

Bowon Lee

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RESEARCH INTERESTS

- ◇ Statistical signal processing
 - Microphone array signal processing for immersive audio communication
 - Multimodal signal processing for rich and intuitive interactions
 - Signal processing algorithms based on human auditory system models
 - Acoustic event detection and localization
 - Accelerometer signal processing

EDUCATION

- ◇ **Ph.D. in Electrical and Computer Engineering**, December 2006
University of Illinois at Urbana-Champaign, Urbana, Illinois
Thesis: "Robust Speech Recognition in a Car Using a Microphone Array"
Advisor: Professor Mark Hasegawa-Johnson
- ◇ **M.S. in Electrical and Computer Engineering**, May, 2003
University of Illinois at Urbana-Champaign, Urbana, Illinois
Thesis: "Open-Loop Multichannel Inversion of Room Impulse Response"
Advisor: Professor Mark Hasegawa-Johnson
- ◇ **B.S. in Electrical Engineering**, February, 2000
Seoul National University, Seoul, Republic of Korea

PROFESSIONAL EXPERIENCE

- ◇ **Research Scientist**, Hewlett-Packard Laboratories, Palo Alto, CA (February 2007 – Present)
Audio and speech signal processing for seamless collaboration:
 - Designed microphone array signal processing algorithms including time-delay estimation, source localization, noise estimation, speech enhancement post-processing, blind source separation, blind dereverberation, and multichannel voice activity detection.
 - Implemented real-time microphone array signal processing applications including source localization, beamforming, speech enhancement, blind source separation, blind dereverberation, and multichannel acoustic echo cancellation as components of a large software package for real-time multimedia streaming.
 - Collaborated with university partners in US and Brazil on audio/speech quality assessment methods and post-processing algorithms for speech enhancement and acoustic echo cancellation.
 - Directed the development of a hardware system for multichannel audio acquisition and real-time processing for a large microphone array.

Multimodal interface for intuitive and rich user experiences:

- Designed multimodal 3D object localization algorithm and developed a real-time implementation for personal devices.
 - Adapted sound source localization algorithms to create multimodal attention and activity detection for intuitive user interface.
 - Developed a multimodal user context analysis application for mobile devices.
- ◇ **Graduate Research Assistant**, University of Illinois, Urbana, IL (May 2003 – December 2006)
AVICAR – Audio Visual speech recognition In a CAR:
- Collected an audio-visual speech database of 100 talkers by designing and building an array of eight microphones and four video cameras.
 - Developed methods for post-processing the collected data for automatic speech recognition research.
 - Distributed the database to about 20 institutions.
 - Worked on missing feature approaches for noise-robust automatic speech recognition using a microphone array, as well as beamforming for speech enhancement.
 - The AVICAR database [25] has been cited in approximately 70 papers.
 - Website: <http://www.isle.illinois.edu/sst/AVICAR>
- ◇ **Summer Engineering Internship**, Motorola Labs, Schaumburg, IL (May 2005 – August 2005)
- Developed software for a digital speech compression application for wireless handheld devices.
 - Optimized a GSM codec for real-time operation on an Intel ARM/XScale processor.
 - Integrated the optimized codec for C++ Linux application environment for 802.11b ad hoc wireless VoIP communication.
- ◇ **Graduate Research Assistant**, University of Illinois, Urbana, IL (May 2001 – May 2003)
ALICE – Multichannel acoustic control for an adaptive Laboratory for Immersive Collaborative Experiments:
- Designed algorithms and built hardware for the multichannel inversion of room impulse response for a virtual reality theater in Beckman Institute.
- ◇ **Research Programmer**, University of Illinois, Urbana, IL (August 2000 – May 2001)
SNDAN – SouND ANalysis:
- Ported SNDAN, a Sun based C software package for music analysis, to Linux systems.
- M4C – Music 4C:*
- Developed a tool for critical band-based analysis/synthesis of piano tones, and integrated its library into the music synthesis software package Music 4C.
- ◇ **Chaplain Assistant**, Republic of Korea Army (November 1995 – January 1998)
- Served as a KATUSA (Korean Augmentation To the United States Army) soldier at Camp Humphreys, the Eighth United States Army.
 - Managed a group of soldiers for maintaining a military chapel and performing administrative tasks for the U.S. and Korean Army Chaplains.
 - Retired as a Sergeant.

- HONORS/
AWARDS
- ◇ **Senior Member**, IEEE (Student 2000, Member 2007, Senior 2011)
 - ◇ **Top 10% Award** for a paper “ConnectBoard: A remote collaboration system that supports gaze-aware interaction and sharing” at the IEEE International Workshop on Multimedia Signal Processing (MMSP), 2009
 - ◇ **Top 10% Award** for a paper “An Objective Method for Quality Assessment of Ultra-Wideband Speech Corrupted by Echo,” IEEE International Workshop on Multimedia Signal Processing (MMSP), 2009
 - ◇ **Scholarship** from the Institute of Information Technology Assessment, Seoul, Korea, 2000–2003.
 - ◇ **Army Commendation Medal (ARCOM)** by the United States Army, 1997
- PROFESSIONAL
ACTIVITIES
- ◇ **Technical Program Committee**
 - IEEE Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA) 2011
 - IEEE International Conference on Multimedia & Expo (ICME) 2010, 2011
 - IEEE Joint Digital Signal Processing Workshop & Signal Processing Education Workshop (DSP/SPE) 2011
 - ◇ **Technical Referee**
 - IEEE Transactions on Audio, Speech, and Language Processing
 - IEEE Transactions on Multimedia
 - IEEE Signal Processing Letters
 - Computer Speech and Language
 - ◇ **Academic Society Membership**
 - IEEE Senior Member (Signal Processing Society)
 - AES Full Member
- FUNDING
RECORD
- ◇ **Immersive Headphone-Free Virtual Reality Audio**
 - Acoustic control of the Beckman Cube as a part of the Adaptive Laboratory for Immersive Collaborative Experiments (ALICE) Project
 - Granted 18,000 USD by University of Illinois Research Board for the academic year 2001-2002.
- INVITED
TALKS
- ◇ **“Immersive Audio Communication”**
 - 3D Applications, Content, and Systems Symposium at University of Illinois at Urbana-Champaign, Urbana, IL, May 2010
 - ◇ **“Sound Source Localization for Multimedia Collaboration”**
 - Federal University of Rio de Janeiro, Brazil, October 2009
 - ◇ **“Open-Loop Dereverberation of Multichannel Room Impulse Responses”**
 - Seoul National University, Seoul, Korea, July 2003
- PRESENTATIONS
- ◇ **“Correlogram Template Matching for Time-Delay Estimation”**
 - International Conference on Acoustics, Speech, and Signal Processing (ICASSP), Prague, Czech Republic, May 2011.

- ◇ “A Phonemic Restoration Approach for Automatic Speech Recognition With Highly Non-stationary Background Noise”
 - The 4th Biennial Workshop on DSP for In-Vehicle Systems and Safety, Dallas, Texas, June 2009.
- ◇ “Maximum a posteriori Multimodal 3D Object Localization With a Depth Sensor and Stereo Microphones”
 - The 2nd International Conference on Immersive Telecommunications (IMMERSCOM), Berkeley, California, May 2009.
- ◇ “Maximum-Likelihood Sound Source Localization With a Multivariate Complex Laplacian Distribution”
 - The 11th International Workshop on Acoustic Echo and Noise Control (IWAENC), Seattle, Washington, September 2008.
- ◇ “Maximum A Posteriori Estimation of Time Delay”
 - The Second International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP), St. Thomas, U.S Virgin Islands, December 2007.
- ◇ “Open-Loop Dereverberation of Multichannel Room Impulse Responses”
 - The 145th Meeting, Acoustic Society of America, Nashville, Tennessee, April 2003.

PUBLICATIONS

◇ *Book Chapters*

1. **Bowon Lee** and Mark Hasegawa-Johnson, “Estimation of High Variance Vehicular Noise,” *Processing of In-Vehicle Signals: Data Collection and Driver Behavior*, K. Takeda, J. H.L. Hansen, H. Erdogan, and H. Abut eds., pp. 221–232, Springer, 2009.
2. Amaro A. de Lima, Sergio L. Netto, Luiz W. P. Biscainho, Fábio P. Freeland, Bruno C. Bispo, Rafael A. de Jesus, Ronald W. Schafer, Amir Said, **Bowon Lee**, Antonius Kalker, “Quality Evaluation of Reverberation in Audioband Speech Signals,” *e-Business and Telecommunications ICETE 2008, Communications in Computer and Information Science Series*, Obaidat, M. S., Filipe, J., eds. Berlin: Springer-Verlag, 2009.

◇ *Journal Papers*

3. Leonardo de O. Nunes, Luiz W. P. Biscainho, **Bowon Lee**, Amir Said, Ton Kalker, Ronald W. Schafer, “Degradation Type Classifier for Full Band Speech Contaminated with Echo, Broadband Noise, and Reverberation.” accepted for publication at *IEEE Transactions on Audio, Speech, and Language Processing*, 2011.
4. Bruno C. Bispo, Paulo A. A. Esquef, Luiz W. P. Biscainho, Amaro A. de Lima, Fabio P. Freeland, Rafael A. de Jesus, Amir Said, **Bowon Lee**, Ronald W. Schafer, and Ton Kalker, “EW-PESQ: A Quality Assessment Method for Speech Signals Sampled at 48 kHz,” *Journal of Audio Engineering Society*, Vol. 58, No. 4, pp 251-268, April 2010.

◇ *Conference Proceedings*

5. Prasenjit Dey, Muthuselvam Selvaraj, and **Bowon Lee**, “Robust User Context Analysis for Multimodal Interfaces,” in *Proc. 13th International Conference on Multimodal Interaction (ICMI)*, Alicante, Spain, November 14 – 18, 2011.

6. Jason Wung, Ted Wada, Biing-Hwang Juang, **Bowon Lee**, Mitch Trott, and Ronald Schafer, "A System Approach to Acoustic Echo Cancellation in Robust Hands-Free Teleconferencing," in *Proc. IEEE International Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA)*, New Paltz, New York, October 16–19, 2011.
7. Leonardo O. Nunes, Flavio R. Avila, Luiz W. P. Biscainho, **Bowon Lee**, Amir Said, Ronald W. Schafer, "Monitoring Scenario for Non-Intrusive Quality Assessment of Teleconference Systems," in *Proc. SBrT 2011*.
8. **Bowon Lee**, Ton Kalker, and Ronald W. Schafer, "Correlogram Template Matching for Time-Delay Estimation," in *Proc. ICASSP 2011*, Prague, Czech Republic, May 22–27, 2011.
9. Jason Wung, Ted Wada, Biing-Hwang Juang, **Bowon Lee**, Ton Kalker, and Ronald Schafer, "A System Approach to Residual Echo Suppression In Robust Hands-Free Teleconferencing," in *Proc. ICASSP 2011*, Prague, Czech Republic, May 22–27, 2011.
10. **Bowon Lee** and Debargha Mukherjee, "Spectral Entropy-Based Voice Activity Detector for Videoconferencing Systems," in *Proc. INTERSPEECH 2010*, Makuhari, Japan, September 26 – 30, 2010.
11. **Bowon Lee** and Ton Kalker, "A Vectorized Method for Computationally Efficient SRP-PHAT Sound Source Localization," in *Proc. 12th International Workshop on Acoustic Echo and Noise Control (IWAENC 2010)*, Tel Aviv, Israel, August 30 – September 2, 2010.
12. Luiz Gonzaga da Silveira Jr., Vicente Peruffo Minotto, Claudio Rosito Jung, **Bowon Lee**, "A GPU Implementation of the SRP-PHAT Sound Source Localization Algorithm," in *Proc. 12th International Workshop on Acoustic Echo and Noise Control (IWAENC 2010)*, Tel Aviv, Israel, August 30 – September 2, 2010.
13. Jason Wung, Biing-Hwang (Fred) Juang, and **Bowon Lee**, "Speech enhancement based on log-spectral amplitude estimator and a postfilter derived from clean speech codebook," in *Proc. European Signal Processing Conference (EUSIPCO 2010)*, Aalborg, Denmark, August 23 – 27, 2010.
14. Amir Said, Ton Kalker, **Bowon Lee**, and Majid Fozunbal, "Massively Parallel Processing of Signals in Dense Microphone Arrays," in *Proc. IEEE International Symposium on Circuits and Systems (ISCAS 2010)*, Paris, France, May 30 – June 2, 2010.
15. **Bowon Lee** and Ton Kalker, "Multichannel Voice Activity Detection With Spherically Invariant Sparse Distributions," in *Proc. IEEE International Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA 2009)*, New Paltz, New York, October 18–21, 2009.
16. Flavio R. Avila, Luiz W. P. Biscainho, Leonardo de O. Nunes, Alan F. Tygel, **Bowon Lee**, Amir Said, Ton Kalker, and Ronald W. Schafer, "A Teleconference Model with Acoustic Impairments Suitable for Speech Quality Assessment," In *Proc. SBrT 2009*.
17. Kar-Han Tan, Ian Robinson, Ramin Samadani, **Bowon Lee**, Dan Gelb, Alex Vorbau, Bruce Culbertson, John Apostolopoulos, "ConnectBoard: A remote collaboration system that supports gaze-aware interaction and sharing," in *Proc. IEEE International Workshop on Multimedia Signal Processing (MMSP 2009)*, Rio de Janeiro, Brazil, October 5–7, 2009. (**Top 10% Award**)
18. Paulo A. A. Esquef, Luiz W. P. Biscainho, Leonardo O. Nunes, **Bowon Lee**, Amir Said, Ton Kalker, and Ronald W. Schafer, "Quality Assessment of Audio: Increasing Applicability Scope of Objective Methods via Prior Identification of Impairment Types," in *Proc. IEEE International Workshop on Multimedia Signal Processing (MMSP 2009)*, Rio de Janeiro, Brazil October 5–7, 2009.

19. Luiz W. P. Biscainho, Paulo A. A. Esquef, Fabio P. Freeland, Leonardo O. Nunes, Alan F. Tygel, **Bowon Lee**, Amir Said, Ton Kalker, and Ronald W. Schafer, "An Objective Method for Quality Assessment of Ultra-Wideband Speech Corrupted by Echo," in *Proc. IEEE International Workshop on Multimedia Signal Processing (MMSP 2009)*, Rio de Janeiro, Brazil, October 5–7, 2009. **(Top 10% Award)**
20. Amaro A. de Lima, Thiago de M. Prego, Sergio L. Netto, **Bowon Lee**, Amir Said, Ronald W. Schafer, Ton Kalker, and Majid Fozunbal, "Feature Analysis for Quality Assessment of Reverberated Speech," in *Proc. IEEE International Workshop on Multimedia Signal Processing (MMSP 2009)*, Rio de Janeiro, Brazil, October 5-7, 2009.
21. **Bowon Lee** and Mark Hasegawa-Johnson, "A Phonemic Restoration Approach for Automatic Speech Recognition With Highly Nonstationary Background Noise," in *Proc. the 4th Biennial Workshop on DSP for In-Vehicle Systems and Safety*, Dallas, Texas, June 2009.
22. **Bowon Lee** and Kar-Han Tan, "Maximum *a posteriori* Multimodal 3D Object Localization With a Depth Sensor and Stereo Microphones," in *Proc. the 2nd International Conference on Immersive Telecommunications (IMMERSCOM 2009)*, Berkeley, California, May 27–29, 2009.
23. Intae Lee, Charles E. Kinney, **Bowon Lee** and Antonius A. C. M. Kalker, "Solving the Acoustic Echo Cancellation Problem in Double-Talk Scenario Using Non-Gaussianity of the Near-End Signal," in *Proc. the 8th International Conference on Independent Component Analysis and Signal Separation (ICA 2009)*, Paraty, Brazil, March 15–18, 2009.
24. **Bowon Lee**, Ton Kalker, Ronald W. Schafer, "Maximum-Likelihood Sound Source Localization With a Multivariate Complex Laplacian Distribution," in *Proc. 11th International Workshop on Acoustic Echo and Noise Control (IWAENC 2008)*, Seattle, Washington, September 14–17, 2008.
25. Amaro A. Lima, Fábio P. Freeland, Paulo A. A. Esquef, Luiz W. P. Biscainho, Bruno C. Bispo, Rafael A. de Jesus, Sergio, L. Netto, Ronald Schafer, Amir Said, **Bowon Lee**, Antonius Kalker, "Reverberation Assessment in Audioband Speech Signals for Telepresence Systems," in *Proc. International Conference on Signal Processing and Multimedia Applications (SIGMAP 2008)*, Porto, Portugal, pp. 257–262, July 26–29, 2008.
26. Amaro A. Lima, Fábio P. Freeland, Rafael A. de Jesus, Bruno C. Bispo, Luiz W. P. Biscainho, Sergio L. Netto, Amir Said, Antonius Kalker, Ronald Schafer, **Bowon Lee**, and Merhban Jam, "On the Quality Assessment of Sound Signals," in *Proc. International Symposium on Circuits and Systems (ISCAS 2008)*, Seattle, Washington, pp. 416-419, May 18-21, 2008.
27. **Bowon Lee**, Amir Said, Ton Kalker, Ronald W. Schafer, "Maximum Likelihood Time Delay Estimation with Phase Domain Analysis in the Generalized Cross Correlation Framework," in *Proc. Hands-Free Speech Communication and Microphone Arrays, (HSCMA 2008)*, Trento, Italy, pp.89–92, May 6-8, 2008.
28. **Bowon Lee** and Ton Kalker, "Maximum A Posteriori Estimation of Time Delay," in *Proc. The Second International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP 2007)*, St. Thomas, U.S Virgin Islands, pp. 285-288, December 12-14, 2007.
29. **Bowon Lee** and Mark Hasegawa-Johnson, "Minimum Mean Squared Error A Posteriori Estimation of High Variance Vehicular Noise," in *Proc. Biennial on DSP for In-Vehicle and Mobile Systems*, Istanbul, Turkey, June 2007.
30. **Bowon Lee**, Mark Hasegawa-Johnson, Camille Goudeseune, Suketu Kamdar, Sarah Borys, Ming Liu, and Thomas Huang, "AVICAR: An Audiovisual Speech Corpus in a Car Environment," in *Proc. Int. Conf. Spoken Lang. Process.(ICSLP 2004)*, Jeju, Korea, October 4-8, 2004. **(70 citations on Google Scholar)**

31. **Bowon Lee**, Mark Hasegawa-Johnson, and Camille Goudeseune, "Open-Loop Dereverberation of Multichannel Room Impulse Responses," *J. Acoust. Soc. Am.*, vol. 113, No. 4, pp. 2202-2203, April 2003.
32. James Beauchamp, Hua Zheng, **Bowon Lee**, and Stephen Lakatos, "A Versatile Wavetable-Based Model for Synthesis of Piano Tones," *J. Acoust. Soc. Am.*, vol. 110, No. 5, pp. 2691-2692, November 2001.

PATENTS

1. **US12580958**, pending, **Bowon Lee** and Debargha Mukherjee, "System and Method for Determining the Active Talkers in a Video Conference", April 21, 2011.
 2. **US12482773**, pending, **Bowon Lee** and Kar-Han Tan, "Multimodal Object Localization", June 11, 2009.
 3. **US12484686**, pending, Thomas A. Baran, **Bowon Lee**, Ronald W. Schafer, and Majid Fozunbal, "Methods and Systems for Blind Dereverberation", June 15, 2009.
- ◇ 6 more patent applications filed.

REFERENCES

Available upon request