Analog VLSI and Biological Systems Group

Academic and Research Staff
Professor Rahul Sarpeshkar

Graduate Students
Michael Baker, Micah O'Halloran, Christopher Salthouse, Ji-Jon Sit, Maziar Tavakoli-Dastjerdi, Heemin Yang, Alex MeVay, Serhii Zhak

Support Staff
Mary O'Malley

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 spike-based hybrid computing project, and the motion-sensing project.

1. The Bionic Ear Project

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

Project Staff
Michael Baker, Christopher Salthouse, Ji-Jon Sit, Serhii Zhak, 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; David and Lucille Packard Foundation Fellowship, under contract number 2001-19533

Project Staff
Micah O'Halloran, Alex Mevay, 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 filtering, pattern recognition, and learning 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 very low

power analog-to-digital converters, compact analog memory circuits, and programmable hybrid computers suited for processing noisy sensory data.

3. The Motion Sensing 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 attempts to combine visual motion sensors, inspired by biological motion processing in the fly with MEMS vibration sensors for active vision systems and robotic applications.

Publications

Journal Articles

Submitted for Publication:

C. Salthouse and R. Sarpeshkar, “A Micropower Programmable Bandpass Filter for use in Bionic Ears”, submitted to the IEEE Journal of Solid State Circuits.

R. Sarpeshkar and M. O’Halloran, “Spike Based Hybrid Computation”, submitted to Neural Computation.

M. Tavakoli and R. Sarpeshkar, “An Offset-Cancelling Low-Noise Lock-in Architecture for Capacitive Sensing”, submitted to the IEEE Journal of Solid State Circuits.

Books/Chapters in Books

R. Sarpeshkar, “The Silicon Cochlea”, in *Sensors and Sensing in Biology and Engineering*, F. G. Barth, editor, in press

R. Sarpeshkar, T. Delbruck, C. Mead, and S. C. Liu, “White Noise in MOS Transistors and Resistors”, in *Analog VLSI Circuits and Principles*, S. Liu et al., MIT Press, in press

Accepted Conference Papers

R. Sarpeshkar, M. Tavakoli-Dastjerdi, “A Low-Noise Nonlinear Feedback Technique for Compensating Offset in Analog Multipliers

R. Sarpeshkar, M. O’Halloran, “A Low Open-Loop Gain, High-PSRR, Micropower CMOS Amplifier for Mixed-Signal Applications”

R. Sarpeshkar, C. Salthouse, “A Micropower Band-Pass Filter for use in Cochlear Implants”

Reports

R. Sarpeshkar, G. Efthivoulidis, *A Squared Plane Geometry for Linear Systems*, RLE Technical Report No. 656, December 2001.

Theses

M. Tavakoli-Dastjerdi, *Analog VLSI Circuits for Inertial Sensory Systems,* Master of Science thesis, Department of Electrical Engineering and Computer Science, MIT, 2001.