BIO-ENGINEERING: AN INTEGRATED SYSTEMS APPROACH

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The theme of the effort is to synergistically integrate investigations in biological systems, primarily in neurobiology and in DNA and genetic processing, with engineering. The view is to begin with the biology to inspire engineering, and subsequently to provide feedback from engineering methodologies into the biological investigations.

Neurobiology and Learning Systems:
This effort investigates learning and adaptation in the natural "balance and motor control system" of squirrel monkeys, and aims at transferring the biological learning mechanisms to artificial learning algorithms applicable to walking robots and other mobile systems. The sense of balance is essential and critical in enabling the coordination of motor response, eye movement, posture, and locomotion. The effort aims at addressing several multidisciplinary scientific problems crucial to understanding natural and artificial balance learning systems.

Through experiments associated with squirrel monkeys at Washington University, we seek to understand the mechanisms of learning and adaptation used by the vestibular (balance) system and the Vestibular-Ocular Reflex (VOR) to achieve remarkably robust sensing and balance control in eye movement, posture, and locomotion. In these mechanisms, the control mechanism is learned and adapted on-line as more (visual and vestibular) information is acquired. Measurements of neural signals during adaptation will provide insight into the learning mechanisms.

These learning principles will be implemented in architectures that mimic the neurobiology to the sub-micro scale level and in real-time. We will model the Vestibular system and the VOR mechanism using mathematical models of the natural interconnected biological neurons as well as the building blocks of CMOS microelectronics and Micro-electromechanical systems (MEMS) technology.

Finally, the biologically inspired learning algorithms and MEMS chip(s) will be tested within a robotic platform. This platform is expected to provide new capabilities for posture and locomotion and will serve as a testbed for aiding biological investigations and experiments.

DNA- and Gene- Chips:

Molecular biological experiments involve manipulation, transporting, and processing of small objects such as cells and tissues. Lack of efficient ways to directly manipulate these objects has made the molecular biological experiments a tedious and time-consuming process. Developing technologies that enable scientists to directly manipulate these micro-objects can significantly improve the process. For instance, direct manipulation of DNA can provide fundamental technologies for disease related gene diagnosis, gene therapy and pharmaco-genomics. These will contribute to the advancement of biological sciences including medicine and pharmacology. In addition, the traditional molecular biological experiment process can be significantly miniaturized. As a result, it would be possible to reduce the quantity of the sample and the reagents, and at the same time increase the efficiency of the process.

In this effort, we work towards the complete micro-scaling and automation of the DNA and microbial processing with a Micro-Electro-Mechanical System (MEMS) chips in the micro-scale. In our present collaboration with industry, we hope to steer our efforts towards developing the technologies of the future in automation, manipulation, and control microbiological systems.

The on-going activities presently include 3 MSU faculty and 2 Faculty from Washington University in St. Louis, Missouri. In addition, the effort includes initial industry collaborators from Bioinformatics, Molecular Biology, Parke-Davis Pharmaceuticals, Ann Arbor, MI, and Progen, Inc. Mountainview, CA.
Further details are included in the B.E.S.T group website at: http://www.egr.msu.edu/best/