the terminal stance phase to provide push-up ankle torque and assist the toe-off. Lower-limb Kinematic time series data are collected for subjects wearing these devices in the passive and active mode. The changes of kinematics with and without these devices on lower-limb motion are first studied. Orbital stability, as one of the commonly used measure to quantify gait stability through calculating Floquet Multipliers (FM), is employed to asses the effects of these wearable devices on gait stability. It is shown that wearing the passive knee exoskeleton causes less orbitally stable gait for users, while the knee joint active assistance improves the orbital stability compared to passive mode. The robotic shoe only affects the targeted joint (right ankle) kinematics, and wearing the passive mechanism significantly increases the ankle joint FM values, which indicates less walking orbital stability. More analysis is done on a mechanically perturbed walking public data set, to show that orbital stability can quantify the effects of external mechanical perturbation on gait dynamic stability. This method can further be used as a control design tool to ensure gait stability for users of lower-limb assistive devices.

June 19, 2018; 10 AM; GWC 107