NARROWBAND ADAPTIVE ACOUSTIC ARRAYS FOR DIRECTIONAL INTERFERENCE NULLING

Victor E. DeBrunner†‡ and A. A. (Louis) Beex‡

‡Bradley Department of Electrical Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0111, USA

†Now with
School of Electrical Engineering and Computer Science
The University of Oklahoma
Norman, OK 73019-0631, USA

Extended Summary

We consider the design and performance of a restricted geometry, narrowband, adaptive 2-element (termed "small") acoustic array as used for directional hearing enhancement. An array is designed to be mobile and burden-free, so that the wearer is not encumbered by the hardware, while remaining useful in noisy environments. The directionality of multi-element arrays, and thus the capability for interference rejection, is greatly superior to that possible with a single-element device. Enhanced directionality comes from the extra knowledge gained when acoustic signals are spatially sampled. Intuitively, we expect such a result since humans have 2 ears to hear with, and we do not have the "extra" one merely for redundancy. This increased knowledge comes at the expense of increased hardware requirements, as well as an increase in real-time computations and communications. We explore the balance between directionality improvement and hardware requirements. Making the array adaptive is shown to enhance the array directionality above that achievable by a fixed array which we have examined previously.

We examine the performance of small, adaptive, nonlinear acoustic arrays for
highly directional applications, where the array elements must be in specified locations due to physical (or other) reasons. The array directionality allows the wearer to better focus in certain directions, eliminating more noise from unwanted directions than is possible with only unaided human hearing. The array may be worn so that the ears are either open or closed to normal hearing. In environments where earplugs would normally be used, the ears would then be occluded. We have previously considered such systems with fixed spatial gain patterns.

Strong interference signals can be localized and attenuated via the simple adaptive beamformer algorithms we examine in this paper: the Griffiths-Jim, Howells-Applebaum and Instrumental Variables narrowband beamformers. The beamformers are kept narrowband for simplicity of design. Wideband beamformers require significantly more hardware, and thus are not as practical at the present time for unobtrusive hearing devices. These three adaptive strategies are examined for their ability to eliminate sounds from unwanted directions, as well as their computational requirements. We have found that while the Griffiths-Jim beamformer requires fewer computations per iteration, it requires many more iterations to converge than the remaining two beamformers. All three effectively cancel the unwanted sounds. While in this paper we only examine 2-element adaptive arrays, we have previously shown that fixed 4-element arrays are considerably more directional, and thus we have recently begun to study the practicality of their adaptive implementation. The additional elements may be placed relatively close together because they control the reception of signals from the back of the array.