

Editorial

Intelligent Control and its Applications to Hard Disk Drives

Recent years have witnessed a tremendous growth of hard disk storage capacity while the cost and physical size of hard disk drives (HDD) continue to shrink. The areal data density of HDDs has increased from 1 GB per square inch in 1996 to 100 GB per square inch in 2006. Today, HDD tracks per inch (TPI) has already been pushed beyond 200K. In order to read/write (R/W) data reliably, servo-positioning system must keep the R/W head with precision less than ± 10 nm under electronic noise, actuator resonance, internal airflow disturbance and external shock and vibration. It is estimated that the areal density of HDDs will increase at the rate of 40% every year. This poses great challenges for HDD servo system to achieve ultra-accurate positioning control.

In the past decades, intelligent control has been one of the most active research areas of control theory, and has become a powerful tool in solving HDD control problems. This special issue aims at providing a forum for control researchers and engineers to report the latest developments and trends in HDD control applications. This special issue contains seven papers [1–7] that cover several HDD control techniques such as iterative learning control (ILC), repetitive control (RC), sliding mode, robust tracking control, H -infinity design, and time-optimal control. The following is a brief summary of each paper.

Chen *et al.* [1] present a tutorial on ILC and RC techniques in HDD industry for compensation of repeatable disturbances. Their paper is an industrial tutorial on using ILC/RC technologies to attack the high TPI challenge. Drive-level results are presented for illustration.

Herrmann *et al.* [2] present a novel discrete sliding mode technique for dual-stage track-seek and track-following servo system. An LQR approach is used to design the sliding mode dynamics by removing the penalty weight on the control signal so that dead beat behavior is created for reaching dynamics of the sliding mode. Linear matrix inequality (LMI) methods are used to solve the singular LQR problem. Superior performance for track-seeking and track-settling processes is demonstrated using an existing practical setup of a dual-stage HDD servo system.

Generally, robustness and performance are incompatible requirements; robustness improvement leads to performance degradation. Both requirements are important for track-following control in HDDs. The motivation of Paper [3] is to provide a way to overcome this incompatibility by developing a set of controllers that gives high tracking performance for a large population of HDDs.

Du *et al.* [4] studied H -infinity compensation of external vibration impact on servo performance of HDDs in mobile applications. Their paper considers the problem of compensation for external vibration impact on positioning accuracy. A feedforward controller is designed to attenuate the disturbances with the aid of vibration detection sensors. Loop shaping in frequency domain and H -infinity method are used to design the feedforward controller. The LMI approach is adopted to solve the H -infinity feedforward control problem.

The Paper by Gao and Hu [5] is about time-optimal control for HDD servo problems. A discrete optimal control method is proposed in a two-degree-of-freedom structure by employing both feedback and feedforward controllers. The time-optimal feedback controller shows remarkable robustness and disturbance rejection in the presence of resonant modes, measurement noises, and

torque disturbances. The proposed feedforward controller proves to be quite beneficial in reducing seek time.

Melkote and McNab [6] present a repetitive process approach to modeling and control for self-servowriting problem in HDDs. A fundamental obstacle in self-servowriting is due to propagation of errors as successive tracks are written. Their paper considers both modeling and control of self-servowriting process in HDDs.

The final paper by Hu *et al.* [7] investigates robust track-following control of HDDs by combining integral sliding mode method and phase lead peak filter. In their paper, an improved sliding mode scheme in conjunction with phase lead peak filter is proposed and applied to a HDD servo system to perform disturbance rejection in track-following control.

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