A LINEAR MMSE FILTER USING DELAYED REMOTE MICROPHONE SIGNALS FOR SPEECH ENHANCEMENT IN HEARING AID APPLICATIONS

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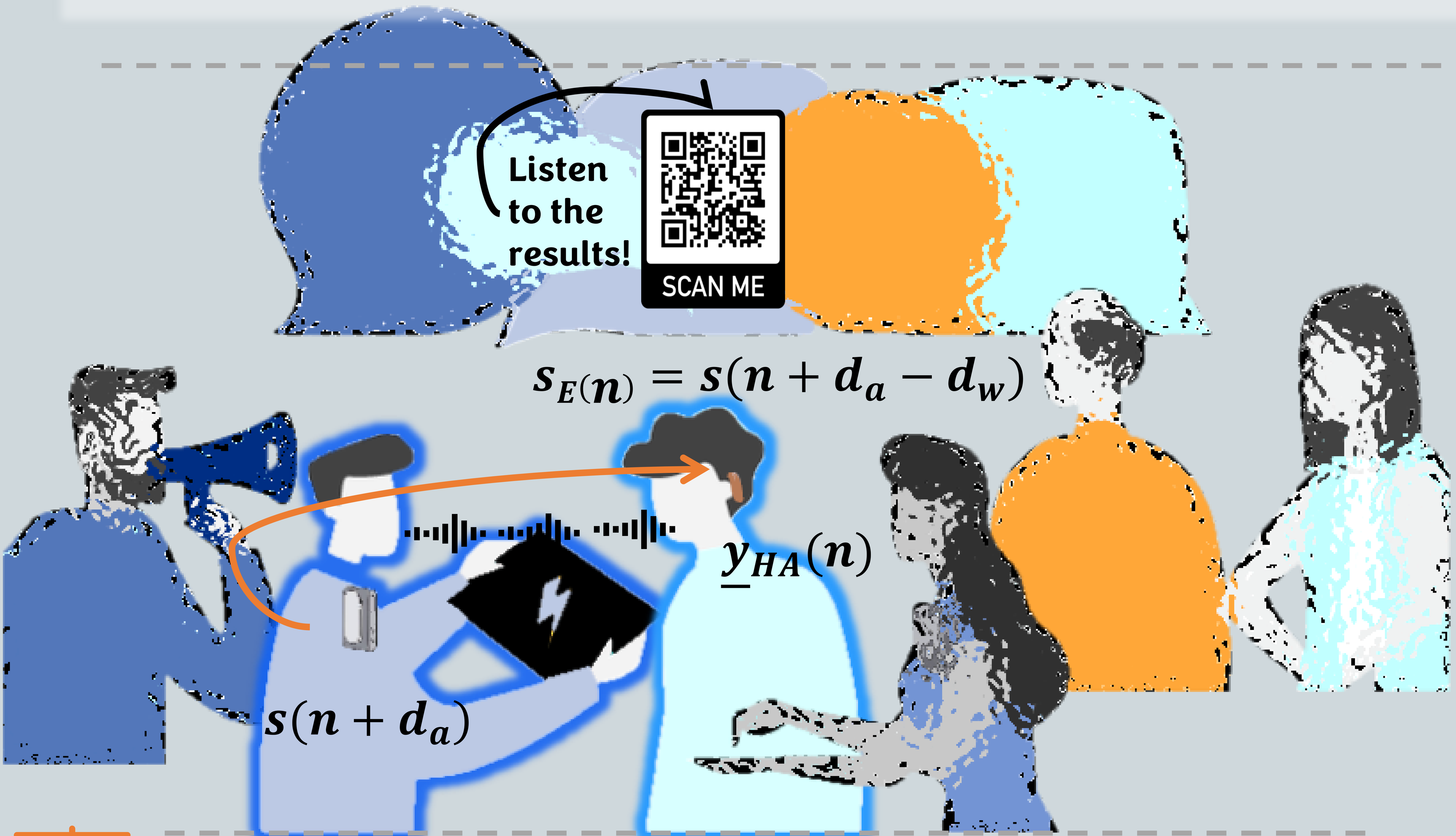
Introduction

- Using remote microphones, placed close to the target source, enhances the noise reduction in hearing assistive devices (HADs) .
- Existing literature ignores the time difference of arrival (TDOA) between the acoustically and wirelessly transmitted signals, which leads to poor noise reduction performance, when applied in practice [1],[2].



Objective

- To estimate, $\hat{x}_{ref}(n) = f(\underline{y}_{HA}(n), s(n-d))$
- Use multiple past frames of the remote microphone signal, with the multi-channel local microphone signals.

$s(n + d_a)$: *anechoic signal*

$s_E(n)$: *remote microphone signal received by the HA*

$\underline{y}_{HA}(n)$: *noisy HA microphone signal vector*

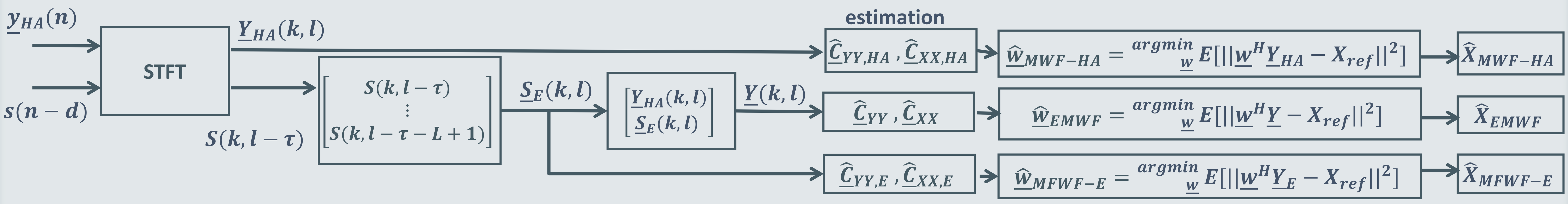
$d = d_a - d_w$: *TDOA*

d_a : *acoustic propagation delay*

d_w : *wireless latency*

n : *clock sample at the HA*

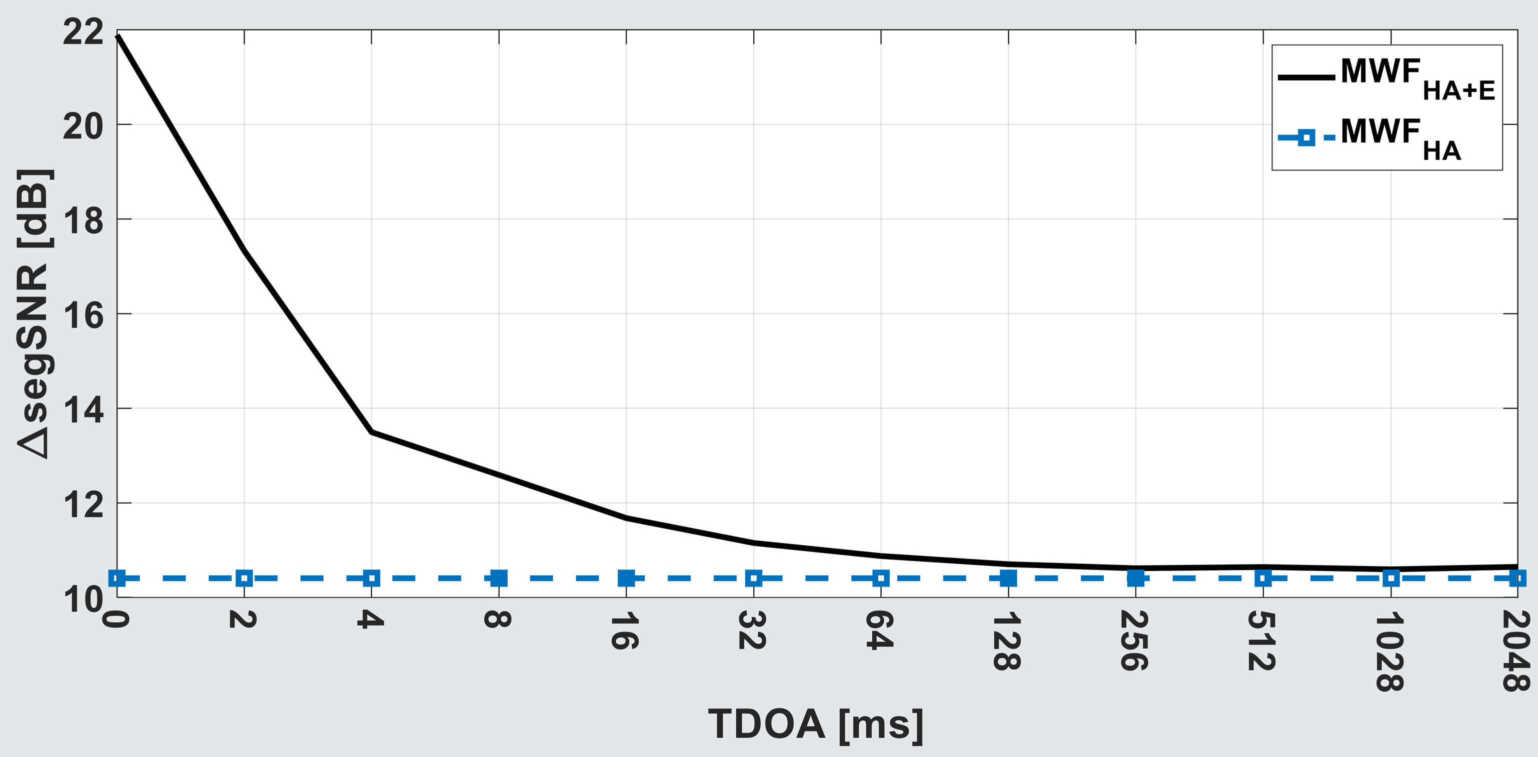
Results and Discussion



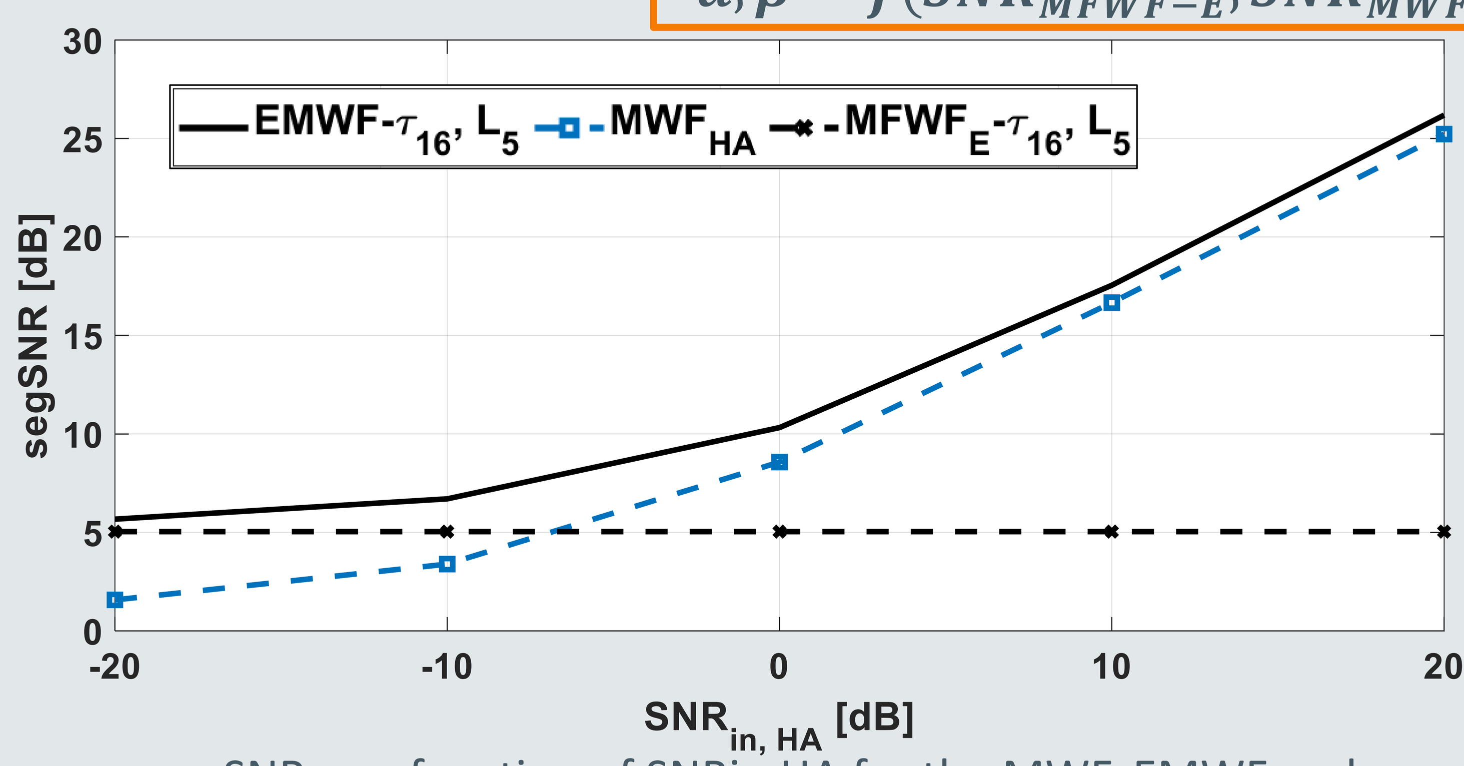
It is a linear combination of existing algorithms!

$$\underline{\hat{w}}_{EMWF} = \begin{bmatrix} \alpha . \underline{\hat{w}}_{MWF-HA} \\ \beta . \underline{\hat{w}}_{MFWF-E} \end{bmatrix}_{(M+L)\times 1}$$

$$\boxed{\alpha, \beta = f(SNR_{MFWF-E}, SNR_{MWF-HA})}$$



Comparing the performance of MWF using HA and remote microphone signals as a function of TDOA (τ).



segSNR as a function of SNRin,HA for the MWF, EMWF and MFWF, at τ = 16 ms and L = 5, estimated for speech signals.

Conclusion

- Resulting beamformer is a simple linear combination of existing multi-channel and multi-frame algorithms.
- Noise reduction and speech intelligibility improves for positive TDOA≤ 16 ms.

References

[1] Bertrand, Alexander, and Marc Moonen, “Robust Distributed Noise Reduction in Hearing Aids with External Acoustic Sensor Nodes.” *EURASIP Journal on Advances in Signal Processing* 2009, no. 1 (December 2009).

[2] Gößling, Nico, Daniel Marquardt, and Simon Doclo, “Performance Analysis of the Extended Binaural MVDR Beamformer with Partial Noise Estimation in a Homogeneous Noise Field.” In *Hands-Free Speech Communications and Microphone Arrays (HSCMA)*, 1–5. San Francisco, CA: IEEE, 2017.

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