HERC

Amplifying Human Strength Through a Virtual Sprung Inertia

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Background and Objectives

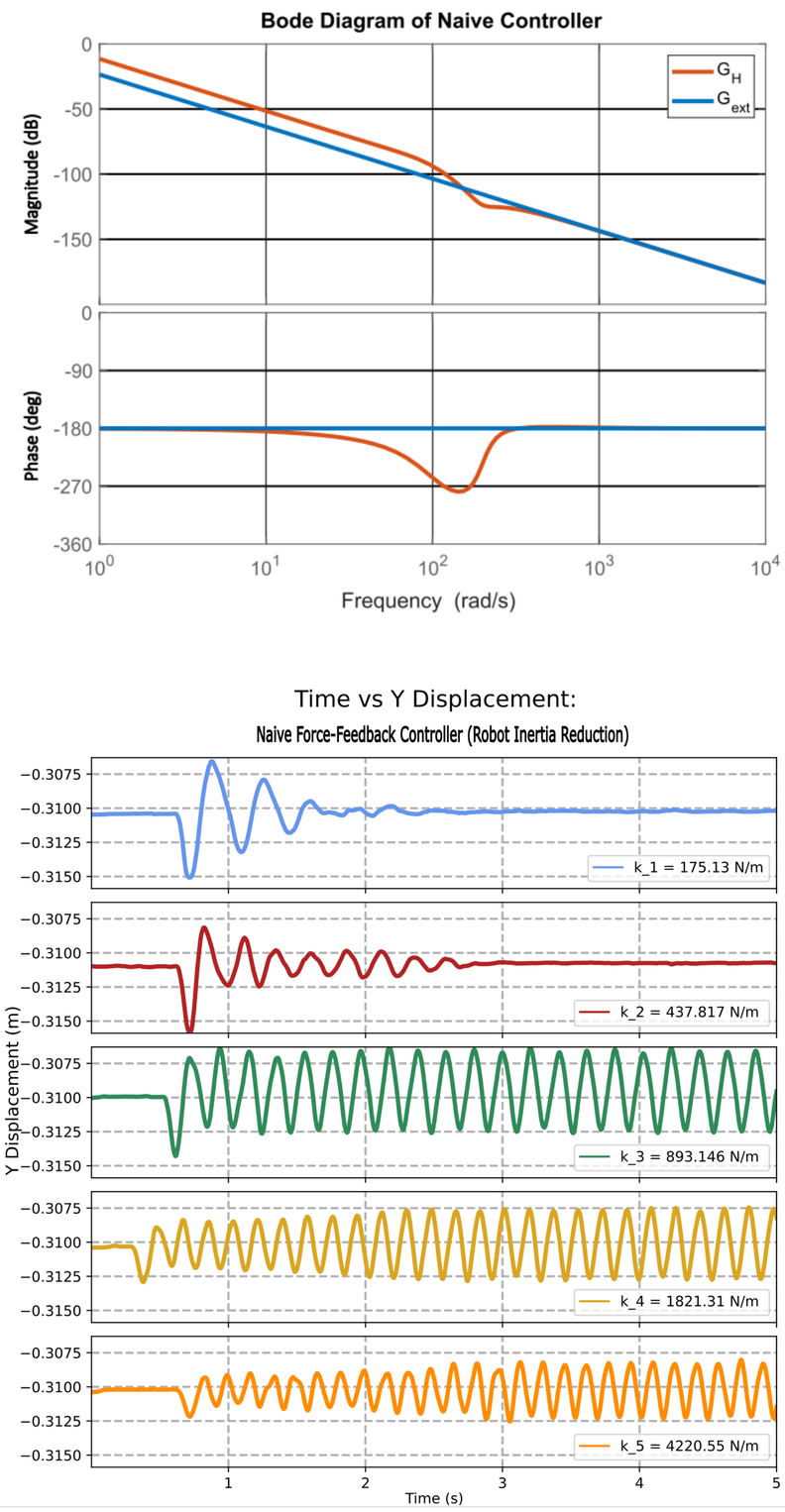
- Robots can assist in rehabilitative care
- Position control unsafe for direct contact HRI
- Many rehab procedures require self-movement
- Force-feedback can amplify human strength
- Force-feedback controllers tend to be sluggish
- Stability issues
- Human mechanical impedance is not static
- Design a controller that is robust to this behavior
- Estimate the mechanical impedance of a “spring-box” system

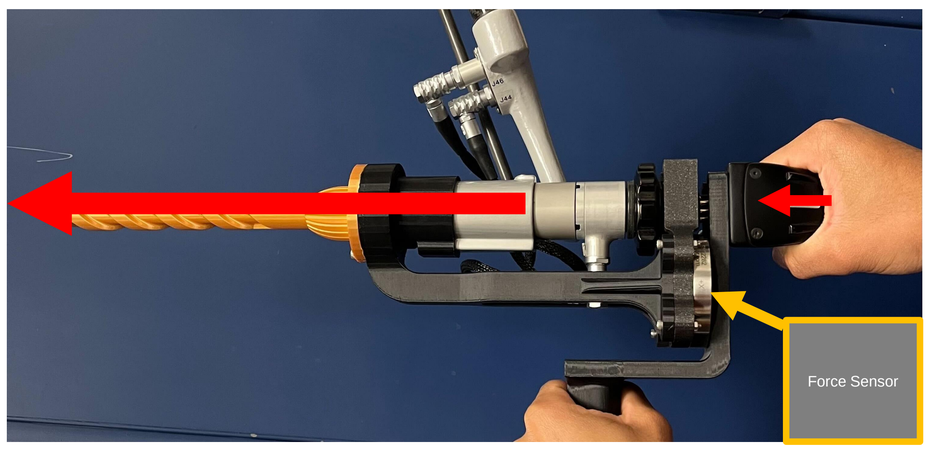
Strength amplification through force-feedback is **more robustly stable** with respect to actuator bandwidth limits if we **avoid reducing robot inertia** by adding virtual mass

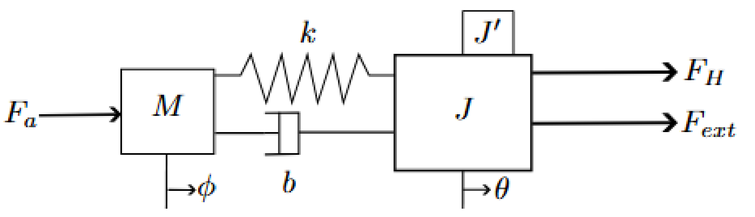
Scan for Full Paper!

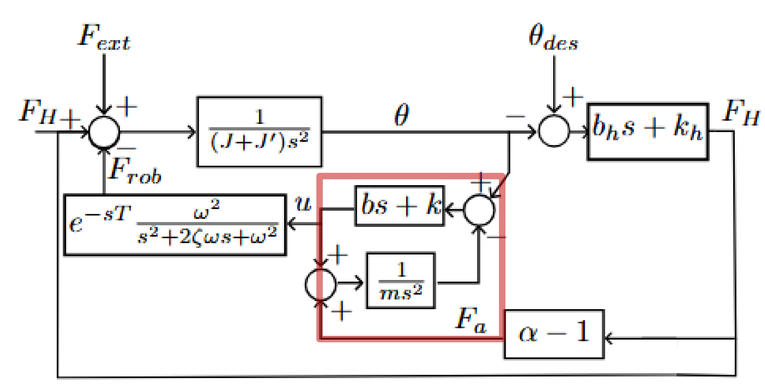
Method

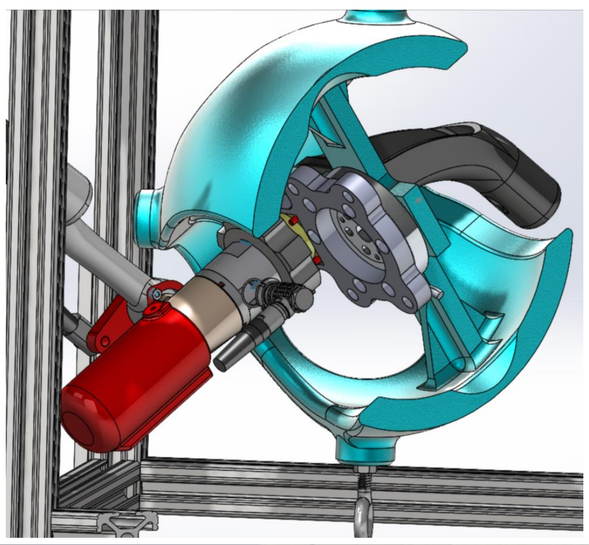
- Unstable due to reduction of robot inertia
- Reduction causes non-passive behavior
- Fix: add virtual mass/inertia!
- Avoids the non-passive behavior

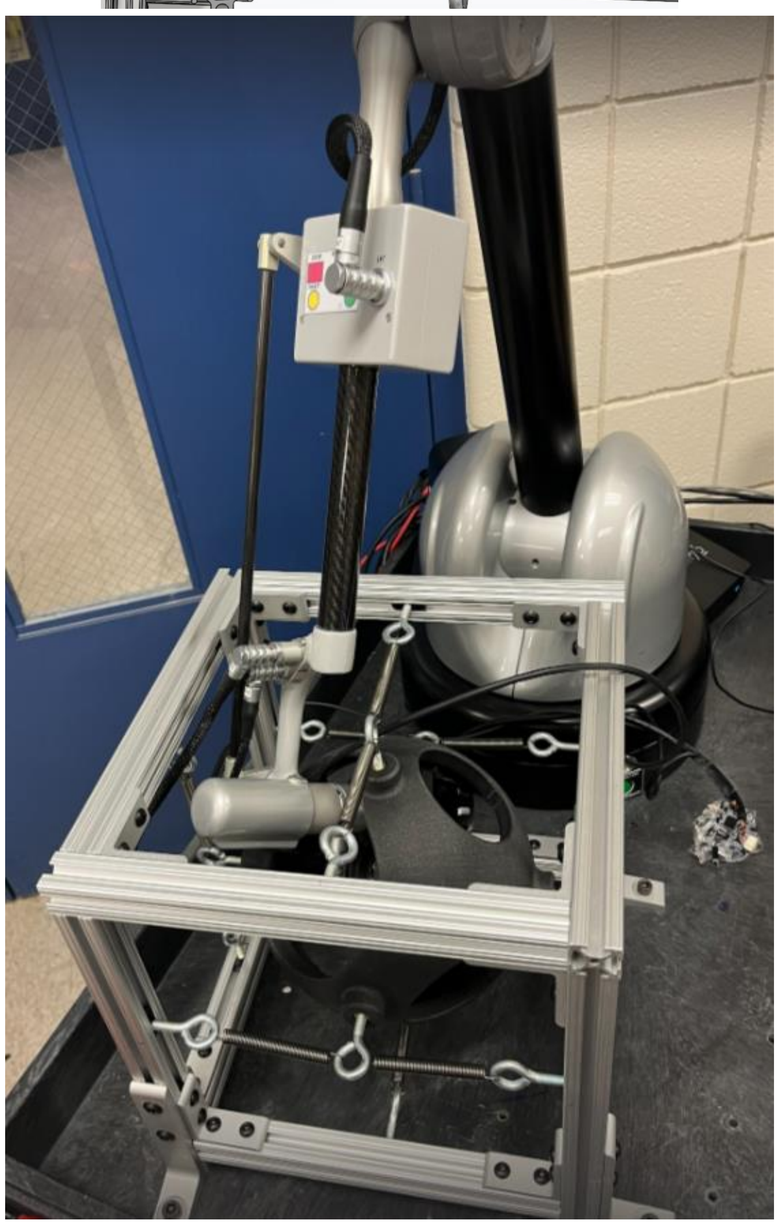


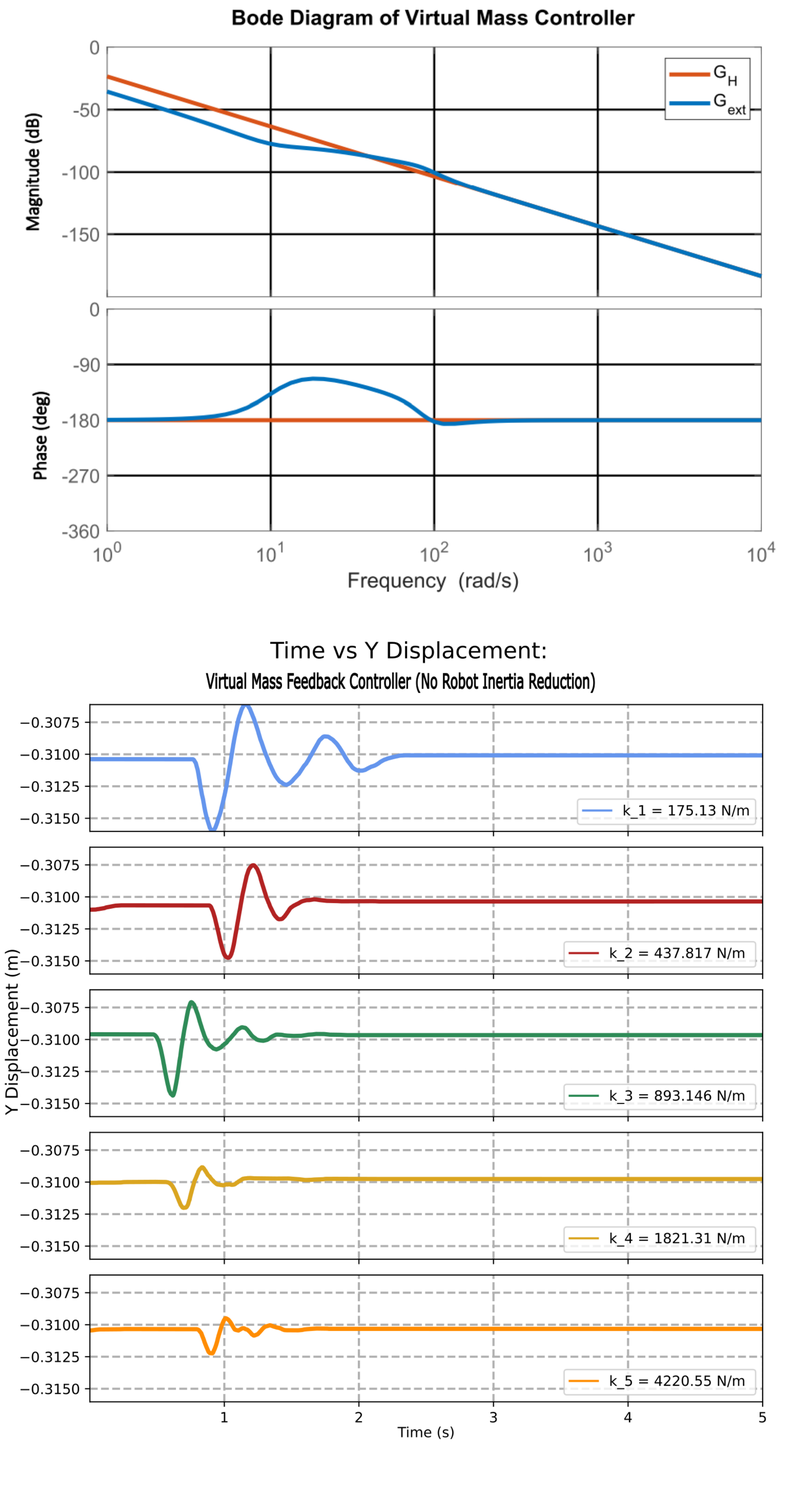












Results

- Bode plots demonstrate passivity/non-passivity
- Tested the two controllers experimentally
- Naïve controller demonstrates instability (oscillations)
- Oscillations increase with increasing “human” stiffness
- Instability due to large phase dip below $-180°$ in naïve controller
- Phase stays constant at $-180°$ for virtual mass controller
- Virtual mass successfully stabilizes system
- Stable for large range of stiffnesses