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EC601 Fall 2023

Project 4: Seminar Review

Topic:

I chose the doctoral thesis *Compressed Sensing Receivers: Theory, design, and performance limits* (2012) by Juhwan Yoo which introduces and investigates the Random Modulator Pre-Integrator (RMPI) receiver architecture for compressive sensing (CS), the first integrated CS front end made. With the ever-increasing demand for more data and at faster rates in communications and sensing systems, the ADC becomes the main bottleneck with its high power consumption at the required data rate. CS front ends show great promise in significantly reducing sampling rates and power consumption for the same data rates. Here the author designs and implements the first ever CS front end.

Main contributions:

The primary contribution of this paper is the introduction of the RMPI architecture and its implementation in hardware. The random modulator pre-integrator serves as an innovative means to exploit the inherent sparsity of signals. The author proposes the RMPI front end for random sampling of sparse signals before the compressive sensing reconstruction stage. RMPI builds on the random demodulator (RD) which generates incoherent samples through time-domain correlation of the input signal with a pseudo-random binary sequence (Bernoulli). RMPI is essentially a bank of RDs. The output is equivalent to the output of the measurement matrix multiplied by the input signal in the analytic CS model.

Results:

The author had designed and implemented the first CS IC in 90nm CMOS capable of 12.5x sub-Nyquist sampling. It is capable of recovering signals with an effective instantaneous bandwidth of 100 MHz to 2 GHz with >54 dB dynamic range. The RMPI design operates at ~500mW whereas traditional ADCs operate on the order of several watts at the same data rate.

My view of the work

The work done here by Juhwan is a great first step in the direction of compressive sensing receivers. The proposed design is only a front end, and does not explore hardware implementations for signal reconstruction, but suggests potential avenues. Because there is currently no efficient sparse signal reconstruction hardware, this design could be employed in offline—not real-time—scenarios.

What I would do as next steps:

The next steps would be to investigate greedy pursuit reconstruction algorithms with efficient hardware implementations to fully realize a CS hardware solution. Ideally, specialized hardware for sparse-approximation should be investigated for the most accurate reconstructions.

Source: https://thesis.library.caltech.edu/7163/2/JuhwanYoo-thesis-update.pdf