

M. ZUHAIR NASHED: A BIOGRAPHICAL TRIBUTE

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1. Introduction. This special issue of the Journal of Integral Equations and Applications is dedicated by the editors and authors to M. Zuhair Nashed as an expression of their high regard for his many contributions to various fields of mathematical analysis related to the theory and application of integral and operator equations. Nashed was a co-founding editor of the progenitor of this journal and is an Editor Emeritus of JIEA. The papers in this issue span many of the areas, from approximations to wavelets, to which Professor Nashed has made contributions.

2. Family Background and Education. Zuhair Nashed is a native of Aleppo in northwest Syria, one of the oldest continuously inhabited cities in the world, which is famous for its architecture and cultural institutions. Aleppo's strategic location, midway between the Euphrates and the Mediterranean, enabled it to flourish as an ancient caravan crossroad and commercial center; it is now a transportation and business hub for the modern middle east. Zuhair is the first born in a large and prosperous family that included two brothers and five sisters. His father, Zaki Nashed, was a prominent businessman in the import/export trade, a revered profession in the Aleppo tradition. Zaki Nashed expanded and transformed a small textile business into a very successful firm with significant international connections. He placed a very high value on education and provided the means for Zuhair to obtain the best education possible.

Nashed attended high school at Aleppo College, an American-style school which operated under the aegis of the Congregational Church. George Miller, then Dean of Aleppo College, recognized his analytical talent and encouraged him to pursue a career in engineering. After spending an undergraduate year at the American University of Beirut (in the late sixties he would return to AUB as a visiting associate

professor), Zuhair was offered admission to several prestigious universities in the United Kingdom and the United States. He enrolled in the Electrical Engineering Department of the Massachusetts Institute of Technology, where he was awarded the S.B. degree in 1957 and the S.M. degree in 1958. Nashed's mathematical interests blossomed in the rich theoretical soil of the School of Engineering at MIT, leading him to enroll in the mathematics doctoral program at the University of Michigan. He was awarded the Ph.D. degree in 1963 for his dissertation "Iterative Methods for the Solution of Nonlinear Operator Equations in Hilbert Space," written under the supervision of R.C.F. Bartels (which makes Nashed a descendent of both Gauss and Lagrange). At Michigan he studied with, and was deeply influenced by, Eric Rothe and Lamberto Cesari. Hence, by mathematical inclination and the influence of Rothe and Cesari, he is in the step-lineage of Hilbert, Schmidt, Arzelà and Tonelli.

The Nasheds are an exceptionally close-knit family. Zuhair's wife Ragda (née Yagan) is a vivacious and successful real estate professional. Their four children are accomplished in various fields. Son Ziad is the owner of a prosperous automobile dealership, son Zaki Nashed, M.D., is a radiologist, son Zane is a manufacturer's representative, and daughter Nadia is a medical student.

3. Mathematical Work A unifying theme of Nashed's mathematical work is the framing of problems of representation, approximation and optimization in an operator theoretic context. The application of methods of functional analysis, linear and nonlinear, to problems arising out of engineering has been an enduring inspiration for his mathematical research. Nashed has made important contributions to: integral and operator equations, generalized inverses, inverse and ill-posed problems, nonlinear functional and numerical analysis, optimization and approximation theory, operator theory, optimal control theory, sampling theory and signal processing, reproducing kernel spaces, variational and operator inequalities, and set valued analysis. The list of Nashed's publications (more than 130) is long and growing. A partial, and nearly current, accounting of his published mathematical works can be had at the MathSciNet website. Here we provide a sampling of representative works in some of the fields to which he has contributed:

Signal Analysis Nashed, Zuhair, Applications of wavelets and kernel methods in inverse problems. *Integral Methods in Science and Engineering*, 189–197, Birkhäuser Boston, Boston, MA, 2006. Xia, Xiang-Gen; Nashed, M. Zuhair, A method with error estimates for band-limited signal extrapolation from inaccurate data. *Inverse Problems* **13** (1997), 1641–1661.

Sampling Theory Nashed, M. Zuhair; Walter, Gilbert G., General sampling theorems for functions in reproducing kernel Hilbert spaces. *Mathematics of Control, Signals, and Systems* **4** (1991), 363–390. van der Mee, Cornelis V. M.; Nashed, M. Z.; Seatzu, Sebastiano, Sampling expansions and interpolation in unitarily translation invariant reproducing kernel Hilbert spaces. *Advances in Computational Mathematics* **19** (2003), 355–372.

Variational Analysis Nashed, M. Z.; Hamilton, E. P., Bivariational and singular variational derivatives. *Journal of the London Mathematical Society* **41** (1990), 526–546. Nashed, M. Z., Differentiability and related properties of nonlinear operators: Some aspects of the role of differentials in nonlinear functional analysis, in *Nonlinear Functional Analysis and Applications*, L.B. Rall. Ed., (Proc. Advanced Seminar, Mathematics Research Center, Univ. of Wisconsin, Madison, Wis., 1970) pp. 103–309, Academic Press, New York, 1971.

Generalized Inverses Nashed, M. Z., Inner, outer, and generalized inverses in Banach and Hilbert spaces. *Numerical Functional Analysis and Optimization* **9** (1987), 261–325. Nashed, M. Z.; Votruba, G. F., A unified approach to generalized inverses of linear operators, I&II, *Bulletin of the American Mathematical Society* **80** (1974), 825–835.

Ill-posed Problems Nashed, M. Zuhair, Operator-theoretic and computational approaches to ill-posed problems with applications to antenna theory. *IEEE Transactions on Antennas and Propagation* **29** (1981), 220–231. Nashed, M. Z.; Wahba, Grace, Generalized inverses in reproducing kernel spaces: an approach to regularization of linear operator equations. *SIAM Journal of Mathematical Analysis* **5** (1974), 974–987. Nashed, M. Z.; Scherzer, O., Least squares and bounded variation regularization with nondifferentiable functionals. *Numerical Functional Analysis and Optimization* **19** (1998), 873–901.

Nonlinear Functional Analysis Moore, R. H.; Nashed, M. Z., Local and asymptotic approximations of nonlinear operators by

(k_1, \dots, k_N) -homogeneous operators. *Transactions of the American Mathematical Society* **178** (1973), 293–305. Nashed, M. Z.; Wong, J. S. W., Some variants of a fixed point theorem of Krasnoselskii and applications to nonlinear integral equations. *Journal of Mathematics and Mechanics* **18** (1969), 767–777.

Mathematical Programming Bazaraa, M. S.; Shetty, C. M.; Goode, J. J.; Nashed, M. Z., Nonlinear programming without differentiability in Banach spaces: necessary and sufficient constraint qualification. *Applicable Analysis* **5** (1975/76), 165–173. Bazaraa, M. S.; Goode, J. J.; Nashed, M. Z., On the cones of tangents with applications to mathematical programming. *Journal of Optimization Theory and Applications* **13** (1974), 389–426.

Numerical Functional Analysis Nashed, M. Z., Steepest descent for singular linear operator equations. *SIAM Journal on Numerical Analysis* **7** (1970), 358–362. Nashed, M. Z.; Chen, X., Convergence of Newton-like methods for singular operator equations using outer inverses. *Numerische Mathematik* **66** (1993), 235–257.

Control Theory Lee, Sung J.; Nashed, M. Zuhair, Constrained least-squares solutions of linear inclusions and singular control problems in Hilbert spaces. *Applied Mathematics and Optimization* **19** (1989), 225–242. Nashed, M. Z., Operator extremal theory of compensation and representation of systems and control problems. *Operator Methods for Optimal Control Problems* (New Orleans, La., 1986), 253–281, Lecture Notes in Pure and Appl. Math., 108, Dekker, New York, 1987.

Integral Equations Appell, J.; Kalitvin, A. S.; Nashed, M. Z., On some partial integral equations arising in the mechanics of solids. *ZAMM Zeitschrift für angewandte Mathematik und Mechanik* **79** (1999), 703–713. Nashed, M. Z.; Wahba, Grace, Convergence rates of approximate least squares solutions of linear integral and operator equations of the first kind. *Mathematics of Computation* **28** (1974), 69–80. Murid, A. H. M.; Nashed, M. Z.; Razali, M. R. M., Numerical conformal mapping for exterior regions via the Kerzman-Stein kernel. *Journal of Integral Equations and Applications* **10** (1998), 517–532.

4. Exposition and Lecturing Zuhair Nashed has a special talent for exposition. His expository abilities were recognized early in his career when he was presented a Lester R. Ford Award by the

Mathematical Association of America for his paper “Some remarks on variations and differentials” (*American Mathematical Monthly* **73** (1966), pp. 63-76). His lucid paper “Generalized inverses, normal solvability, and iteration for singular operator equations” in *Nonlinear Functional Analysis & Applications* (L. Rall, Ed., Academic Press, 1971) had a profound and lasting effect on one of the authors of this essay (CWG). His more than fifty book reviews that have appeared in such publications as the Bulletin of the American Mathematical Society, SIAM Review, and the American Mathematical Monthly also form a rich vein of expository ore.

Nashed has been for decades, and remains, a sought after conference speaker. In 1973, at the invitation of the American Mathematical Society, he delivered a one hour address, “Regularization and numerical analysis of ill-posed operator equations” at the 709th AMS meeting in Atlanta, GA. A tireless and peripatetic traveler, he has delivered invited plenary lectures at conferences in every inhabited region of the globe (an unconfirmed rumor has it that tracking Zuhair was used by the Defense Department decades ago as a beta test of the Global Positioning System).

5. Editorial Work of M.Z. Nashed Nashed is the founding editor of the journal *Numerical Functional Analysis and Optimization* (currently published by Taylor and Francis) and the founding co-editor (with Phil Anselone) of the *Journal of Integral Equations and Applications*. While he was at Michigan he and Albert Bharucha-Reid, who was at Wayne state at the time, conceived the idea of a journal devoted to integral equations. In 1979 they, as co-editors, launched the Journal of Integral Equations (JIE), published by North Holland. On the death of Bharucha-Reid in 1985 the JIE ceased publication and was resurrected, with the support of the Rocky Mountain Mathematics Consortium, in 1987 as the Journal of Integral Equations and Applications. He currently serves on, or has served on, the editorial boards of more than a score of research journals in the mathematical sciences. In addition to his work for research journals he has edited or coedited many conference proceedings. His first effort in this area was the monumental volume on generalized inverses published in 1976, a work which after thirty years is still treasured by generalized inverse enthusiasts everywhere. Among the conference proceedings that Nashed has had a

hand in editing are:

Generalized Inverses and Applications. Proceedings of an Advanced Seminar sponsored by the Mathematics Research Center at the University of Wisconsin, Madison, Wis., October 8-10, 1973. Edited by M. Zuhair Nashed. University of Wisconsin, Mathematics Research Center, Publication No. 32. Academic Press [Harcourt Brace Jovanovich, Publishers], New York-London, 1976.

Functional Analysis Methods in Numerical Analysis. Proceedings of a Special Session held at the Annual Meeting of the American Mathematical Society in St. Louis, Mo., January 27-31, 1977. Edited by M. Zuhair Nashed. Lecture Notes in Mathematics, 701. Springer-Verlag, Berlin-New York, 1979.

Morozov, V. A., *Methods for Solving Incorrectly Posed Problems.* Translated from the Russian by A. B. Aries. Translation edited by M. Z. Nashed. Springer-Verlag, New York, 1984.

Mathematical Analysis, Wavelets, and Signal Processing. Proceedings of the International Conference on Mathematical Analysis and Signal Processing held at Cairo University, Cairo, January 3-9, 1994. Edited by Mourad E. H. Ismail, M. Zuhair Nashed, Ahmed I. Zayed and Ahmed F. Ghaleb. Contemporary Mathematics, 190. American Mathematical Society, Providence, RI, 1995.

Approximation Theory. In memory of A. K. Varma. Edited by N. K. Govil, R. N. Mohapatra, M. Z. Nashed, A. Sharma and J. Szabados. Monographs and Textbooks in Pure and Applied Mathematics, 212. Marcel Dekker, Inc., New York, 1998.

Inverse Problems, Image Analysis, and Medical Imaging. Proceedings of the American Mathematical Society Special Session on Interaction of Inverse Problems and Image Analysis held in New Orleans, LA, January 10-13, 2001. Edited by M. Zuhair Nashed and Otmar Scherzer. Contemporary Mathematics, Vol. 313. American Mathematical Society, Providence, RI, 2002.

Integral Methods in Science and Engineering. Theoretical and Practical Aspects. Papers from the International Conference (IMSE2004) held at the University of Central Florida, Orlando, FL, 2004. Edited by C. Constanda, M. Z. Nashed and D. Rollins. Birkhäuser Boston, Inc., Boston, MA, 2006.

Mathematical Models and Methods for Real World Systems. Edited by K. M. Furati, Zuhair Nashed and Abul Hasan Siddiqi. Lecture Notes in Pure and Applied Mathematics, 247. Chapman & Hall/CRC, Boca Raton, FL, 2006.

Advances in Applied and Computational Mathematics. Proceedings of the Applied Mathematics Summer Workshop held at Delaware State University, Dover, DE, August 18–20, 2005. Edited by Fengshan Liu, Zuhair Nashed, Gaston M. N’Guerekata, Dragoljub Pokrajac, Zhijun Qiao, Xiquan Shi and Xianggen Xia. Nova Science Publishers, Inc., Hauppauge, NY, 2006.

Frontiers in Interpolation and Approximation. Dedicated to the memory of Ambikeshwar Sharma. Edited by N. K. Govil, H. N. Mhaskar, Ram N. Mohapatra, Zuhair Nashed and J. Szabados. Pure and Applied Mathematics (Boca Raton), 282. Chapman & Hall/CRC, Boca Raton, FL, 2007.

Frames and Operator Theory in Analysis and Signal Processing. Edited by David R. Larson, Peter Massopust, Zuhair Nashed, Minh Chuong Nguyen, Manos Papadakis, and Ahmed Zayed, American Mathematical Society, Providence, RI, 2008.

6. Service Zuhair Nashed has served the international mathematical community as a researcher, educator, editor, organizer, and administrator. After completing his PhD he was at various times on the faculties of Georgia Tech, the American University of Beirut, the University of Michigan, King Faud University of Petroleum and Minerals, the University of Delaware, and the University of Central Florida. Nashed supervised eight Ph.D. dissertations at Georgia Tech, the University of Michigan, Washington University, the Technological University of Malaysia, and the University of Delaware and he has thirty seven “mathematical descendants”. In 2002 he moved to the University of Central Florida as chair of the Department of Mathematical Sciences after a long career at the University of Delaware.

Nashed has organized numerous conferences, the most memorable of which is probably the *International Conference on Ill-posed Problems* that he hosted at the University of Delaware in the fall of 1979. This was the first major meeting on ill-posed problems to be held in the United States. The plenary speakers were pioneers in the field:

A.N. Tikhonov, V.A. Morozov, Fritz John, Jim Douglas, and Carlo Pucci. He has served on the SIAM Education Committee, has been a SIAM Visiting Lecturer since the inception of that program and has chaired the SIAM Visiting Lecturers Committee. Many universities have sought his advice on their mathematics programs. From 1984-85 he was a visiting professor at King Faud University of Petroleum and Minerals where he played a major role in setting up the Ph.D. program in mathematics.

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