Localization and Spatial Processing for Users of Hearing Aids and Cochlear Implants

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Understanding speech and communicating is generally more difficult with hearing impairment, but noisy and reverberant spaces pose particular challenges. Binaural hearing mechanisms help normally hearing persons in these situations, but their benefits are often limited with hearing impairment. Hearing aids and cochlear implants aim to support in these situations by, e.g., emphasizing the target sound. Yet, measuring the benefit from modern processing approaches is challenging itself since creating listening environments representative of everyday situations accurately and reproducibly in the laboratory requires advanced technology and testing needs sophisticated psychophysical procedures. Nevertheless, further progress will only be made if benefits from such algorithms can be reliably measured.

The real-time Simulated Open Field Environment (rtSOFE) is a new laboratory to interactively simulate and reproduce acoustic scenes with multiple sound sources and the reverberation of rooms with high fidelity over loudspeakers in the new anechoic chamber at TUM. By presenting sounds in the free-field, participants can interact with sound stimuli in a natural way using head turns and movements – important when working with participants inexperienced with laboratory procedures. Through efficient room simulation software the rtSOFE can play interactive acoustic scenes with naturalistic room reverberation, thereby creating life-like listening situations with high realism.

We have used the SOFE to study spatial hearing abilities and assess performance in noise and in room reverberation with users of bilateral cochlear implants. These studies showed that some users benefit from binaural temporal information carried in sharp onsets. Based on this finding we have developed a new speech coding algorithm for bilateral cochlear implants leading to improved sound localization ability in reverberation.

Using hearing aid microphones behind the ears as opposed to in the ear canal leads to inferior spatial sound quality though directionality can be stronger. We have used the SOFE to develop and evaluate a new signal processing approach for hearing aids which combines the benefits from beamforming and pinna filtering. I will address how the SOFE can be used to tease out qualitative benefits in spatial perception, quantify performance of the new algorithm and show that modern virtual acoustics techniques can be used successfully for audiological and neuroscientific research to improve hearing devices.