Function Approximation Technique-based Adaptive Force-Tracking Impedance Control for Unknown Environment

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Abstract

An accurate force-tracking in various applications may not be achieved without a complete knowledge of the environment parameters in the force-tracking impedance control strategy. Adaptive control law is one of the methods that is capable of compensating parameter uncertainties. However, the direct application of this technique is only effective for time-invariant unknown parameters. This paper presents a Function Approximation Technique (FAT)-based adaptive impedance control to overcome uncertainties in the environment stiffness and location with consideration of the approximation error in the FAT representation. The target impedance for the control law have been derived for unknown time-varying environment location and constant or time-varying environment stiffness using Fourier Series. This allows the update law to be derived easily based on Lyapunov stability method. The update law is formulated based on the force error feedback. Simulation results in MATLAB environment have verified the effectiveness of the developed control strategy in exerting the desired amount of force on the environment in x-direction, while precisely follows the required trajectory along y-direction, despite the constant or time-varying uncertainties in the environment stiffness and location. The maximum force error for all unknown environment tested has been found to be less than 0.1 N. The test outcomes for various initial assumption of unknown stiffness between 20000N/m to 120000N/m have shown consistent and excellent force tracking. It is also evident from the simulation results that the proposed controller is effective in tracking time-varying desired force under the limited knowledge of the environment stiffness and location.

Author keywords

Adaptive Control; Force Control; Robot Finger Control; Time-Varying Uncertainties; Uncertain-Environment

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