Mechanical Engineering Master's Defense

Regulation of 3D Human Arm Impedance

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abstract

Humans have an inherent capability of performing highly dexterous and skillful tasks with their arms, involving maintaining posture, movement and interacting with the environment. The latter requires for them to control the dynamic characteristics of the upper limb musculoskeletal system. Inertia, damping and stiffness, a measure of mechanical impedance, gives a strong representation of these characteristics. Many previous studies have shown that the arm posture is a dominant factor for determining the end point impedance in a horizontal plane(transverse plane). The objective of this thesis was to characterize end point impedance of the human arm in a 3D space. Moreover it investigates and models the regulation of the arm impedance due to increasing levels muscle co-contraction. The characterization is done through experimental trials where human subjects maintained arm posture, while perturbed by a robot arm. Moreover, the subjects where asked to control the level of their arm muscles' co-contraction, using visual feedback of their muscles' activation, in order to investigate the effect of the muscle co-contraction on the arm impedance. The results of this study showed a very interesting, anisotropic increase of the arm stiffness due to muscle co-contraction. This can lead to very useful conclusions about the arm biomechanics as well as many implications for human motor control and more specifically the control of arm impedance through muscle co-contraction. The study finds implications for the EMG-based control of robots that physically interact with humans.

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