

SIGNAL, MULTIMEDIA AND TELECOMMUNICATIONS

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**Sinais, Multimídia e Telecomunicações
COPPE/Poli-UFRJ**

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CONTACT

Mail Address:

Signal Multimedia and Telecommunications
COPPE/Poli/UFRJ
P.O. Box 68504
Rio de Janeiro, RJ
BRAZIL, 21945-970

Visiting Address:

Av. Athos da Silveira Ramos, 149,
Centro de Tecnologia – UFRJ
Block H, room 221 and Block I, room 146
Cidade Universitária – Ilha do Fundão – Rio de Janeiro – RJ
CEP: 21941-598
Brazil

Phone Office: +55 21 3938 8207

Fax: +55 21 3938 8207

Webpage: <http://www.smt.ufrj.br>

Contents

[The Federal University of Rio de Janeiro](#)

[The Signal, Multimedia and Telecommunications Laboratory](#)

[Faculty and Their Research Interests](#)

[Staff and Their Activities](#)

[Main research projects](#)

[Data-Selective Adaptive Systems](#)

[Superfast Transceivers with Reduced Redundancy](#)

[Physical Layer of Telecommunication System](#)

[Efficient Multicarrier Systems](#)

[Reliable Communication](#)

[Low-Complexity Adaptive Filters](#)

[Signal, Image and Video Coding and Filter Design Using Generalized Bit-Planes and Matching Pursuits](#)

[Signal Encoding Using Multiscale Recurrent Patterns](#)

[Brazilian Digital TV System](#)

[Compressive Sensing](#)

[Analysis of Electric Power System Signals](#)

[Image Analysis and Pattern Recognition](#)

[Quality Evaluation of Images, Video and 3D Video](#)

[Automatic Detection of Highlights in Soccer Matches](#)

[Image Fusion Techniques](#)

[Digital Filter Design for Econometric Series](#)

[Signal Denoising](#)

[Digital Audio Restoration](#)

[Spatial Sound](#)

[Analysis and Synthesis of Audio Signals](#)

[Coding and Quality Evaluation of Audio Signals](#)

[Theses](#)

[M. Sc. Theses](#)

[D. Sc. Theses](#)

[Publications](#)

[Books](#)

[Book Chapters](#)

[Refereed Papers Published in Journals](#)

[Refereed Papers Published in National Journals](#)

[Refereed Papers Published in International Conferences](#)

[Papers Published in National Conferences](#)

[Patents Granted](#)

[Recent Professional Activities](#)

[Research Grants Obtained](#)

[Summary of Achievements](#)

1. The Federal University of Rio de Janeiro

The Federal University of Rio de Janeiro (UFRJ) carries its present name since 1965. Previously known as University of Brazil, the original schools which now form the UFRJ date back to the 18th and 19th centuries. UFRJ has about 50000 students where approximately 9000 are graduate students. The University has four large campuses and several buildings scattered throughout the city of Rio de Janeiro. UFRJ is the largest federal university and the second largest university in Brazil.

The Polytechnic School of Engineering has its origin in the late 18th century, being one of the oldest schools of engineering education in the American continent. The Polytechnic School of Engineering is responsible for the undergraduate programs in engineering of UFRJ. It has around 250 faculty members and 5000 students and grants engineering degrees in a wide range of options. In particular, the Department of Electronics and Computer Engineering has 52 faculty members and around 500 students.

The graduate Polytechnic School in Engineering of UFRJ is called COPPE. For historical reasons the undergraduate and graduate schools developed separately. COPPE started in 1965 and before that the graduate degrees in engineering were awarded by the Polytechnic School of Engineering. COPPE has around 330 full time faculty members and 16.321 graduate students, being the largest graduate school in Brazil. The Program of Electrical Engineering of COPPE/UFRJ has 49 full-time faculty members, 141 D. Sc. and 170 M. Sc. students.

All Most Professors of the signal multimedia and telecommunications group belong simultaneously to the Department of Electronics and Computer Engineering of the Polytechnic School of Engineering (undergraduate school) of UFRJ and to the Program of Electrical Engineering of COPPE/UFRJ (graduate school).

The Program of Electrical Engineering is considered one of the top graduate departments in Electrical Engineering in Brazil. A third of the faculty is listed as senior researchers of the national research council (CNPq).

2. The Signal, Multimedia and Telecommunications Laboratory

The field of Signal Processing has developed so fast that it was incorporated into the graduate and undergraduate programs of all universities. The development of microelectronics technology caused a great impact in our modern life, making available a number of electronic equipment such as mobile phones, iPads, computers, video, and audio systems at a reasonable cost. This development occurred in parallel with the advances in the technology of transmission, processing, recording, reproduction, and general treatment of signals through analog and digital electronics as well as other means such as acoustics, mechanical, optical etc.

The signals, multimedia, and telecommunications (SMT) group consists of 6 full-time faculty members where four is Full Professor, two are Associate Professors. The group has its origins in 1995 with the inauguration of the Signal Processing Laboratory. The signal processing activities originated from the circuit theory group that started at COPPE in the early seventies. The signal multimedia and telecommunications group had only three Professors until 1993. In 2012 the SMT was formed and officially currently the group has 7 professors.

The group contributions cover a wide range of activities. They include contributions to electrical engineering education, especially in personnel training and on dissemination of modern signal processing techniques, including audio, speech, video, telecommunications, and applications in Brazil and abroad.

There is a good balance between graduate and undergraduate teaching. The members of the signal multimedia and telecommunications group have taught the following undergraduate courses in recent years: Signal Processing, Electronics, Analog Communications, Digital Communications, Image Processing, Linear Systems, Statistical Signal Processing, Probabilistic Models, Electromagnetics, Linear Algebra, Wireless Communications, Speech Processing, Audio Processing, among others.

At graduate-level the courses recently offered are Digital Filters, Stochastic Processes, Adaptive Filtering, Image Processing, Spectral Estimation, Wavelets and Filter Banks, Signal Compression, Detection and Estimation, Optimization, Array Processing, Information Theory, Speech Processing, Audio Processing, and Video, Wireless Communications among others

Some of the most important research topics of the group are adaptive systems, image and video processing, digital signal processing and its applications, speech processing, audio processing, wireless communications, and distributed processing.

The members of the group advised over 150 EE, 131 M.Sc., 66 D.Sc., and 15 Ph.D. theses in signal processing theory and applications. two members of the group chaired the Program of Electrical Engineering, one chaired the Department of Electronics and Computer engineering and two members of the group acted as undergraduate course coordinators.

Some members of the signal multimedia and telecommunications group are also very active in scientific policy at the national level. They worked in accreditation visiting teams, and all are members of consulting committees of several research funding agencies.

There are a number of consulting activities being developed by the signal multimedia and telecommunications group with national and international companies such as CEPEL (Power systems research center), Petrobras (Brazilian petroleum company), IPqM (Navy Research Institute), smaller Brazilian industries, NOKIA, INdT, GE, HP, Statoil/Equinor, Halliburton, EMC-DELL, Anatel, Samsung, Siemens, Microsoft and a number of projects supported by the European Commission.

The SMT occupies on an area of 310 square meters. Its asset includes computers, spectrum analyzers, digital oscilloscopes, signal generators, real-time video storage system, PXT Wireless Communications Test Set and several DSP development systems among other things.

3. Faculty and Their Research Interests

Eduardo A. B. da Silva was born in Rio de Janeiro, Brazil. He received the Electronics Engineering degree from Instituto Militar de Engenharia (IME), Brazil, in 1984, the M.Sc. degree in Electrical Engineering from Universidade Federal do Rio de Janeiro (COPPE/UFRJ) in 1990, and the Ph.D. degree in Electronics from the University of Essex, England, in 1995.

In 1987 and 1988 he was with the Department of Electrical Engineering at Instituto Militar de Engenharia, Rio de Janeiro, Brazil. Since 1989 he has been with the Department of Electronics Engineering (the undergraduate dept.), UFRJ. He has also been with the Department of Electrical Engineering (the graduate studies dept.), COPPE/UFRJ, since 1996. He has been head of the Department of Electrical Engineering, COPPE/UFRJ, Brazil, for the year 2002. In 2007 he has been a Visiting Professor at the University of Nice Sophia-Antipolis. His teaching and research interests lie in the fields of digital signal, image and video processing. In these fields, he has published over 60 peer reviewed papers in journals and book chapters. He won the British Telecom Postgraduate Publication Prize in 1995, for his paper on aliasing cancellation in subband coding. He is also co-author of the book "Digital Signal Processing - System Analysis and Design", published by Cambridge University Press, in 2002, that has also been translated to the Portuguese and Chinese languages, whose second edition has been published in 2010.

He has served as associate editor of the IEEE Transactions on Circuits and Systems - Part I, in 2002, 2003, 2008 and 2009, of the IEEE Transactions on Circuits and Systems - Part II in 2006 and 2007, and of Multidimensional, Systems and Signal Processing, Springer since 2006. He has been a Distinguished Lecturer of the IEEE Circuits and Systems Society in 2003 and 2004. He is Technical Program Co-Chair of ISCAS2011. He is a member of the Board of Governors of the IEEE Circuits and Systems Society for the term 2012 to 2014.

He has given training and consultancy for several Brazilian cable and satellite television companies on digital television. He was part of the team that worked in the development of the Brazilian Digital Television System. His research interests lie in the fields of digital signal and image processing, especially signal compression, digital television, wavelet transforms, mathematical morphology and applications to telecommunications. He is a senior member of the IEEE, of the Brazilian Telecommunication Society, and also a member of the Brazilian Society of Television Engineering.

E-mail: eduardo@smt.ufrj.br

Site: <http://www.smt.ufrj.br/~eduardo>

Luiz W. P. Biscainho was born in Rio de Janeiro, Brazil, in 1962. He received his Elec. Eng. degree (magna cum laude) from the EE (now Poli) at Universidade Federal do Rio de Janeiro (UFRJ), Brazil, in 1985, and his M.Sc. and D.Sc. degrees in Electrical Engineering from the COPPE at UFRJ in 1990 and 2000, respectively. Having worked for the telecommunications industry until 1993, Dr. Biscainho is currently Associate Professor at DEL/Poli and PEE/COPPE, at UFRJ. His research area is digital signal processing, particularly for audio applications. He is currently a

member of the IEEE (Institute of Electrical and Electronic Engineers), the AES (Audio Engineering Society), the SBrT (Brazilian Telecommunications Society), and the SBC (Brazilian Computer Society).

E-mail: wagner@smt.ufrj.br

Site: <http://www.smt.ufrj.br/~wagner>

Marcello Luiz Rodrigues de Campos Marcello L. R. de Campos was born in Niterói, Brazil, in 1968. He received the Engineering degree (cum laude) from the Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil, in 1990, the M.Sc. degree from COPPE/UFRJ in 1991, and the Ph.D. degree from the University of Victoria, Victoria, BC, Canada, in 1995, all in electrical engineering.

In 1996, he was postdoctoral fellow with the Department of Electronics, School of Engineering, UFRJ, and with the Program of Electrical Engineering, COPPE/UFRJ. From January 1997 until May 1998, he was Associate Professor with the Department of Electrical Engineering (DE/3), Military Institute of Engineering (IME), Rio de Janeiro. Since June 1998 he has been with the Program of Electrical Engineering, COPPE/UFRJ, as Associate Professor. He served as Department Vice-Chair and Chair in the years 2004 and 2005, respectively.

From September to December 1998, he visited the Laboratory for Telecommunications Technology, Helsinki University of Technology (now Aalto University), Espoo, Finland. He served as IEEE Communications Society Regional Director for Latin America in 2000 and 2001. In 2001, received a Nokia Visiting Fellowship to visit the Centre for Wireless Communications, University of Oulu, Oulu, Finland. From January until April 2008, visited UNIK - University Graduate Center at University of Oslo, in Kjeller, Norway.

Marcello Campos served as Local-Arrangements Co-Chair for GLOBECOM'99 in Rio, as Finance Chair for SPAWC 2008 in Recife, as Plenary Chair for ISCAS 2011 in Rio, and as Technical Program Co-Chair for the 2013 edition of the Brazilian Telecommunications Symposium. He founded and is the current Chair of the IEEE Signal Processing Society Rio de Janeiro Chapter.

His research interests include adaptive signal processing for centralized and distributed networks, adaptive beamforming, statistical signal processing, signal processing for communications, underwater, mobile and wireless communications, and MIMO systems. He has taught over 150 courses in 15 countries on mobile communications.

Dr. de Campos is a Senior Member of IEEE and a Member of the Brazilian Telecommunications Society and the Brazilian Mathematical Society.

E-mail: campos@smt.ufrj.br

Site: <http://www.smt.ufrj.br/~campos>

Paulo Sergio Ramirez Diniz was born in Niterói, Brazil. He received the Electronics Eng. degree (Cum Laude) from the Federal University of Rio de Janeiro (UFRJ) in 1978, the M.Sc. degree from COPPE/UFRJ in 1981, and the Ph.D. from Concordia University, Montreal, P.Q., Canada, in 1984, all in electrical engineering.

Since 1979 he has been with the Department of Electronics and Computer Engineering (the undergraduate dept.) UFRJ. He has also been with the Program of Electrical

Engineering (the graduate studies dept.), COPPE/UFRJ, since 1984, where he is presently a Professor.

He served as Undergraduate Course Coordinator and as Chairman of the Graduate Department. He is one of the three senior researchers and coordinators of the National Excellence Center in Signal Processing. He has also received the Rio de Janeiro State Scientist award, from the Governor of Rio de Janeiro state. From January 1991 to July 1992, he was a visiting Research Associate in the Department of Electrical and Computer Engineering of University of Victoria, Victoria, B.C., Canada. He also holds a Docent position at Helsinki University of Technology. From January 2002 to June 2002, he was a Melchor Chair Professor in the Department of Electrical Engineering of University of Notre Dame, Notre Dame, IN, USA. His teaching and research interests are in analog and digital signal processing, adaptive signal processing, digital communications, wireless communications, multirate systems, stochastic processes, and electronic circuits. He has published several refereed papers in some of these areas and wrote the books: ADAPTIVE FILTERING: Algorithms and Practical Implementation, Springer, Fourth Edition 2013; DIGITAL SIGNAL PROCESSING: System Analysis and Design, Cambridge University Press, Cambridge, UK, Second Edition 2010 (with E. A. B. da Silva and S. L. Netto); and Block Transceivers: OFDM and Beyond, Morgan & Claypool, 2012 (with W. A. Martins and M. V. S. Lima). He was the General Co-Chair 2011 IEEE ISCAS held in Rio de Janeiro, Brazil. He has been on the technical committee of several international conferences including ISCAS, ICECS, EUSIPCO and MWSCAS. He has served Vice President for region 9 of the IEEE Circuits and Systems Society and as Chairman of the DSP technical committee of the same Society. He is also a Fellow of IEEE (for fundamental contributions to the design and implementation of fixed and adaptive filters and Electrical Engineering Education). He has served as associate editor for the following Journals: IEEE Transactions on Circuits and Systems II: Analogy and Digital Signal Processing from 1996 to 1999, IEEE Transactions on Signal Processing from 1999 to 2002, and the Circuits, Systems and Signal Processing Journal from 1998. He was a distinguished lecturer of the IEEE Circuits and Systems Society for the year 2000 to 2001. In 2004 he served as distinguished lecturer of the IEEE Signal Processing Society, received the 2004 Education Award of the IEEE Circuits and Systems Society, the 2006 Guillemin-Cauer best paper award from the IEEE Circuits and Systems Society, and some best paper awards from international conferences. In 2014 he received the prestigious Charles A. Desoer Technical Achievement award from the IEEE Circuits and Systems Society.

E-mail: diniz@smt.ufrj.br

Site: <http://www.smt.ufrj.br/~diniz>

Sergio Lima Netto was born in Rio de Janeiro, Brazil, in 1967. He received the B.Sc. degree from the Federal University of Rio de Janeiro (UFRJ) in 1991, the M.Sc. degree from COPPE/UFRJ in 1992, and the Ph.D. degree from the University of Victoria, Canada, in 1996, respectively, all in Electrical Engineering. Since 1997 he has been Associate Professor at the Department of Electronics, School of Engineering, at UFRJ, and since 1998, also with the Program of Electrical Engineering, COPPE/UFRJ.

He served as the Region-9 (Latin-America) Vice-President for the IEEE Circuits and Systems Society for 2002-2003, and acted as an Associate Editor for the Circuits,

Systems and Signal Processing journal (2002-2005) and for IEEE Transactions on Circuits and Systems, Part II: Express Letters (2004-2006).

He co-authored (with Paulo S. R. Diniz and Eduardo A. B. da Silva) the book "Digital Signal Processing: System Analysis and Design" by Cambridge University Press, 2nd ed., 2010, with several international editions including translations to Portuguese and Chinese. He has also authored "Geometric Constructions: Exercises and Solutions" (in Portuguese) by the Brazilian Mathematical Society, 2009, and "Mathematics Exams for the Military Institute of Engineering" (in Portuguese) by VestSeller, 2011.

His research interests include digital signal processing, adaptive filtering, and speech processing.

E-mail: sergioln@smt.ufrj.br

Site: <http://www.smt.ufrj.br/~sergioln>

Wallace A. Martins was born in Brazil in 1983. He received the Electronics Engineering degree (Cum Laude) from the Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil, in 2007, and the M.Sc. and D.Sc. degrees in Electrical Engineering from COPPE/UFRJ in 2009 and 2011, respectively. In 2008, he was a research visitor at the Department of Electrical Engineering, University of Notre Dame, Notre Dame, IN. From 2010 to 2013, he was with the Department of Control and Automation Industrial Engineering of CEFET/RJ. Dr. Martins is currently Associate Professor of the Department of Electronics and Computer Engineering (DEL/Poli) at UFRJ. His research interests are in the fields of digital communication with focus on multicarrier systems, digital signal processing for machine learning and adaptive algorithms, acoustic-based localization of sources and sensors, and underwater wireless communications. Mr. Martins received the Best Student Paper Award from EURASIP at EUSIPCO-2009, Glasgow, Scotland, and the Best D.Sc. Thesis Award from Capes, Brazil, 2012. He is currently a member of the IEEE (Institute of Electrical and Electronic Engineers).

Site: <http://www.smt.ufrj.br/~wallace.martins>

4. Staff and Their Activities

Manager

- Michelle Nogueira
E-mail: michelle.nogueira@smt.ufrj.br
Phone: +55 21 3938-8206

TI Management

- Gabriella Trigueiro
E-mail: suporte@smt.ufrj.br
Phone: +55 21 3938-8880

5. Main research projects

5.1. Data-Selective Adaptive Systems

Paulo Sergio Ramirez Diniz, Marcello Luiz Rodrigues de Campos, Wallace Alves Martins

This investigation addresses new adaptive filtering solutions for several equalization and channel identification problems in communications. We have proposed several set-membership affine projection algorithms incorporating selective updating mechanisms. However there are some open research problems that need to be addressed in order to foster the adoption of data-selective algorithms in practical applications. In particular, the application of data-selective algorithms in the context of spectrum sensing using cognitive radios or in the context of sparse system identification is currently being considered.

5.2. Superfast Transceivers with Reduced Redundancy

Wallace Alves Martins e Paulo Sergio Ramirez Diniz

A significant part of physical- and link-layer research in communication systems focuses on either developing new methods or enhancing the existing ones in order to increase throughput. From a practical point of view, these investigations should always take into account the fundamental trade-off between performance gains and cost effectiveness. The computational complexity is amongst the factors that directly affects the cost effectiveness of new advances in communications. This explains why linear transceivers are still preferred in several practical applications. This research project aims at proposing new structures for linear block-based transceivers with reduced redundancy. Such new structures must allow one to equalize the received data blocks efficiently. In other words, the structures are constrained to use only superfast algorithms, while saving bandwidth resources by transmitting a reduced amount of redundant symbols.

5.3. Physical Layer of Telecommunication System

Paulo Sergio Ramirez Diniz, Marcello Luiz Rodrigues de Campos

There are a wide variety of issues, services and products related to the communications business worldwide.

Since the technological development in the communications field changes rapidly and is costly, it is crucial that the systems deployed provide as much coverage as possible to increase the number of potential users. The most fragile step of a wireless communication system is the radio link of the physical layer. The coverage and the transmission capacity are basically determined by the performance of the physical layer.

As a consequence, it is important to study methods to improve the use of the radio resources in order to allow higher bit rate and/or wider coverage. For wireline systems, good design strategies for the physical layer are also critical for the overall performance of the system. The challenges in this context are, to some extent, different from those in wireless systems. For instance, the transmitter in wireline systems generally has some information about the communications channel. This

knowledge opens up the possibility of new transmitter design strategies that fully exploit the channel capacity, such as water-filling and bit loading. Some current communications systems do not fully capitalize on the available transport domains, namely space, time and frequency. In these domains, information can be protected by inserting redundancies in several ways. So far the proposed solutions are not integrated being as a result limited, by reducing the capacity and the integration of different services. The theoretical source information compression can be improved by joint exploration of the mentioned domains.

The objective of this research is to find viable solution to improve the reliability and the spectral usage in communications systems. As an example, an issue under current study is how to improve the performance of the coherent detection is utilized in most of the transmission systems for mobile wireless communications. The pilot-symbol patterns play a key role in system performance leading to conservative and robust pilot-symbol patterns choices by the standardization organizations such as long-term evolution (LTE).

This research addresses how to design optimal pilot-symbol patterns in dispersive channels with an optimal power distribution between pilot- and data-symbols, in addition to find a solution for adaptive pilot-symbol patterns that adapt to the varying channel conditions.

5.4. Efficient Multicarrier Systems

Paulo Sergio Ramirez Diniz, Marcello Luiz Rodrigues de Campos

Multicarrier modulation methods play a key role in modern data transmission channels with severe and moderate intersymbol interference. The key idea behind the success of this technique is the partition of a physical channel in non-overlapping narrowband subchannels through a transmultiplexer. If the subchannels are narrow enough the associated channel response in each subchannel frequency range appears to be flat avoiding the use of equalizers with memory. In addition, the subchannel division allows, whenever possible, the exploitation of signal-to-noise ratio (SNR) in the different subbands in order to manage the data load in each subchannel. Typically, subchannels with high SNR utilize high-order modulation whereas in subchannels with moderate SNR lower order modulation should be used. On the other hand, subchannels with severe interference are not used for data transmission. Such schemes are employed in a number of high speed digital subscriber line (XDSL) systems. An efficient multicarrier technique to communicate high-speed data through dispersive channels is the orthogonal frequency division multiplex (OFDM), which has been used in a number of standards related to: Digital radio broadcasting radio; High-definition TV; Wireless Local Area Networks (WLAN); Wireless Broadband Links (WIMAX, IEEE 802.16, LTE); High-speed Digital Subscriber Line (XDSL).

In the last decade there is a growing interest to investigate new multicarrier systems to meet the demands for constant evolution of radio performance in order to allow better mobility and higher data rate required in broadband communications. A critical component of the multicarrier systems is the transmitter and receiver designs (transceiver) which in many cases are modelled as a filter-bank based transmultiplex (TMUX). The ideal situation requires the design of transceivers to avoid crosstalk between subchannels, and that the subfilters frequency responses are narrow enough

such that channel response in each subband appears to be flat. The latter condition is achieved by filter banks with very large number of subbands, whose design with the currently available techniques leads to an optimization problem with a prohibitive number of parameters.

These transceivers are instrumental to the design of high performance broadband wireless and wired communications utilizing multicarrier transmissions or performing equalization in the frequency domains. In many cases the ideal solution requires a method for jointly optimizing transmitter and receiver FIR multiple-input multiple-output (MIMO) filters in the presence of near-end crosstalk an additive noise source independent of the original signal.

For a given channel with a maximum allowable input power, the transmitter and receiver FIR MIMO filters are jointly optimized to minimize the bit-error rate. These types of solutions, despite of being ideal to improve the spectral efficiency, require sophisticate transceivers which are difficult to design. An alternative way to improve spectral efficiency is to reducing the amount of transmitted redundancy inserted in the physical layer so that multicarrier systems with reduced-redundancy can be designed and efficiently implemented. The reduction in the amount of redundancy leads to increased spectral efficiency. In the context of fixed and memoryless TMUXes, it is possible to show that the minimum redundancy required eliminating IBI and still allowing the design of zero-forcing (ZF) solutions is only half the amount of redundancy used by standard OFDM and SC-FD systems.

In this context, we have studied how to design memoryless LTI transceivers with reduced redundancy whose computational complexity is comparable to OFDM and SC-FD systems. That is, these transceivers should be amenable to superfast implementations in order to keep their computational complexities competitive with practical OFDM-based systems. This research addresses how transceivers with reduced redundancy can be implemented employing superfast algorithms based on the concepts of structured matrix representations..

5.5. Reliable Communication

Marcello Luiz Rodrigues de Campos and Paulo Sergio Ramirez Diniz

An area of interest is to address reliable communications solutions for demanding applications and challenging environments, such as: underwater communications, remotely controlled instrumentation and signal processing; power-line communications; non-standard wireless networks; and satellite links. Our group has been working for more than a decade on smart transceivers for mobile communications, MIMO systems, adaptive and blind equalizers, smart antennas, UWB pulse formatting, and, more recently, underwater acoustic communications systems.

5.6. Low-Complexity Adaptive Filters

Marcello Luiz Rodrigues de Campos and Paulo Sergio Ramirez Diniz (in collaboration with José A. Apolinário Jr. from the Military Institute of Engineering and Stefan Werner from the Aalto University - Finland).

When implementing an adaptive-filtering algorithm, the affordable number of coefficients that can be used will depend on the application in question, the adaptation algorithm, and the hardware chosen for implementation. With the choice of algorithms

ranging from the simplest to the more complex, tradeoffs between performance criteria such as, e.g., computational complexity and convergence rate, have to be made. In certain applications, the use of a complex algorithm is prohibitive due to the high computational complexity and in such cases we must resort to simpler algorithms. As an alternative, instead of reducing filter order, one may choose to update only part of the filter coefficient vector at each time instant. Such algorithms are referred to as partial-update (PU) algorithms. Set-membership filtering (SMF) is a complementary approach to reduce computational complexity in adaptive filtering. SMF algorithms employ a deterministic objective function related to a bounded error constraint on the filter output such that the updates belong to a set of feasible solutions. The SMF algorithms feature reduced computational complexity primarily due to (in data-selective) updates rendering an overall complexity that is usually much less than that of their conventional counterparts. The sparse updating in time can provide substantial savings in computations because it enables sharing of processor capacity and less power consumption.

Although the aforementioned adaptive filtering algorithms have already proven their values, their related convergence speeds degrade as the number of parameters to be adjusted is large. Fortunately, in several practical cases the parameters are sparse / compressible, i.e., most of their components have values close to zero. The sparsity inherent to such systems can be exploited in order to increase the convergence speed of adaptive filtering algorithms. Sparsity is directly revealed by the l_0 norm, but minimization of such a norm is a very difficult task (NP-hard problem). Solutions can be derived by exploiting the compressed sensing literature, in particular the equivalence between l_0 and l_1 minimizations for sufficiently high dimensional problems. The minimization leads to a convex problem, which is much more tractable. In this research we propose solutions to address the sparse problem aiming at deriving new AP algorithms.

5.7. Signal, Image and Video Coding and Filter Design Using Generalized Bit-Planes and Matching Pursuits

Eduardo Antonio Barros da Silva (in collaboration with Prof. Paulo S. R. Diniz and Luiz Wagner P. Biscainho, from LPS/COPPE/UFRJ, Lisandro Lovisolo and Michel Tcheou, from Universidade do Estado do Rio de Janeiro, Brazil, Alessandro J. S. Dutra, from General Electric, Brazil.)

Among the state-of-the-art in wavelet image coding one can point out the ones that use successive approximations, due to both compression efficiency and ease of implementation. Initially the most successful successive approximation quantization methods were based on scalar quantization. The attempts to employ successive approximation vector quantization methods resulted in codebooks that were very complex to generate. However, it has been developed a successive approximation vector quantization method that uses regular lattices as codebooks, which are very easy to generate. This has opened new avenues of research in the area. It has been shown that this method can be extended to Hilbert spaces, and can be seen as a generalization of signal decompositions followed by quantization and bit-plane encoding. Conditions for the convergence of successive approximation vector quantization have been determined. However, those results have been obtained only

experimentally. Its mathematical analysis has led to analytical results and theorems that have set the basis for deeper studies and the development of image and video encoders. Following this line, we have been investigating the relations of successive approximation vector quantization with iterated function systems, since this has been shown to be a good tool for the analytical development of the successive approximation theory. With the help of this theory, along with ergodic theory and the expansive transformations theory, more efficient methods of vector successive approximation have been investigated. As a natural development of this research, extensions of this theory to Hilbert spaces were investigated, leading to a theory of signal decompositions in generalized bit-planes. Its applications to video compression are being investigated, using the framework of the matching pursuits algorithm. It has also been investigated the dictionary design for such decompositions, based on recent development in the area of two-dimensional function decomposition using geometrically significant components, known as ridgelets, curvelets and contourlets. Applications of generalized bitplanes to the compression of hyperspectral images are also being considered. We also investigate the use of the matching pursuits algorithm for encoding signals from the electric system, as well as audio signals. Recently, we started investigation the use of generalized bitplanes to the design of efficient digital filters, to be implemented using sum of powers of two (SPTs).

5.8. Signal Encoding Using Multiscale Recurrent Patterns

Eduardo Antônio Barros da Silva (in collaboration with Sergio L. Netto, from SMT/COPPE/UFRJ, Brazil, Murilo B. de Carvalho, Federal University Fluminense, Brazil, Sergio M. M. de Faria and Nuno M. M. Rodrigues, Instituto de Telecomunicações, Portugal, Vitor Silva, University of Coimbra, Portugal, and Carla L. Pagliari, Instituto Militar de Engenharia, Brazil)

Lossy string matching methods have been attracting the interest of the data compression community, since they provide forms of efficiently integrating the quantization and coding operations. In this research the use of multiresolution techniques in recurrent pattern matching has been investigated. With this method, one obtains an integration of the operations of transformation, quantization and coding. Results show that these methods are promising, especially when associated with advanced prediction techniques. We research alternatives for the design of efficient signal compressors based on this paradigm. We also perform the theoretical development of its relation with orthogonal transforms. We have been applying this paradigm to image and video coding, including 3D coding, both stereo and texture plus depth. In addition, we are investigating its applications to speech coding, as well as ECG (electrocardiogram) and EMG (electromyogram) compression.

5.9. Brazilian Digital TV System

Eduardo Antônio Barros da Silva, Gelson Vieira Mendonça (in collaboration with Instituto Militar de Engenharia, Brazil, Universidade Federal Fluminense, Brazil, Universidade do Estado do Rio de Janeiro, Brazil, Universidade de Brasília, Brazil, and Universidade Federal do Rio Grande do Sul Brazil).

Brazil has recently adopted its Digital Television System. Upon this adoption, the Brazilian government has been pushing forward research in Digital Television in

several Universities and research centers around the country. The team in LPS has active participation in this process, specially in the video compression part. This includes working on enhanced techniques that can be applied both in future codec implementations and in future standards, as well as investigating ways of configuring the present codecs based on the H.264 standard for increased compression performance given complexity restrictions.

5.10. Compressive Sensing

Eduardo Antônio Barros da Silva (in collaboration with Lisandro Lovisolo, from Universidade do Estado do Rio de Janeiro).

In signal compression, what one normally does is to first acquire a signal using and A/D conversion, followed by a compression algorithm to reduce the amount of information stored/transmitted. Recently, there has been a great deal of interest in a new paradigm, referred to as compressive sensing, where the acquisition and compression processes are integrated into one. One can show that, if a signal is k -sparse in a given basis, one can sample it using a limited number of measurement functions, that depend on the sparsity k . This is done by using convex optimization algorithms that minimize the L_1 norm of the transform coefficients of the recovered signal. In this project we investigate the effects of quantization of measurements in the signal recovery. In addition, we also investigate the use of compressive sensing strategies when sensing in wireless sensor networks, where constraints like power consumption and packet loss are taken into consideration.

5.11. Analysis of Electric Power System Signals

Eduardo Antonio Barros da Silva (in collaboration with Moisés Vidal Rodrigues from Universidade Federal de Juiz de Fora, Brazil, and Lisandro Lovisolo and Michel P. Tcheou, from Universidade do Estado do Rio de Janeiro, Brazil, and Marco A. M. Rodrigues, from Centro de Pesquisas em Energia Elétrica (CEPEL), Brazil)

In power systems, several measurements can be made in order perform both signal analysis and fault detection. Oscilography deals with both the acquisition and analysis of such signals. In oscilography, it is extremely important that there can be good estimates of the magnitude and phase of the electrical quantities. Fourier filters and PLLs are often used for that. However, their performance tends to degrade when there are small variations on the frequency of the power source. We investigate the design of digital filters that can be good substitutes for Fourier filters, minimizing the frequency variation problem.

5.12. Image Analysis and Pattern Recognition

Eduardo Antonio Barros da Silva (in collaboration with Siome Klein Goldenstein, UNICAMP, Brazil, Waldir S. Silva Jr., Universidade Federal do Amazonas, Brazil)

Image analysis has a fundamental role in systems that rely on visual information for some sort of decision making. One of the first steps in image analysis is segmentation that consists in identifying image areas that contain objects of interest. Several segmentation techniques have been investigated. One application in which we have been working is on target segmentation in infrared images, using wavelets combined with mathematical morphology. Another important operation in image

analysis is pattern recognition. We investigate the use of linear discriminative filtering and correlation filters to identify patterns in images, in particular fiducial points, with applications in video tracking. A theoretical analysis of the problem regarding it as an image restoration problem has been leading to encouraging results. We also study the use of discriminative filters in the context of boosted and cascaded classifiers. Face recognition applications are being considered.

5.13. Quality Evaluation of Images, Video and 3D Video

Eduardo Antônio Barros da Silva (in collaboration with Alexandre G. Ciancio and José F. L. de Oliveira, from LPS/COPPE/UFRJ, Brazil, and Amir Said, from HP Labs, Palo Alto, EUA).

In many applications it is interesting to have a method to automatically analyze the quality of digital pictures. This is especially important in the case of photo printing, when it would be convenient to automatically detect blurred or out-of-focus images and not to print them. The problem of identifying blurring in images has been studied for more than 30 years, but the methods developed are both computationally very expensive and work for a restricted class of problems. This project aims at developing low complexity methods to just detect blurred or out-of-focus images, as well as grading the level of degradation present. Another important application is the quality evaluation of high-definition videoconference sequences, where little work has been done. We also focus on the analysis of the quality of experience of 3D video in augmented reality applications, where head tracking is used to change the point of view in both computer graphics models and multiview camera systems. The effects of factors such as amount of parallax, disparity and number of views on the quality of experience are being evaluated through extensive subjective tests.

5.14. Automatic Detection of Highlights in Soccer Matches

Eduardo Antônio Barros da Silva (in collaboration with Sergio L. Netto, from SMT/COPPE/UFRJ).

The annotation of highlights in sports videos, unless carried out online during the live match broadcasting, is a very time consuming task. One example is given by the soccer matches, where there is a great need of a tool for automatic annotation of highlights. In this line of research we investigate the combination of both audio (speaker voice) and video features, allied to pattern recognition techniques for automatic highlight annotation in soccer matches.

5.15. Image Fusion Techniques

Eduardo Antônio Barros da Silva (in collaboration with Carla Liberal Pagliari, from Instituto Militar de Engenharia, Brazil and Sergio Rodrigues Neves, from Instituto de Pesquisas da Marinha, Brazil).

The fusion of images from the visible and infrared spectra has several applications, both civilian and military. Among them, one can mention night vision systems, robot vision, etc. In this line of research we investigate image fusion algorithms for military applications. The emphasis is on image fusion systems based on multiresolution decompositions, where we search for alternatives both to the

wavelets used and to the coefficient combination methods, which include image segmentation techniques.

5.16. Digital Filter Design for Econometric Series

Eduardo Antônio Barros da Silva (in collaboration with Sheila Cristina Zain, IBGE, Brazil and Reinaldo Castro e Souza, PUC-Rio).

The treatment of time series, specially the one of econometric series, strongly uses digital filtering techniques. One popular example is the seasonal adjustment of econometric time series. However, either the filters are designed resorting to autoregressive moving average models (which work well only for "well behaved" time series), or the filters are designed using heuristic time domain techniques. In this line, we investigate the use of alternatives for these filters using advanced frequency domain design techniques.

5.17. Signal Denoising

Sergio Lima Netto.

This research project aims at the development of a package tool for signal denoising in several applications. Such package includes techniques such as spectral subtraction, Wiener filtering, adaptive signal processing (with several adaptive algorithms), wavelet analysis, independent component analysis, classic digital filtering, and system modeling. All these tools will be integrated in a single framework and user will be able to combine methods in a very friendly environment with a powerful graphic-user interface. The whole system includes a how-to-use demo with applications in biosignal processing and spark detection (from partial discharges) in power transformers.

5.18. Digital Audio Restoration

Luiz Wagner Pereira Biscainho (in collaboration with Paulo Antonio Andrade Esquef, PhD).

Application: To offer to a modern audience historical recordings with acceptable sound quality.

Objective: To attain the maximum sound quality with minimum signal processing.

The treatment of different types of corrupting noises requires specific techniques, such as spectral subtraction and Wiener filtering for broadband background noise, and Bayesian methods for localized disturbances.

We have investigated issues such as transfer function sensitivity, ARMA modeling in sub-bands, correction of AR-model for quantized signals, impulsive noise removal via AR modeling and threshold criteria, long pulse detection via FFT and its suppression through TPSW filtering, wavelet-based background noise reduction, and signal reconstruction over long gaps of missing samples via bi-directional AR extrapolations in sub-bands.

Some aims: Efficient Bayesian restoration, use of frequency warping and Psychoacoustics in audio restoration, treatment of clipped signals and correction of variations in playback speed.

5.19. Spatial Sound

Luiz Wagner Pereira Biscainho, Paulo Sergio Ramirez Diniz (in collaboration with Fábio Pacheco Freeland, DSc).

Application: Surround sound for movie theaters, home theater systems, computer games, and virtual reality scenarios.

Objective: To assign spatial location and ambience to a given sound source.

It is possible to present 3D sound through either multiple loudspeakers (multichannel systems - differences in amplitude and reproduction delay can put a sound source at a virtual position) or headphones (binaural systems - the sound is processed via "head-related transfer functions" from the source to the listener ears). The environmental effect on the sound is linked essentially with reverberation.

We have tackled efficient means for HRTF interpolation, including the use of fractional delay filters.

Now we investigate indirect interpolation methods and the correlation between multichannel and binaural models for 3D sound reproduction. A software meant to provide a graphical support for rendering 3D sound, including reverberation for a greater sense of immersion and realism, is currently under development.

5.20. Analysis and Synthesis of Audio Signals

Luiz Wagner Pereira Biscainho, Sergio Lima Netto (in collaboration with Paulo Antonio Andrade Esquef, PhD).

Application: Music remixing and editing, transcription, composition and performance; sound synthesis of musical instruments; instrument sound, theme and style recognition; compact representation, etc.

Objective: To analyze sound into component parts for studying, independent processing, resynthesis or new sound synthesis.

Usual tools: Time-frequency representations, statistical models, neural networks, etc.

We have approached neural networks for music transcription, the use of highly selective filter banks for the detection of musical notes in polyphony as well as in practical equalization systems, and the use of independent component analysis for source separation purposes. Adaptive filtering has been associated to sinusoidal modeling and to voice modification strategies.

Other targets: Refinement of current analysis methods based on sinusoidal modeling; application of matching pursuit to audio representation; strategies for music information retrieval (MIR) in general; development of a content analysis system for musical signals, including expressiveness, for subsequent resynthesis.

5.21. Coding and Quality Evaluation of Audio Signals

Luiz Wagner Pereira Biscainho, Eduardo Antonio Barros da Silva (in collaboration with Paulo Antonio Andrade Esquef, PhD).

Application: Consumer audio and telecommunications.

Objective: Storage and transmission of audio signals with maximum information and quality within minimum space and bandwidth.

Audio compression requires specific techniques. They can be either lossless (invertible, based on redundancy suppression) or lossy (discarding information psychoacoustically not perceptible). Objective evaluation which can emulate subjective opinion has become an essential research topic in contexts like audio streaming and VOIP.

We have investigated the use of perceptual audio quality measures for assessing the performance of audio restoration algorithms.

We are currently involved in the implementation of standard audio codices for applications in multimedia communication systems, including watermarking techniques. In objective evaluation of audio quality, special effort is being dedicated to high-quality voice evaluation as well as methods that dispense with reference signal.

6. Theses

6.1. M. Sc. Theses

1. Ribeiro, F. M. L., “Detecção de Pontos Fiduciais em Faces Usando Filtragem Linear”, M. Sc. Thesis, COPPE/UFRJ, February 24, 2014 (Eduardo Antonio Barros da Silva).
2. Wegelin, F. A., “Sistema de Detecção de Vazamentos em Dutos Utilizando Filtragem Adaptativa”, M. Sc. Thesis, COPPE/UFRJ, March 20, 2014 (Paulo Sergio Ramirez Diniz and Wallace Alves Martins).
3. Guarino, A. G. L., “Comunicações Acústicas Submarinas Utilizando Diversidade Espacial a partir da Construção de um Arranjo Linear de Oito Sensores Hidroacústico”, M. Sc. Thesis, COPPE/UFRJ, June 06, 2014 (Marcello Luiz Rodrigues de Campos).
4. Almeida, R. M., “Separação de Fontes Sonoras por Fatoração Duplamente Deconvolutiva de Matrizes Não-Negativas com Uso de Restrições”, M. Sc. Thesis, COPPE/UFRJ, September 29, 2014. (Luiz Wagner Pereira Biscaíno).
5. Irigaray-Baiarres, I., “Transient and Steady-State Component Separation for Audio Signals”, M. Sc Thesis, Universidad de la Republica Uruguay, October 20, 2014. (Luiz Wagner Pereira Biscaíno and Dr. Pablo Monzón).
6. Freitas, M. de, “Equalização Adaptativa Utilizando Seleção de Dados em Transceptores em Bloco com Redundância Reduzida”, UFAM, 2014. (Wallace Alves Martins).
7. Winter, N., “Joint Channel and CFO Estimation for Filter Bank Based Multi-Carrier”, M. Sc Thesis, Forschungspraxis, Technical University of Munich, October, 2014. (Paulo Sergio Ramirez Diniz, Leonardo G. Baltar and Tadeu Nagashima Ferreira).
8. Fanzeres, L. A., “Ampliação da Consciência Situacional do Indivíduo Surdo através de Sistema de Reconhecimento de Sons do Ambiente”, M. Sc Thesis, UFRJ,

- December 16, 2014. (Luiz Wagner Pereira Biscainho and Adriana Santarosa Vivacqua).
9. Silva, A. F. da, "Determinação de Trajetória de Câmera para Detecção de Objetos Abandonados", M. Sc. Thesis, COPPE/UFRJ, March 04, 2015. (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
 10. Thomaz, L. A., "Abandoned Object Detection Using Operator-Space Pursuit", M. Sc. Thesis, COPPE/UFRJ, March 04, 2015. (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
 11. Frensch, Thiago, "Optimization of Automatic Highlight Detection for Football Broadcasts", M. Sc. Thesis, COPPE/UFRJ, March 30, 2015. (Sergio Lima Netto and Eduardo Antônio Barros da Silva).
 12. Costa, M. do V. M. da, "Sistemas de Consulta Cantarolada com Geração Automática de um Banco de Músicas Adaptativo, M. Sc. Thesis, COPPE/UFRJ, September 16, 2015. (Luiz Wagner Pereira Biscainho).
 13. Apolinário. I. F., "Contribuições a Métodos para Representação Tempo-Frequencial de Sinais de Música", M. Sc. Thesis, COPPE/UFRJ, September 18, 2015. (Luiz Wagner Pereira Biscainho).
 14. Gouvêa, G. M., "Representações Tempo-Frequenciais com Resolução Adaptativa com Aplicação em Áudio", M. Sc. Thesis, COPPE/UFRJ, March 28, 2016. (Luiz Wagner Pereira Biscainho and Wallace Alves Martins).
 15. Jordão, P. H. R., "Sistema de Recomendação de Músicas Usando LDA e Atributos de Áudio", M. Sc. Thesis, COPPE/UFRJ, March 30, 2016. (Luiz Wagner Pereira Biscainho and Gerson Zaverucha).
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 18. Maia, L. S., "Formalismos da Composição Algorítmica - Um Experimento com Canções Folclóricas Brasileiras", M. Sc. Thesis, COPPE/UFRJ, March 31, 2016. (Luiz Wagner Pereira Biscainho).
 19. López, R. Z., "On the Enhancement of Speech Dereverberation Algorithms Using Multiple Objective Assessment Measures", M. Sc. Thesis, COPPE/UFRJ, September 1, 2016 (Sergio Lima Netto and Thiago de Moura Prego).

20. Gois, J. N., “Fusão de Vídeos Utilizando Decomposições Multirresolução Espaço-Temporais”, M. Sc. Thesis, COPPE/UFRJ, September 16, 2016 (Eduardo Antônio Barros da Silva and Carla Liberal Pagliari).
21. Tavares, L. G. C., “Comparative Performance of Hvc-Based Codecs for Static Linearly-Arranged Light Fields”, M. Sc. Thesis, COPPE/UFRJ, September 21, 2016 (Eduardo Antônio Barros da Silva and Fernando Manuel Bernardo Pereira).
22. Verdun, C. M., “Compressive Sensing”, M. Sc. Thesis, Instituto de Matemática da UFRJ, December 2016 (Eduardo Antônio Barros da Silva, Cesar Javier Niche Mazzeo and Bernardo Freitas Paulo da Costa, from Instituto de Matemática, UFRJ).
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24. Andrade, I. G., “Sistemas de Transmissão Multiportadora Aplicados em um Canal Acústico Submarino na Presença de Efeito Doppler”, M. Sc. Thesis, COPPE/UFRJ, March 29, 2017 (Marcello Luiz Rodrigues de Campos)
25. Quintanilha, I. M., “End-to-End Speech Recognition Applied to Brazilian Portuguese Using Deep Learning”, M. Sc. Thesis, COPPE/UFRJ, March 30, 2017 (Luiz Wagner Pereira Biscainho and Sergio Lima Netto).
26. Costa, V. P. da, “Técnicas para Conversão de Orador em Sinais de Voz”, M. Sc. Thesis, COPPE/UFRJ, March 31, 2017 (Luiz Wagner Pereira Biscainho).
27. Ávila de Melo, M. M. de C. B., “Coded OFDM System for Underwater Acoustic Communications”, M. Sc. Thesis, Instituto Superior Técnico, May, 2017 (Paulo Sergio Ramirez Diniz and J. P. Gomes).
28. Qinghui Liu, “Deep Learning Applied to Automatic Polyp Detection in Colonoscopy Images”, M. Sc. Thesis, University College of Southeast Norway, 2017 (Sergio Lima Netto and António L. L. Ramos).
29. Braga-Brum, J. P., “Alineación entre Audio y Partitura para Obras del Repertorio de la Flauta Traversa”, M. Sc. Thesis, Universidad de la República, February 19, 2018 (Luiz Wagner Pereira Biscainho and Oswaldo Budón).
30. Silva, F. B. da, “Nonlinear Adaptative Equalization with Data Selection in VLC Systems”, M. Sc. Thesis, COPPE/UFRJ, March 08, 2018 (Wallace Alves Martins).
31. Chaves, R. da S., “Joint Precoding and Antenna Selection in Massive MIMO Systems”, M. Sc. Thesis, COPPE/UFRJ, March 16, 2018 (Wallace Alves Martins).

32. Carvalho, G. L. A., "Uso de Técnicas de Aprendizado de Máquina para Previsão de Falhas em Turbogeneradores", M. Sc. Thesis, COPPE/UFRJ, March 2018. (Sergio Lima Netto and Dr. Amaro A. de Lima)
33. Carvalho, L. F. V. de, "Contributions to Automatic Multiple of Detection in Polyphonic Music Signals", M. Sc. Thesis. COPPE/UFRJ, March 29, 2018 (Luiz Wagner Pereira Biscainho).
34. Mendonça, M. O. K., "Antenna Selection in Massive MIMO Based on Matching Pursuit", M. Sc. Thesis, COPPE/UFRJ, August 2018. (Paulo Sergio Ramirez Diniz and T. N. Ferreira)
35. Marins, M. A., "Machine Learning Techniques Applied to Hydrate Failure Detection on Production Lines". M. Sc. Thesis, COPPE/UFRJ, September 2018. (Eduardo Antônio Barros da Silva and Sergio Lima Netto)
36. Barros, B. D'Avila, "On Data Augmentation Techniques for The Automatic Detection of Mosquito Breeding Grounds Using Videos". M.Sc. Thesis, COPPE/UFRJ, February 2019, (Eduardo A. B. da Silva and Sergio Lima Netto)
37. Passos, W. L., "Automatic Aedes Aegypti Breeding Grounds Detection Using Computer Vision Techniques". M.Sc. Thesis, COPPE/UFRJ, February 2019. (Eduardo A. B. da Silva and Prof. Gabriel Matos Araújo, from CEFET-RJ)
38. Alves, G. de O. e, "A 4-D Discrete Cosine Transform-Based Light Field Coding Solution". M.Sc. Thesis, COPPE/UFRJ, March 2019. (Eduardo A. B. da Silva and Prof. Fernando Manuel Bernardo Pereira, from Instituto Superior Técnico de Lisboa)
39. Figueirêdo, R. S. de , "Abordagens para Análise e Extração de Características de Radares LPI". M.Sc. Thesis, COPPE/UFRJ, March 2019. (Eduardo A. B. da Silva and Dr.Sergio Rodrigues Neves, from Instituto de Pesquisas da Marinha)
40. Lordelo, C. P. V., "Automatic Removal of Music Tracks from TV Programmes", M.Sc. Thesis, COPPE/UFRJ, September 2018. (Luiz W. P. Biscainho)

6.2. D. Sc. Theses

1. Valdman, C., "Identificação de Sistemas Não Lineares Baseada no Algoritmo LAR: Proposta de um Critério de Parada Geométrico e sua Aplicação para a Consciência Situacional", D. Sc. Thesis, COPPE/UFRJ, February 12, 2014 (Marcello Luiz Rodrigues de Campos and José Antonio Apolinário Jr.).
2. Nunes, L. de O., "Algoritmos para Análise Rítmica Computacional", D. Sc. Thesis, COPPE/UFRJ, September 24, 2014 (Luiz Wagner Pereira Biscainho).

3. Szczupak, A. L., "Filtros Notch IIR Adaptativos: Adaptação de Largura de Banda e Rastreamento de Sinais Quasi-Harmônicos", D. Sc. Thesis, COPPE/UFRJ, December 19, 2014.(Luiz Wagner Pereira Biscainho).
4. Araújo, G. M., "Detection and Tracking of Facial Landmarks in High Definition Video Sequences", D. Sc. Thesis, COPPE/UFRJ, March 17, 2015 (Eduardo Antônio Barros da Silva).
5. Andrade Junior, J. F. de, "Filtragem Adaptativa com Solução Esparsa para Arranjo de Sensores", D. Sc. Thesis, COPPE/UFRJ, March 27, 2015 (Marcello Luiz Rodrigues de Campos and José Antonio Apolinário Junior).
6. Oliveira, T. R., "The Characterization of Hybrid PLC-wireless and PLC Channels in the Frequency Band Between 1.7 and 100 MHz for Data Communication", D. Sc. Thesis, UFJF, March, 2015 (Sergio Lima Netto and Dr. Moisés V. Ribeiro).
7. Carvalho, G. H. F. de, "Automatic Detection of Abandoned Objects with a Moving Camera using Multiscale Video Analysis", D. Sc. Thesis, COPPE/UFRJ, June 18, 2015 (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
8. Jorge, C. A. F., "Received Radiation Dose Assessment for Nuclear Plants Personnel by Video-Based Surveillance", D.Sc.Thesis, COPPE/UFRJ, June 25, 2015 (Eduardo Antônio Barros da Silva, José Manoel de Seixas and Antônio Carlos de Abreu Mól).
9. Henriques, F. da R., "Contributions to Energy Conservation in Wireless Sensor Networks", D. Sc. Thesis, COPPE/UFRJ, December, 2015 (Eduardo Antônio Barros da Silva and Lisandro Lovisolo).
10. Lucas, L. F. R., "Predictive Coding Algorithms for Lossy Image and Video Compression", D.Sc.Thesis, COPPE/UFRJ, January 29, 2016 (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
11. Borzino, A. M. C. R., "Processamento de Sinal de Áudio Proveniente de Disparo de Arma de Fogo e Aplicações", D. Sc. Thesis, IME, July 25, 2016 (Marcello Luiz Rodrigues de Campos and José Antonio Apolinário Junior).
12. Nakahata, M. T., "Anomaly Detection With a Moving Camera Using Spatio-Temporal Codebooks", D. Sc. Thesis, COPPE/UFRJ, September 16, 2016 (Sergio Lima Netto and Eduardo Antônio Barros da Silva).
13. Carvalho, H. T. de, "Bayes Meets Bach: Application of Bayesian Statistics to Audio Restoration", D. Sc. Thesis, COPPE/UFRJ, January, 2017 (Luiz Wagner Pereira Biscainho and Flávio Rainho Ávila).
14. Campos, R. S., "Contributions to Radio Frequency Indoor Positioning and Through-the-Wall Mapping", D. Sc. Thesis, COPPE/UFRJ, June 05, 2017 (Marcello Luiz Rodrigues de Campos and Lisandro Lovisolo).

15. Silva, R. C. da, "Towards Visualization and Searching: A Dual-Purpose Video Coding Approach", D. Sc. Thesis, COPPE/UFRJ, February 05, 2018 (Eduardo Antônio Barros da Silva and Fernando Manuel Bernardo Pereira).
16. Rocamora-Martínez, M., "Computational Methods for Percussion Music Analysis: The Afro-Uruguayan Candombe Drumming as a Case Study", D. Sc. Thesis, Universidad de la República, Uruguay, April 2018 (Luiz Wagner Pereira Biscainho, Luis Jure and Alvaro Pardo).
17. Yazdanpanah, H., "On Data-Selective Learning", D. Sc. Thesis, COPPE/UFRJ, March 23, 2018 (Paulo Sergio Ramirez Diniz and Markus Vinicius Santos Lima).
18. Gussen, C. M. G., "Underwater Acoustic Communication Under Doppler Effects", D. Sc. Thesis, COPPE/UFRJ, March 26, 2018 (Paulo Sergio Ramirez Diniz and Wallace Alves Martins).
19. Ribeiro, F. M. L., "Similarity-based Methods for Machine Diagnosis", D. Sc. Thesis, COPPE/UFRJ, August 2018. (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
20. Silva, E. C. J., "Anomaly Detection in Moving-camera Videos with Sparse and Low-rank Matrix Decompositions", D. Sc. Thesis, COPPE/UFRJ, September 2018. (Eduardo Antônio Barros da Silva and Sergio Lima Netto).
21. Thomaz, L. A.I., "The Use of Sparse Plus Low-rank Decomposition on Moving Object and Change Detection on Videos". D.Sc. Thesis, COPPE/UFRJ, December 2018. (Eduardo A. B. da Silva and Sergio Lima Netto)

7. Publications

7.1. Books

2014

1. Diniz, P. S. R., Silva, E. A. B. da, Netto, S. L., “Processamento Digital de Sinais- Análise e Projeto de Sistemas”, Cambridge University Press, vol 1, pp. 1-1000, 2^a edição, Porto Alegre, Bookman, 2014. ISBN: 9788582601235

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2. Lucas, L. F. R., Silva, E. A. B. da, Faria, S. M. M. de, Rodrigues, N. N. M., Pegliari, C. L., “Efficient Predictive Algorithms for Image Compression”, Springer International Publishing, Switzerland, 2017. ISBN: 978-3-319-51179-5. DOI: 10.1007/978-3-319-51180-1

7.2. Book Chapters

2014

1. Lovisollo, L., Silva, E. A. B. da, “Frames in Signal Processing”, In: Ramma Chellappa; Sergios Theodoridis. (Org.). Academic Press Library in Signal Processing - Signal Processing Theory and Machine Learning, 1ed., Chennai, Academic Press, vol. 1, pp. 561-590, 2014.

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2. Pagliari, C. L., da Silva, E. A. B., “Three-Dimensional Television (3DTV)”, In: Signals and Images: Advances and Results in Speech, Estimation, Compression, Recognition, Filtering, and Processing, Rosângela Fernandes Coelho, Vitor Heloiz Nascimento, Ricardo Lopes de Queiroz, João Marcos Travassos Romano, Charles Casimiro Cavalcante (Ed.), pp. 1-19, 2015. ISBN: 9781498722360
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4. Diniz, P. S. R., Widrow, B., "The History of Adaptive Filters", In: F. Maloberti and A. C. Davies, A Short History of Circuits and Systems, IEEE Circuits and Systems Society, pp. 81-86, 2016. ISBN: 9788793379718.

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2. Lovisolo, L., Pereira, M. P., Silva, E. A. B. da, Campos, M. L. R., "On the Design of Maximally Incoherent Sensing Matrices for Compressed Sensing and its Extension for Biorthogonal Bases Case", *Digital Signal Processing*, Elsevier, vol. 27, pp. 12-22, 2014. DOI: 10.1016/j.dsp.2014.01.006, ISSN: 1051-2004. A1
3. Silva, E. A. B. da, Lovisolo, L., Dutra, A. J. S., Diniz, P. S. R., "FIR Filter Design Based on Successive Approximation of Vectors", *IEEE Transactions on Signal*

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7.4. Refereed Papers Published in National Journals

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7.5. Refereed Papers Published in International Conferences

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31. Costa, M. do V. M. da, Biscainho, L. W. P., "Combining Time-frequency Representations for Music Information Retrieval", *Anais do Congresso de Engenharia de Áudio da AES-Brasil*, Florianópolis, Brazil, pp. 12-18, October 23-25, 2017. ISBN: 2177-529X.

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32. Passos, W. L., Dias, T. M., Alves Jr., H. M., Barros, B. D., Araujo, G. M., Lima, A. A., Silva E. A. B. da, and Netto, S. L., "Acerca da detecção automática de focos do mosquito *Aedes aegypti*", *Anais do Simpósio Brasileiro de Telecomunicações e Processamento de Sinais*, Campina Grande, Brasil, September 2018.
33. Quintanilha, I. M., Biscainho, L. W. P. and Netto, S. L., "A new automatic speech recognizer for Brazilian Portuguese based on deep neural networks and transfer learning", *Anais do Latin American Congress of the Audio Engineering Society*, Montevideo, Uruguay, September 2018.
34. Apolinário, I. F., Costa, M. do V. M. da, Biscainho, L. W. P., "Structure Tensor Applied to Parameter Estimation in the Fan-Chirp Transform", *Congreso Latinoamericano de Ingeniería de Audio de la AES*, Montevideú. Memorias del AES LAC 2018, 2018. p. 70-77.
35. Braga-Brum, J. P., Cancela-Aresqueta, P. A., Biscainho, L. W. P., "Alineación audio-partitura para música ejecutada con flauta traversa", *Congreso Latinoamericano de Ingeniería de Audio de la AES*, Montevideú. Memorias del AES LAC 2018, 2018. p. 45-52.

36. Costa, M. do V. M. da, Biscainho, L. W. P., “Combining Time-Frequency Representations via Local Sparsity Criterion”, *Congreso Latinoamericano de Ingeniería de Audio de la AES*, Montevidéo. Memorias del AES LAC 2018, 2018. p. 78-85.
37. Maia, L. S., Tomaz JR., P. D. de, Fuentes-Lujambio, M., Rocamora-Martinez, M., Biscainho, L. W. P., Costa, M. do V. M. da, Cohen, S., “A Novel Dataset of Brazilian Rhythmic Instruments and Some Experiments in Computational Rhythm Analysis”, *Congreso Latinoamericano de Ingeniería de Audio de la AES*, Montevidéo. Memorias del AES LAC 2018, 2018. p. 53-60.
38. Spelta, M. J. M., Martins, W. A., “Online temperature estimation using graph signals”, *XXXVI Simpósio Brasileiro de Telecomunicações e Processamento de Sinais (SBrT)*, 2018, Campina Grande, 2018. v. 1. p. 1-5.
39. Pinho, V. M., Chaves, R., Campos, M. L. R., “On Equalization Performance in Underwater Acoustic Communication”, *Anais do XXXVI Simpósio Brasileiro de Telecomunicações*, Campina Grande, 2018. p. 799-803.
40. Henriques, F. R., Lovisolo, L., da Silva, E. A. B., "Requirements for IoT Sensors Using Embedded Compressed Sensing Encoders with Deterministic Sensing Matrices", *XXXVI Simpósio Brasileiro de Telecomunicações e Processamento de Sinais*, pp. 286-290, Campina Grande, Brasil, September 2018.

8. Patents Granted

1. Campos, M. L. R., Pinho, R. T. D. A., Ciarlini, A. E. M., Bordignon, A. L. “Content-Aware Compression of Data Using Selection from Multiple Weighted Prediction Functions.” Instituição de registro: United States Patent and Trademark Office. Depósito: 29/11/2016; Concessão: 16/10/2018. Pat. no. 10,103,745.
2. Bordignon, A. L., Ciarlini, A. E. M., Campos, M. L. R., Pinho, R. T. D. A., “Content-Aware Compression of Data Using Multiple Parallel Prediction Functions.” Instituição de registro: United States Patent and Trademark Office. Depósito: 25/03/2016; Concessão: 20/11/2018. Pat. no. 10,133,551.
3. Bordignon, A. L., Campos, M. L. R., Ciarlini, A. E. M., Pinho, R. T. D. A., “Content-Aware Compression of Floating-Point Time-Series Data Using Multiple Prediction Functions and Estimated Bit-Savings Thresholds.” Instituição de registro: United States Patent and Trademark Office. Depósito: 25/04/2017, No. registro: 15/496528. Concessão: 11/12/2018.

9. Recent Professional Activities

Eduardo Antonio Barros da Silva

- Guest Editor of the Special Issue on Challenges, Trends and Solutions for 3-D, Multidimensional Systems and Signal Processing, Springer, 2011/2012.
- Guest Editor of the Special Issue on ISCAS 2011, IEEE Transactions on Circuits and Systems - Part I.
- Associate Editor, IEEE Transactions on Circuits and Systems - Part I, 2008 and 2009.
- Associate Editor, Multidimensional Systems and Signal Processing, 2006 to date.
- Associate Editor, IEEE Transactions on Circuits and Systems - Part II, 2006 and 2007.
- Associate Editor, IEEE Transactions on Circuits and Systems - Part I, 2002 and 2003.
- Member of the IEEE Publication Services and Products Board (PSPB) Strategic Planning Committee, 2013.
- Member of the IEEE CASS Board of Governors, 2012 to 2014.
- Counselor of the IEEE Student Branch from Universidade Federal do Rio de Janeiro, 2003 to 2009.
- Member CASS Guillemin-Cauer and Darlington Awards Committee, IEEE CASS - 2010 and 2011.
- Member of the "Regional Activities Division" from IEEE Circuits and Systems Society, 2012 to 2014.
- Member of the "Finance Division" from IEEE Circuits and Systems Society, 2012 to 2014.
- Member of the "Membership Survey Committee" from IEEE Circuits and Systems Society, 2012.
- Member of the "Meritorious Service Award Committee" from IEEE Circuits and Systems Society, 2012 and 2013.
- Member of the "Chapters of the Year Awards Committee" from IEEE Circuits and Systems Society, 2012 and 2013. Gelson Vieira Mendonça
- Reviewer for IEEE Transactions on Image Processing; SBA Controle & Automação; Brazilian Telecommunication Symposium- SBT.
- Consulting member for the State Agency for Research Support: FAPERJ and FAPESP; Brazilian National Research Council: CNPq, CAPES.

Luiz Wagner Pereira Biscainho

- Conference Chair for Congresso Brasileiro de Engenharia de Áudio (AES-Brasil), 2004/2005.
- Reviewer for Book: Advances in Audio and Speech Signal Processing (IGI), 2006.
- Reviewer for Journal: Circuits, Systems, and Signal Processing (Springer), 2006.
- Reviewer for IEEE Transactions on Circuits and Systems II, 2006.
- Reviewer for IEEE Transactions on Signal Processing, 2006.

- Reviewer for Brasileira de Engenharia Biomédica (Sociedade Brasileira de Engenharia Biomédica), 2006.
- Reviewer for Sociedade Brasileira de Telecomunicações, 2006.
- Reviewer for Conference IEEE Symposium on Circuits and Systems, 2006.
- Reviewer for Conference IEEE International Conference on Communications, 2006.
- Reviewer for Conference IEEE South-American Workshop on Circuits and Systems, 2006.
- Reviewer for International Telecommunications Symposium, 2006.
- Reviewer for Conference Simpósio Brasileiro de Telecomunicações (SBrT), 2006.
- Reviewer for Congresso Brasileiro de Engenharia de Áudio (AES-Brasil), 2006.
- Technical Program Committee Chair for Congresso Brasileiro de Engenharia de Áudio (AES-Brasil), 2006.

Marcello Luiz Rodrigues de Campos

- Director for Latin America, IEEE Communications Society. 2000-2001.
- Local Arrangements Co-Chair of the 1999 Edition of IEEE GLOBECOM, Rio de Janeiro, December 1999.
- Rio de Janeiro local co-chair for the First IEEE South-American Workshop on Circuits and Systems (SAWCAS'2000).
- Reviewer for IEEE Press, IEEE Trans. on Circuits and Systems PII, IEEE Trans. on Signal Processing, IEEE Signal Processing Letters, and several international and local conferences.
- Consulting member for the Rio de Janeiro State Agency for Research Support (FAPERJ).
- Department Vice-chair, Electrical Engineering Program, COPPE/UFRJ, 2004.
- Department Chair, Electrical Engineering Program, COPPE/UFRJ, 2005.
- Finance Chair, SPAWC 2008.
- Plenary-Session Co-Chair, ISCAS 2011.
- Technical Program Co-Chair, SBrT 2013.
- Senior Member, IEEE.

Paulo Sergio Ramirez Diniz

- Reviewer for: IEEE (several Transactions including CAS, and SP); IEEE Signal processing Letters; Electronics Letters; IET etc.
- Member of the Fellow and some Awards Committee of the CAS Society.
- General Co-Chair do 2011 --- IEEE International Symposium on Circuits and Systems (ISCAS-2011), realizado no Rio de Janeiro em 15-18 maio de 2011.
- Associate Editor of the IEEE Transactions on Signal Processing, from October 1999 to December 2002.
- Associate Editor of the Circuits, Systems and Signal Processing Journal, from October 1999 to December 2002.
- Distinguished Lecturer of the IEEE Circuits and Systems Society, During 2000 and 2001.

- Member of the Digital Signal Processing Technical Committee of the IEEE Transactions on Circuits and Systems - from 1997 to 2012. He has served as secretary in 1998 and 1999, and as Chairman 2000-2002.
- Member of the Editorial Board of the Circuits, Systems and Signal Processing, Birkhauser, starting 2002.
- Member of the Editorial Board of the IEEE Circuits and Systems Magazine 2001-2003.
- Distinguished Lecturer of the IEEE Signal Processing Society, During 2004.
- Diniz, P. S. R. - Fellow of IEEE - The Institute of Electrical and Electronics Engineers. - Citation: For fundamental contributions to the design and implementation of fixed and adaptive filters and Electrical Engineering Education 2005-2006.
- Membro do comitê assessor de Engenharia Elétrica do CNPq - 1995 à 1998 e de 2009 à 2013.
- Membro de banca de promoção de docentes nas seguintes universidades: Universidade de Macau, Sultan Qaboos University, Nanyang Technological University, University of Santa Clara, John Hopkins University, Tampere University of Technology, Illinois Institute of Technology.

Sergio Lima Netto

- Special Session co-chair for IEEE Int. Symposium on Circuits and Systems, Rio de Janeiro, Brazil, 2011.
- Rio de Janeiro Chapter Chair for the IEEE Circuits and Systems Society (2010-2011).
- Rio de Janeiro local co-chair for the First IEEE South-American Workshop on Circuits and Systems (SAWCAS'2000).
- Vice-President elect for IEEE Circuits and Systems Society in Region 9 (Latin America) (for 2002-2003).
- IEEE Senior Member (from July 2004 on).
- IEEE Circuits and Systems Society Guillemin-Cauer Award for paper M. B. Furtado, Jr., P. S. R. Diniz, S. L. Netto, and T. Saramäki, "On the design of high complexity cosine-modulated transmultiplexers based on the frequency-response masking," IEEE Trans. Circuits and Systems, Part I: Regular Papers, vol. 52, no. 11, pp. 2413-2426, Nov. 2005. ISSN: 1057-7122.
- Academic Dean for the Electrical Engineering Program at COPPE/UFRJ (2005).
- Associate Editor of Journal on Circuits, Systems, and Signal Processing (from July 2002 to May 2005).
- Associate Editor for IEEE Transactions on Circuits and Systems, Part II: Express Letters (from October 2004 to March 2006).

Wallace Alves Martins

- Reviewer for: IEEE Communications Letters,
- IEEE Transactions on Vehicular Technology,
- IEEE Transactions on Signal Processing,
- IEEE Transactions on Circuits and Systems - I,
- IEEE Transactions on Wireless Communications,

- EURASIP Journal on Wireless Communications and Networking, and Signal Processing, in addition to many IEEE sponsored conferences, such as ICC, ICASSP, ISWCS, and SPAWC.
- TPC Member of Brazilian Telecommunications Symposium (SBRT-2013).

10. Research Grants Obtained

1. Young Scientist of Rio de Janeiro granted by FAPERJ to Sergio Lima Netto. Project Speech Processing and Filter Banks for Communications Systems, number E-26/150.358/2002, 2002-2003.
2. Universal Edital granted by CNPq to Marcello Luiz Rodrigues de Campos. Project *FARAAA / Constrained Adaptive Filtering: Algorithms, Analyses, and Applications*, number 477770/2003-7, 2003.
3. Research support to project granted by CNPq to Paulo Sergio Ramirez Diniz. Project *Communications and Information Processing Technology for Applications in Public Security*, number 55.2038/2002-4, 2003-2005. It is a program for funding research, development and innovation related to information technology. The grant amounted of an over US\$ 300 000.
4. Research support to project granted by CNPq to Marcello Luiz Rodrigues de Campos. Project *BEAMA / Adaptive Beamformer - Implementation of Algorithms for A Estimation and Spatial Filtering*, number 503356/2004-2, 2004.
5. Universal Edital granted by CNPq to Eduardo Antonio Barros da Silva. Project *Intelligent Coding for Video, Images, Speech and Audio (CIVIVA)*, number 471880/2003-5, 2004-2005.
6. Universal Edital granted by CNPq to Marcello Luiz Rodrigues de Campos. Project *FAR / Constrained Adaptive Filtering: Applications to Smart Antennas*, number 474765/2004-0, 2005.
7. Project H264BRASIL, towards the definition of the Brazilian Digital Television System, with other 9 Brazilian Universities (COPPE/UFRJ, PUC-Rio, UFF, IME, UNICAMP, UnB, UFRGS, UFRN, CEFET-CE), Eduardo Antonio Barros da Silva, 2005.
8. Young Scientist of Rio de Janeiro granted by FAPERJ to Luiz Wagner Pereira Biscainho, number E-26/170.582/2004, 2004-2006.
9. Scientist of Rio de Janeiro granted by FAPERJ to Eduardo Antonio Barros da Silva. Project number E-26/151.992/2004, 2005-2007.
10. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project number E-26/152.398/2002, 2002-2007.
11. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project number E-26/152.754/2006, 2007-2009.

12. Universal Edital granted by CNPq to Eduardo Antonio Barros da Silva. Project *Multimedia Processing for Entertainment and Communications (PROMET)*, number 475283/2006-6, 2007-2008.
13. Universal Edital granted by CNPq to Marcello Luiz Rodrigues de Campos. Project *MIMO Systems for Cooperative Mobile Communications*, number 478282/2007-9, 2007-2008.
14. Research support to project granted by MCT/FINEP/INFO – SOFTWARE 01/2005 to Paulo Sergio Ramirez Diniz. Project *Software System for Voice Over Internet Protocol - MARITACA*, number 01.05.07.14.01, 2006-2009.
15. Universal Edital granted by CNPq to Paulo Sergio Ramirez Diniz. Project *Communications Systems to Signal Processing*, number 474334/2008-2, 2009-2011.
16. Universal Edital granted by CNPq to Eduardo Antônio Barros da Silva. Project *Multimedia Processing to Entertainment and Telecommunications*, number 476651/2008-5, 2009-2011.
17. Young Scientist of Rio de Janeiro granted by FAPERJ to Luiz Wagner Pereira Biscainho, number E-26/ 103.098 / 2008, 2009- 2012.
18. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project number E-26/ 102.921/2008, 2009-2012.
19. Universal Edital granted by CNPq to Sergio Lima Netto. *Applications of High-Selectivity Filter Banks*, number 473180/2007-3, 2008-2009.
20. Research support to project granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Digital Signal Processing*, number E-26/110.757/2009 - APQ1, 2009-2011.
21. Scientist of Rio de Janeiro granted by FAPERJ to Eduardo Antônio Barros da Silva. Project number E-26/ 102.367/ 2009, 2009-2012.
22. Support to Teaching and Research Institute of Rio de Janeiro, granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Advanced Applications of Signal Processing: Communications and Multimedia*, number E-26/111.755/2011, 2011-2013.
23. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project number E-26/103.133/2011, 2012-2016.
24. Universal Edital granted by CNPq to Eduardo Antônio Barros da Silva. Project *Multimedia Processing to Entertainment and Telecommunications*, number 473951/2011-8, 2012-2014.
25. Udelar Program granted by CAPES to Luiz Wagner Pereira Biscainho. Project *Signals and Music Analysis*, number 037/2011, 2012-2013.
26. Universal Edital granted by CNPq to Paulo Sergio Ramirez Diniz. Project *Signals and Optimization Processing to Communications Systems*, number 471174/2011-4, 2012-2014.

27. Scientist of Rio de Janeiro granted by FAPERJ to Eduardo Antônio Barros da Silva. Project number E-26/102.779/2012, 2012-2016.
28. Universal Edital granted by CNPq to Sergio Lima Netto. Project *Advanced Applications of Speech / Audio Processing*, number 471475/2012-2, 2013-2016.
29. Universal Edital granted by CNPq to Luiz Wagner Pereira Biscainho. Project *Restoration and Evaluation of Audio Quality*, number 474678/2012-1, 2013-2016.
30. Supporting Institutions Headquartered in the State of Rio de Janeiro, granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Advanced Applications of Signal Processing: Communications and Multimedia*, number E-26/111.755/2011, 2011-2013.
31. Research support to project granted by FAPERJ to Marcello Luiz Rodrigues de Campos. Project *Adaptive Filters with Low Power and Cooperation in Selective Signal Processing Distributed*, number E-26/111.959/2012- APQ1, 2013-2014.
32. Research Support by the Centro de Pesquisa e Desenvolvimento Leopoldo Américo Miguêz de Mello (CENPES/Petrobras-UFRJ) to Marcello L. R. de Campos. Project *Deep Water Subsea Acoustic Communications*, 2013-2015.
33. Thematic Project Support in the State of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Signal, Multimedia and Telecommunications*, number E-26/110.187/2013, 2013-2016.
34. Engineering Support Program granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Signal, Multimedia and Telecommunications*, number E-26/111.080/2013, 2013-2015.
35. Signal Processing Applications for Communications with Reduced Redundancy and for Acoustic Source/sensor Localization - Capes Ph.D. Dissertation Award 2012 – CAPES, 23.038.009440/2012-42 e 49/2014, 2014-2016.
36. Signal processing applications in defense - Pró-Defesa – CAPES, 23038.009094/2013-83 e 2992/2013, 2014 – 2016.
37. Subsea communications - CSUB (SMT/PEE/COPPE, MB/IEAPM e LIOC/PENO/COPPE) - Coordination MB/IEAPM – FINEP, 45, 2014-2016.
38. Industrial applications of signal processing: monitoring, modeling and optimization - Support for Educational Institutions and Research in the State of Rio de Janeiro - FAPERJ, E-26/010.002897/2014, 2014-2016.
39. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project Signal processing theory with applications in communications. Number E-26/210.390/2014, 2014-2018.
40. Universal Edital granted by CNPq to Wallace Alves Martins. Project *Using Communication Channels Efficient Wireless*, number 453868/2014-2, 2015-2017.

41. Scientist of Rio de Janeiro granted by FAPERJ to Eduardo Antônio Barros da Silva. Project *Multimedia signal processing*, number E-26/202.932/2015, 2015-2018.
42. Young Scientist of Rio de Janeiro granted by FAPERJ to Wallace Alves Martins. Project *Improvements in the wireless channel usage, source and sensor localization, and signal recovery*, number E-26/202.890/2015, 2015-2018.
43. PRONEX by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Signal processing in multimedia, communication and intelligent instrumentation*, number E-26/010.00129/2016, 2016-2020.
44. Support to Emerging Research Groups in the State of Rio de Janeiro by FAPERJ to Wallace Alves Martins. Project *Intelligent signal processing in multidisciplinary areas*, number E-26/010.001573/2016, 2016-2020.
45. Universal Edital granted by CNPq to Eduardo Antônio Barros da Silva. Project *Multimedia processing for entertainment, telecommunications and industry*, number 407842.2016-0, 2017-2020.
46. Universal Edital granted by CNPq to Paulo Sergio Ramirez Diniz. Project *Signal processing and applications in communications*, number 420623/2016-7, 2017-2020.
47. Scientist of Rio de Janeiro granted by FAPERJ to Paulo Sergio Ramirez Diniz. Project *Signal processing and adaptive systems with communications applications*. Number E-26/202.823/2017, 2018-2021.
48. Scientist of Rio de Janeiro granted by FAPERJ to Eduardo Antônio Barros da Silva. Project *Multimedia signal processing*, number E-26/202.856/2018, 2018-2021.
49. Young Scientist of Rio de Janeiro granted by FAPERJ to Wallace Alves Martins. Project *Digital Signal Processing on Graphs and for Broadband Communications*, number E-26/202.676/2018, 2018-2021.

11. Summary of Achievements

	2014-2019
M.Sc.	40
D.Sc.	21
Books	2
Books Edited	0
Chapters Books	6
Refereed Papers Published in Journals	59
Refereed Papers Published in National Journals	01
Refereed Papers Published in International Conferences	75
Refereed Papers Published in National Conferences	40
Patents Granted	3