SONY AKKARAKARAN

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OBJECTIVE

A research & development position in the broad area of communications and digital signal processing.

EDUCATION

California Institute of Technology — Pasadena, California
Ph.D. degree in Electrical Engineering — June 2001
Thesis : Filter bank optimization for noise suppression and communications
Advisor : Professor P. P. Vaidyanathan

California Institute of Technology — Pasadena, California
M.S. degree in Electrical Engineering — June 1997
Field of specialization : Digital Signal Processing — GPA : 4/4

Indian Institute of Technology — Bombay, India
B.Tech. degree in Electrical Engineering — June 1996
Graduated ranked third in a class of 60
Senior Projects:
Design of Audio Codec using Wavelets. (Advisor: Prof. U.B. Desai, I.I.T. Bombay)
Study of Routing Strategies for Telecommunication Networks.
(Advisor: Prof. P.G. Poonacha, I.I.T. Bombay)

RESEARCH INTERESTS:

Digital communications, wireless communications, digital signal processing, filter banks and wavelets

EXPERIENCE

Sequoia Communications — Los Angeles, August 2001-2003
San Diego, September 2003-present

I was on a team designing and implementing the physical layer algorithms for baseband units of mobile terminals supporting the **WCDMA** and **CDMA2000** standards. I also worked on interfacing issues between the baseband and RF units, and on modelling of some modules of the RF unit. Specific projects / tasks conducted or participated in include:

- **Cell-Search:** Design and C++ simulation of algorithms to acquire the WCDMA base-station scrambling code using the primary and secondary synchronization codes.
- **Matched Filtering:** Design of an algorithm to optimize the SNR loss due to non-ideality of the matched filter, subject to a constraint on the filter implementation complexity. Filter taps were realized using the efficient canonical-signed-digits representation. The algorithm is flexible and allows imposing constraints on out-of-band attenuation, necessary to meet the standard specifications.

- **Rake receiver, path searcher and finger manager:** Involved in design of these modules. Optimized the channel estimation filter time-constant for different mobile speeds. Tested an algorithm to estimate the mobile speed and accordingly choose this time-constant.
- **Antenna diversity:** Simulation of various schemes for combining information from two receiver antennas, such as antenna switching and combining the outputs of two independent Rake receivers.
- **Quantization:** Through simulations, determined the bit-widths required for various registers in the cell-search, matched filter and Rake receiver modules.
- **AGC:** Designed the automatic gain control module that outputs a pulse-width modulated (PWM) control signal to the RF amplifier. Determined the parameters such as time-window for power measurement, maximum pulse-width duration and filtering required on the PWM waveform. The parameters were chosen based on the resulting performance of the overall receiver.
- **Polar modulator modeling:** Built a time-domain C++ model for a RF polar modulator consisting of an oscillator in a phase-locked loop with fractional divide ratio implemented using a sigma-delta modulator.
- **Rectangular to polar conversion:** This module is necessary to interface a baseband processor outputting in-phase and quadrature components with a RF polar modulator that requires amplitude and frequency inputs. Determined the complexity (number of bits required) for an implementation of this module based on a lookup table. Determined the sampling rate and designed the filters required for an alternative implementation of this interface using a 1-bit sigma-delta modulator.
- **HDL coding and cycle-true simulations:** Maintenance and debugging of the verilog HDL code for some modules such as Rake receiver and matched filter. Running cycle-true C++ simulations and verifying match between the C++ and verilog models.
- **GUI design:** Involved in design and maintenance of the graphical user interface (using C++ Microsoft Foundation Classes) for running simulations of the WCDMA baseband receiver.

RESEARCH

Research assistant, California Institute of Technology 1997-2001

- Developed a unified theory of optimal orthonormal filter banks. Proved optimality of principal component filter banks for a large family of signal processing problems. Showed the fundamental reason for this optimality.
- The work leads to solutions for the optimal transforms for use in discrete multitone (DMT) communications. For given channel error probabilities, these transforms minimize the total transmitted power for a given total bitrate, and maximize total bitrate for a given total transmitted power.
- The work develops optimal transforms for many white noise suppression problems, including Wiener filtering and thresholding of subbands. When the noise is colored, showed that principal component forms have a more restricted optimality. Developed algorithms to approximate the optimal transform as closely as desired. The algorithms are especially efficient for transforms with small number of channels.
- Developed the first coherent theory of principal component forms for nonuniform filter banks. Contributed towards a complete theory of perfect reconstruction in nonuniform filter banks.
- Developed the first analytical proofs of nonexistence of principal component forms for certain classes of filter banks. Explained how such nonexistence usually makes finding the exact optimal filter bank analytically intractable.
- Used the bifrequency description to analyze the action of multirate systems on stochastic inputs. Showed that this leads to simple and elegant solutions to many otherwise complicated problems involving conditions for stationarity of the system output.

TEACHING

Instructor, California Institute of Technology 1999
Conducted a graduate level course on digital signal processing for two academic terms.

Teaching assistant, California Institute of Technology 1996-2001
Assisted in teaching the following courses:

- Digital Signal Processing Principles
- Multirate Systems, Filter Banks, and Wavelets
- Optimal Signal Processing, Quantization, and Compression
- Adaptive Signal Processing

SUMMER PROJECTS

SAMEER, Bombay, India Summer 1995
A microwave engineering research laboratory. Built software for electromagnetic simulation using the beam propagation method.

Indian Institute of Technology, Bombay Summer 1994
Studied and implemented 'shape from shading' algorithms in image processing.

SKILLS

- Software packages: Matlab, Mathematica, LATEX, Microsoft Office
- Programming languages : C, C++, Verilog HDL, Fortran, Assembly Language
- Operating Systems : UNIX, MSDOS, Windows

ACTIVITIES

- Member of the Institute of Electrical and Electronics Engineers (IEEE). Member of the IEEE Signal Processing and Communication Societies.
- Active as a reviewer for several engineering journals and conferences, including the IEEE Transactions on Signal Processing and Circuits and Systems, the IEEE Signal Processing Letters, Applied and Computational Harmonic Analysis Journal, and IEEE International Conference on Communications.
- Strong interest in music — whistle, play the violin and harmonica.
- Interested in hiking, skiing, table–tennis, swimming, figure-skating.

REFERENCES

- Dr. Dariush Divsalar, Jet Propulsion Laboratory. (dariush@shannon.jpl.nasa.gov)
- Tom Hardin, Sequoia Communications. (thardin@sequoia-communications.com)
- Dr. P.P. Vaidyanathan, California Institute of Technology. (ppvnath@systems.caltech.edu)

LIST OF PUBLICATIONS

Journal Publications :

- S. Akkarakaran and P. P. Vaidyanathan, "Filter bank optimization with convex objectives, and the optimality of principal component forms," *IEEE Trans. Signal Processing,* vol. 49, no. 1, Jan. 2001, pp. 100-114.
- S. Akkarakaran and P. P. Vaidyanathan, "Results on principal component filter banks: colored noise suppression and existence issues," *IEEE Trans. Inform. Theory,* vol. 47, no. 3, Mar. 2001, pp. 1003-1020.
- S. Akkarakaran and P. P. Vaidyanathan, "Bifrequency and bispectrum maps: a new look at multirate systems with stochastic inputs," *IEEE Trans. Signal Processing,* vol. 48, no. 3, Mar. 2000, pp. 723-736.
- P. P. Vaidyanathan and S. Akkarakaran, "A review of the theory and applications of principal component filter banks," *Appl. Comput. Harmonic Analysis,* vol. 10, no. 3, May 2001, pp. 254-289.
- P. P. Vaidyanathan, Y.-P. Lin, S. Akkarakaran, and S.-M. Phoong, "Discrete multitone modulation with principal component filter banks," *IEEE Trans. Circuits and Systems–I,* vol. 49, no. 10, Oct. 2002, pp. 1397-1412.

Book Chapter :

- S. Akkarakaran and P. P. Vaidyanathan, "Nonuniform filter banks: New results and open problems," in '*Beyond Wavelets*', G. V. Welland, Ed., Academic Press, 2003.

Conference Publications :

- S. Akkarakaran and P. P. Vaidyanathan, "New insights into multirate systems with stochastic inputs using bifrequency analysis," in *Proc. IEEE Int. Symp. Circuits and Systems,* Monterey, CA, June 1998.
- S. Akkarakaran and P. P. Vaidyanathan, "New results and open problems on nonuniform filter-banks," in *Proc. IEEE Int. Conf. Acoust. Speech, and Signal Proc.,* Phoenix, AZ, Mar. 1999.
- S. Akkarakaran and P. P. Vaidyanathan, "Optimized orthonormal transforms for SNR improvement by subband processing," in *IEEE Workshop on Signal Proc. Advances in Wireless Comm.,* Annapolis, MD, May 1999.
- S. Akkarakaran and P. P. Vaidyanathan, "On optimization of filter banks with denoising applications," in *Proc. IEEE Int. Symp. Circuits and Systems,* Orlando, FL, June 1999.
- S. Akkarakaran and P. P. Vaidyanathan, "The best basis problem, compaction problem and PCFB design problems," in *Proc. IEEE Int. Symp. Circuits and Systems,* Orlando, FL, June 1999.
- S. Akkarakaran and P. P. Vaidyanathan, "The role of principal component filter banks in noise reduction," in *Proc. SPIE,* Denver, CO, July 1999.
- S. Akkarakaran and P. P. Vaidyanathan, "Principal component filter banks: existence issues, and application to modulated filter banks," in *Proc. IEEE Int. Symp. Circuits and Systems,* Geneva, May 2000.
- S. Akkarakaran and P. P. Vaidyanathan, "On Nonuniform Principal Component Filter Banks: Definitions, Existence and Optimality," in *Proc. SPIE,* San Diego, CA, July 2000.
- S. Akkarakaran and P. P. Vaidyanathan, "Are Nonuniform principal component filter banks optimal?", in *Proc. EUSIPCO,* Tampere, Finland, Sept. 2000.
- P. P. Vaidyanathan, Y.-P. Lin, S. Akkarakaran, and S.-M. Phoong, "Optimality of principal component filter banks for discrete multitone communication systems," in *Proc. IEEE Int. Symp. Circuits and Systems,* Geneva, May 2000.

- Y.-P. Lin, P. P. Vaidyanathan, S. Akkarakaran, and S.-M. Phoong, "On the duality of optimal DMT systems and biorthogonal subband coders," in *Proc. IEEE Int. Conf. Acoust. Speech, and Signal Proc.,* Istanbul, Turkey, June 2000.
- P. P. Vaidyanathan, Y.-P. Lin, S. Akkarakaran, and S.-M. Phoong, "Optimizing the capacity of orthogonal and biorthogonal DMT channels," in *Proc. EUSIPCO,* Tampere, Finland, Sept. 2000.
- S. Akkarakaran and P. P. Vaidyanathan, "On optimal transforms for subband domain suppression of colored noise," in *Proc. IEEE Int. Conf. Acoust. Speech, and Signal Proc.,* Salt Lake City, UT, May 2001.
- S. Akkarakaran and P. P. Vaidyanathan, "Discrete multitone communication with principal component filter banks," in *Proc. Int. Conf. Comm.,* Helsinki, Finland, June 2001.

OTHER ACHIEVEMENTS

- Won the prestigious J.N.Tata scholarship for the higher education of Indians (1996).
- Selected to the director's honor list for being among the top 10 students in the university (I.I.T. Bombay) in the first year of the B.Tech program.
- Ranked 328 in the nationwide joint entrance examination (1992) for admission to the undergraduate program in the Indian Institute of Technology.
- Within top 100 in the National Standards Examination in Physics (1992).