Signal Transformation and Information Representation Group

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The primary focus of the Signal Transformation and Information Representation Group is the analysis and design of building blocks for practical compression systems. We tend to work at a level of abstraction where our parts fit in many applications, but we also sometimes follow through to final applications. Being practical means that we emphasize structured signal transformations and scalar and lattice quantization. Beyond just compression, we are interested in whole communication systems, including channel coding, networking, and congestion control.

One area of particularly strong interest is oversampling. Though it is not obvious on the surface, the power of oversampled representations is central to the digitization that surrounds us in this digital age. For scientific processing but also for most communication and storage, acquired signals are quantized to discrete values in the process of analog-to-digital conversion (ADC). ADC is made orders of magnitude cheaper by having very coarse (e.g., one bit) discretization of a highly oversampled version of a signal; it is much cheaper to run fast than to be accurate in analog electronics. The ubiquity of these techniques in audio processing is evidenced by the obscure "1-bit DAC" imprint on CD players, yet the full power of oversampled representations for higher-dimensional signals remains to be exploited.

Another area of emphasis is nonlinear signal processing. For reasons of both computational complexity and mathematical elegance, linear transformations are central to the theory and practice of signal processing. But there are many nonlinear operations that are not too difficult to describe or implement that provide very valuable properties. Examples include sorting, as in the Burrows-Wheeler Transform or permutation coding; thresholding, which is prominent in denoising; and pseudolinear integer-to-integer transforms, which are promising for conventional lossy source coding and multiple description coding. We are interested in developing tools based on tractable nonlinearities.

Publications

Journal Articles, Published
R. Venkataramani, G. Kramer, and V. K. Goyal, "Multiple Description Coding with Many Channels," *IEEE Trans. Inform. Theory*, 49(9):2106-2114 (2003).

Journal Articles, Accepted for Publication
G. Schuller, J. Kovacevic, F. Masson, and V. K. Goyal, "Robust Low-Delay Audio Coding Using Multiple Descriptions," *IEEE Trans. Speech Audio Proc.*, forthcoming.

International Standards
M. Luby and V. Goyal, "Wave and Equation Based Rate Control (WEBRC) Building Block," *Internet Engineering Task Force RFC 3738*, April 2004.

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Meeting Papers, Published

A. K. Fletcher, V. K. Goyal, and K. Ramchandran, "Iterative Projective Wavelet Methods for Denoising," *Proceedings of Wavelets: Applications in Signal & Image Processing X*, part of SPIE Int. Symp. on Optical Sci. & Tech., San Diego, California, August 3-8, 2003, vol. 5207, pp. 9-15.

A. K. Fletcher, V. K. Goyal, and K. Ramchandran, "On Multivariate Estimation by Thresholding," *Proceedings of the IEEE International Conference on Image Processing*, Barcelona, Spain, September 14-17, 2003, vol. 1, pp. 61-64.

A. K. Fletcher, S. Rangan, and V. K. Goyal, "Estimation from Lossy Sensor Data: Jump Linear Modeling and Kalman Filtering," *Proceedings of the Third International Symposium on Information Processing in Sensor Networks*, Berkeley, California, April 26-27, 2004, pp. 251-258.