# Mechanical Engineering Doctoral Defense

## Development of a Novel Low Inertia Exoskeleton Device for Characterizing the Neuromuscular Properties of the Human Shoulder

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## Abstract

The human shoulder plays an integral role in upper limb motor function. As the basis of arm motion, its performance is vital to the accomplishment of daily tasks. Impaired motor control, as a result of stroke or other disease, can cause errors in shoulder position to accumulate and propagate to the entire arm. This is why it is a highlight of concern for clinicians and why it is an important point of study. One of the primary causes of impaired shoulder motor control is abnormal mechanical joint impedance, which can be modeled as a 2nd order system consisting of mass, spring and damper. Quantifying shoulder stiffness and damping between healthy and impaired subjects could help improve our collective understanding of how many different neuromuscular diseases impact arm performance. This improved understanding could even lead to better rehabilitation protocols for conditions such as stroke through better identification and targeting of damping dependent spasticity and stiffness dependent hypertonicity. Despite its importance, there is a fundamental knowledge gap in the understanding of shoulder impedance, mainly due to a lack of appropriate characterization tools. Therefore, in order to better quantify shoulder stiffness and damping, a novel low-inertia shoulder exoskeleton is introduced in this work. The device was developed using a newly pioneered parallel actuated robot architecture specifically designed to interface with complex biological joints like the shoulder, hip, wrist and ankle. In addition to presenting the kinematics and dynamics of the shoulder exoskeleton, a series of validation experiments are performed on a human shoulder mockup to quantify its ability to estimate known impedance properties. Finally, some preliminary data from human experiments is provided to demonstrate the device's ability to collect the measurements needed to estimate shoulder stiffness and damping while worn by a subject.

September 30, 2020; 12 PM;

Zoom Link: https://asu.zoom.us/j/6053670919