Analog VLSI and Biological Systems Group

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Introduction

The aim of biologically inspired electronics is to emulate biology in building ultra low power, real-time, compact systems from an analog circuit engineer's or physicist's point of view. Such systems are useful as smart sensors. They are also useful in biomedical applications where the low power and biomimetic capabilities are particularly advantageous. Biologically inspired systems yield insights into how biology works via engineering synthesis that would be very hard to attain via scientific analysis. Work in the group focuses on three projects, the bionic ear project, the hybrid computing project, and the Biologically Inspired Vision Systems project.

1. The Bionic Ear Project

Sponsors
Advanced Bionics Corporation, UNDER AGREEMENT DATED 9-01-00

Project Staff
Dr. George Efthivoulidis, Michael Baker, Christopher Salthouse, Ji-Jon Sit, Professor Sarpeshkar

The aim of the project is to construct a bionic ear processor for the deaf that has the potential to reduce the current power consumption of such processors by more than an order of magnitude via low power analog VLSI processing, and the potential for revolutionizing the performance of such processors in noise via architectures that are modeled after the operation of the inner ear or cochlea.

2. Spike-Based Hybrid Computers Project

Sponsors
Office of Naval Research, UNDER CONTRACT NUMBER N00014-00-1-0244

Project Staff
Dr. George Efthivoulidis, Micah O Halloran, Heemin Yang, Professor Sarpeshkar

This project attempts to combine the best of analog and digital computation to compute more efficiently than would be possible in either paradigm of computation. Several moderate precision analog computing units interact with each other to efficiently implement computations such as arithmetic, filtering, and pattern recognition which are significantly more expensive to implement with digital logic. Periodic discrete signal restoration prevents analog noise and offset from degrading the precision of the computation. This project is inspired by the duality of analog spike-time and digital spike-count codes of the brain's neurons. It is being applied to create an "analog"

DSP, and to create programmable hybrid computers that are suited for processing noisy analog sensory data.

3. The Biologically Inspired Vision Systems Project

Sponsors

Defense Advanced Research Projects Agency, through Office of Naval Research grant number N00014-99-1-0438, to California Institute of Technology, UNDER SUBCONTRACT NUMBER 1007021

Project Staff

Maziar Tavakoli-Dastjerdi, Professor Sarpeshkar

This project maps the distributed feedback loops of biological photoreceptors to silicon to create low-power high-bandwidth silicon photoreceptors. Such photoreceptors are useful as front ends in VLSI motion sensors, important in robotic and active-vision applications. An ultra-low-noise MEMS vibration sensor, that provides inertial information to a vibrating visual sensor at Caltech, a collaborator on this project, is also being built.

Publications

Journal Articles Published

Hahnloser, R., R. Sarpeshkar, M. Mahowald, R. Douglas and S. Seung, "Digital Selection and Analogue Amplification Coexist in a cortex-inspired silicon circuit," *NATURE*, Vol. 405(6789): 947-951, (2000).

Meeting Papers Presented

Sarpeshkar, R., "Traveling Waves Versus Bandpass Filters: The Silicon and Biological Cochlea," *Proceedings of the International Symposium on Recent Developments in Auditory Mechanics*, Editors H. Wada et al, pp. 216-222, World Scientific, 2000.

R. Sarpeshkar, R. Herrera, and H. Yang, "A Current-Mode Spike-Based Overrange-Subrange Analog-to-Digital Converter," *Proceedings of the IEEE Symposium on Circuits and Systems*, IV-397, Geneva, May 2000.

Theses

Brooks, Lane G., *Amplitude and Frequency Demodulation Controller for MEMS Accelerometer*; MEng degree awarded 21st February 2001.