IASTED SIP'99 Tutorial on Wavelets, Wavelet Transforms, and Computational Experiments in Wavelet-Based Signal Processing

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1 Course Objectives

The tutorial will provide a practical introduction to the wavelet field including wavelets, wavelet transforms, adaptive wavelet decompositions, and applications using wavelet-based analysis. Practical engineering (rather than mathematical theory) will be emphasized with software demonstrations of all concepts and methods using the functions from a wavelet function programming library (WAVBOX Software) to show how to design, build, and run complete wavelet-based systems and signal processing experiments.

2 Course Prerequisites

The presentation will assume general background in undergraduate signal processing and mathematics (including linear algebra and calculus). However, *no* prior background in *multirate* signal processing or wavelets will be required.

3 Course Topics

Signal, Filter, and Convolution Operators: basic signal operators (shift, reverse, extend, restrict, convolve); scalet and wavelet filter operators (paraconjugate, QMF, and CQF filters, M^{th}-band, orthogonal, biorthogonal, and non-orthogonal scalets and wavelets); signal scale and resolution operators (splitting and merging, down and up sampling, scaling, and resolving); finite-length convolution operators (circularly periodized, symmetrically reflected, linearly extended, boundary adjusted).

Filters and Filter Design: IIR Morlet, Meyer, Mexican hat wavelets; FIR Haar, spline, Daubechies, Coifman wavelets; spectral factorization and the systematized collection of Daubechies wavelets.

Transforms, Expansions, and Decompositions: multiresolution analysis, pyramid and cascade algorithms; discrete, semi-discrete, and continuous wavelet transforms, adaptive wavelet packet decompositions, best and near-best bases; matching pursuit decompositions.

Applications: data analysis (time-frequency analysis, singularity detection); data compression (speech and image compression); data extraction (signal denoising with wavelet shrinkage and non-parametric regression); fast numerical methods (fast matrix multiplication and solution of linear systems in the wavelet domain).

Computational Experiments: reproducibility specifications for wavelet transforms and algorithms; design and reporting of methods and results for wavelet-based experiments; statistical variability of results; statistical validity of inferences and conclusions.

4 Brief Biography

Carl Taswell was born in Jersey City, New Jersey in 1956. He received a B.A. in biochemistry in 1978 from Harvard University, an M.Sc. in mathematics in 1984 and M.D. in medicine in 1985 both from New York University, and an M.Sc. in 1991 and Ph.D. in 1995 both in scientific computing and computational mathematics from Stanford University.

Since receiving a top ten scholarship award in the 1974 Westinghouse Science Talent Search, Dr. Taswell has published several dozen research papers spanning the years 1975-98 and the fields of biochemistry, immunology, medicine, biostatistics, and computational mathematics. He has authored several software packages including LDACPA Software, ELIDA Software, the WAVBOX Software Library, and the FirWav Filter Library.

He is now with Computational Toolsmiths, Stanford, CA 94309-9925. His research interests focus on wavelet transforms with data compression and pattern recognition applications in biomedical signal and image processing.