A Quasi-Repetitive Controller for Accurate Imaging in Atomic Force Microscopy

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ABSTRACT

While the classical Repetitive Controller provides a highly effective framework for asymptotic tracking of periodic signals, many signals of practical importance are quasiperiodic, i.e., are a function of periodic and aperiodic components. This paper focuses on modeling a class of quasiperiodic signals and deriving an internal-model based controller to asymptotically track/reject such signals. The quasiperiodic signals of interest are referred to as additive and multiplicative quasiperiodic. Additive (multiplicative) quasiperiodic signals are defined as signals that can be expressed as an algebraic sum (product) of periodic and polynomial signals. The resulting quasi-repetitive controller (QRC) is an extension of the classical repetitive controller, and asymptotic convergence is guaranteed by choosing an appropriate order of the controller based on the order of the quasiperiodic signal intended to be tracked. The QRC retains the plug-in structure of the repetitive controller, which enables it to be augmented with other feedback controllers. The motivation behind this work is the control of atomic force microscopy (AFM), where raster scanning non-planar and misaligned surfaces generates quasiperiodic disturbances in the feedback loop. Experimental AFM imaging results demonstrate that tracking performance can be increased by multiple-fold using the quasi-repetitive controller.

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