PROFESSOR RUI J. P. DE FIGUEIREDO

CV *(Abbreviated)*

(25 Pages)

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PART A: ACCOMPLISHMENTS AND ACHIEVEMENTS

Dr. Rui J. P. de Figueiredo, B.S. and M.S in Electrical Engineering (MIT) and Ph.D. in Applied Mathematics (Harvard), is Research Professor (Above-Scale) of Electrical Engineering and Computer Science and of Mathematics at the University of California, Irvine (UCI). He is also a member of the UCI Institute of Mathematical Behavioral Sciences (IMBS). His Laboratory is affiliated with the California Institute for Telecommunications and Information Technology.

Professor de Figueiredo has made pioneering contributions to the theory and applications of signal and image processing, machine intelligence and neural and soft computing; and played an extraordinary role as educator and leader in his field and in his profession, all of which have won him a number of awards and symbols of international acclaim. These include: *election to* the UN-sponsored *International Informatization Academy* (2003), the 1999 *IEEE Circuits and Systems (CAS) Society Golden Jubilee Medal*, the 2000 *IEEE Tri-Millennium Medal*, the 2003 *Gh. Asachi Medal* from the Technical University of Iasi (TUI), Romania, from which he also received the title of *Honorary Professor* (2003), the *IEEE Fellow Award* (1976), the 1987 *Amer. Assoc. for Artificial Intelligence Conference/ Texas Instruments Best Paper Award*, the *NCR Faculty Excellence Award* (1988), the *IEEE/ ISA/ AIAA Technical-Educator- of- the- Year- Award* (1990), the *1994 IEEE CAS Society Technical Achievement Award*, the 2000 *IEEE Neural Networks Transactions Best Paper Award*, the *IEEE Circuits and System Society Distinguished Lecturer Award* (1996-2001), the *2002 IEEE CAS Society M. E. Van Valkenburg Society Award*, the *2003 IEEE Circuits and Systems Transactions Guillemin-Cauer Best Paper Award*, his election to *President of IEEE CAS Society* in 1998, his election to *Honorary Member* of the *Russian Popov Society*, his election to *Foreign Member* of *the Russian Academy of Natural Sciences (RANS)(US Branch)(2007)* from which he also received the *Chillingar Medal of Honor (2007),* and, last but not least, his selection by IEEE to be one of its 50 leaders, among its over 360,000 members spread over 175 countries, to present the IEEE vision of the new century in the book *ENGINEERING TOMORROW: Today's Technology Experts Envision the Next Century, Janie Fouke, Editor, IEEE Press, 2000*. Other members included in this select list of 50 are Winton C. Cerf, co-inventor of the Internet and of the TCP/IP protocol, and the Nobel Laureates Arno A. Penzias and Charles H. Townes.

Professor de Figueiredo's accomplishments and achievements are highlighted below in five categories, keyed to the references that then follow. An Appendix provides his biographical data in an outline form, comments on of some of his key publications, as well as a selected list of his books and reviewed papers.

1. Pioneering Research Contributions and their Impact on Applications

In Signal and Image Processing

(a) Professor de Figueiredo introduced "generalized" splines into signal processing and pioneered their use as "information-bearing objects" rather than merely "computational objects", developing, in this process, novel algorithms for optimal reconstruction and estimation of signals and systems from linear observations (see, e.g., [1][*]). In this context, he invented the "Butterworth" and "Chebyshev" generalized splines [2] (the differential operators which generate them being those associated with Butterworth and Chebyshev filters) as a more powerful alternative to prolate spheroidal wavefunctions and sinc functions for the recovery of "essentially" (not ideally) band-limited signals from their samples.

(b) He pioneered intelligent processing of signals and images based on their attributed graph representations, with a consequent impact in aerospace electronics [3][4] (*Best Paper Award*), petroleum exploration [5], and active sonar [6].

(c) He co-invented (with R. Oten) the adaptive SWO Order Statistic Filter [7] (*Best Paper Award*), with exceptional attributes w.r.t. speed, effectiveness, robustness, design simplicity, and adaptability for non-Gaussian noise suppression.

In Biomedical Signal and Image Processing Applications

(a) His approach to the analysis of electro-myographic (EMG) signal processing [8] led to novel algorithms as well as to a computer program considered by experts to be one of the two best then available for this application.

(b) He developed a new methodology [9] for histological brain tissue color image analysis to quantify beta-amyloid growth in Alzheimer's disease. Also, he developed, based on the neural network technology mentioned below, an algorithm for early detection of this disease from Brain Spectrogram images, which was shown to outperform the clinical diagnostician [17].

In Computational Intelligence and Neural and Soft Computing

One of the most far-reaching contributions of Professor de Figueiredo in nonlinear mathematics which impacted applications is the one in which he generalized and converted the conventional Fock Space (used in the representation of Boson fields in quantum field theory) [10-11] into a Reproducing Kernel Hilbert Space for input-output maps of nonlinear filters. He used the orthogonal projection in this space to derive optimal neural network structures, capable of adjusting their parameters, structure, and size to optimally adapt, learn, and evolve in a dynamically changing environment. These are described in [12-14] as well as in a chapter of a special book on computational intelligence published by IEEE and Wiley [15]. In short, Prof. de Figueiredo laid the mathematical foundations of the kernel-based machines which he invented and which, since then, have been advocated by others, in one form or another, in the literature.

One of the new neural networks, which he co-invented (with T. Eltoft), named CDL (Cluster-Detection-and Labeling) network has been shown [16] (*Best Paper Award*) to significantly outperform the best existing neural network of its class, namely the

[*] Numbers in [.] refer to publications listed under References in pages 5-6 of this Memorandum.

Kohonen WTA (Winner-Take-All) network, and perform well even in some cases in which the WTA network fails. Many successful applications of these networks have been made in biomedical engineering (see e.g. [17]), and in the defense and commercial sectors.
Recently, Prof. de Figueiredo developed a new mathematical framework for enhancing the concepts and technology of fuzzy sets [18] [19].

2. Extraordinary Role as Educator

Both at Rice University where he was until 1990 and at the University of California Irvine, Professor de Figueiredo established a distinguished record as *educator*. He directed 29 Mater's degree theses and 40 Ph.D. dissertations, several of which received research excellence awards. Several of his former students occupy prominent positions in industry and academia. Examples are: *in industry,* Dr. A.N. Netravali, former President of Lucent Technologies Bell Laboratories, member of NAE, and recipient of the 2001 National Medal of Technology; and *in academia*, Professors K.S. Chao (Texas Tech Univ.), N. Kehtarnavaz (Univ. of Texas, Dallas), S. Starks (Univ. of Texas, El Paso), Sarah Rajala (Associate Dean, North Carolina State Univ.), and H. Tagare (Yale Univ.).

At Rice, Professor de Figueiredo played a major role in the formulation of undergraduate and graduate curricula in signal and image processing and systems as well as of new directions of mathematical sciences. In February of 1999, he was honored by Rice University, with Professors C. S. Burrus, T. W. Parks, and Don H. Johnson, as a co-founder of the wrld-class DSP (Digital Signal Processing) Program at Rice at a celebration called DSP-30 in observance of the Program's 30^{th} Anniversary. Many Rice undergraduates who benefited from his role as a teacher and advisor went on car

At UC Irvine, Professor de Figueiredo has served on important Campus committees including: in 1992-93, as Chair of the Faculty of Engineering; in 1993, as a member of the Campus Academic Planning Task Force, a blue ribbon panel, chaired by Ralph Cicerone, charged with the mission of advising the Chancellor on how to best utilize the campus resources; and in 2000, as member of the team planning the establishment of California Institute for Telecommunications and Information Technology.

Professor de Figueiredo's extraordinary contributions to education have also been recognized by *two major awards* listed as awards numbered 3 and 4 in section 5.

3. Outstanding Leadership in the Field

In addition to inspiring his students, colleagues, and peers with his research work and ideas,

(i) Professor de Figueiredo contributed to the technical leadership in his field by helping in the creation and direction of four major laboratories, namely the Laboratory for Nuclear Physics and Engineering in Portugal (1960), the Image

Processing Laboratory at Rice (1978), the Cooperative Intelligent Mobile Robot Laboratory at Rice (1988) and the Laboratory for Machine Intelligence and Neural and Soft Computing at UC Irvine (1990).

(ii) In the 1970's he served as a Research Coordinator for a major program based at Rice for providing technical support to the NASA-Johnson-Space-Center-based LANDSAT program; and in the 1980's he led the creation and served as the first Chair of a Consortium of NASA Johnson Space Center and four leading universities in Texas (University of Texas in Austin, University of Texas in Arlington, Texas A&M University, and Rice University) cooperating through a unique telerobotic network in the Space Station program.

(iii) He also served on various panels and missions at national and international levels. These include (a) various NSF panels, (b) *Position of Special Consultant and Advisor to the Council on Industrial and Scientific Research, Government of India, under the sponsorship of U.N. Development Program (1987*), and (c) the recent *Advisory Panel to the Minister of Science and Technology of Portugal to help in the planning of the entry of Portugal into the Presidency of the European Union in the year 2000.*

(iv) Finally, through his IEEE Distinguished Lecturer's travels, *he energized the technical activities in South America and Russia.* As consequence of these efforts, the *IEEE CAS Society Chapter in Argentina* was consolidated (1997), and a *new IEEE CAS Society Chapter was established in St. Petersburg, Russia in 2000. This also led to the organization and launching by him of the new 2002 IEEE First International Conference on Circuit\s and Systems for Communications (ICCSC '02) held in St. Petersburg, Russia on June 26-28, 2002, of which he served as Co-Chairman. This conference was a huge success and is evolving into a biennial event on circuits and systems applications to broadband and mobile wireless communications. At the next two conferences in the series, held in Moscow on June 30 – July 2, 2004, and in Bucharest, Romania, Prof. de Figueiredo served again as Co-Chairman, and the meetings continued to be real successes. Also, Prof. de Figueiredo was invited, as a distinguished guest, by Prof. Vagan Shackgyldian to the Feb 2005 celebration of the Moscow Technical University of Communications and Informatics (MTUCI).*

4. Exceptional service and leadership contributions to the IEEE Circuits and Systems Society.

The IEEE Circuits and Systems Society has constituted over the years the main forum through which Professor de Figueiredo disseminated his ideas to, and interacted with his peers. His extensive contributions to the Society are listed under his Short Biography and key and selected publications list attached as Appendix to this letter.

In recent years he led the IEEE Circuits and Systems Society as Vice-President for Publications in 1996, President Elect in 1997, President in 1998, and Former President since then. His actions promoted a significant expansion of the activities and growth of the Society internationally.

See also his contributions as IEEE Distinguished Lecturer in Section 5 under the heading of "Outstanding Leadership in the Field".

Prof. de Figueiredo was the lead speaker at a Forum on "The Future of Circuits and Systems" in the Program of the 2004 IEEE International Symposium on Circuits and Systems, to be held in Vancouver, Canada on May 23-26, 2004.

Among his most recent contributions, Prof. De Figueiredo served as Chair of the IASTED 9th International Conference on Signal and Image Processing (SIP 2007) in Honolulu, Hawaii, on August 20-22, 2007, and the Keynote Lecturer at the 2007 IEEE International Workshop on Nonlinear Signal and Image Processing (NSIP 2007), held in Bucharest, Romania on September 10-12, 2007.

5. Symbols of International Acclaim

Professor de Figueiredo's contributions have won him international acclaim in the form of medals, awards, and commendations by professional organizations in his field. Some of these symbols of acclaim are listed below (others are listed under his Short Biography).

(a) Academy

UN-Sponsored **International Informatization Academy**, January 2003.
New York Academy of Sciences
Foreign Member of the Russian Academy of Natural Sciences (RANS) (US Branch) (2007) from which he also received the Chillingar Medal of Honor (2007),

(b) Medals

1. IEEE **Third Millennium Medal**, January 2000
   Citation: *"In recognition and appreciation of valued services and outstanding contributions"*
2. IEEE Circuits and Systems Society **Golden Jubilee Medal**, 1999
   Citation: *"In recognition of outstanding contributions to Society"*
3. **Gh. Asachi Medal**, of the Senate of Technical University of Iasi, Romania, 2003
   Citation: *"For contributions in developing cooperation between the faculty of this Technical University and the IEEE Circuits and Systems Society"*

4. **Chillingar Medal of Honor**, Russian Academy of Natural Sciences (US Branch)
   Citation: *"For important contributions to science and engineering"*.

(c) Major Awards

1. **IEEE Life Fellow Award,** 1976
2. 1987 Amer. Assoc. for Artificial Intelligence Conference/ Texas Instruments **Best Paper Award**

For outstanding paper entitled "A Framework for Automation of 3D Machine Vision", also published [4] in the *Texas Instruments Journal*, Winter 1987, pp. 67-72.

3. **NCR Faculty Excellence Award**, 1988
4. IEEE, ISA, AIAA **Technical-Educator- of- the- Year- Award**, 1990
5. IEEE Circuits and Systems Society, **Distinguished Lecturer Award,** 1996-2001
6. IEEE Circuits and Systems Society **Technical Achievement Award**, 1994.
   Citation: *" For sustained and very fundamental contributions to the analysis and applications of nonlinear circuits and systems and to spline-based algorithms for signal and image processing".*
   Description of the award: This is the second most prestigious award of the Society. It honors a person with outstanding technical contributions over a period of years within the scope of the CAS Society as documented by publications (including patents). The award is based on the general quality and originality of contributions and continuity of effort. Anyone who is a member of the CAS Society is eligible.
7. 2000 IEEE Transactions on Neural Networks **Best Paper Award**, June 2000
   For outstanding paper [10] entitled "A New Neural Network for Cluster Detection and Labeling*" IEEE Transactions on Neural Networks*, vol.9, no. 5, pp. 1021-1035, Sept. 1998.
8. IEEE Circuits and Systems Society **Mac Van Valkenburg Society Award**, 2002

   Citation: "*For sustained fundamental contributions to signal and image processing and neural networks and the major impact that these contributions have had on a number of applications, as well as outstanding leadership in his field and at the level of the IEEE Circuits and Systems Society*".

   Description of the award: This is the most prestigious award of the Society. It honors a person with outstanding technical contributions in a field within the scope of the CAS Society and outstanding leadership in the field. The award is based on quality and significance of contribution and continuity of technical leadership. Anyone who is a member of the CAS Society is eligible.
9. IEEE Circuits and Systems Society **Guillemin-Cauer Best Paper Award**, 2003

   For the paper [7], co-authored with Remzi Oten, entitled "Sampled-Function Weighted Order Filters", *IEEE Transactions on Circuits and Systems – Part II: Analog and Digital Signal Processing*, vol. 49, pp. 1-10, January 2002.

Description of the Award: Recognizes the best paper published in the *IEEE Transactions on Circuits and Systems*. The award is based on general quality, originality, contributions, subject matter and timeliness. Anyone who is an author

of a paper published in the *IEEE Transactions on Circuits and Systems* during the two calendar years preceding the award is eligible.

(d) Commendations

1. Honoree at **DSP-30** Commemorative Event at Rice University to celebrate the initiators/pioneers of the Digital Signal Processing Program at Rice, February 1999.
2. Contribution to **Engineering Tomorrow**, a volume published by the IEEE Press to commemorate the Third Millennium, edited by Janie Fouke. Professor de Figueiredo was one of the fifty experts from the world-wide 350,000 invited to present their technological vision of the new century. Other contributors included Vinton E. Cerf, co-inventor of the Internet and Nobel Laureates Arno A. Penzias and Charles H. Townes.
3. **Invited Chapter** [9] in the book **"Computational Intelligence: The Experts Speak"**, edited by Charles Robinson and David Fogel, a volume commemorative of the 2002 World Congress on Computational Intelligence, published by IEEE and John Wiley and Sons, 2002
4. **Honorary Professor of Electronics and Telecommunications** of the Technical University of Iasi, Romania, nominated and approved by the Senate of the University.
5. Honorary Member, Russian Popov Society

References

[1] "Optimal spline digital simulators of analog filters" (with A.N. Netravali), in the special issue on "Active and Digital Filters," ed. by I.W. Sandberg and J.F. Kaiser, of the *IEEE Trans. on Circuit Theory*, vol. CT-18, pp. 711-717, 1971.

[2] 'Butterworth and Chebyshev splines," in *Approximation Theory*, (ed. G.G. Lorentz), New Work: Academic Press, 1973, pp. 341-343

[3]"A General Moment-Invariants/Attributed-Graph Method for 3D Object Recognition from a Single Image" (with B.Bamieh), *IEEE Journal of Robotics and Automation*, vol. RA-2, no. 1, pp. 31-41, March 1986.

[4]"A Framework for Automation of 3D Machine Vision," *Texas Instruments Technical Journal*, Winter 1987, pp. 62-72 (Received 1987 AAAI Conference/Texas Instruments (**Best Paper Award***).*

[5]"Spectral and artificial intelligence methods for seismic stratigraphic analysis" (with S.W. Shaw), in *Handbook of Geophysical Exploration*, sec. 1, Seismic Exploration, vol. 20, Pattern Recognition and Image Processing (edited by F. Aminzadeh), pp. 426-446, London-Amsterdam: Geophysical Press 1987.

[6] "Structural Processing of Waveforms as Trees" (with S.W. Shaw), *IEEE Trans. on ASSP, vol. 38, no. 2, February 1990, pp. 328-338*.

[7]"Sampled Function Weighted Order (SFWO) Filters" (with R. Oten), *IEEE Transactions on Circuits and Systems – II*, vol. 49, no. 1, January 2002. (2003 TCAS **Guillemin-Cauer Best Paper Award**).

[8]"A new framework and computer program for quantitative EMG signal analysis" (with A. Gerber, R.M.Studer, and G.S. Moschytz*), Centennial Issue of the IEEE Trans. on Biomedical Eng*., vol. BME-31, pp. 857-863, December 1984.

[9] "Color image analysis in neuro-anatomical research: Application to senile plaque subtype quantification in Alzheimer's disease" (with B.J. Cummings, P.Y. Mundkur, C.W. Cotman), *Neurobiology of Aging*, vol. 16, no. 2, pp. 211-223, 1995.
[10] "A best approximation framework and implementation for simulation of large-scale nonlinear systems" (with T.A.W. Dwyer, III), *IEEE Trans. on Circuits and Systems*, vol. CAS-27, no. 11, pp. 1005-1014, November 1980.
[11] "A generalized Fock space framework for nonlinear system and signal analysis," *IEEE Trans. on Circuits and Systems*, vol. CAS-30, no. 9, pp. 637-647, September 1983 (Special invited issue on "Nonlinear Circuits and Systems").
[12] "Mathematical Foundations of Optimal Interpolative Neural Networks", in *Artificial Intelligence, Expert Systems, and Symbolic Computing*, E. Houstis and J.R. Rice (Eds.), Elsevier, Amsterdam, 1992, pp. 303-319.
[13] "Efficient Learning Procedures for Optimal Interpolative Nets," (with S.K. Sin), *Neural Networks*, Vol. 6, 99-113, 1993.
[14] "Optimal interpolating and smoothing functional artificial neural networks (FANNs) based on a generalized Fock space framework," *Circuits, Systems, and Signal Processing, vol.17, (no.2)*, Birkhauser Boston, 1998. p.271-87
[15] "Beyond Volterra and Wiener: Optimal Modeling of Nonlinear Dynamical systems in a Neural Space for Applications in Computational Intelligence", in the book "*Computational Intelligence: The Experts Speak*", edited by Charles Robinson and David Fogel, volume commemorative of the 2002 World Congress on Computational Intelligence, IEEE and John Wiley & Sons, 2003.
[16] "A new neural network for cluster-detection-and-labeling" (with Eltoft, T.) *IEEE Transactions on Neural Networks*, vol.9, no.5, pp. 1021-35, Sept. 1998 (2000 TNN **Best Paper Award**)
[17]"Neural-network-based classification of cognitively normal, demented, Alzheimer's disease and vascular dementia from brain SPECT image data" (with W.R. Shankle, A. Maccato, M.B. Dick, P.Y. Mundkur, I. Mena, C.W. Cotman), *Proceedings of the National Academy of Sciences USA*, vol 92, pp. 5530-553
[18] "Processing fuzzy set membership functionals as vectors", *IJSF Special Issue* commemorative of the 40th anniversary of the invention of fuzzy sets by L. A. Zadeh *(in press)*
[19] "A Nonlinear Functional Analytic Framework for Modeling and Processing Fuzzy Sets", Chapter 9 of the book *"Forging New Frontiers: Fuzzy Pioneers I - Studies in Fuzziness and Soft Computing*" edited by M. Nikravesh, J. Kacprzyk and L. A. Zadeh, First of two Volumes commemorative of the 40th anniversary of the invention of fuzzy sets by L. A. Zadeh, Springer Press, 2007 *(in press)*

PROFESSOR RUI J. P. DE FIGUEIREDO
CV (CONT.)

PART B: KEY DETAILS

I. Short Biography

A. Personal Data

Name: **Rui J. P. de Figueiredo**

Titles: Research Professor (Above-Scale) of Electrical Engineering and Computer Science, and Mathematics,
Director, Laboratory for Machine Intelligence and Neural and Soft Computing,
University of California, Irvine

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Tel: (949) 854 8710

Place and Date of Birth: Panjim, Goa (Until 1961, Oversea's Province of Portugal), India
April 19,1929

Citizenship: Portugal and U.S.A.

Marital Status: Married to Maria Isabel das Dores Colaco
five children (Alcina, Paul, John, Rui, Jr., and Miguel)

B. Degrees: B.S.(1950, M.I.T).; M.S. (1952, M.I.T) both in Electrical Engineering, and Ph.D.(1959, Harvard) in Applied Mathematics

LTCL [Licentiate (Piano), Trinity College of Music, London (1946), and winner of British Empire Exhibition for performance in this exam in Bombay, India]

C. Positions Held

- 1952-1953: Research Specialist, Transistor Products Inc., Waltham, Mass, USA
- 1953 (Spring & Summer): Visiting Research Fellow at the Ecole Normale Superieure, Laboratory of Prof. Yves Rocard and Dr. Pierre Aigran
- 1955-1959: Research Fellow of the Portuguese Govt., in residence at Harvard University and the Nuclear Physics Laboratory of MIT. During this period, served as:
  1. Consultant to the Junta de Energia Nuclear, Portugal, in the installation of the Laboratorio de Fisica e Engenharia Nucleares, Sacavem, Portugal;
  2. Member of the Portuguese Government delegations to the First and Second International Conferences on Peaceful Uses of Atomic Energy, Geneva, Switzerland, August 1955 and September 1958.
  3. Member (representing Portugal) of the Portuguese delegation to the Working Group that drafted the Statute of the International Atomic Energy Agency (IAEA) (Several meetings held in Washington, D.C., and United Nations, New York, N.Y. in 1955 and 1956.)
  4. Representative of Portugal in the American-European Nuclear Data Committee (EANDAC), 1959-1961. Also, served as consultant to IAEA, Vienna in the preparation of the "Manual on Safe Operation of Critical Assemblies and Nuclear Reactors"
- 1959-62: Head, Appl. Math and Phys. Div., Lab. de Fisica e Engenharia Nucleares.,
- 1962-64: Associate Professor, School of Electrical Engineering, Purdue University, Lafayette, Indiana
- 1964-65: Visiting Assoc. Professor, University of Illinois at Urbana-Champagne
- 1972-73: Visiting Professor of Mathematics and Res. Fellow (U.S. Army), Math. Res. Ctr., University of Wisconsin at Madison
- 1973 (Spring): Visiting Professor of Electrical Engineering and Computer Science, University of California at Berkeley
- 1981 (summer): Visiting Research Professor, Swiss Federal Institute of Technology E.T.H., Zurich, Switzerland
- 1965-1990: Professor of Electrical and Computer Engineering and of Mathematical Sciences, Rice University
- 1990 to-2006: Professor (Above Scale) of Electrical and Computer Engineering, Biomedical Engineering, and Mathematics, University of California, Irvine. Also, Member, Institute of Mathematical Behavioral Sciences (IMBS)
- July 2006 to-date: Research Professor (Above Scale) of Electrical and Computer Engineering and Mathematics, University of California, Irvine, and Member, IMBS

D. IEEE Activities and Offices

(a) Circuits and Systems Society:

1. **Chairman, Houston Chapter** of the IEEE Circuits and Systems Society (1976-90);
2. Associate Editor, IEEE Trans. Circuits and Systems 1977-79;
3. Chairman, Awards Committee on Prize Papers, Circuits and Systems Society, 1977;
4. Representative of the Circuits and Systems Society in the IEEE Ocean Engineering Council (during the period of the Council until it became a Society);
5. Representative of the Circuits and Systems Society in the IEEE Council on Robotics and Automation (during the period of the Council until it became a Society);
6. **General Chairman, 1980 IEEE Int'l Symposium on Circuits and Systems**;
7. Co-Chairman, First NSF sponsored CAS Society Workshop on Nonlinear Circuits and Systems, 1980;
8. Member, Guest Editorial Board, Nov. '80 special issue on Nonlinear Circuits and Systems of the IEEE Trans. Circuits and Systems;
9. Chairman, Nonlinear Circuits and Systems Technical Committee of the Circuits and Systems Society (1989-90);
10. Member, Neural Networks Committee, Circuits and Systems Society (1989-);
11. Member of Program Committee of various ISCAS's;
12. Session Chair at various ISCAS's;
13. Chairman, Faculty Advisory Committee, IEEE UCI Student Chapter (1990-1992);
14. Member, Board of Governors, CAS Society (1994, 1995).
15. Associate Editor, IEEE Transactions on Neural Networks (1994-1996);
16. Vice-President for Publications, IEEE Circuits and Systems Society (1996);
17. President Elect, IEEE Circuits and Systems Society (1997);
18. **President, IEEE Circuits and Systems Society** (1998);
19. Past President, IEEE Circuits and Systems Society(1999);
20. Chair, Standing Committee for Nominations, IEEE Circuits and Systems Society (2000).
21. **General Co-Chair, 2002 IEEE First International Conference on Circuits and Systems for Communications**, St. Petersburg, Russia, June 26-28, 2002.
22. **General Co-Chair, 2nd. IEEE First International Conference on Circuits and Systems for Communications,** Moscow, Russia, June 30-July 2, 2004.
23. **General Co-Chair, IEEE Emerging Technologies Workshop on Mobile Wireless Communications**, St. Petersburg, Russia, June 2005

24 **General Co-Chair, 3rd. IEEE First International Conference on Circuits and Systems for Communications,** Bucharest, Romania, June, 2006.

(b) Other IEEE Activities:

1. Control Society: Member, Adaptive and Learning Systems Committee (1967-69), and of Program Committee of CDC-1970;
2. Systems, Man, and Cybernetics Society: Past member of various committees;
3. Robotics and Automation Society: Technical Editor for Space Applications of the IEEE Journal on Robotics and Automation (1984-89);
4. Ocean Engineering Society (OES): Senior Guest Editor, January 1984 special issue on Oceanic Seismic Exploration of the IEEE Journal of Ocean Engineering; Member of

ADCOM (1989-93); and General Chair of the 1991 IEEE OES Conference on Neural Networks for Ocean Engineering (August 15-17, 1991);
5. **IEEE: Member, IEEE Delegation to the 1977 U.S.S.R. Popov Society Congress, Moscow, U.S.S.R.**;
6. IEEE: Member, IEEE Fellow Award Committee (National) (1986-88)
7. **Member, IEEE-USA Technology Policy Council**, an IEEE body based in Washington D.C. that serves as an advisory role to U.S. Congress regarding IEEE based technologies.

E. Other Society Memberships and Offices

(a) SPIE (Society of Photo-optical Instrumentation Engineers):
1. Co-chair, SPIE Conferences on Space Station Automation III and IV, Cambridge, MA, Nov. 2-6, 1987 and Nov. 6-11, 1988;
2. Co-chair, SPIE/SPSE Int'l Conf. on Curves and Surfaces in Computer Vision and Graphics, Santa Clara, CA, Feb. 13-15, 1990;
3. General Chair, SPIE Conf. on Cooperative Intelligent Robotics in Space, Boston, MA, Nov. 4-9, 1990;
4. Co-Chair, SPIE Conf. on Cooperative Intelligent Robotics in Space II, Boston, MA, Nov. 10-15, 1991.
5. Chair, 2007 IASTED International conference on Signal and Image Processing (SIP 2007), Honolulu, Hawaii, August 20-22, 2007

(b) SIAM (Society of Industrial and Applied Mathematics):
1. Member and Reviewer.

(c) Other Offices:
1. Associate Editor, Circuits, Systems, and Signal Processing, 1986-;
2. Editorial Board, Neurocomputing, An International Journal, 1993-;
3. Founding Chair, NASA/JSC Universities Space Automation & Robotics Consortium (USA/RC), consisting of Rice University, UT-Austin, Texas A & M Univ., and UT-Arlington (1989-90);
4. Member of several NSF panels;
5. Member, Advisory Panel to Minister of Science and Technology, Portugal (1999-2000).

F. Awards, Honors, and Inventions

(a) International and National:
1. Distinguished Service Award, Junta de Energia Nuclear, Portugal, 1960.
2. U.S. Army Senior Research Fellowship, 1972.
3. **IEEE Fellow**, 1976- .
4. Who's Who in Engineering (formerly Engineers of Distinction), 1976- .
5. New York Academy of Sciences, 1984- .
6. **Distinguished Lecturer**, IEEE Circuits and Systems Soc., 1991-92, 96- .
7. Eta Kappa Nu; Sigma Xi; American Men of Science.
8. **Technical Educator of the Year Award** by the Houston/Clear Lake Professional Societies (IEEE, ISA, AIAA) Council, 1990.

9. Golden Eagle Award Nominee, McDonnell Douglas Aerospace Company, 1992.
10. **NCR Faculty Excellence Award** for Outstanding Contributions to Academic Education, 1998.
11. IEEE Circuits and Systems Society **Technical Achievement Award**, 1994.
12. IEEE Circuits and Systems Society **Golden Jubilee Medal**, 1999.
13.IEEE **Millennium Medal**, 2000.
14. Gh. **Asachi Medal,** of the Senate of Technical University of Iasi, Romania, 2003
15. **Honorary Professor,** Technical University of Iasi, Romania, 2003
16. IEEE Circuits and Systems Society **M. E. Van Valkenburg Society Award**, 2002.
17. **Elected Member**, UN-sponsored **International Informatization Academy**, 2003
18. Honorary Member, **Russian Popov Society**
19. **Foreign Member of the Russian Academy of Natural Sciences** (RANS) (US Branch) (2007) from which he also received the
20. **Chillingar Medal of Honor** (RANS) (US Branch)

(b) Best Paper Awards:

1. 1987 Outstanding Paper Award, Texas Instruments, 1987 AAAI Conference;
2. 1989 Instrumentation Society of America ROBEXS (Robotics and Expert Systems) Workshop Best Paper Award (Palo Alto, CA, Aug. 2-3, 1989).
3. 2000 IEEE Transactions on Neural Networks Best Paper Award for the paper entitled "A New Neural Network for Cluster Detection and Labeling (CDL)", vol. 9, no. 5, pp. 1021-1035, Sept. '99.
4. IEEE Circuits and Systems Society M. E. Van Valkenburg Society Award, 2002

(d) Graduate Advisee Awards:

1. **Number of Master's thesis supervised: 27; Number of PhD dissertations supervised: 40**.
2. Ralph Budd Best Engineering Ph.D. Dissertation Award from Rice University (1980 Commencement) for graduate advisee Sarah A. Rajala (Dissertation no. 17);
3. Ralph Budd Best Engineering Ph.D. Dissertation Award from Rice University (1981 Commencement) for graduate advisee T. C. Chen (Dissertation no.20);
4. The Space Foundation National Excellence Recognition Award for graduate advisee Nasser Kehtarnavaz (Dissertation no. 26);
5. UC Regents' Fellowships to several graduate research advisees and the Matheson Gas Fellowship to the Graduate advisee Prashanth Mundkur, at UC Irvine, 1993 to-date.

(e) Some Distinguished Former Ph.D. Advisees

Dr. A.N. Netravali, former President of Lucent Technologies Bell Laboratories, member of NAE, and recipient of the 2001 National Medal of Technology; and *in academia*, Professors K.S. Chao (Texas Tech Univ.), N. Kehtarnavaz (Univ. of Texas, Dallas), S. Starks (Univ. of Texas, El Paso), Sarah Rajala (Associate Dean, North Carolina State Univ.), and H. Tagare (Yale Univ.).

(f) Inventions:

1. 1987 NASA Certificate of Recognition for Creative Development and Technical Innovation;

2. 1988 NASA Certificate for an Inventive Contribution;
3. U.S. Patent No. 5,005,147 entitled "Method and Apparatus for Sensor Fusion" (with K. Krishen and S.W. Shaw) (April 2, 1991).
4. U.S. Patent Pending No. 10/310,236 entitled "Scatterer Modeling Using Scattering-Based Tomography" (with B. S. Denney and K. N. Estabridis) (May 16, 20030

II. Key Publications

Professor de Figueiredo's publications consist of 3 books in print, and others under review, 10 book chapters, and about 350 articles in journals and reviewed conference proceedings a selection of which is listed in section IV.

Ten of his important publications, together with their significance, follow. Some of these have been already highlighted in the section I-A on Research.

Ten Most Significant Publications:

1. "Existence and uniqueness of the periodic solution of an equation for autonomous oscillations", *Annals of Mathematics Studies No.45* (Edited by Cesari, LaSalle and Lefschetz), pp. 269-284 (Princeton, NJ: Princeton University Press, 1960).

Significance: This is a fundamental contribution to the theory of autonomous oscillations. Based on a rigorous mathematical treatment, new general conditions for the existence and uniqueness of the limit cycle of Lienard's equation are presented. These conditions significantly generalize previous theorems of Lienard and Norman Levinson and O. K. Smith of MIT by enabling (foreseeing) the occurrence of a unique stable limit cycle to take place even when negative damping prevails over large amplitudes (Previous theories by the experts on the Van der Pohl type equations required that the damping be positive for large amplitudes). The results had a major impact on the theory of business cycles being developed at that time by the famous Cambridge University economics professor Richard Goodwin. These results were further generalized by de Figueiredo to the case of multiple limit cycles (for the Van der Pohl/Lienard equation) and are serving as a basis for a study by Professor R. W. Newcomb's group at the University of Maryland oriented toward gaining insight and understanding of the role of negative resistance in the design of oscillators and tunneling devices.

2. "A generalized Fock space framework for nonlinear system and signal analysis", *IEEE Trans. on Circuits and Systems*, vol. CAS-300, no.9, pp. 637-647, September 1983 (Special invited issue on "Nonlinear Circuits and Systems").

Significance: This paper reviews the theory of generalized Fock spaces (GFSs) pioneered by the author, in collaboration with L. V. Zyla and T. W. Dwyer, III, and then shows how the underlying best approximation framework can be used for modeling nonlinear solid state devices and circuits, identification of nonlinear systems, and

canceling distortion in communication circuits. In this and previous related papers it was shown that the GFS is a Reproducing Kernel Hilbert Space (RKHS). This in turn allows one to obtain the desired optimal solution to the above problems as an orthogonal projection in GFS, an elegant approach similar to the one previously used by Wiener, Kalman, and Kailath for linear problems. It should be emphasized that the use of an orthogonal projection in a RKHS for obtaining a closed form solution for a strictly nonlinear problem constitutes a conceptual breakthrough in nonlinear signal processing and system analysis. It constitutes the basis of optimal kernel-based machines.

3. "Mathematical foundations of optimal interpolative neural networks", in *Artificial Intelligence, Expert Systems, and Symbolic Computing*, E. Houstis and J.R. Rice, Editors, Elsevier, Amsterdam 1992, pp. 303-319.

Significance: These nets, first introduced by the author at ISCAS-90, and called Optimal Interpolative (OI) nets and Optimal Multilayer Neural Interpolating (OMNI) nets, have a number of advantages: A closed form solution of the optimal synaptic weights is obtained, which can be computed, if derived, in a single step, rather than through a gradient search algorithm as in conventional back propagation methods. Hence, there is no convergence problem with the OI nets. The OI net solution is robust since it is derived using a mini-max criterion. The OI net has an optimal structure dependent on the given training set. As explained in the significance of the previous paper, *this neural network structure is obtained by an orthogonal projection in a GFS onto the subspace spanned by the representers of the training data functionals in GFS*. For this reason, such a net has been interpreted by de Figueiredo as an *abstract (nonlinear spline)*. No prescribed network structure is necessary and the net can tune itself to the optimal structure through training. Using an appropriate prototype selection procedure, the OI net can be pruned to achieve a net that is only as complex as necessary for a training set. As reported in recent conference and journal papers, these nets are having an enormous impact on the classification of ocean acoustic data and on the diagnosis of Alzheimer's disease and other dementia from brain SPECT image data (see, e.g., **5** below).

4. "Efficient learning procedures for optimal interpolative nets", (with S. K. Sin), *Neural Networks,* vol. 6, pp. 99-113, 1993.

Significance: In this paper, a recursive learning algorithm is introduced for the OI net. This algorithm selects a small but meaningful (consistent) subset of exemplars, called prototypes, and recursively updates the synaptic weights of the net as each new prototype is found and incorporated in the net structure. This makes the net sparse and evolutionary. No pre-specification of the architecture is required. During training, the net grows from a single neuron to the approximately minimal size needed to solve a given problem. Impact is the same as in the preceding publication.

5. "Neural-network-based classification of cognitively normal, demented, Alzheimer disease and vascular dementia from single photon emission with computed tomography image data from brain" (de Figueiredo (Principal Author) and several co-authors), *Proc. Natl. Acad. Sci. USA*, vol. 92, pp. 5530-5534, June 1995.

Significance: In this seminal paper, single photon emission with computed tomography (SPECT) hexamethylphenylethyleneamineoxime technetium-99 (abbreviated as HMPAO-99Tc) images were analyzed by an Optimal Interpolating (OI) neural network to test how well the network could discriminate among clinically diagnosed groups of elderly normal, Alzheimer's disease (AD), and vascular dementia (VD) subjects. After initial image preprocessing and registration, image features were obtained that were representative of the mean regional tissue uptake. These features were then analyzed by the OI net. The OI net agreement was 80 and 86% for probable AD and probable/possible VD respectively, which is considered to be a very encouraging result with regard to this application.

6. "Optimal spline digital simulators of analog filters" (with A.N. Netravali), in the special issue on "Active and Digital Filters", ed. by I.W. Sandberg and J.F. Kaiser, *IEEE Trans. on Circuit Theory*, vol. CT-18, pp. 711-717, 1971.

Significance: This seminal paper presents a fundamental model-based approach to the reconstruction of analog signals from their samples. It is based on a dynamical model for the source that generates the analog signals. The differential operator L that describes the source model is used to construct an appropriate Hilbert space H (called Sobolev space) for the signals generated by the source. The desired optimal reconstruction is then obtained as a projection of the unknown analog signal x (to be constructed from its samples) as an orthogonal projection of x on the subspace of H spanned by the representers of the sampling functionals in H. This reconstruction is the generalized L-spline interpolating or smoothing (if noise is present) the samples of the desired analog signal. The paper presents methods for obtaining optimal interpolating and smoothing filters based on these concepts. These results have been further generalized by de Figueiredo by his invention of the *Butterworth and Chebishev splines,* for optimally interpolating essentially bandlimited signals, with certain advantages over the prolate spheoidal functions; and by his invention of the nonlinear functional splines, which manifest themselves of OI neural networks as mentioned under **3** above.

7. "PDLg splines defined by partial differential operators with initial and boundary value conditions" (with G. Chen), *SIAM Journal on Numerical Analysis*, April 1990.

Significance: These are novel generalized splines generated by a general partial differential operator. They permit the modeling of multidimensional data and the Hilbert space formulation on which they are based permits their use in the interpolation of randomly placed knots (these splines are not necessarily tensor products of univariate splines). They had impact on interpolation and smoothing of image data and oceanographic data.

8. "A new framework and computer program for quantitative EMG signal analysis" (with A. Gerber, R. M. Studer, G. S. Moschytz), *IEEE Trans. on Biomedical Engineering*, vol. BME-31, no. 12, Dec. 1984 (Centennial Issue), pp. 857-863.

Significance: This paper synthesizes in the final form the pioneering work on adaptive algorithms for decomposition of a mixture of overlapping analog EMG (Electromyographic) signals for the diagnosis of neurogenic and myogenic (muscular) diseases. A computer program resulted from this effort which was considered by Prof. Carlo De Luca of Harvard and MIT to be one of the two best available world-wide for this application.

9. "Model-based orientation-independent 3D machine vision techniques" (with N. Kehtarnavaz), *IEEE Trans. on Aerospace and Electronic Systems*, vol.24, no.5, September 1988, pp. 597-607.

Significance: A new approach for recognition of 3D objects from camera data is presented. Invariants obtained by contraction of the image moment tensors are used as features. The resultant algorithms permit not only the identification of objects independent of 3D translation, rotation, and scaling, but also their 3D orientation with respect to the direction of look. A software package with these results was written and transferred to the NASA/JSC automation and robotics testbed for the Space Station Freedom. Further developments, described in other papers, led to a central piece of software for space robot vision at the McDonnell Douglas Aerospace Company facility in Huntington Beach, California.

10. "Structural Processing of Waveforms as Trees" (with S.W. Shaw), IEEE Trans. on Acoustics, Speech, and Signal Processing, vol.38, no.2, February 1990, pp. 328-338.

Significance: This provides a novel way of processing rich (complex) waveforms symbolically. Such waveforms are represented as trees. Tree transformations are used to reduce the size of the original tree space. In the reduced space, trees are classified by a nearest neighbor classification method using tree metrics. The results were very successfully applied to the classification of EKG, seismic, and sonar data. Theoretically, they provide the foundations for multiscale signal processing using attributed graph theoretic concepts.

III. Select List of Publications
(Out of 370)

BOOS AND BOOK CHAPTERS (peer reviewed)

[1] Contributions to the Theory of Certain Nonlinear Differential Equations. Lisboa, Portugal: Junta de Investigacoes do Ultramar, 1960.
[2] Concepts and Techniques in Oil and Gas Exploration (co-editor and author). Tulsa, Oklahoma: Society of Exploration Geophysics, October 1982.
[3] Nonlinear Feedback Control Systems: An Operator Theory Approach (with G. Chen). San Diego, CA: Academic Press, 1993.
[4] "Butterworth and Chebyshev splines," in Approximation Theory, (ed. G.G. Lorentz), New Work: Academic Press, 1973, pp. 341-343.
[5] "Design of optimal feature extractors by mathematical programming techniques." Pattern Recognition and Artificial Intelligence, (ed. C.H. Chen), New York: Academic Press, 1977, pp. 185-194.
[6] "Spectral and artificial intelligence methods for seismic stratigraphic analysis" (with S.W. Shaw), in Handbook of Geophysical Exploration, sec. 1, Seismic Exploration, vol. 20, Pattern Recognition and Image Processing (edited by F. Aminzadeh), pp. 426-446, London-Amsterdam: Geophysical Press 1987.
[7] "Space Robots" (with Lyle M. Jenkins), in International Encyclopedia of Robotics Applications and Automation, J. Wiley and Sons, pp. 1626-1635, 1988.
[8] "Optimal Interpolation and a Best Approximation Problem on a Generalized Fock Space of Analytic Functions" (with G. Chen), in Approximation Theory, VI, (ed. by C.K. Chui, et al.), New York: Academic Press, 1989, pp. 247-250.
[9] "Optimal Nonlinear Feedback System Design for a General Tracking Problem" (with G. Chen) in Robust Control of Linear Systems and Nonlinear Control, (edited by M.A. Kaashoek at al), Birkhauser, Boston, 1990, pp. 429-436.
[10] "An Optimization Framework for Nonlinear Control Systems Design Based on Multi-Constraints and Multi-Criteria" (with G. Chen), in Recent Advances in Robust Control, (edited by P. Dorato and R.K. Yedavalli), IEEE Press, N.Y., 1990, pp. 334-338.
[11] "Formulation and error analysis for a generalized image point correspondence algorithm" (with S. Fotedar and K. Krishen), in Progress in Computer Vision and Image Understanding (edited by L. Shapiro and A. Rosenfeld), Academic Press, Cambridge, MA, pp. 593-607, 1992.
[12] "Mathematical Foundations of Optimal Interpolative Neural Networks", in Artificial Intelligence, Expert Systems, and Symbolic Computing, E. Houstis and J.R. Rice (Eds.), Elsevier, Amsterdam, 1992, pp. 303-319.
[13] "Nonlinear System Realization in the Structure of Natural and Artificial Intelligence," in Fundamentals of Discrete-Time Systems: A Tribute to Professor Eliahu L. Jury, edited by M. Jamshidi, M. Mansour, B.D.O. Anderson, and N.K. Bose, TSI Press, pp. 63-69, 1993.
[14] "Neural Modeling and Identification of Nonlinear Systems in An Abstract Space Setting," in Mechanics and Control, V, R.S. Gutalu, Editor, Plenum Press, 1993, pp. 309-317.

[15] "Amyloid deposition in cerebrovascular angiopathy" (with Oten, R.; Su, J.; and Cotman C.W.) Annals of The New York Academy of Sciences, Special Issue on Cerebrovascular Pathology in Alzheimer's Disease, Edited by Jack C. de la Torre and Vladimir Hachinski, Vol. 826, pp. 463-471, 1996.

[16] "On nonlinear filtering of non-Gaussian processes through Volterra series", in Volterra Equations and Applications [Volterra Centennial Anniversary Volume], C. Cordoneanu and I. W. Sandberg, Editors, Gordon & Breach, Reading, UK, 2000.

[17] "Beyond Volterra and Wiener: Optimal Modeling of Nonlinear Dynamical systems in a Neural Space for Applications in Computational Intelligence: The Experts Speak", edited by Charles Robinson and David Fogel, volume commemorative of the 2002 World Congress on Computational Intelligence, IEEE and John Wiley & Sons, 2003.

[18] "A Nonlinear Functional Analytic Framework for Modeling and Processing Fuzzy Sets", Chapter 9 of the book *"Forging New Frontiers: Fuzzy Pioneers I - Studies in Fuzziness and Soft Computing*" edited by M. Nikravesh, J. Kacprzyk and L. A. Zadeh, First of two Volumes commemorative of the 40th anniversary of the invention of fuzzy sets by L. A. Zadeh, Springer Press, 2007 *(in press)*

SELECT PUBLICATIONS IN PEER-REVIEWED JOURNALS

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[24] Manual on Safe Operation of Critical Assemblies and Research Reactors (Vienna, Austria: International Atomic Energy Agency, 1961). (Dr. deFigueiredo served as a member of the Advisory Panel in the formulation of this manual.)

[25] "A theorem on the existence of n stable limit cycles for Lienard's equation" (Summary), Notices of the Amer. Math. Soc., vol. 10, p. 112, January 1963.

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