Presentation Abstract

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Title:	Time variant system identification of human limb dynamics using wavelets
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Abstract:

The dynamic behavior (i.e. admittance) of a human limb results from the interaction between limb inertia, muscles and the central nervous system. System identification techniques assess the dynamic behavior of a limb by analyzing the limb's response to certain perturbations. Most identification techniques require the system to behave linear and time invariant, i.e. the system's response to the perturbation must remain unchanged during observation. However it is known that neuromuscular properties change for example with fatigue. Furthermore it has been found that the strength of afferent feedback (e.g. from muscle spindles and Golgi tendon organs) adapts to conditions like task instruction and mechanical load. So far, research mainly focused on the the steady state behavior after the system had been adapted but not on the adaptation process itself.
In this study we developed a closed-loop time-variant identification technique based on wavelet cross spectra to continuously identify the admittance, i.e. the dynamic relation between input force (or torque) and the output displacement. This identification technique allowed for measurement of the human joint dynamics as a function of time while the human interacts with a mechanical load. As a second step the afferent feedback strengths were quantified by fitting a neuromuscular control model onto the admittance for each time instant. The model fit produced physiological relevant parameters, like muscle visco-elasticity resulting from (co-)contraction, afferent feedback from muscle spindles and Golgi tendon organs including neural time delays.
Simulations demonstrated that the developed method is able to track time-variant behavior. Preliminary results of experimental data showed that human subjects adapt their admittance to an instantaneous change of a viscous load. In particular, the gain of the afferent feedback

changed within seconds. The estimated dynamic behavior of the human joint before and after the change of the viscous load resembled the behavior as identified using traditional time-invariant techniques in two separate experiments with constant viscous loads. However, the accuracy of the estimated adaptation time of the system is yet to be determined as the method in its current form is less able to track fast changes in system behavior. Further research into time-variant closed-loop identification is recommended to improve the temporal accuracy.

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