**REPORT DOCUMENTATION PAGE**

**Feature Extraction by Best-Basis and Wavelet Methods**

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**Funding Numbers**

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**Supplementary Notes**

Approved for public release: distribution is unlimited

**Abstract**

In the past year, support from this contract has been acknowledged in 14 published articles and one book. New characterizations of wavelets have been found leading to new constructions and new wavelets. Advances were made in the theory of multipliers in Fourier analysis. Wavelet technology was transferred to four commercial products: liquid crystal matrix display driver simulation, de-noising software for medical images, image compression algorithms for the FBI, and image analysis software for automatic fingerprint identification systems from compress images. One book and seven technical reports on new algorithms have been submitted or are in preparation. One patent was issued, US No. 5,384,725, "Method and Apparatus for Encoding and Decoding Using Wavelet Packets" (R. R. Coifman, Y. Meyer, M. V. Wickerhauser). An improve version (AWA 3.0) of earlier commercial software package, the "Adapted Wavelet Analysis Library", was released. Travel funds supported about one dozen seminars, colloquia and minicourses in Australia, Croatia, France, Germany, Italy, Spain and the United States.

**Subject Terms**

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Research results. In the past year, support from AFOSR Research Contract F 49620-92-J-0106, "Feature Detection with Wavelet Packets," has resulted in the following acknowledged work:

In 1994, 15 journal articles or book chapters plus one advanced textbook, listed in the bibliography below, acknowledged partially support by AFOSR. Wavelet technology has been transferred to three commercial and government products:

- wavelet decomposition and synthesis software for simulating new methods of driving flat panel matrix displays such as LCDs;
- de-noising software for cleaning up medical images;
- image compression algorithms used by the FBI in their WSQ fingerprint image compression standard;
- image analysis software for designing new and faster automatic fingerprint identification systems from compressed images.

So far in 1995, AFOSR support resulted in one book chapter, one journal article, and two technical reports on new algorithms suggested by previous results:

- a method for quickly computing tables for multiplying functions superposed from just a few wavelets, which give good approximations to vorticity fields in fully-developed turbulence;
- a method for rapidly computing the rate-distortion curve produced by transform coding image compression, which can then be used to set the quantization to get a target compression ratio.

US Patent No. 5,384,725, "Method and Apparatus for Encoding and Decoding Using Wavelet Packets," was granted to R. R. Coifman, Y. Meyer, and M. V. Wickerhauser. An improved version (AWA 3.0) of an earlier commercial software package, the "Adapted Wavelet Analysis Library," was released.

Considerable progress was achieved by Weiss, X. Fang, E. Hernández and X. Wang in characterizing minimally supported frequency wavelets. Weiss, A. Bonami, S. Durand and F. Soria found a geometric construction of Lemarié-Meyer wavelets from Shannon and Daubechies wavelets. These results advance the program of finding constructions of all orthonormal wavelets bases. In fact, the various constructions obtained have produced new classes of wavelets.

Weiss, E. Berkson, M. Paluszynski and A. Založnik found a new formulation of the theory of transference which has important applications to the theory of multipliers in Fourier analysis.

Travel support in the past year has funded a score of seminars, colloquia and minicourses in Australia, Croatia, France, Germany, Italy, Spain, and throughout the United States, and resulted in new and continuing collaborations with researchers in those places.

Technology transfers. AFOSR sponsored research has produced the following transitions to commercial and government industrial technologies:

- A software package "Graphical Work Station" (GWS) was written by M. V. Wickerhauser, R. R. Coifman and K. Ukraincik (of Digital Diagnostics Corporation) for Positive Technologies, Inc. That company is working to implement "adaptive scanning" pixel driver algorithms for twisted nematic passive matrix liquid crystal displays (TN-LCDs). The use of adapted wavelet transforms allows larger or higher-resolution TN-LCD screens (more rows and columns) without the loss of contrast that occurs with the traditional Alt-Pleshko line-at-a-time driving method. Source codes descendent from AFOSR-sponsored research software (WPLW and AWA 2.0) are the basis for both display simulation and preprocessing for actual display driving. Positive Technologies, Inc. has invested approximately $200,000 and ARPA has supplied an additional $900,000 to develop 3 prototype TN-LCD development workstations.

- A software package "denoise" was built from AWA 2.0 for Numerics Medical Imaging, Inc., a startup company in Connecticut which supplies software to remove speckle and distortion from echo-planar magnetic resonance tomographic images (EP-MRIs). The software finds a best-adapted wavelet packet decomposition of a sequence
of EP-MRIs by minimizing an information cost functional, then discards the signal portion with high cost but low energy. The retained portion has a dramatically greater signal-to-noise ratio and allows the diagnosing physician to see small features, such as arterial blockages, which were masked by the noise in the original. Numerics Medical Imaging, Inc. has invested approximately $100,000 in software development for this package.

- The FBI Automatic Fingerprint Identification System (AFIS) project decided to fund Martin-Marietta (MM) corporation to develop new algorithms to search a WSQ-coded database of fingerprint images. M. V. Wickerhauser completed a $17,000 contract with MM to supply software for feature extraction from WSQ and wavelet coefficients. That software will in one form or another be used in the large integrated system that MM has contracted to deliver.

Sample publications.


5. Article: “Experiments with Adapted Wavelet De-Noising for Medical Signals and Images” (Coifman and Wickerhauser), in Time-Frequency and Wavelets in Biomedical Engineering (Metin Akay, ed.), IEEE Press, Piscataway, New Jersey, 1995


Postdocs: X. Fang, N, Hess-Nielsen, F. Pascal, E. Wesfreid, A. Trgo, V. Perrier

Graduate Students: X. Wang, S. Tourville, S. Littlewood, E. Goirand

Professional Honors.

• G. L. Weiss: Chauvenet Prize, 1968; Honorary Doctorates from Beijing, Barcelona, and Milan.


• Marie Farge: Cray Prize, 1988.