Multi-rate Nonlinear Control for Enhancing the Servo Performance of HDD Systems

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May 2013

Abstract

In hard disk drives (HDDs), vibrations caused by abrupt control input variations and other external disturbances would affect the servo performance seriously and limit the application of HDDs in modern multimedia devices. Nonlinear control techniques can be potentially applied to enhance servo performance of HDDs.

One promising algorithm is to combine sliding mode controller and nonlinear PID controller to enhance the transient performance. When the tracking error is large, sliding mode control and nonlinear PID control work together to rapidly reduce the error; when the error is small, sliding mode control is turned off to ensure good steady state performance. As to the nonlinear PID, the tracking error signal will be utilized to tune the nonlinear integral gain and nonlinear derivative gain, aiming to (1) shorten the settling time, (2) reduce the peak error, and (3) keep the good steady state performance.

Another promising algorithm is the pure discrete-time sliding mode control. Sliding mode control has strong robustness to large disturbance and model uncertainty. By unifying tasks such as track-seeking and track-following into one control scheme, sliding mode control would perhaps reduce possible vibrations caused by the switching between different control schemes. Multi-rate control techniques can be utilized to increase the sampling rate of other aspects of the system, such as the control signal. Such a multi-rate approach can help mitigate vibrations and enhance the servo performance by reducing the change of control input at each sampling instance. Combining the aforementioned ideas together, multi-rate nonlinear control are utilized for enhanced vibration rejection especially in the steady-state performances of HDDs.