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PROFESSIONAL TIMELINE

Associate Research Specialist (1993–present), **Visiting Faculty** (2004–2006), **Visiting Postdoctoral Computer Scientist** (1991–1993), University of California at Berkeley, Computer Science Division.

Visiting Associate, California Institute of Technology, (1994–1997).

Research Assistant Professor, University of Colorado at Boulder, Department of Electrical and Computer Engineering (1990–1991).

Education: Ph.D. (June 1990) and M.S. (June 1986) in Computer Science, California Institute of Technology (Advisor: Carver Mead). B.S., Electrical Engineering and B.S., Computer Science, University of Pennsylvania, May 1984.

TEACHING

Since 2009, served as a member of a team that teaches a graduate course in VLSI systems design (CS250) each Fall. Organized class projects and presented lectures in an undergraduate digital systems design project class (CS 194-6, Fall 2008). Taught (Fall 2006, Fall 2005, and Spring 2005) and co-taught (Fall 2004, with Professor David Patterson) an upper-division undergraduate course, Computer Architecture and Engineering (CS152). In Spring 2006, co-taught a graduate music course (Music 209) with Professor David Wessel. In Spring 1994, taught a graduate course on VLSI systems design (CS250).

MAJOR RESEARCH FOCUS

My current research activity, in collaboration with John Wawrzynek, focuses on providing guidance to graduate-student research projects in the CS department. Recent assignments include guiding Alex Krasnov's research in passive sonar algorithms, and assisting in the planning of a new ASIC design research effort in the CS department (including the integration of an ASIC design flow into the Fall 2009 version of CS 250). I also assist Professor David Wessel with his computer systems collaborations with the PAR lab.

A recently completed research project, also in collaboration with John Wawrzynek, focused on the development of the RTP MIDI networking protocol. RTP MIDI, an RTP payload format for the MIDI command language, is a Proposed Standard protocol (RFC 4695 and RFC 4696) of the Internet Engineering Task Force (IETF). Standards associated with RTP MIDI are also under development by the MIDI Manufacturers Association (MMA). RTP MIDI is the transport protocol for Apple Computer's MIDI Network Driver, a part of Mac OS X since the Tiger release.

The Web page <http://www.cs.berkeley.edu/~lazzaro/rtpmidi/> describes this research in more detail.

RTP MIDI grew out of our research in network musical performance (NMP). NMP occurs when musicians who are in different locations interact over a network as if they were in the same room. Our work focuses on multimedia networking, low-latency real-time environments, and compiler optimization techniques, and builds on IETF (RTP, SIP, SDP), MPEG (Structured Audio), and MMA (MIDI) standards.

The Web page <http://www.cs.berkeley.edu/~lazzaro/sa/> describes this research in more detail.

Before this audio project, I worked (in collaboration with John Wawrzynek) on neural-network algorithms for reducing visual artifacts in JPEG images via transcoding. Our algorithm works directly on the compressed representation, turning a small JPEG file with many artifacts into a larger JPEG with fewer artifacts. The

problem and the algorithm were both chosen to be a good fit for reconfigurable computing hardware, as small, irregularly-sized JPEG coefficients are the underlying data type the system uses.

The Web page <http://www.cs.berkeley.edu/~lazzaro/jqt/> describes this research in more detail.

Before my JPEG research, I spent 15 years (my undergraduate and graduate school years, and many of my Berkeley years) working on the design of real-time, low-power analog VLSI systems to model biological auditory processing, and the engineering applications of these implementations.

The Web page <http://www.cs.berkeley.edu/~lazzaro/biblio/index.html> describes the analog VLSI research in more detail.

OTHER RESEARCH PROJECTS

I served on the management team of T0, a digital vector microprocessor project at Berkeley. I participated in weekly design review meetings, and reviewed project reports (but did no actual design), as the chip progressed through several architectural redefinitions, final architecture freeze, circuit schematic freeze, layout freeze, tapeout, successful first silicon, and successful prototype board operation.

The Web page <http://www.icsi.berkeley.edu/real/spert/t0-intro.html> describes this research in more detail.

For my Master's thesis at Caltech, I designed and implemented **ana**, a functional simulator for analog VLSI circuits. The program, about 35,000 lines of C source code running under the X Window System, works in conjunction with the schematic editor LOG. Together, ana and LOG implement a simulated laboratory bench, where system topology and parameter values can be altered without stopping a simulation. See the web page <http://www.cs.berkeley.edu/~lazzaro/chipmunk> to download the system and learn about the tools.

PROFESSIONAL SERVICE

Implementations Area Chair, Neural Information Processing Systems (NIPS) Conference, 1999, 1994, and 1993. I selected reviewers and made final accept/reject recommendations for implementations papers.

Tutorial Chair, Neural Information Processing Systems (NIPS) Conference, 1996. Selected presenters and introduced speakers.

Treasurer, Neural Information Processing Systems (NIPS) Conference, 1995. Handled the ledger for a six-figure conference budget.

Tutorial Presenter, Neural Information Processing Systems (NIPS) Tutorial, 1993. Presented a 2-hour tutorial on VLSI Implementations, and prepared a 100-page tutorial booklet (bibliography and selected papers) for the attendees.

STANDARDS DOCUMENTS

Lazzaro, J. and Wawrzynek, J. (2011). RTP Payload Format for MIDI, RFC 6295, IETF Proposed Standard Protocol.

Lazzaro, J. and Wawrzynek, J. (2006). RTP Payload Format for MIDI, RFC 4695, IETF Proposed Standard Protocol.

Lazzaro, J. and Wawrzynek, J. (2006). An Implementation Guide for RTP MIDI, RFC 4696, IETF Standards Track (Informational).

Lazzaro, J. (2006). Framing Real-time Transport Protocol (RTP) and RTP Control Protocol (RTCP) Packets over Connection-Oriented Transport, RFC 4571, IETF Proposed Standard Protocol.

JOURNAL PUBLICATIONS

- Lazzaro, J. and Wawrzynek, J. (1999). JPEG Quality Transcoding Using Neural Networks Trained with a Perceptual Error Measure. *Neural Computation*, Vol. 11, No. 1, January.
- Lazzaro, J., Wawrzynek, J., Lippmann, R. P. (1997). A micropower analog circuit implementation of hidden markov model state decoding. *IEEE Journal Solid State Circuits* **32**:8, 1200–1209.
- Lazzaro, J. P., Wawrzynek, J. (1997). Speech recognition experiments with silicon auditory models. *Analog Integrated Circuits and Signal Processing*, **13**:1-2, 37-51.
- Lazzaro, J. P., Wawrzynek, J., and Kramer, A (1994). Systems technologies for silicon auditory models. *IEEE Micro*, **14**:3. 7-15.
- Lazzaro, J. P., Wawrzynek, J., Mahowald., M., Sivilotti, M., Gillespie, D. (1993). Silicon auditory processors as computer peripherals. *IEEE Journal of Neural Networks* **4**:3 523–528.
- Horiuchi, T., Bair, W., Bishofberger, B., Moore, A., Koch, C., Lazzaro, J. (1992). Computing motion using analog VLSI chips - an experimental comparison among different approaches. *International Journal of Computer Vision* **8**:3, 203-216.
- Lazzaro, J. P. (1991). A silicon model of an auditory neural representation of spectral shape. *IEEE Journal Solid State Circuits* **26**: 772–777.
- Mead, C. A., Arreguit, X., and Lazzaro, J. P. (1991). Analog VLSI models of binaural hearing. *IEEE Journal of Neural Networks* **2**: 230–236.
- Lazzaro, J. and Mead, C. (1989). Silicon modeling of pitch perception. *Proceedings National Academy of Sciences* **86**: 9597–9601.
- Lazzaro, J. and Mead, C. (1989). A silicon model of auditory localization. *Neural Computation* **1**: 41–70.

CONFERENCE PUBLICATIONS (COMPETITIVE)

- Lazzaro, J. P. and Wawrzynek, J. (2004). An RTP payload format for MIDI. *The 117th Convention of the Audio Engineering Society (AES)*, October 28-31, 2004, San Francisco, CA.
- Lazzaro, J. P. and Wawrzynek, J. (2001). A case for network musical performance. *The 11th International Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV 2001)*, June 25-27, 2001, Port Jefferson, New York.
- Lazzaro, J. P. and Wawrzynek, J. (2001). Compiling MPEG 4 Structured Audio into C. *Proceedings of the Second IEEE MPEG-4 Workshop and Exhibition (WEMP)* June 18-20, 2001, San Jose, CA.
- Lazzaro, J. P., Wawrzynek J., and Lippmann, R. (1996). A micropower analog VLSI HMM state decoder for wordspotting. In Jordan, M., Mozer, M., and Petsche, T. (eds), *Advances in Neural Information Processing Systems 9*. Cambridge, MA: MIT Press.
- Lazzaro, J. P., Wawrzynek J. (1995). Silicon models for auditory scene analysis. In Mozer, M., Touretsky, D., and Hasselmo, M. (eds), *Advances in Neural Information Processing Systems 8*. Cambridge, MA: MIT Press.
- Lazzaro, J. P. and Wawrzynek, J. (1995). A multi-sender asynchronous extension to the address-event protocol. In Dally, W. J., Poulton, J. W., Ishii, A. T. (eds), *16th Conference on Advanced Research in VLSI*, pp. 158–169.
- Lazzaro, J. P., Wawrzynek, J., Mahowald., M., Sivilotti, M., Gillespie, D. (1993). Silicon auditory processors as computer peripherals. In Hanson, S., Cowan, J., and Giles C., (eds), *Advances in Neural Information Processing Systems 5*. San Mateo, CA: Morgan Kaufmann Publishers, 820–827.

Lazzaro, J. P. (1992). Temporal adaptation in a silicon auditory nerve. In Moody, J., Hanson, S., Lippmann, R. (eds), *Advances in Neural Information Processing Systems 4*. San Mateo, CA: Morgan Kaufmann Publishers, pp 813–820.

Lazzaro, J. P., Schwaber, J., and Rogers, W. (1991). Silicon baroreceptors: modeling cardiovascular pressure transduction in analog VLSI. In Sequin, C. (ed), *Advanced Research in VLSI, Proceedings of the 1991 Santa Cruz Conference*, Cambridge, MA: MIT Press, pp. 163–177.

Horiuchi, T., Lazzaro, J. P., Moore, A., and Koch, C. (1991). A correlation-based motion detection chip. In Lippman, R., Moody, J., Tourestzky, D. (eds), *Advances in Neural Information Processing Systems 3*. San Mateo, CA: Morgan Kaufmann Publishers, 406–413.

Lazzaro, J., Ryckebusch, S., Mahowald, M. A., and Mead, C. (1988). Winner-take-all networks of $O(n)$ complexity. In Tourestzky, D. (ed), *Advances in Neural Information Processing Systems 1*. San Mateo, CA: Morgan Kaufmann Publishers, pp. 703-711.

Mueller, P. and Lazzaro J. (1986). A machine for neural computation of acoustical patterns with applications to real-time speech recognition. In Denker, J. (ed), *Neural Networks for Computing (Snowbird, Utah)*. American Institute of Physics Conference Proceeding 151, pp. 321-327.

CONFERENCE PUBLICATIONS (INVITED)

Lazzaro, J. P., Wawrzynek, J., and Kramer, A (1994). Systems technologies for silicon auditory models. *Fall Meeting of the Biomedical Engineering Society*, published in the abstract supplement to the *Annals of Biomedical Engineering*, **22**:1, p. 53.

Lazzaro, J. P. (1992). Low-power silicon spiking neurons and axons. *IEEE International Symposium on Circuits and Systems* San Diego, CA, pp. 2220-2224.

Lazzaro, J. P. (1991). Biologically-based auditory signal processing in analog VLSI. *IEEE Asilomar Conference on Signals, Systems, and Computers*, pp. 790-794.

BOOK CHAPTERS

Lazzaro, J. P. and Wawrzynek, J. (2004). Subtractive Synthesis without Filters. In *Audio Anecdotes II*, edited by Ken Greenebaum, A. K. Peters.

Lazzaro, J. P., Wawrzynek, J. (1998). Speech recognition experiments with silicon auditory models. In Lande, T. S. (ed), *Neuromorphic systems engineering : neural networks in silicon*. Boston : Kluwer Academic.

Lazzaro, J. P., and Wawrzynek, J. (1994). Low-power silicon axons, neurons, and synapses. In Zaghloul, M. E., Meador, J. L., and Newcomb, R. W., (eds) *Silicon Implementations of Pulse Coded Neural Networks*. Norwell, MA: Kluwer Academic Publishers, pp. 153-164.

Lazzaro, J. and Mead, C. (1990). Silicon models of auditory localization. In Zornetzer, Davis, and Lau (eds), *An Introduction to Neural and Electronic Networks*. New York: Academic Press, pp. 158–174.

Lazzaro, J. and Mead, C. (1989). Circuit models of sensory transduction in the cochlea. In Mead, C. and Ismail, M. (eds), *Analog VLSI Implementations of Neural Networks*. Norwell, MA: Kluwer Academic Publishers, pp. 85-101.

WEB BOOK

Lazzaro, J. and Wawrzynek, J. (2000). MPEG 4 Structured Audio: Developers Tools. An online book and a software decoding system for Structured Audio. <http://www.cs.berkeley.edu/~lazzaro/sa/>