Preservation of interaural cues using a binaural multichannel wiener filter (MWF-ITF): Localization performance

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1. Introduction

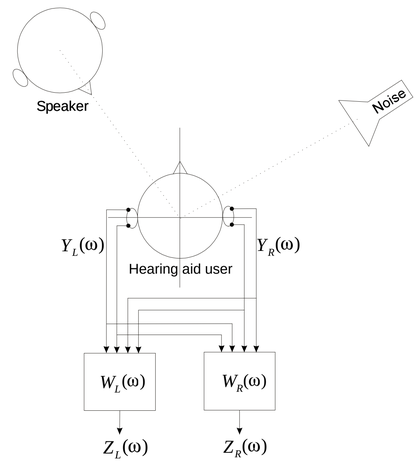
- Wearing independent bilateral hearing aids can have a significant negative impact on localization performance [1].
- Adaptive noise reduction schemes typically do not preserve interaural cues [2].
- The MWF-ITF algorithm is an extension of the adaptive MWF noise red. approach [3,4] and is designed to preserve interaural cues [5].

2. The algorithm [3][4][5]*1

- Binaural multichannel wiener filter

$$J(W)=\varepsilon\left\{\left\|\begin{bmatrix}X_{L_0}-W_L^H X\\ X_{R_0}-W_R^H X\end{bmatrix}\right\|^2+\mu\left\|\begin{bmatrix}W_L^H V\\ W_R^H V\end{bmatrix}\right\|^2\right\}$$

μ trade off between noise reduction and speech distortion



Binaural hearing aid listening scenario

- Binaural multichannel wiener filter with Interaural Transfer Function (ITF) extension

$$J(W)=\varepsilon\left\{\left\|\begin{bmatrix}X_{L_0}-W_L^H X\\ X_{R_0}-W_R^H X\end{bmatrix}\right\|^2+\mu\left\|\begin{bmatrix}W_L^H V\\ W_R^H V\end{bmatrix}\right\|^2+\alpha\left|W_L^H X-ITF_{X_{des}}W_R^H X\right|^2+\beta\left|W_L^H V-ITF_{V_{des}}W_R^H V\right|^2\right\}$$

with: $ITF_{X_{des}}=\dfrac{\varepsilon\{X_{L0}X_{R0}^*\}}{\varepsilon\{X_{R0}X_{R0}^*\}}$ $\quad ITF_{V_{des}}=\dfrac{\varepsilon\{V_{L0}V_{R0}^*\}}{\varepsilon\{V_{R0}V_{R0}^*\}}$

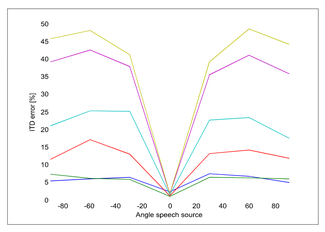
α is related to the preservation of the speech ITF
β Is related to the preservation of the noise ITF

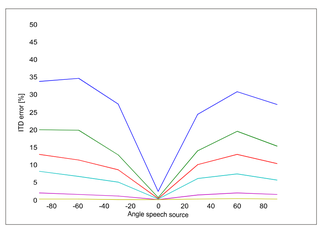
- Research question: determine the optimal parameter settings for this algorithm in terms of sound localization using physical and perceptual measures.

3. Physical evaluation

- $\Delta ITD_x=\sum I(\omega_i)\Delta ITD_x(\omega_i)$ With $\Delta ITD_x(\omega_i)=\langle\varepsilon\{X_L(\omega_i)X_R^*(\omega_i)\}$

ITD error on signal S using filters trained on SxN0 for different beta values

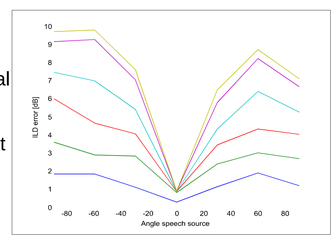


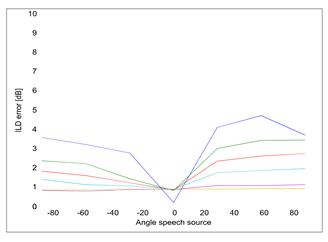


ITD error on the noise N using filters trained on SxN0 for different beta values

- $\Delta ILD_x=\sum_i\left|10\log_{10}ILD_x^{out}(\omega_i)-10\log_{10}ILD_x^{in}(\omega_i)\right|$

ILD error on signal S using filters trained on SxN0 for different beta values

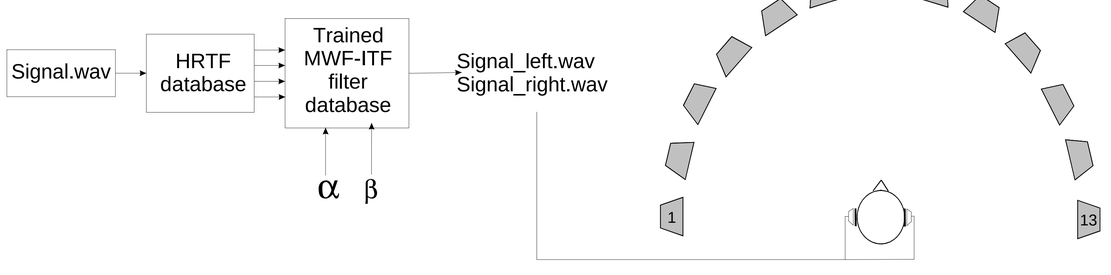




ILD error on the noise N using filters trained on SxN0 for different beta values

4. Perceptual evaluation

- Headphone experiment with off line processing



- Task for the subjects

  Localize Sx and N0 when the filters are trained for the condition SxN0 using different parameter settings.

  Localize S0 and Nx when the filters are trained for the condition S0Nx using different parameter settings.

  With x an angle from 90 to -90 degrees in discrete steps of 30 degrees. For both S and N a telephone ringing signal was used (S and N were not played simultaneously).

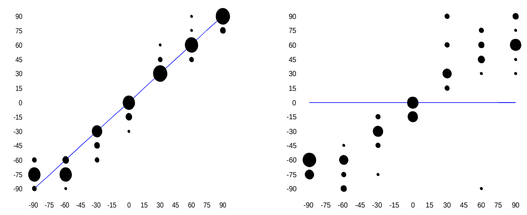
- Parameter space

  α = 0 and 0.5
  β = 0, 0.1, 0.3, 1, 10 and 100

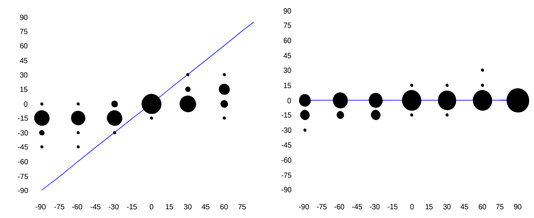
- SxN0

Localization of Sx | Localization of N0

α = 0, β = 0

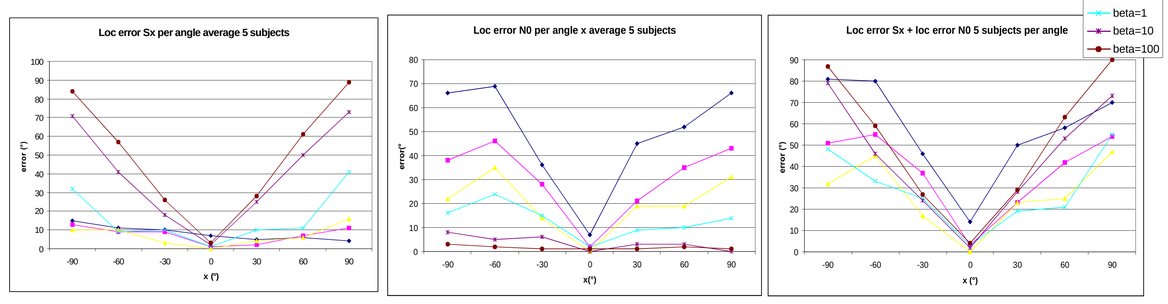


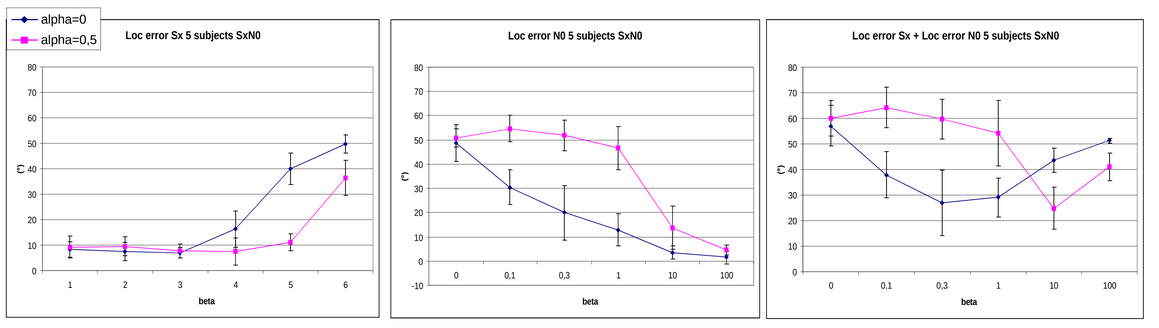
α = 0, β = 10



Responses of 5 subjects

Without beta the noise is mapped on the speech location, adding too much beta "pulls" the speech component to the noise location. Can the locations of noise and speech be preserved by a good parameter setting ?





5. Conclusions

- Alpha and beta have a large impact on localization performance
- Alpha and beta can be tuned to achieve a better overal localization performance at the cost of some noise reduction.*1
- The perceptual evalutations seems to correlate well with the physical measures

6. References

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[5] Klasen T.J., Doclo S., Van den Bogaert T., Moonen M., Wouters J., "Binaural multi-channel Wiener filtering for hearing aids: preserving interaural time and level differences", in Proc. of IEEE International Conf. on Acoustics, Speech and Signal Processing (ICASSP), Toulouse, France, May 2006, pp. V 145-148

*1= will also be presented in an oral presentation of S. Doclo at this conference

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