The IEEE Pittsburgh Section Signal Processing and Communications Society Chapters Present:

Asynchronous Signal Processing and Communications for Wireless Sensor Networks

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Refreshments 11:30am – 12:00pm
Talk 12:00pm – 1:00pm

Power consumption in sensor networks is an overriding design consideration not only in the data collection but in their transmission. Synchronous signal processing requires ever faster clocks, and the transmission of one bit is equivalent to about a thousand computations with a 32-bit precision. Moreover, in biomedical applications the presence of clocks might cause hazardous electromagnetic field effects. The conventional Nyquist-Shannon sampling theory is not realistic or appropriate for the processing of commonly bursty signals encountered in many applications. Its dependency on uniform sampling times, which cannot be realized in practice, on a sinc interpolation that cannot be finitely implemented, and on the unrealistic band-limited assumption makes that theory not applicable to data gathering and reconstruction of data from a set of sensors. In this presentation we will show that it is possible to develop a more efficient 'event-driven' sampling and communication approach. Applying Prolate Spheroidal Wave Functions instead of sinc functions, under the assumption that the signal being processed is time-limited and essentially band-limited, permit us to obtain a reconstruction from non-uniform samples whenever the corresponding sampling times are estimated. Two more practical methods are provided by level-crossing (LC) sampling and asynchronous delta modulation (ASDM) approaches. Quantizing the signal amplitude --the essence of level-crossing sampling-- provides a non-uniformly sampled signal with no quantization error and no band-limited condition. The ASDM is a non-linear feedback system that time-encodes the amplitude of signals providing a binary output signal with zero-crossing times can be used to obtain an interpolation of its input signal. The ASDM can be seen as an optimal LC sampler that uses duty-cycle modulation, and time-coding for reconstruction. These methods do not use clocks, consume small power, and have the opportunistic philosophy of the compressive sampling methods that have been recently introduced. The event driven transmission can be efficiently implemented using orthogonal frequency division multiplexing (OFDM) for the outputs of one or more sensors gathering data with ASDMs.

Professor Chaparro's research interests are in statistical time-frequency signal processing, software-defined radio and asynchronous signal processing. He obtained his BS in electrical engineering from Union College in Schenectady, NY, and his MS and PhD in electrical and computer science from the University of California at Berkeley. He has been with the Department of Electrical and Computer Engineering since 1979. He is Senior Member of IEEE, served as associate editor of the IEEE Transactions on Signal Processing, and was also associate editor of the Journal of the Franklin Institute. He has served as special editor of several conference sessions and special issues in time-frequency and its application to bioengineering and communications. He is the author of "Signals and Systems using MATLAB" published in October 2010.