Noise and Echo Control for Immersive Voice Communication in Spacesuits

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Collaboration and cooperation between the crewmembers in space and the mission control center on the earth are the lifeline of astronauts and space shuttles. Bright sunlight washes out LCD screens and makes it difficult for astronauts to read instructions, data, or instant messages from a portable electronic device. Clear and reliable voice communications are essential to astronaut safety and the success of every NASA flight mission. But the special design of an astronaut's spacesuit forms an extreme acoustic environment that imposes unique challenges for capturing and transmitting speech to and from a crewmember. The in-suit acoustic environment is characterized by a highly reflective helmet surface (causing high levels of reverberation) and a spacesuit-unique noise field (noise is generally nonstationary, inherently wideband, and possibly either directional or dispersive).

The current solution is a communication cap-based audio (CCA) system which consists of a pair of differential microphones (a redundant design for reliability). The differential microphones need to be close to the astronaut's mouth, leading to a number of recognized logistical issues and inconveniences particularly during extravehicular activity (EVA) operations which last from 4 to 8 hours. Unfortunately these problems cannot be resolved with incremental improvements to the basic design of the CCA systems. We have been sponsored by the NASA SBIR program to develop an integrated audio (IA) system that can possess similar performance to a CCA while offering astronauts inherent comfort and ease of use. This talk presents our efforts in the last two years that focused primarily on combating noise with microphone arrays mounted on spacesuits. They encompass both algorithm development and real-time prototype implementations with FPGA (field-programmable gate array) processors. We will conclude by describing a number of other acoustic signal processing problems for IA systems. They include control of stereo acoustic echo between inbound and outbound audio, and spatial sound reproduction inside spacesuits.

Yiteng (Arden) Huang received the B.S. degree from the Tsinghua University, Beijing, China, in 1994 and the M.S. and Ph.D. degrees from the Georgia Institute of Technology (Georgia Tech), Atlanta, in 1998 and 2001, respectively, all in electrical and computer engineering. From March 2001 to January 2008, he was a Member of Technical Staff at Bell Laboratories, Murray Hill, NJ. In January 2008, he joined the WeVoice, Inc., Bridgewater, NJ and served as its CTO. His current research interests are in acoustic signal processing and multimedia communications.

Dr. Huang served as an Associate Editor for the EURASIP Journal on Applied Signal Processing from 2004 and 2008 and for the IEEE Signal Processing Letters from 2002 to 2005. He served as a technical Co-Chair of the 2005 Joint Workshop on Hands-Free Speech Communication and Microphone Array and the 2009 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics. He is a coeditor/coauthor of the books Noise Reduction in Speech Processing (Springer-Verlag, 2009), Microphone Array Signal Processing(Springer-Verlag, 2008), Springer Handbook of Speech Processing (Springer-Verlag, 2007), Acoustic MIMO Signal Processing (Springer-Verlag, 2006), Audio Signal Processing for Next-Generation Multimedia Communication Systems (Kluwer, 2004), and Adaptive Signal Processing: Applications to Real-World Problems (Springer-Verlag, 2003). He received the 2008 Best Paper Award and the 2002 Young Author Best Paper Award from the IEEE Signal Processing Society, the 2000-2001 Outstanding Graduate Teaching Assistant Award from the School Electrical and Computer Engineering, Georgia Tech, the 2000 Outstanding Research Award from the Center of Signal and Image Processing, Georgia Tech, and the 1997-1998 Colonel Oscar P. Cleaver Outstanding Graduate Student Award from the School of Electrical and Computer Engineering, Georgia Tech.

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