Space-aware hearing devices - Making hearing aids smarter

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Abstract

In spite of the tremendous advances in hearing device technology since the introduction of the first hearing aid with digital signal processing in 1996, the rehabilitation of acoustic communication in patients with sensorineural hearing loss is still limited. In particular, significant problems are reported in difficult acoustic conditions characterized by high levels of background noise and reverberation. In addition to a reduction in speech intelligibility, other important factors are affected, such as the awareness of the acoustic space and of the spatial configuration and movement of sound sources.

To tackle these problems, recent approaches incorporate knowledge about the principles of human auditory scene analysis to build a representation of the acoustic environment and to decide about the appropriate filtering that makes the attended sound source better audible while keeping the sound features that affect the perception of the acoustic space intact. As an example, a binaural multi-microphone system will be described that estimates the direction of arrival of several sound sources present in the scene, and selects and enhances one of the sources that was identified as the attended (target) source by analyzing the eye movements of the subject.

To develop and test such "space-aware" hearing devices and their underlying signal processing schemes, established lab-based methods are not sufficient, as they make unrealistic assumptions about the acoustic conditions in real life. In particular, different from the stationary spatial configuration of fixed sound sources used in lab-based setups, real-life scenarios are dynamic in the sense that the sound sources constantly move, that the attended source may switch and that the subject is actively listening, i.e., moves in response to visual and auditory input conditioned on its current hearing wish. To incorporate these key factors of acoustic communication in reproducible lab-based measurement setups, virtual audiovisual environments in combination with "subject-in-the-loop" evaluation methods are increasingly used. One study will presented that tested the performance of different classes of hearing aid algorithms in a number of different virtual acoustic environments including scenes with a moving listener. The results confirm previous findings that spatial complexity has a major impact on algorithm benefit and shows that performance measured with established lab-based setups does not predict performance in more complex conditions well. In a second study, the influence of visual cues on motion behavior and involvement of the subject in the listening task was measured. It was found that subjects have different movement strategies when following a conversation. This shows that active listening is individual and requires the hearing devices to accurately represent the acoustic scene and to dynamically detect the attended sound source in order to keep the spatial impression intact while enhancing the target source.