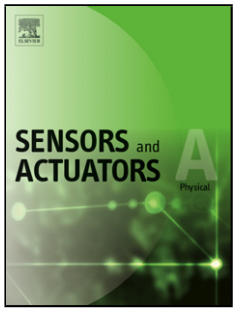

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Model-based feedforward and cascade control of hydraulic McKibben muscles

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Abstract

McKibben artificial muscle actuators are predominantly pneumatically powered. Recently, hydraulic operation has gained interest due to its higher rigidity and efficiency. While there has been extensive control system development for pneumatic artificial muscles, little has been conducted hydraulically. This paper investigates three different controllers developed for a loaded robotic arm actuated with oil-hydraulic McKibben muscles. The goal was to achieve good angular position tracking over a range of frequencies up to 1 Hz. The first scheme, serving as the baseline, is a proportional-integral controller. The second architecture adds a nonlinear model-based feedforward term to the baseline controller; the feedforward includes the expected flowrate demands based on the actuator kinematics as well as the valve flow gain. The last scheme adds an inner pressure feedback loop to the second architecture. All controllers were evaluated with frequency and step response experiments. The results show that a simple proportional-integral controller has significant phase lag and attenuation at the higher frequencies tested; including the feedforward term almost completely eliminates these. The cascaded loop improves rise and settling times.

Keywords: McKibben muscle, fluidic artificial muscle, hydraulic artificial muscle, fluid power control, hydraulic control, robotics

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