Signal Processing Seminar

Title: Biologically Inspired Beamforming

Speaker: Professor Douglas L. Jones
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Date: Wednesday, February 11, 2009
Time: 4:00 - 5:00 pm
Where: 4269 Beckman Institute

Abstract: Array processing is a well-developed, even mature technology that has been very successfully used in a number of applications such as radar and sonar. However, many animals have various multi-element sensory systems with capabilities unmatched by existing engineered technologies. For example, human binaural hearing performance greatly exceeds that of conventional adaptive beamformers or blind source separation, particularly in the "cocktail party" environment. The parasitoid fly Ormia ochracea can determine the direction of its cricket prey to within two degrees using a directional "ear" that is less than two millimeters across. Many fish have lateral line and weak electrosense systems that provide some kind of high-resolution near-field "imaging" of flow disturbances or nearby objects or prey, and bats can feed and navigate in complex environments using a sonar array of only two sensors.

Inspired by these remarkable capabilities, and in collaboration with biologists and MEMS sensor researchers, we have developed novel sensor arrays and signal processing algorithms that duplicate some of these feats. Biologically inspired binaural beamforming algorithms show much better performance than existing methods in the cocktail party environment, and suggest that the brain's "secret" lies in exploitation of the time-frequency sparseness of real-world sources. A "zero-aperture" acoustic vector sensor array approaches the directional resolution of Ormia with similar aperture. Application of beamforming methods to a novel array of MEMS flow sensors achieves high-resolution imaging of moving objects in water near the array. A novel electronic weak electrosense system, coupled with a new sparse beamforming signal processing paradigm shows experimentally the ability to simultaneously locate several nearby objects.

The talk will give a high-level overview of these systems and their biological inspiration and argue that unconventional beamforming applications have a bright, varied, and largely unexplored future.

This is joint work with Nam Nguyen, Matt Kleffner, Hamed Asghari, David Jun, Mike Lockwood, and Chris Schmitz.

Bio: Douglas L. Jones received the BSEE, MSEE, and Ph.D. degrees from Rice University in 1983, 1986, and 1987, respectively. During the 1987-1988 academic year, he was at the University of Erlangen-Nuremberg in Germany on a Fulbright postdoctoral fellowship. Since 1988, he has been with the University of Illinois at Urbana-Champaign, where he is currently a Professor in Electrical and Computer Engineering, the Coordinated Science Laboratory, and the Beckman Institute.

In the Spring semester of 1999 he served as the Texas Instruments Visiting Professor at Rice University. He is a Fellow of the IEEE and was member of the Board of Governors of the IEEE Signal Processing Society.

He is an author of the laboratory textbook ``A Digital Signal Processing Laboratory Using the TMS32010" and was named the 2003 Connexions Author of the Year. His research interests are in digital signal processing and communications, including time-frequency signal analysis, adaptive processing, multisensor data processing, OFDM, and various applications such as advanced hearing aids.