



## Technion: Compressed sensing ups data acquisition resolution, cuts cost

**R. Colin Johnson**

**8/18/2010 9:44 AM EDT**

Algorithms that harness inexpensive A/D channels at sub-Nyquist frequencies could replace costly high-speed data acquisition, with higher-resolution results, say Technion researchers.

PORTLAND, Ore. — Compressed sensing has been a laboratory curiosity for several years, but now the technology has been cast in an inexpensive hardware prototype that could enable ultrasound, radar and other data-acquisition applications to increase resolution while reducing costs.

In medical applications, the technique could also reduce the exposure time for patients undergoing MRI, X-ray and CT scans.

"Data acquisition is the bottleneck facing almost all digital applications today; that is the part which is often the most expensive, consumes the most power, takes the longest time and limits the resolution of your results," said professor Yonina Eldar, an electrical engineer at the Israel Institute of Technology (Technion, Haifa). "For instance, one reason ultrasound machines are so massive is the difficulty of obtaining and processing the data.

"Data acquisition is also one of the reasons it takes so long to perform an MRI scan, and it limits the resolution in a variety of military applications, such as radar."

Compressed sensing can let lower-speed hardware acquire data just as accurately as existing systems or can be used to make systems more accurate at the same sampling speed. Defense contractors are working with Technion to increase the resolution of existing radar systems; medical contractors are seeking to downsize their hardware at the same resolution.

The government of Israel, for example, is supporting a collaboration between Eldar and General Electric Israel to bring the resolution of handheld ultrasound scanners to the level achieved by larger, medical laboratory models.

Compressed sensing works like data compression, squeezing data into previously sparse encodings. But it is performed during data acquisition rather than after data is collected, thereby reducing the sampling rate so that even cheap, low-speed analog/digital converters can accurately represent high-frequency signals. Usually, high-frequency signals require A/D converters twice as fast (what's called the Nyquist frequency), but Technion's compressed sensing approach allows the use of A/Ds running up to 10 times slower than

the highest frequency in a signal.

"What we wanted to do is make better use of existing A/D converters—not invent new ones—by adding some steps to the process that allow sub-Nyquist sampling rates by processing aliased data," said Eldar.

### **'We're doing what we teach EEs not to do'**

Technion's approach, the result of work conducted with Technion doctoral candidate Moshe Mishali, applies a modulation sequence to an input signal before supplying it to multiple (four, in the prototype), separate low-speed A/D channels. Each channel's modulation sequence is a pulse-width-modulated signal running at the expected speed of the input signal, but with different spectral densities. Digital postprocessing steps compare the output from the slow A/Ds to the high-frequency modulation sequences to reconstruct the original signal.

"The trick is that the modulation sequence being used spans a higher frequency band than the sampling rate. Therefore, instead of sampling at a high rate, we modulate at a high rate, which is much easier to do," said Eldar.

Usually, A/D converters must be preceded by an anti-aliasing low-pass filter that removes all frequencies above the Nyquist frequency, but Technion's approach embraces aliasing as a method for cramming information into sparse encodings that can later be recovered by its digital postprocessing steps.

"We are creating aliasing—just what we teach EEs not to do," said Eldar. "We are folding the high-frequency signal into the lower-frequency domain, all aliased, but modulated by a known high-frequency signal. The key to the postprocessing step is to recognize that all the information is still there, just aliased into a low-frequency domain, [and that] by using all four channels together, the original [signal] can be reconstructed."

With the help of Technion's High-Speed Digital System Laboratory and resources from National Instruments, a board-level prototype was recently demonstrated using off-the-shelf analog components, A/D converters and a standard microprocessor for postprocessing. Next the researchers are working on perfecting an FPGA version, after which they plan to offer their intellectual property to ASIC manufacturers.