THEME ISSUE ON
WAVELET AND FRACTAL METHODS IN
SCIENCE AND ENGINEERING: PART II

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PREFACE

In 2001, the Editorial Board of the Arabian Journal of Science and Engineering decided to devote a Special Issue of the Journal to the theory and applications of wavelets and fractals. The Call for Papers, published in several subsequent issues of AJSE, and sent by e-mail and mail to friends and colleagues worldwide, created an unexpected amount of interest: we received more than 40 papers on various theoretical and technical aspects of these emerging, closely related modern topics. This abundance of papers has enabled us to apply a stringent reviewing process to select only the best of these submissions, and to publish them in two volumes. The first volume appeared in June, 2003. In both volumes, we have tried to keep a balance between wavelets and fractals, as well as between applications and theory.

As in the first volume, the articles in the present second volume are grouped in two sections, one devoted to wavelets, one to fractals. The first wavelet paper, Abdelnour and Selesnick’s Symmetric Nearly Orthogonal, and Orthogonal Nearly Symmetric Wavelets, addresses the well-known problem that – except for the Haar wavelet – filter-banks cannot be made both symmetric and orthogonal. The authors use the theory of Gröbner bases to construct a set of symmetric filters close to orthogonal, and a set of orthogonal filters which are almost symmetric. The next paper (Naldi, Urban, and Venini: A Convergent Adaptive Wavelet–Rothe Method for Elastoplastic Hardening) is a progress report on a promising application of wavelets. In elastoplastic hardening problems, wavelets seem to provide a more accurate characterization of the moving, irregular elastic/plastic interface than hitherto available techniques. The preliminary numerical results show the feasibility of the Wavelet–Rothe method, though the optimal algorithm and its final implementation are still in the research stage.

There are two case histories on wavelet applications: one from meteorology; one from exploration geophysics. The One-Dimensional Wavelet and Reanalysis of Gravity Waves (Can, Aslan, and Oguz) is an interesting contribution to the emergent field of wavelets in meteorology. The FAWAV® Wavelet Software, and Matlab® wavelet tools, were used to analyze the seasonal variation of gravity waves over the north-western part of Turkey. It is shown that the use of wavelets has made possible an objective detection of jumps in meteorological time series. Khène (Fast 3-D Seismic Adaptive Compression Using the Lifted Wavelet Transform) proposes a new, fast, 3-D seismic adaptive compression strategy based on Lifted Wavelet
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Transform (LWT). The application example is a 3-D seismic data set from a South Texas gas field, consisting of $6.02 \times 10^6$ voxels. The quality of the compressed data and the computational speed favorably compare with other compression techniques.

The first paper in the fractal section (Ochotta and Saupe: Edge-Based Partition Coding for Fractal Image Compression) also deals with image compression, but from the fractal viewpoint. The authors introduce a new fractal image compression technique based on split/merge image partition. The new algorithm is described in full detail, and it is experimentally verified on the benchmark Lenna, Boat, Peppers, and Barbara images. The rate distortion performance of the new technique is superior to all pure fractal coding methods in spatial domain, and it is comparable with the state-of-art wavelet coders up to less than 0.5 dB PSNR.

Two related papers (a Technical Note by Lancia, On Some Second Order Transmission Problems, and Capitanelli and Lancia’s Nonlinear Energy Forms and Lipschitz Spaces on the Infinite Koch Curve) are devoted to the important new application of fractals in modeling transmission through heterogeneous random structures. Lancia’s Note lists some very recent results (mostly achieved in her own group) concerning transmission phenomena across layers modeled as prefractal curves approximating the Koch curve, or by the final Koch curve itself. For the readers’ convenience, all basic concepts (such as Koch curve, energy forms, Besov, and Sobolev spaces) are defined, and the most important Theorems are stated. The paper of Capitanelli and Lancia generalizes a recent result of the first author (J. Nonlin. Convex Anal., 2002), originally proved for Koch curves on a finite interval, to infinite Koch curves. The authors claim that the results are of great importance in certain applications, such as transmission through a fractal layer separating two domains, and we look forward to such practical examples in future publications from this group. Brandt and Mubarak’s Distribution of Distances and Interior Distances for Certain Self-Similar Measures is an elegant study of the geometry of paths and probability distribution of distances in Sierpinski fractals. As the Sierpinski gasket and carpet are standard models for transport in porous media, the paper might prove useful in understanding percolation phenomena, random walk, and electric conductivity in sedimentary rocks.

Enthusiasts for recreational mathematics and fractal computer graphics will welcome the Technical Note by Rani and Kumar (New Fractal Carpets). The paper introduces some new colored variants of the classic Sierpinski carpet, with their construction algorithms and, in some cases, their fractal dimensions. One cannot help but recall Cantor’s remark (Math. Annalen, 1883) – which he made in connection with his construction of the “Cantor set” – that “ähnliche Beispiele lassen sich für $n>1$ leicht bilden”.

The last two papers are devoted to rock-physical and seismological applications of fractals. Barri-Brunetto, Chiaia, and Invernizzi’s study (Lacunarity of Contact Domains and Multifractality of Pressures in Rough Rock Interfaces) proves that the true contact domains at the interfaces between rough rocks are lacunary fractals and the microforces at the interface have multifractal properties. A numerical method is proposed, and applied to the digitized image of the surface of a rock sample. The method offers wide application possibilities for the analysis of other mechanical, electric, and chemical surface phenomena. Nanjo and Nagahama, in their Discussion on Fractals, Aftershocks and Active Faults: Diffusion and Seismo–Electromagnetism discuss the fractal spatio–temporal statistics of the aftershocks following an earthquake, and their connections with the pre-existing fractal fault system. It is shown that the seismo–electric and seismo–magnetic fields also obey fractal scaling laws and thus they should be considered as potential short-term earthquake precursors.

The Editorial Board of AJSE and the Editors of this Theme Issue express their deepest thanks and appreciation to all Authors and the Referees involved with the Second Volume of the Wavelet and Fractal Methods in Science and Engineering.

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PAPERS ON THEME:
WAVELET AND FRACTAL METHODS IN SCIENCE AND ENGINEERING
PART II