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Preface
Special Issue: "Modern Spectral Methods for Direct and Inverse problems"

This Special Issue deals with the subject of analyzing the performance of a number of selected modern spectral methods for both direct and inverse problems that have important practical ramifications. Particular attention is focused on properly highlighting a number of the most recent achievements encompassing:

(i) new non-linear methods for convergence acceleration in evaluating multi-dimensional series and integrals,

(ii) novel rational approximations for spectral analysis of data embedded in noise,

(iii) multi-exponential mathematical modeling of thermally activated processes in the presence of noise,

(iv) iterative diagonalization of large matrices for complex molecular structures in quantum chemistry,

(v) obtaining the key spectroscopic observables, especially for large-dimensional problems, with no recourse to eigen-functions,

(vi) reconstruction algorithms for emission tomography using varying attenuation coefficients with applications in medicine,

(vii) expansion methods based upon the complete set of the spheroidal wave-functions for signal processing,

(viii) consistent designs for the adequate statistical interpretation of performance of algorithms applied to data corrupted with noise,

(ix) versatile time-frequency and time-scale representations of signals recorded in magnetic resonance spectroscopy for non-invasive medical diagnostics.

The idea behind putting the above-listed variety of problems into the same Special Issue is to emphasize that apparently very different methods and fields are tightly intertwined from both thematic and methodological viewpoints. Indeed such a goal is deeply rooted in the very essence of the Aims and Scopes of this journal, JCMSE. For the purpose of illustration, it suffices to give two examples of the problems studied in this Special Issue:

(a). The spheroidal wave-functions are customarily used in solving difficult eigen-value equations in the so-called two-center Coulomb problems in quantum mechanics and quantum chemistry. The same complete basis set of functions can advantageously be used in signal processing for high resolution spectral analysis.

(b) The so-called attenuated Radon transform has been known in mathematics for some 80 years with a debate about its injectivity. However, such a situation has not stopped useful applications of iterative inversions of this transform in medicine within the single photon emission computerized tomography. The injectivity problem has been successfully solved only last year by R. Novikov who used scattering theory to obtain the first explicit inversion formula for the attenuated Radon transform. In this way one of the most difficult inverse problems was converted into a direct problem, which can be solved exactly through quadratures for noiseless data. It was scattering theory which bridged the gap between mathematics and medicine so that new algorithms could now be built on this basis and thereby help improve diagnostics in medicine.

Other examples from the above-enumerated problems, (i)-(ix), could also be quoted for their respective merits to illustrate the goal of this Special Issue. Overall, it is hoped that this Special Issue will be useful in initiating fruitful promotion of ideas across the borders of various fields using spectral methods for data processing in one or in several dimensions.

Dževad Belkić
Guest Editor