CURRICULUM VITA

Richard M. Stern, Jr.

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PROFESSIONAL INTERESTS

Automatic speech recognition, auditory perception, acoustics, signal processing, biomedical instrumentation

EDUCATION

Ph.D. (1977)	Electrical Engineering and Computer Science Massachusetts Institute of Technology, Cambridge, MA
M.S. (1972)	Electrical Engineering and Computer Sciences University of California, Berkeley, CA
S.B. (1970)	Electrical Engineering Massachusetts Institute of Technology, Cambridge, MA

EXPERIENCE

1995 - present	Professor of Electrical and Computer Engineering Carnegie Mellon University.
1988 - present	Associate Professor and Professor by Courtesy, Language Technologies Institute, Computer Science Department, Biomedical Engineering Department
2009 - present	Artist Lecturer, School of Music Carnegie Mellon University
1995 - 2003	Associate Director of the Information Networking Institute Carnegie Mellon University
1982 - 1995	Associate Professor of Electrical and Biomedical Engineering Carnegie Mellon University
1985	Visiting Professor in Speech and Communication Sciences, Nippon Telegraph and Telephone Electrical Communications Laboratory, Tokyo, Japan
1977 - 1982	Assistant Professor of Electrical and Biomedical Engineering Carnegie Mellon University

LGE EXHIBIT 1017
Amazon v. Jawbone
U.S. Patent 7,246,058
Amazon Ex. 1017

1979 - 1981	Adjunct Assistant Professor of Otolaryngology University of Pittsburgh School of Medicine
1973 - 1976	Teaching and Research Assistant, Department of Electrical Engineering, Massachusetts Institute of Technology

PROFESSIONAL ACTIVITIES (partial listing)

Distinguished Lecturer, International Speech Communication Association, 2008-2009.

General Chair, INTERSPEECH International Conference on Spoken Language Processing, September, 2006.

Technical Program Co-Chair, IEEE Workshop on Automatic Speech Recognition and Understanding, December 2005.

Technical Program Chair, 141st meeting of the Acoustical Society of America, June 2002.

General Chair, DARPA Spoken Language Technologies Workshop, March, 1994.

Publications Chair, ARPA Spoken Language Technology and Applications Day, April, 1993.

Publications Chair, IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, October, 1993.

Chair, standing DARPA Speech and Natural Language Workshop Organizing Committee, 1991 1992.

Secretary, ARPA Spoken Language Coordinating Committee, 1990 - 1995.

General Chair, DARPA Speech and Natural Language Workshop, June, 1990.

International Advisory Board, International Speech Communication Association, 2006 - present.

International Advisory Board, Center for Speech and Language Technologies, Tsinghua University, Beijing, China, 2007 - 2010.

Chair, Selection Committee for IEEE James L. Flanagan Speech & Audio Processing Award, 2006 - 2008.

IEEE Signal Processing Society Technical Committee on Audio and Electroacoustics, 1991 1995.

IEEE Signal Processing Society Technical Committee on Speech, 1993 - 1997.

Editorial board, *Journal of Computer Speech and Language*, 1994 - 2010.

Ongoing collaborative research in binaural hearing with the Department of Otolaryngology at the University of Connecticut Medical School, Farmington, CT.

Member of Institute of Electrical and Electronics Engineers, Acoustical Society of America, International Speech Communication Association, Association for Research in Otolaryngology, Audio Engineering Society

Reviewer for National Science Foundation, International Speech Communication Association, IEEE, *J. Acoust. Soc. Amer.*, *Hearing Research*, *IEEE Transactions on Signal Processing*, *IEEE Transactions on Speech and Language*, *IEEE Transactions on Systems, Man, and Cybernetics*, and *Communications of the Association of Computing Machinery.*

HONORS AND AWARDS

Fellow, Institute of Electrical and Electronics Engineers (IEEE)

Fellow, International Speech Communication Association (ISCA)

Fellow, Acoustical Society of America (ASA)

Distinguished Lecturer of the International Speech Communication Association, 2008 to 2009

Allen Newell Award for Research Excellence, Carnegie Mellon University Department of Computer Science, 1992

IEEE Student Branch Award for Teacher of the Year, Carnegie Mellon University Department of Electrical Engineering, 1979

Joel and Ruth Spira Excellence in Teaching Award (with three colleagues), Carnegie Mellon University Department of Electrical and Computer Engineering, 2018

PUBLICATIONS AND PAPERS

Papers in Archival Journals

STERN, R. M., COLBURN, H. S., BERNSTEIN, L. R., AND TRAHIOTIS, C. (2019). "The fMRI data of Thompson *et al.* (2006) do not constrain how the human midbrain represents interaural time delay," *Journal of the Association for Research in Otolaryngology* **20**:305-311.

DIETZ, M., LESTANG, J.-H., MAJDAK, P., STERN, R. M., MARQUARDT, T., EWERT, S. D., HARTMANN, W. M., and GOODMAN, D. F. M. (2017). "A Framework for Testing and Comparing Binaural Models," *Hearing Research* **360**:92-106.

DE LA CALLE SILOS, F., and STERN, R. M. (2017). "Synchrony-based feature extraction for robust automatic speech recognition," *IEEE Signal Processing Letters* **24:**1158-1162.

FREDES, J., NOVOA, J., KING, S., STERN, R. M., and BECERRA YOMA, N. (2017). "Locally-normalized filter banks applied to deep neural network-based robust speech recognition," *IEEE Signal Processing Letters* **24:**377-381.

KIM, C., and STERN, R. M. (2016). "Power-normalized cepstral coefficients (PNCC) for robust speech recognition," *IEEE Trans. on Audio, Speech, and Language Processing* **24:**1315-1329. **[Received IEEE Signal Processing Society Best Paper Award, 2019]**

CHO, B. J., KWON,H. Cho, J.-W., KIM, C., STERN, R. M. and PARK, H.-M. (2016). "A subband-based stationary-component suppression method using harmonics and power ratio for reverberant speech recognition, *IEEE Signal Processing Letters*, **23**:780-784.

ROMIGH, G. D., BRUNGART, D. S., STERN, R. M., and SIMPSON, B. D. (2015). "Efficient real spherical harmonic representation of head-related transfer functions," *IEEE Journal of Selected Topics in Signal Processing*, **9**: 921-930, August 2015.

POBLETE, V., ESPIC, F., KING, S., STERN, R. M., HUENEPAN, F., and BECERRA YOMA, N. (2015). "A perceptually-motivated low-complexity channel normalization technique applied to speaker verification." *Computer Speech and Language,* **31**1-27, 2015.

POBLETE, V., BECERRA YOMA, N., and STERN, R. M. (2014). "Optimizing the parameters characterizing sigmoidal rate-level functions based on acoustic features," *Speech Communication,* **56:**19-34, January 2014.

HERMANSKY, H., COHEN, J. R., and STERN, R. M. (2013). "Perceptual properties of current speech recognition technology," *Proc. IEEE* **101**:1968-1985, September 2013.

STERN, R. M., and MORGAN, N. (2012). "Hearing is believing: biologically-inspred methods for robust speech recognition," *IEEE Signal Processing Magazine* **29**:34-43, November, 2012.

CHIU, Y.-H. B., RAJ, B., and STERN, R. M. (2012). "Learning-based auditory encoding for robust speech recognition," *IEEE Trans. on Audio, Speech, and Language Processing* **20:**900914, March 2012.

KIM, W., and STERN, R. M. (2011). "Mask classification for missing-feature reconstruction for robust speech recognition," *Speech Communication*, **53:**1-11, January 2011.

PARK, H.-M., and STERN, R. M. (2009). "Spatial Separation of Speech Signals using Continuosly-Variable Weighting Factors Estimated from Comparisons of Zero Crossings, *Speech Communication Journal,* **51**(1):15-25, January 2009.

SELTZER, M. L., and STERN, R. M. (2006). "Subband Likelihood-Maximizing Beamforming for Speech Recognition in Reverberant Environments," *IEEE Transactions of Speech, Language, and Audio Processing* 14(6): 2109-2121, November 2006.

RAJ, B., and STERN, R. M. (2005). "Missing-Feature Methods for Robust Automatic Speech Recognition," *IEEE Signal Processing Magazine*, September 2005.

KIM, N. S., LIM, W., and STERN, R. M. (2005). "Feature compensation based on switching linear dynamic model," *IEEE Signal Processing Letters*, **12**(6): 473-476.

SELTZER, M. L., RAJ, B., and STERN, R. M. (2004). "Likelihood-Maximizing Beamforming for Robust Hands-Free Speech Recognition," *IEEE Transactions of Speech and Audio Processing*, **12**(5): 489-498, September 2004. **[Received IEEE Signal Processing Society Best Student Paper Award, 2007]**

OBUCHI, Y., HATAOKA, N., and STERN, R. M. (2004), "Normalization of Time-Derivative Parameters for Robust Speech Recognition in Small Devices," *IEICE Trans. on Information and System*s, **87-D**(4): 1004:1011, April 2004.

RAJ, B., SELTZER, M. L., and STERN, R. M. (2004), "Reconstruction of Missing Features for Robust Speech Recognition," *Speech Communication Journal*, **43**(4): 275-296, September 2004.

SELTZER, M. L., RAJ, B,, and STERN, R. M. (2004). "A Bayesian Framework for Spectrographic Mask Estimation for Missing Feature Speech Recognition," *Speech Communication Journal,* **43**(4): 379-393, September 2004.

SINGH, R., RAJ, B., and STERN, R. M. (2001), "Automatic Generation of Sub-Word Units for Speech Recognition Systems," *IEEE Trans. on Speech and Audio Proc.* **10**(2):89-99.

HUERTA, J. M., and STERN, R. M. (2001). "Distortion-Class Modeling for Robust Speech Recognition under GSM RPE-LTP Coding," *Speech Communication Journal*, **34:**213-225 (invited paper).

MORENO, P. J., RAJ, B., and STERN, R. M. (1998). "Data-Driven Environmental Compensation for Speech Recognition: A Unified Approach," *Speech Communication Journal*, **24:** 267-85.

STERN, R. M., and SHEAR, G. D. (1996a) "Lateralization and Detection of Low- Frequency Binaural Stimuli: Effects of Distribution of Internal Delay," *J. Acoust. Soc. Amer.* **100**: 2278-2288.

STERN, R. M., and SHEAR, G. D. (1996b) "Lateralization and Detection of Low- Frequency Binaural Stimuli: Specification of the Extended Position-Variable Model," *Physics Auxiliary Publication Service*, AIP document E-JASMA-100-2278- 0.175MB via http://www.aip.org/epaps/ epaps.html.

TRAHIOTIS, C., and STERN, R. M. (1994) "Across-Frequency Interaction in Lateralization of Complex Binaural Stimuli," *J. Acoust. Soc. Amer.* **96**: 3804- 3806 (L).

STERN, R. M., ZEPPENFELD, T., and SHEAR, G. D. (1991). "Lateralization of RectangularlyModulated Noise: An Explanation for Counterintuitive Reversals," *J. Acoust. Soc. Amer.* **90:** 1901-1907.

COAST, D. A., STERN, R. M., CANO, G. G., and BRILLER, S. A. (1990). "An Approach to Cardiac Arrhythmia Analysis Using Hidden Markov Models," *IEEE Trans. Biomed. Eng*. **37**: 826836.

TRAHIOTIS, C., and STERN, R. M. (1989). "Lateralization of Bands of Noise: Effects of Bandwidth and Differences of Interaural Time and Phase," *J. Acoust. Soc. Amer.* **86**: 1285-1293.

RUDNICKY, A. I., and STERN, R.M. (1989). "Spoken Language Research at Carnegie Mellon," *Speech Technology Magazine* **4:** 38-43.

STERN, R. M., ZEIBERG, A. S., and TRAHIOTIS, C. (1988). "Lateralization of Complex Binaural Stimuli: A Weighted Image Model," *J. Acoust. Soc. Amer.* 84, 156-165.

STERN, R. M., and LASRY, M. J. (1987). "Dynamic Speaker Adaptation for Feature-Based Isolated Letter Recognition," I*EEE Trans. on Acoustics, Speech, and Signal Processing* **35:** 751763.

STERN, R. M., and COLBURN, H. S. (1985). "Lateral-Position Models of Interaural Discrimination," J*. Acoust. Soc. Amer.* **77:** 753-755.

STERN, R. M., and COLBURN, H. S. (1985). "Subjective Lateral Position and Interaural Discrimination," *Physics Auxiliary Publication Service*, AIP document no. PAPS JASMA-77-753-29.

LASRY, M. J., and STERN, R. M. (1984). "A Posteriori Estimation of Correlated Jointly Gaussian Mean Vectors," *IEEE Trans. on Pattern Anal. and Mach. Intel.* **6:** 530-535.

CROWLEY, J. L., and STERN, R. M., Jr. (1984). "Fast Computation of the Difference of Low Pass (DOLP) Transform," *IEEE Transactions on Pattern Analysis and Machine Intelligence* **6:** 212-222.

STERN, R. M., Jr., SLOCUM, J. E., and PHILLIPS, M. S. (1983). "Interaural Time and Amplitude Discrimination in Noise", *J. Acoust. Soc. Amer.* **73:**1714-1722.

YOST, W. A., GRANTHAM, D. W., LUFTI, R. A., and STERN, R. M., Jr. (1982). "The Phase Angle of Addition in Temporal Masking for Diotic and Dichotic Listening Conditions," *Hearing Res.* **7:** 247-259.

MURTI, K. G., STERN, R. M., CANTEKIN, E. I. and BLUESTONE, C. D. (1982). "Classification of Spectral Patterns Obtained from Eustacian Tube Sonometry," *IEEE Trans. Biomed. Eng.* **29:** 473-477.

MURTI, K. G., STERN, R. M., Jr., CANTEKIN, E. I. and BLUESTONE, C. D. (1980). "Sonometric Evaluation of Eustachian Tube Function Using Broadband Stimuli", *Annals of Otology, Rhinology, and Laryngology*, (Suppl. 68) 89, 178-189.

RUOTOLO, B. R., STERN, R. M., Jr., and COLBURN, H. S. (1979). "Discrimination of Symmetric, Time-Intensity Traded Binaural Stimuli," *J. Acoust. Soc. Amer.*, **66:** 1733-1737.

STERN, R. M., Jr. and COLBURN, H. S. (1978). "Theory of Binaural Interaction Based on Auditory-Nerve Data. IV. A Model for Subjective Lateral Position," *J. Acoust. Soc. Amer.*, **64:** 127140.

Critically-Reviewed Books, Book Chapters, and Theses

STERN, R. M. and MENON, A. (2020). "Binaural Technology for Machine Speech Recognition and Understanding," Chapter in *The Technology of Binaural Understanding*, J. Blauert and J. Braasch, Eds., Springer Nature.

MITRA, V., FRANCO, H., STERN, R. M., VAN HOUT, J., FERRER, L.,GRACIARENA, M., WANG, W., VERGYRI, D., ALWAN, A., and HANSEN, J.H.L. (2017). "Robust features in Deep Learning based Speech Recognition," Chapter in *New Era for Robust Speech Recognition: Exploiting Deep Learning*, S. Watanabe, M. Delcroix, F.Metze, & J. R. Hershey (eds.), pp. 165196, Springer International Publishing.

STERN, R. M. and MORGAN, N. (2013). "Features Based on Auditory Physiology and Perception," Chapter in *Noise-Robust Techniques for Automatic Speech Recognition,* T. Virtanen, R. Singh, and B. Raj, Eds., Wiley Press.

STERN, R. M., WANG, D., and BROWN, G. (2006). "Binaural Sound Localization," Chapter in *Computational Auditory Scene Analysis: Principles, Algorithms and Applications*, D. Wang and G. Brown, Eds., Wiley and IEEE Press.

STERN, R. M., TRAHIOTIS, C., and RIPEPI, A. M. (2006). "Fluctuations in Amplitude and Frequency Enable Interaural Delays to Foster the Identification of Speech-like Stimuli," Chapter in *Dynamics of Speech Production and Perception*, P. Divenyi, Ed., IOS Press.

TRAHIOTIS, C., BERNSTEIN, L. R., STERN, R. M., and BUELL, T. N. (2005). "Interaural Correlation as the Basis of a Working Model of Binaural Processing: An Introduction," Chapter in *Springer Handbook of Auditory Research: Sound Source Localization*, R. Fay and T. Popper, Eds., Springer-Verlag.

STERN, R. M. (2004). "Signal Separation Motivated by Human Auditory Perception: Applications to Automatic Speech Recognition," Chapter in *Speech Separation by Humans and Machines*, P. Divenyi, Ed., Springer-Verlag.

SINGH, R., STERN, R. M., and RAJ, B. (2002). "Signal and Feature Compensation Methods for Robust Speech Recognition," Chapter in *CRC Handbook on Noise Reduction in Speech Applications*, Gillian Davis, Ed., Boca Raton: CRC Press.

SINGH, R., RAJ, B., and STERN, R. M. (2002). "Model Compensation and Matched Condition Methods for Robust Speech Recognition," Chapter in *CRC Handbook on Noise Reduction in Speech Applications*, Gillian Davis, Ed., Boca Raton: CRC Press.

STERN, R. M., ACERO, A., LIU, F.-H., and OHSHIMA, Y. (1996). "Signal Processing for Robust Speech Recognition," Invited chapter in *Speech Recognition*, pp. 351-378, C.-H. Lee and F. Soong, Eds., Boston: Kluwer Academic Publishers.

STERN, R. M., and TRAHIOTIS, C. (1996). "Models of Binaural Perception," Invited chapter in *Binaural and Spatial Hearing in Real and Virtual Environments*, pp. 499-531, R. Gilkey and T. R. Anderson, Eds. New York: Lawrence Erlbaum Associates

STERN, R. M. (1995). "Robust Speech Recognition," Invited chapter in *Survey on the State of the Art in Speech and Natural Language Processing*, R. A. Cole et al., Ed.

STERN, R. M., and TRAHIOTIS, C. (1995). "Models of Binaural Interaction," Invited chapter in *Handbook of Perception and Cognition, Volume 6: Hearing*, pp. 347-386, B. C. J. Moore., Ed. New York: Academic Press.

STERN, R. M., Jr. (1976b). *Lateralization, Discrimination, and Detection of Binaural Pure Tones*, Ph.D. Thesis, Electrical Engineering Department, MIT, December, 1976.

Non-reviewed Book

STERN, R. M. (2020). *Selected Advanced Topics in Digital Signal Processing.* Textbook for CMU course 18-792.

Invited Conference Presentations

STERN, R. M. (2017). "Predicting Binaural Lateralization, Interaural Discrimination, and Binaural Detection Using the Position-Variable Model," invited talk at the Macquarie University ARC Laureate Workshop: Creating a Sense of Auditory Space, October 2017, Sydney, Australia.

STERN, R. M, KIM, C., MOGHIMI, A.R., and MENON, A. (2016). "Binaural technology and automatic speech recognition," invited talk at the International Congress on Acoustics, September 2016, Buenos Aires, Argentina.

STERN, R. M. (2016). "Applying Models of Auditory Processing to Automatic Speech Recognition: Progress and Promise," invited keynote talk at the 2015 Meeting of the Information Processing Sociaty of Japan: Special Interest Group in Spoken Language Processing, Toyama, Japan, February, 2016.

STERN, R. M. (2014). "Applying Models of Auditory Processing to Automatic Speech Recognition: Progress and Promise," invited talk at the Frederick Jelinek Memorial Workshop on Meaning Representations in Language and Speech Processing, Prague, Czech Republic, July, 2014.

STERN, R. M. (2014). "Robust Automatic Speech Recognition in the 21st Century," invited keynote talk at the 2014 AFEKA Conference for Speech Processing, Tel Aviv, Israel, July, 2014.

STERN, R. M. (2014). "Applying Models of Auditory Processing to Automatic Speech Recognition: Promise and Progress," International Symposium on Speech Recognition, University of Zaragoza, Spain, May, 2014.

STERN, R. M. (2011). “Applying Physiologically-Motivated Models of Auditory Processing to Automatic Speech Recognition,” invited talk at the Third International Symposium on Auditory and Audiological Research, Nyborg, Denmark, August, 2011.

STERN, R. M. (2010). “The impact of the distribution of internal delays in binaural models on predictions for psychoacoustical data,” invited talk at the 161th Meeting of the Acoustical Society of America, Cancun, Mexico, November, 2010.

STERN, R. M. (2009). “New Directions in Robust Speech Recognition: What We Can Learn from Auditory Models,” invited keynote address at the Symposium on Frontiers of Research in Speech and Music, Gwalior, India, December, 2009.

STERN, R. M. (2009). “New Directions in Robust Automatic Speech Recognition,” invited keynote address at the Workshop on Image and Speech Processing, Hyderabad, India, December, 2009.

STERN, R. M. (2008). “Applying Physiologically-Motivated Models of Auditory Processing to Automatic Speech Recognition: Promises, Progress, and Problems,” Invited keynote address at the ISCA Tutorial and Research Workshop on Statistical and Perceptual Audition, Brisbane, Australia, September, 2008.

STERN, R. M, GOUVEA, E., KIM, C., KUMAR, K., and PARK, H.-M. (2008). “Binaural and Multiple-Microphone Processing for Robust Automatic Speech Recognition,” Invited keynote address at the IEEE Workshop on Hands-free Speech Communication and Microphone Arrays, Trento, Italy, May, 2008.

STERN, R. M. (2004). “Signal Processing for Sound Separation and Robust Representation,” Invited keynote address at AFOSR/NSF Symposium on Speech Separation and Comprehension in Complex Acoustic Environments, Montreal, Quebec, November 2004.

STERN, R. M. (2003). “Signal Separation Motivated by Auditory Processing: Applications to Speech Recognition,” invited review talk at the NSF Symposium on Signal Separation, Montreal, Quebec, November, 2003.

STERN, R. M. (2003). “Signal Processing for Robust Recognition,” invited talk at the NAIST International Center of Excellence Symposium, Nara, Japan, March, 2003.

STERN, R. M. (2002). “Using Computational Models of Binaural Hearing to Improve Automatic Speech Recognition Accuracy: Promise, Progress, and Problems,” AFOSR Workshop on Computational Audition, Columbus, Ohio, August, 2002.

STERN, R. M. (2000). “Robust Signal Representations for Automatic Speech Recognition,” Institute for Mathematics and Its Applications Workshop on the Mathematical Foundations of Speech Processing and Recognition, Minneapolis, Minnesota, September, 2000.

STERN, R. M. (2000). “The Language of Music,” invited keynote talk presented at the Third International Symposium on Text, Speech, and Dialog, Brno, Czech Republic, September, 2000.

STERN, R. M. (2000). “Tendencias Actuales en el Procesamiento del Lenguaje Hablado y Sistemas Conversacionales (Current Trends in Spoken Language Processing and Conversational Systems)”, invited keynote talk at the XV Simposium Internacional de Electrónica y Comunicación, Instituto Tecnológico de Estudios Superiores de Monterrey Mexico, February, 2000.

STERN, R. M. (1999). “Tendencias Actuales en el Procesamiento del Lenguaje Hablado y Sistemas Conversacionales (Current Trends in Spoken Language Processing and Conversational Systems)”, invited

keynote talk at the XXIV Simposium Internacional de Sistemas Computacionales, Instituto Tecnológico de Estudios Superiores de Monterrey, Monterrey, Mexico, March, 1999.

STERN, R. M., and TRAHIOTIS, C. (1997). "Binaural Mechanisms that Emphasize Consistent Interaural Timing Information over Frequency," invited keynote talk in *Psychophysical and Physiological Advances in Hearing,* Proceedings of the XI International Symposium on Hearing, August, 1997, Grantham, United Kingdom. A. R. Palmer, A. Rees, A. Q. Summerfield, and R. Meddis, Eds., Whurr Publishers, London, 1998.

STERN, R. M., RAJ, B., and MORENO, P. J. (1997). "Compensation for Environmental Degradation in Automatic Speech Recognition," invited keynote talk presented at the *Proc. of the ESCA Tutorial and Research Workshop on Robust Speech Recognition for Unknown Communication Channels*, April, 1997, Pont-au-Mousson, France, pp. 33-42.

STERN, R. M. (1996). "The Current State of the Art of in Speech Recognition (Estado-da-Arte em Reconhecimento de Voz)," invited keynote talk presented at VOICETECH'96, the First Brazilian Workshop in Automatic Speech Recognition Campinas, Sao Paolo, Brazil, September, 1996.

STERN, R. M. (1996). "New Directions in Spoken Language Processing," invited talk at the Second Joint NSF/CONACyT Workshop on Bilateral Collaboration, Jalapa, Mexico, March, 1996.

STERN, R. M. (1996). "Tendencias Actuales en el Procesamiento del Lenguaje Hablado (Current Trends in Spoken Language Processing)", invited talk at the Universidad Veracruzana, Jalapa, Mexico, March, 1996.

STERN, R. M., and SULLIVAN, T. M. (1996). "Robust Speech Recognition Using Signal Processing Based On Binaural Perception," invited talk presented at the First Forum Acusticum, Antwerp, Belgium, April, 1996.

STERN, R. M., MORENO, P.J., and RAJ, B. (1996). "Compensation for Speech Recognition in Degraded Acoustical Environments," invited talk at the 132th meeting of the Acoustical Society of America, Honolulu, Hawaii, December, 1996.

STERN, R. M. (1995). "Nuevos Enfoques en Procesamiento de Lenguaje Hablado (New Directions in Spoken Language Processing)," invited talk at the Universitat Politecnica de Catalunya, Barcelona, Spain, September, 1995.

STERN, R. M. (1995). "New Directions in Spoken Language Processing," invited talk presented at the Telefónica Investigación y Desarrollo Laboratory Symposium on Spoken Language Processing, Madrid, Spain, September 1995.

STERN, R. M. (1995). "Automatic Speech Recognition using Signal Processing based on Auditory Physiology and Perception," invited paper presented at the 129th meeting of the Acoustical Society of America, Washington, D.C., June, 1995.

MORENO, P. J., RAJ, B., and STERN, R. M. (1995). "Approaches to Environmment Compensation in Automatic Speech Recognition," invited paper presented at the 15th International Conference on Acoustics, Trondheim, Norway, Vol. III, pp. 109-112, June, 1995.

STERN, R. M., and SULLIVAN, T. M. (1994). "Robust Speech Recognition Based on Human Binaural Perception," invited paper presented at the ATR workshop on A Biological Framework for Speech Perception and Production, Kansai Science City, September, 1994. Reprinted in ATR technical report TR-

H-121: *Proceedings of the ATR workshop on A Biological Framework for Speech Perception and Production*, 122 pages, (1995).

STERN, R. M. LIU, F.-H., SULLIVAN, T. M., MORENO, P. J., and ACERO, A. (1994). "Multiple Approaches to Robust Speech Recognition," invited keynote paper at the Fifth Western Pacific Regional Acoustical Conference, Seoul, Korea, August, 1994.

STERN, R. M. (1993). "Models of Binaural Interaction," invited keynote paper at the AFOSR Conference on Binaural and Spatial Hearing, Wright-Patterson Air Force Base, September, 1993.

STERN, R. M. (1993). "Psychoacoustical Basis of Machine Speech Recognition," invited talk at the Annual Meeting of the American Association for the Advancement of Science, February, 1993.

STERN, R. M. (1989). "Recent Progress in Spoken-Language Systems," invited lecture at the Second International Symposium on Artificial Intelligence, Monterrey, Mexico, October, 1989.

STERN, R. M. (1988). "Overview of Models of Binaural Perception," invited review paper at the 1988 National Research Council CHABA Symposium, Washington, D.C., October, 1988.

STERN, R. M. (1988). "Estado Actual de la Tecnología de Entradas/Salidas de Canales de Voz (Overview of Current Voice Input/Output Technologies)," invited keynote lecture at the XIII Simposium Internacional de Sistemas Computacionales, Monterrey, Mexico, March, 1988.

COLE, R. A., STERN, R. M., and LASRY, M. J. (1986). "Performing Fine Phonetic Distinctions: Templates vs. Features," invited talk, reprinted in *Invariance and Variability of Features in Spoken English Letters*, J. Perkell *et al*., eds., Lawrence Erlbaum, New York.

Critically-Reviewed Conference Presentations

VUONG, T., XIA, Y., and STERN, R. M. (2021). "The application of learnable STRF kernels to the 2021 Fearless Steps Phase-03 SAS Challenge," Interspeech *2021*, September 2021, Brno, Czech Republic.

XIA, Y., CHEN, L.—W., RUDNICKY, A., and STERN, R. M. (2021). "Temporal context in speech emotion recognition," Interspeech *2021*, September 2021, Brno, Czech Republic.

VUONG, T., XIA, Y., and STERN, R. M. (2021). "A modulation-domain loss for neural-network-based real-time speech enhancement," Proc. IEEE ICASSP *2021*, June 2021, Toronto, Canada.

VUONG, T., XIA, Y., and STERN, R. M. (2020). Learnable Spectro-temporal Receptive Fields for Robust Voice Type Discrimination, Interspeech *2018*, September 2020, Shanghai, China.

MENON, A., Kim, C., and STERN, R. M. (2019), "Robust recognition of reverberant and noisy speech using coherence-based processing," *IEEE International Conference on Acoustics, Speech, and Signal Processing*, May 2019, Brighton, United Kingdom.

XIA, Y. and STERN, R. M. (2018). *A Priori* SNR Estimation Based on a Recurrent Neural Network for Robust Speech Enhancement, *Interspeech 2018*, September 2018, Hyderabad, India.

MICHELSON, J., STERN, R. M., and SULLIVAN, T. M. (2018), "Automatic guitar tablature transcription from audio using inharmonicity regression and Bayesian classification," *145th Convention of the Audio Engineering Society*, October 2018, New York City.

KIM, C., MENON, A., BACCHIANI, M., and STERN, R. M. (2018), "Source separation using phase difference and reliable mask selection," *IEEE International Conference on Acoustics, Speech, and Signal Processing*, April 2018, Calgary, Alberta, Canada.

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STERN, R. M., and ACERO, A. (1990b). "Signal Processing for Robust Spoken Language Systems," invited tutorial lecture at the Satellite Workshop on Statistical Approaches to Spoken Language Processing, Tokyo, Japan, November 17, 1990.

STERN, R. M., and RUDNICKY, A. I. (1990). "Spoken-Language Workstations in the Office Environment," invited lecture at the SpeechTech90 Conference, New York City.

STERN, R. M., SHEAR, G. D., and ZEPPENFELD, T. (1988). "Lateralization Predictions for High-Frequency Binaural Stimuli," *J. Acoust.Soc. Amer*. **84**: S80 (A).

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SLOCUM, J. E., and STERN, R. M., Jr., (1980). "Interaural Time and Amplitude Discrimination in Noise," *J. Acoust. Soc. Amer*. 68, S60(A).

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STERN, R. M., Jr. (1976a). "Lateral Position, Interaural Discrimination, and Binaural Detection: Model Based on Auditory-Nerve Activity," *J. Acoust. Soc. Amer*., 59, S23(A).

STERN, R. M., Jr. (1972). "Perception of Simultaneously-Presented Musical Timbres," *Quart.*

Prog. Rep. No. 106, Res. Lab. of Electronics, MIT, Cambridge, MA.

Ph.D. THESES SUPERVISED

D. A. Coast, *Cardiac Arrhythmia Analysis Using Hidden Markov Models*, September, 1988.

A. Acero, *Acoustical and Environmental Robustness for Automatic Speech Recognition*, September, 1990.

W. A. Rozzi, *Speaker Adaptation in Automatic Speech Recognition via Estimation of Correlated Mean Vectors*, May, 1991.

Y. Ohshima, *Environmental Robustness in Speech Recognition using Physiologically-Motivated Signal Processing*, December, 1993.

F.-H. Liu, *Environmental Adaptation for Robust Speech Recognition*, June, 1994.

P. J. Moreno, *Speech Recognition in Noisy Environments*, May, 1996.

T. M. Sullivan, *Multi-Microphone Correlation-Based Processing for Robust Automatic Speech Recognition*, June, 1996.

E. Gouvea, *Acoustic-Feature-Based Frequency Warping for Speaker Normalization,* February, 1999.

M. Siegler, *Integration of Continuous Speech Recognition and Information Retrieval for Mutually Optimal Performance*, December, 1999.

B. Raj, *Reconstruction of Incomplete Spectrograms for Robust Speech Recognition,* April, 2000.

J. Huerta, *Robust Speech Recognition in GSM Codec Environments*, April, 2000.

S.-J. Doh, *Enhancements to Transformation-Based Speaker Adaptation: Principal Component and Inter-Class Maximum Likelihood Linear Regression*, July, 2000.

M. Seltzer, *Microphone Arrays for Robust Speech Recognition,* July, 2003.

J, Nedel, *Duration Normalization for Robust Recognition of Spontaneous Speech via Missing Feature Methods,* April, 2004.

X. Li, *Combination and Generation of Parallel Feature Streams for Improved Speech Recognition*, February, 2005.

Z. Al Bawab, *An Analysis-by-Synthesis Approach to Vocal Tract Modeling for Robust Speech Recognition,* September, 2009.

Y.-H. Chiu, *Learning-Based Auditory Encoding for Robust Speech Recognition,* April, 2010.

L. Gu, *Single-Channel Speech Separation Based on Instantaneous Frequency,* May, 2010.

C. Kim, *Signal Processing for Robust Speech Recognition Motivated by Auditory Processing*, September, 2010.

K. Kumar, *A Spectro-Temporal Framework for Compensation of Reverberation for Speech Recognition,* January, 2011.

G. Romigh, *Individualized Head-Related Transfer Functions: Efficient Modeling and Estimation from Small Sets of Spatial Samples*, December, 2012.

A. Moghimi, *Array-Based Spectro-Temporal Masking for Automatic Speech Recognition,* April, 2014.

M. J. Harvilla, *Compensentation for Nonlinear Distortion in Noise for Robust Speech Recognition,* October, 2014.

A. Menon, *Robust Recognition Of Binaural Speech Signals Using Techniques Based On Human Auditory Processing*, February, 2019.

CURRENT Ph.D. STUDENTS

Y. Xia, entered August 2016.

T. Vuong, entered August 2017.

P. Conrey, entered August 2019.

M. Lindsay, entered August 2019.

M.S. THESES and PROJECTS SUPERVISED

K. G. Murti, *Sonometric Evaluation of Eustacian-Tube Function*, May, 1979.

G. J. DuMond, *A Forced-Choice Paradigm for Pulsation-Threshold Measurement of Monaural and Binaural Phenomena*, August, 1979.

E. M. Rubinov, *Auditory Lateralization in Noise*, September, 1979.

J. E. Slocum, *Discrimination of Interaural Time and Intensity in Noise*, November, 1980.

D. L. Kaiser, *Interaural Time Discrimination in Tonal Maskers*, June, 1982.

A. H. Ferguson, *Effects of Frequency Modulation on Complex Pitch Perception*, December, 1982.

M. J. Lasry, *Dynamic Adaptation of Statistical Parameters in a Feature-Based Isolated Letter Recognition System*, December, 1982.

Y. L. Chu, *Zero Crossings and Ear Modelling in Speech*, February, 1983.

S. J. Bachorski, *Dynamic Cues in Binaural Perception*, December, 1983.

W. J. Lue, *Identification of Transient Features in Speech*, January, 1984.

L. E. Beecher, *Perception of Modulations in Pitch, Pitch Strength, and Subjective Lateral Position*, December, 1986.

S. J. Bartschat, *Bayesian Combination of Knowledge Sources in Automatic Speech Recognition*, August, 1987.

M. P. Vea, *Multisensor Signal Enhancement for Speech Recognition*, September, 1987.

G. D. Shear, *Modelling the Dependence of Auditory Lateralization on Frequency and Bandwidth*, September, 1987.

B. Chigier, *Classification of Stop Consonants in Natural Continuous Speech*, May, 1988.

P. H. Dietz, *Simulation of Trumpet Tones Via Physical Modeling*, December, 1988.

S. Palm, *Enhancement of Reverberated Speech using Models of the Human Binaural System*, April, 1989.

A. Liss, *Lateralization of Complex Binaural Sounds*, July, 1990.

S. H. Tao, *Additive versus Multiplicative Combination of Differences of Interaural Time and Intensity*, May, 1992.

P. J. Moreno, *Speech Recognition in Telephone Environments*, January, 1993.

J. Nehme, *Robust Recognition of Speech Input to Computer Workstations*, March, 1993.

N. Hanai, *Speech Recognition in the Automobile*, May, 1993.

W. Lee, *Lateralization of High-Frequency Bandpass Noise*, May, 1994.

M. Siegler, *Effects of Speech Rate on Speech Recognition Accuracy*, December, 1995.

U. Jain, *Speech Recognition over the Telephone*, May, 1995.

J. Nedel, *Integration of Speech and Video. Applications for Lip Synch: Lip Movement Synthesis and Time Warping,* May, 1999.

A. Ripepi, *Lateralization and Identification of Simultaneously-Presented Whispered Vowels and Speech Sounds,* May, 1999.

M. Seltzer, *Automatic Detection of Corrupted Speech Features for Robust Speech Recognition*, May, 2000.

M. Balakrishnan, *Extracting Additional Information from Gaussian Mixture Probabilities for Unsupervised Text-Independent Speaker recognition,* May 2005.

D. Zurale, *TaanSyn - A Synthesizer to add critical Indian Classical Singing elements to Western Vocals,* May 2017.

J. Michelson, *Unsupervised Guitar String Classification for Tablature Transcription*, August 2017.

C. Liang, *A Comparative Evaluation of Statistical Models for Score Following,* October 2017.

M. Yu. *How Important are the Headphone and Ear Canal Frequency Responses in Music Perception?* October, 2018.

Y. Zhang. *Design of Matching Criteria for Audio-Based Polyphonic Score-following Systems Using Harmonic Product Spectra,* December 2018.

COURSES TAUGHT AT CARNEGIE MELLON UNIVERSITY

18-101	Linear Circuit Analysis (Sophomore)
18-290	Signals and Systems (Sophomore and Junior)
18-396	Signals and Systems (Junior)
18-301	Fundamentals of Control (Senior)
18-308	Introduction to Digital Communication (Senior)
18-491	Introduction to Signal Processing (Junior/Senior)
18-493	Electroacoustics (Senior)
18-550	Fundamentals of Communication (Senior)
18-551	Communication and Signal Processing Project Laboratory (Senior)
18-340	Senior Seminar on Speech Processing
18-762	Signal Transmission and Detection (Graduate)
18-791	Digital Signal Processing (Graduate)
18-792	Advanced Digital Signal Processing (Graduate)
18-799	Digital Signal Processing for Robust Speech Recognition (Graduate)

18/42-795 Sensory Processes: Perception and Psychophysics (Graduate/ Senior)

42-726 Hearing: Physiology and Perception (Graduate Seminar)

(18-308, 18-493, 18-791, 18-792, 18-795, and 42-726 were all new courses when first taught)

SERVICE ON DEPARTMENT AND UNIVERSITY COMMITTEES

Major contributions and initiatives:

Developed and obtained university approval for the CMU Programs in Music and Technology. Service on the CMU Music and Technology Executive Committee, 2009 - present.

As Associate Director of the CMU Information Networking Institute managed the MSIN master's program that spanned the engineering, computer science, management, and public policy colleges, and had primary responsibility for admissions and recruiting, 1994 - 2003.

Chair, Faculty Senate Intellectual Property Policy Committee, 1983 - 1986. Drafted and negortiated the approval of the intellectual property policy now in use by CMU. Chairing committee to review and recommend modifications to the Policy, 2017 - present.

Faculty Senate International Affairs Forum, 1989 - 1991. Initiated cooperative educational programs with Latin American universities.

Chair and Senate Delegate, Faculty Senate Student Affairs Council, 1981 - 1984. Drafted CMU alcohol policy and set faculty policy on a range of other student-related issues.

Other activities (partial listing):

Faculty Senate Executive Committee

University Trustees Student Affairs Council

University Education Council

University Research Council

University Review Committee for Non-Tenured Appointments Senate

Delegate, Faculty Senate Student Affairs Council

Senate Delegate, Faculty Senate Educational Affairs Council

International Committee of the Dean's Council

Carnegie Institute of Technology Faculty Chair

MISCELLANEOUS SKILLS AND INTERESTS

Solo and chamber music performance on harpsichord with ensembles playing historical instruments, and with members of the Pittsburgh Symphony Orchestra. Participation in mountain biking, running, backpacking, racquet sports.

Extensive travel experience throughout Europe, Latin America, and Asia. Fluent in Spanish; some French, Italian, and German.