HIL SIMULATION SYSTEM FOR THE HDD SERVO FIRMWARE

Yosuke SENTA, Yuichi SATO, and Eiji OKAMURA
Fujitsu Limited, 1-1 Kamikodanaka, 4-Chome, Nakahara-ku, Kawasaki, JAPAN

Introduction

With the aim of constructing servo firmware for a hard disk drive (HDD), we have constructed a Hardware-in-the-Loop Simulation (HILS) System that uses a computer-based virtual mechanism instead of an actual mechanism (Fig. 1).

Experimental and Discussion

The introduction of an HILS has already been achieved in such fields as missile guidance systems and electronic automotive devices [1-2]. In the case of an HDD, an HDD is a relatively small object in physical terms when compared to a missile or a motor vehicle, and its eigenfrequencies are extremely high as a consequence. To therefore perform simulations with sufficient accuracy, a very short sampling interval must be used, which means that real-time simulation cannot be performed. Under these circumstances, we decided to synchronize the firmware and simulator. This enables a precise simulation to be performed, albeit in a somewhat slow-motion manner. In our experiment, the model was described using the MATLAB/Simulink® and operated at a simulation interval of 1 μ s. As a result of synchronous processing, the simulation speed turned out to be about 300 times that of the actual speed. Figure 2 compares the VCM current and the offset for the same seek operation between an actual mechanism and a simulation. Considering that the data obtained from the actual mechanism was measured every sector (every 100 μ s) while the simulation data was measured every 1 μ s, the results show very good agreement.

FUJITSU Ltd. is currently using this HILS system in the development of HDD products. The system has been effective in several ways, such as elucidating problems that could not have been discovered with actual mechanisms and by shortening development periods.

References

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Figure 1. Overview of HILS

Figure 2. VCM current and arm position during seeking

LARGE CAPACITY PROBE RECORDING USING STORAGE ROBOTS (StoBots)

Leon Abelmann, Thijs Bolhuis and Cock Lodder

Systems and Materials for Information storage (SMI), MESA⁺ Research Institute,
University of Twente, Enschede, The Netherlands, www.cl.utwente.nl/smi

The progress in data-rate and access time of the hard disk drive has not kept pace with the tremendous increase in data density. This has a deteriorating effect on the total performance of desktop computer systems. The underlying cause of this problem is that only a few heads are responsible for all data transfer. It would be better if the number of heads scales proportionally with the capacity. Probe recording systems, which use thousands of heads in parallel, might offer a solution. The disadvantage of the probe array architectures that have been suggested up to now [1, 2], is that the total storage area, and therefore the capacity, is low. For areas of several tens of cm², the probe array would be difficult to realize and too expensive. In order to reach high capacity, we suggest to break up the array in smaller subarrays of about 10 probes each, and distribute them over a large area (a tile). This requires that the sub-arrays have actuators with which they can move over the medium surface, like miniature data storage robots, or *StoBots*, with dimensions of a few 100 μ m.

The access time of a *StoBot* drive is expected to be longer than that of systems based on one single probe array, since the probes have to be translated over much larger distances. To investigate whether the concept can still lead to decent drive performance, Monte-Carlo type simulations were performed with variation in the number of *StoBots*, their speed, data-rate and most importantly the file access strategy. Figure 1 shows that the speed of the *StoBots* has more impact on access time than the total number of *StoBots* on the tile. For single file access, it is better to restrict the movement of the *StoBots* to sectors, and distribute the file over these sectors (Solitary approach, indicated by solid symbols), rather than to keep the file geometrically confined and allow the *StoBots* to travel over the complete tile (Mass approach, open symbols). In this paper the effect of *StoBot* data-rate and parallel file access are discussed, as well as advanced file access strategies and the technological possibilities of high speed *StoBots*.

Figure 1: Access time versus number of *StoBots* to restrict the movement of the *StoBots* to sectors, and distribute the file over these sectors (Solitary approach, indicated by solid symbols), rather than to keep the file geometrically confined and allow the *StoBots* to travel over the complete tile (Mass approach, open symbols). In this paper the effect of *StoBot* data-rate and parallel file access are discussed, as well as advanced file access strategies and the technological possibilities of high speed *StoBots*.

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