RICE UNIVERSITY DSP

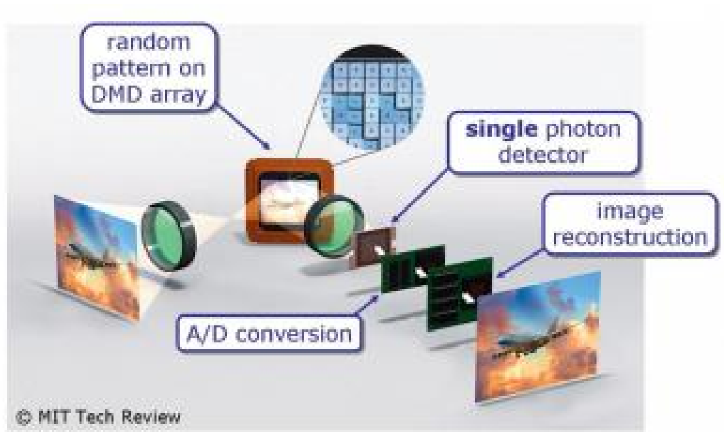
Research at Rice

Major Research Initiatives

ARO Opportunistic Sensing MURI (/research/opportunistic-sensing)
DARPA A2I Receiver Program (/a2i)
Learning Machines Lab (/research/learning-machines-lab)

Current Research Projects

(/research/compressive-sensing)
Compressive sensing and sparse approximation (/research/compressive-sensing)

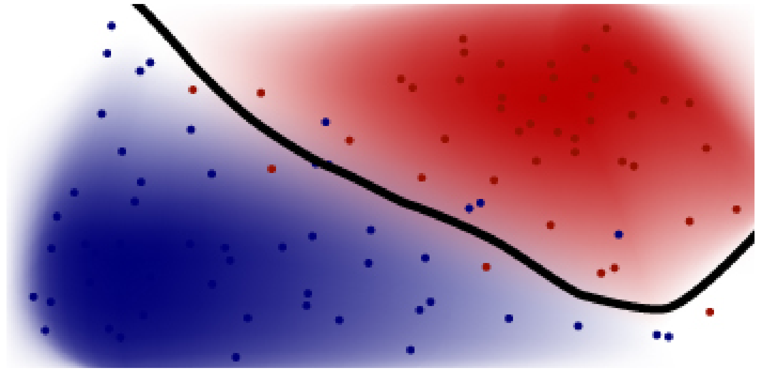


The present dogma of signal processing maintains that a signal must be sampled at a rate at least twice its highest frequency in order to be represented without error. However, in practice, we often compress the data soon after sensing, trading off signal representation complexity (bits) for some error (consider JPEG image compression in digital cameras, for example). Clearly, this is wasteful of valuable sensing resources. Over the past few years, a new theory known as compressive sensing has emerged, in which a signal is sampled (and simultaneously compressed) to its “information rate” using non-adaptive, linear measurements. For “sparse” signals that can be represented using just a few terms from a basis expansion, this corresponds to sub-Nyquist sampling. Interestingly, random measurements play a starring role. The compressive sensing concept has led to the development of new signal acquisition hardware and has inspired a variety of new techniques for processing sparse data.

- Specific projects (#)

Specific projects (#)

(/research/machine-learning) **Machine learning** (/research/machine-learning)



In addition to the challenges we face in acquiring, storing, and transmitting very large amounts of data, we also frequently desire to "learn" from the data in a number of senses. This arises in many important and emerging signal processing problems when we lack a priori analytical models. In this case we must learn data models and tune processing algorithms based entirely on training data. Example applications include search engines, medical diagnosis, detecting credit card fraud, stock market analysis, speech and handwriting recognition, object recognition in computer vision, and spam filtering. We are exploring a wide range of machine learning algorithms to that aid in tasks including data visualization and exploration, dimensionality reduction, nonlinear regression, and pattern classification.

Specific projects (#)

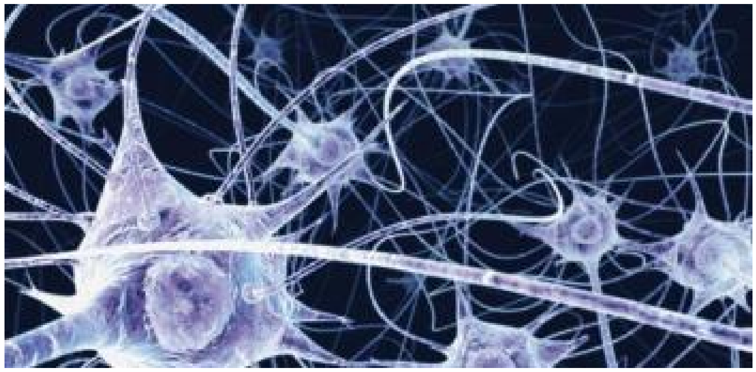
(/research/image-processing) **Image processing** (/research/image-processing)

The Rice DSP group has a long history of developing multiscale analysis and processing algorithms based on wavelets, filterbanks, and statistical models. In addition to compressive sensing for image and video data, current image processing research directions include dual-tree complex and quaternion wavelets and graphical models.

Specific projects (#)

(/research/neural-information-processing) **Neural information processing** (/research/neural-information-processing)

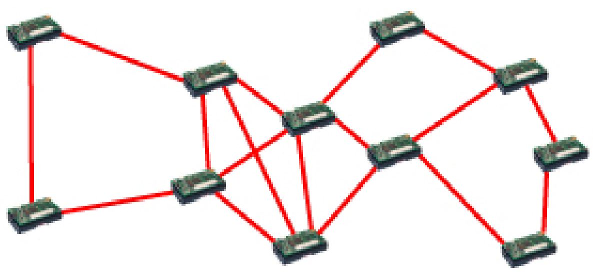
While much progress is being made on computer vision and machine learning techniques, they are still no match for animal visual systems. One unique feature of the visual cortex is the amount of effort it spends determining a "good encoding" of raw sensory stimuli before sending this representation to higher areas where more complicated tasks are performed. We are developing novel approaches for dimensionality reduction and information fusion that may yield superior performance in higher-level vision tasks. In addition to neurally inspired techniques for dimensionality reduction, we also work with experimental collaborators at Baylor College of Medicine on analyzing multi-electrode array and two-photon imaging data recorded from sensory neurons.



Specific projects (#)

(/research/sensor-networks) **Sensor networks and distributed systems** (/research/sensor-networks)

The rapid increase in the speed and resolution of distributed signal and image acquisition systems has led to a veritable data deluge. This in turn has fueled the need for efficient hardware for data acquisition, as well as efficient, distributed algorithms for analysis, inference, and control. The challenge is to manage the system’s sensing, processing, and communication resources in an economical fashion. Our approach is based on the exploiting the sparse and multiscale geometrical structure of many types of sensor data to enable scalable encoding, communication, and processing.



Specific projects (#)

(/research/connexions) **Connexions** (/research/connexions)

A grassroots movement is sweeping through the academic world. The "open access movement" is based on a set of intuitions that are shared by a remarkably wide range of academics: that knowledge should be free and open to use and re-use; that collaboration should be easier, not harder; that people should receive credit and kudos for contributing to education and research; and that concepts and ideas are linked in unusual and surprising ways and not the simple linear forms that traditional media present. Connexions (http://www.cnx.org) invites authors, educators, and learners worldwide to "create, rip, mix, and burn" textbooks, courses, and learning materials from a global open-access repository.

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