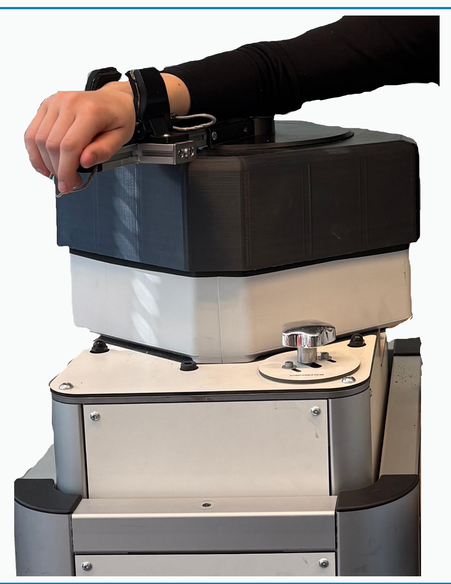
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System performance analysis of the Shoulder-Elbow Perturbator



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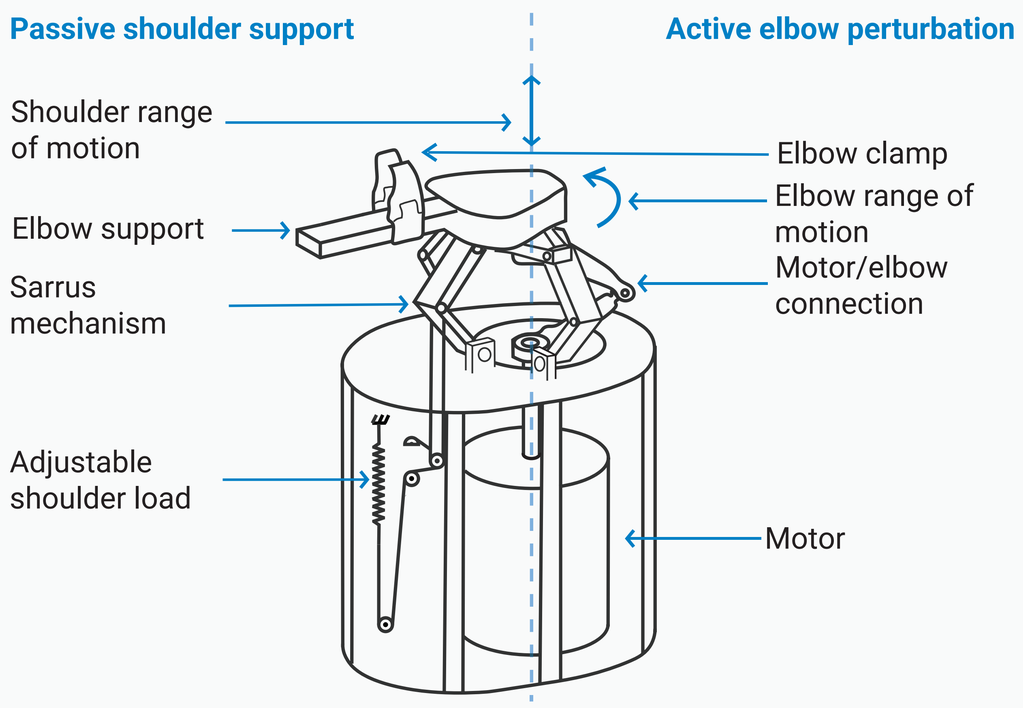
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Introduction

Manual assessment of motor impairment after a stroke makes quantification and distinguishing between various causes of motor impairments challenging [1]. To address this, system identification techniques uses robotic measurements to objectively determine the mechanical properties of the human limb [2].

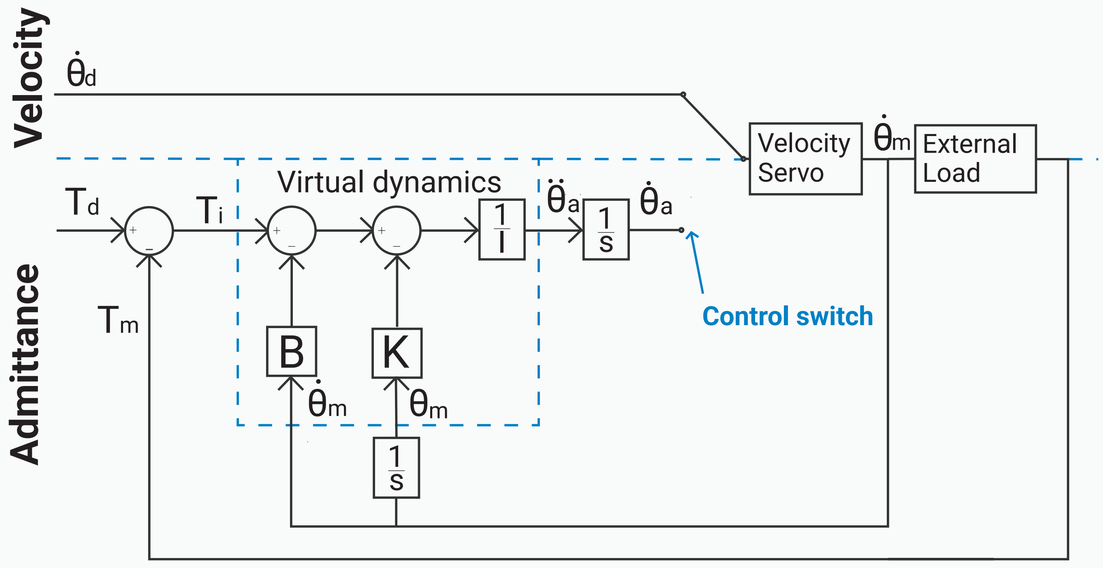
For reliable robotic measurements, a device must have a bandwidth at least three times greater than the joint's eigenfrequency [3], and have stable control. This paper shows the bandwidth and stability of the Shoulder - Elbow Perturbator [4] (SEP, Hankamp Rehab) and shows the ability to identify introduced dynamics on the SEP.

Design



The SEP can actively perturb the elbow in the horizontal plane with a passive adjustable shoulder support.

Controller



The SEP has two modes of control one being velocity control and the other being admittance control

Acknowledgements

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Conclusion

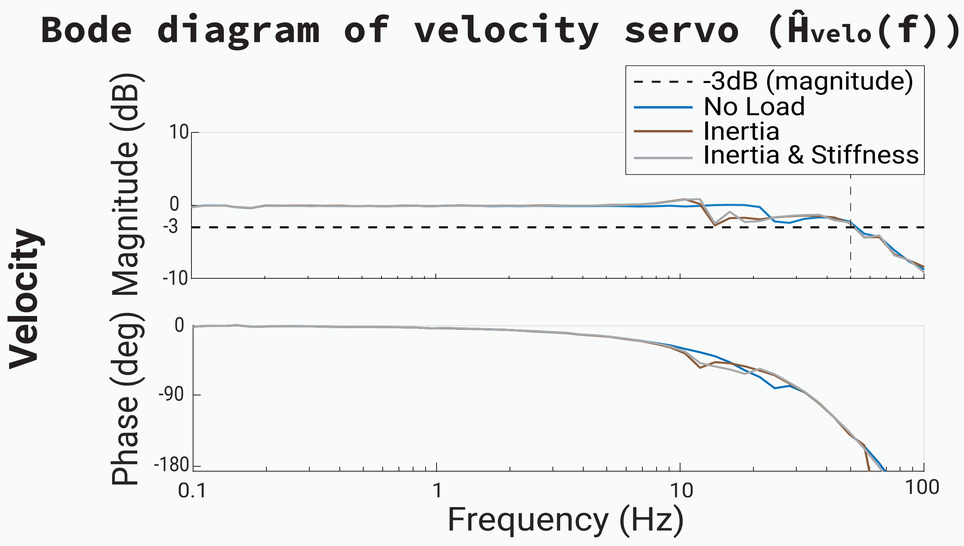
The SEP can stably perturb the elbow with a minimum bandwidth of 50 Hz. Additionally, the SEP can effectively identify any dynamics introduced into the system. These results show that the SEP should be able to provide the desired perturbations and experimental conditions needed for system identification of the human elbow.

Performance analysis

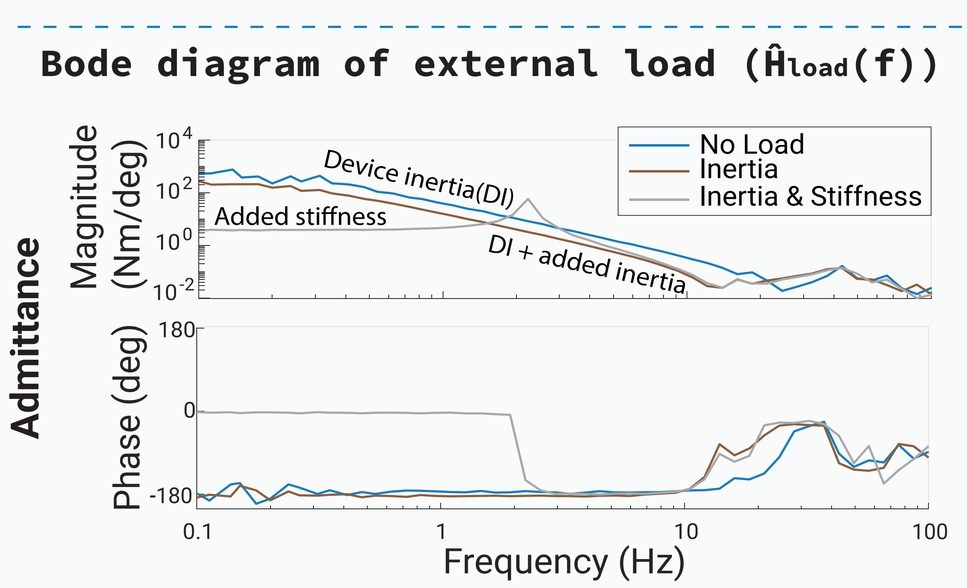
	Input signal	External loading	Transfer function
Velocity	θ_d: Velocity multisine signal	1: No load 2: Inertia 3: Inertia & Stiffness	$\hat{H}_{velo}(f) = \frac{\hat{S}_{\Theta_m\Theta_d}(f)}{\hat{S}_{\Theta_m\Theta_m}(f)}$
Imittance	T_d: Torque multisine signal		$\hat{H}_{load}(f) = \frac{\hat{S}_{\Theta_m T_d}(f)}{\hat{S}_{T_d T_m}(f)}$

For the different modes of control the SEP was evaluated under external loading conditions mimicking a heavy human arm

Results



The bandwidth of the controller is 50Hz (vertical dashed line)



The different external loads introduced into the system are identified by the SEP

References

[1]: van der Krogt et al. - Journal of NeuroEngineering and Rehabilitation (Aug. 2012)
[2]: M. van de Ruit et al. - Journal of NeuroEngineering and Rehabilitation (May 2023)
[3]: A. C. Schouten et al. - Journal of Neuroscience Methods (June 2006)
[4]: Van der Velden et al. - Journal of NeuroEngineering and Rehabilitation (Dec. 2022)