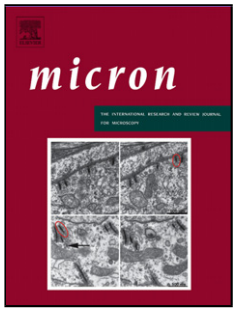

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Intelligent Tuning Method of PID Parameters Based on Iterative Learning Control for Atomic Force Microscopy

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Highlights

- A novel intelligent tuning method of PID parameters based on iterative learning control for Atomic
- Force Microscopy is proposed.
- The proposed method can achieve excellent tracking performance by the experimental results of imaging calibration grating sample and CD-R sample.
- The learning feature of iterative learning control can guarantee the automatic tuning of PID parameters in the process of imaging and improve the intelligent level of AFM system.

Abstract: Proportional-integral-derivative (PID) parameters play a vital role in the imaging process of an atomic force microscope (AFM). Traditional parameter tuning methods require a lot of manpower and it is difficult to set PID parameters in unattended working environments. In this manuscript, an intelligent tuning method of PID parameters based on iterative learning control is proposed to self-adjust PID parameters of the AFM according to the sample topography. This method gets enough information about the output signals of PID controller and tracking error, which will be used to calculate the proper PID parameters, by repeated line scanning until convergence before normal scanning to learn the topography. Subsequently, the appropriate PID parameters are obtained by fitting method and then applied to the normal scanning process. The feasibility of the method is demonstrated by the convergence analysis. Simulations and experimental results indicate that the proposed method can intelligently tune PID parameters of the AFM for imaging different topographies and thus achieve good tracking performance.

Keywords: Intelligent tuning method, PID parameters, Iterative Learning Control, Atomic Force Microscopy

1 Introduction

Atomic Force Microscope (AFM) is a common instrument that can image the surface topography of samples at atomic resolution (Binnig et al., 1986). The proportional-integral-derivative (PID) controller, which is one of the core components of AFM, is widely applied to control the scanner to maintain an appropriate distance between the sample and the probe (Hosseini et al., 2016; Korayem et al., 2010). The PID parameters should be set suitably to keep tracking (Carlucho et al., 2017). Therefore, the parameter tuning method becomes particularly important. Generally speaking, the parameter tuning methods are divided into two categories (Manoharan et al., 2017). One is the engineering adjustment method, which mainly relies on the engineering experience and the qualitative relationship between the dynamic and the stead-state performance of the controlled system. However, the engineering method requires experienced engineers to monitor the whole system in