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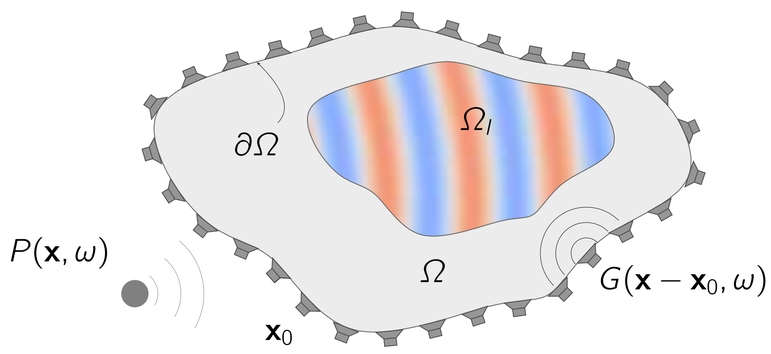
Colouration in 2.5D Local Wave Field Synthesis using Spatial Bandwidth-Limitation

Abstract

Sound Field Synthesis techniques, such as Wave Field Synthesis aim at a physically accurate reproduction of a desired sound field inside an extended listening area. This area is surrounded by loudspeakers individually driven by their respective driving signals. Due to practical limitations, artefacts impair the synthesis accuracy resulting in a perceivable change in timbre compared to the desired sound field. Recently, an approach for so-called Local Wave Field Synthesis was published which enhances the reproduction accuracy in a limited region by applying a spatial bandwidth limitation in the circular/spherical harmonics domain to the desired sound field. This paper reports on a listening experiment comparing conventional Sound Field Synthesis techniques with the mentioned approach. Also the influence of the different parametrisations for Local Wave Field Synthesis is investigated. The results show that the enhanced reproduction accuracy in Local Wave Field Synthesis leads to an improvement with regard to the perceived colouration.

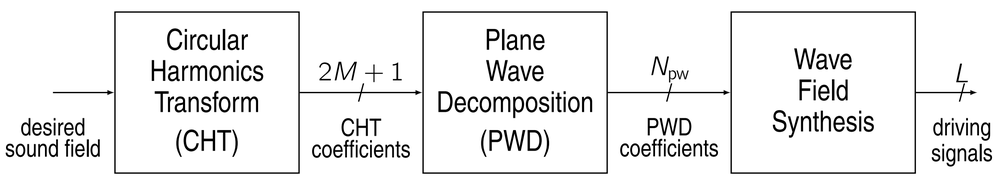
Local Wave Field Synthesis



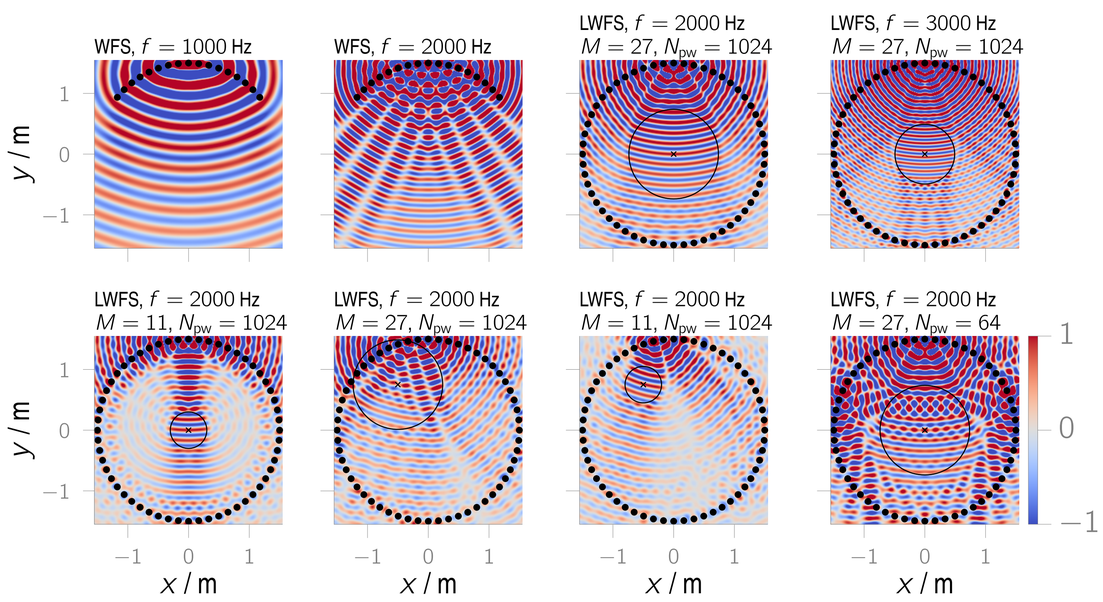
- **goal**: accurate reproduction of desired sound source in target local region Ω_l using a loudspeaker distribution along $\partial\Omega$ (loudspeaker symbols)
- determine driving signals for each loudspeaker such that

$$\underbrace{P(\mathbf{x}, \omega)}_{\text{desired sound field}} = \sum_{\mathbf{x}_0} \underbrace{D(\mathbf{x}_0, \omega)}_{\text{driving signals}} \underbrace{G(\mathbf{x} - \mathbf{x}_0, \omega)}_{\text{sound field of loudspeakers}} \qquad \forall \mathbf{x} \in \Omega_l \,.$$

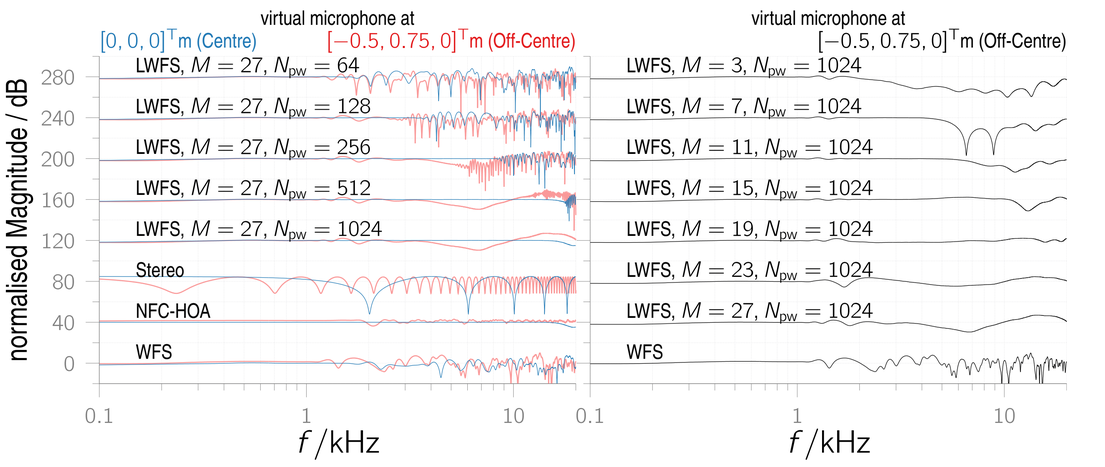
- the Local Wave Field Synthesis approach of this study uses spatial Bandwidth-Limitation in the Circular Harmonics domain to increase synthesis accuracy inside a local region



- comparison with conventional Wave Field Synthesis shows locally improved synthesis accuracy, if parameters are chosen adequately



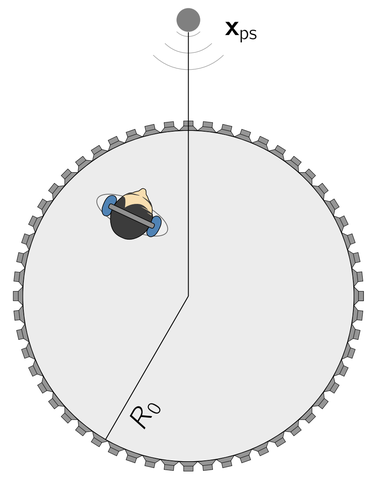
- hence, parametrisation has strong influence on spectral properties of the reproduced sound field



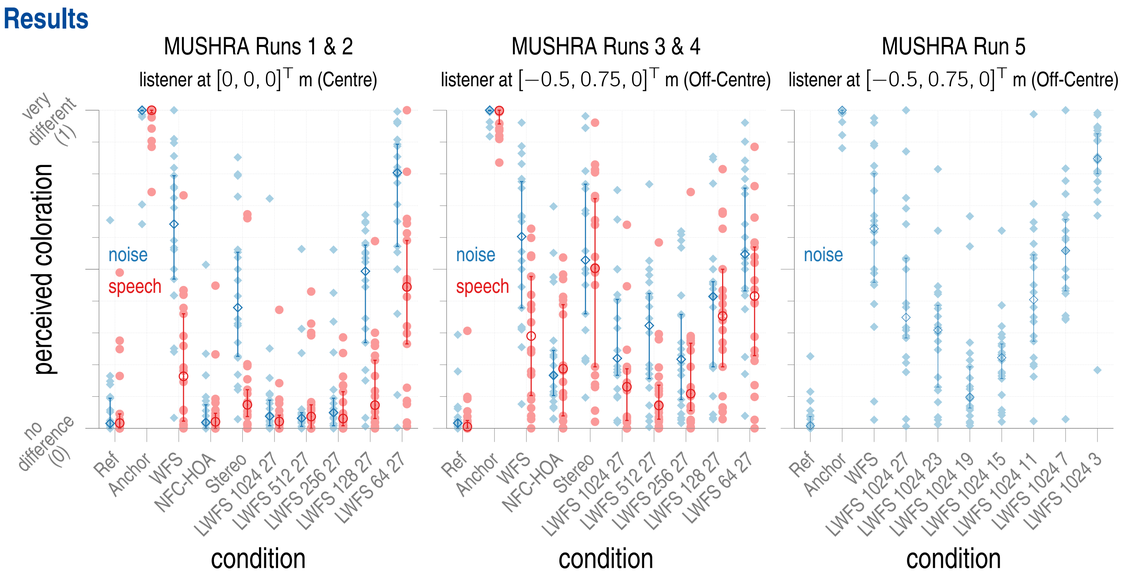
Listening Experiment

Setup

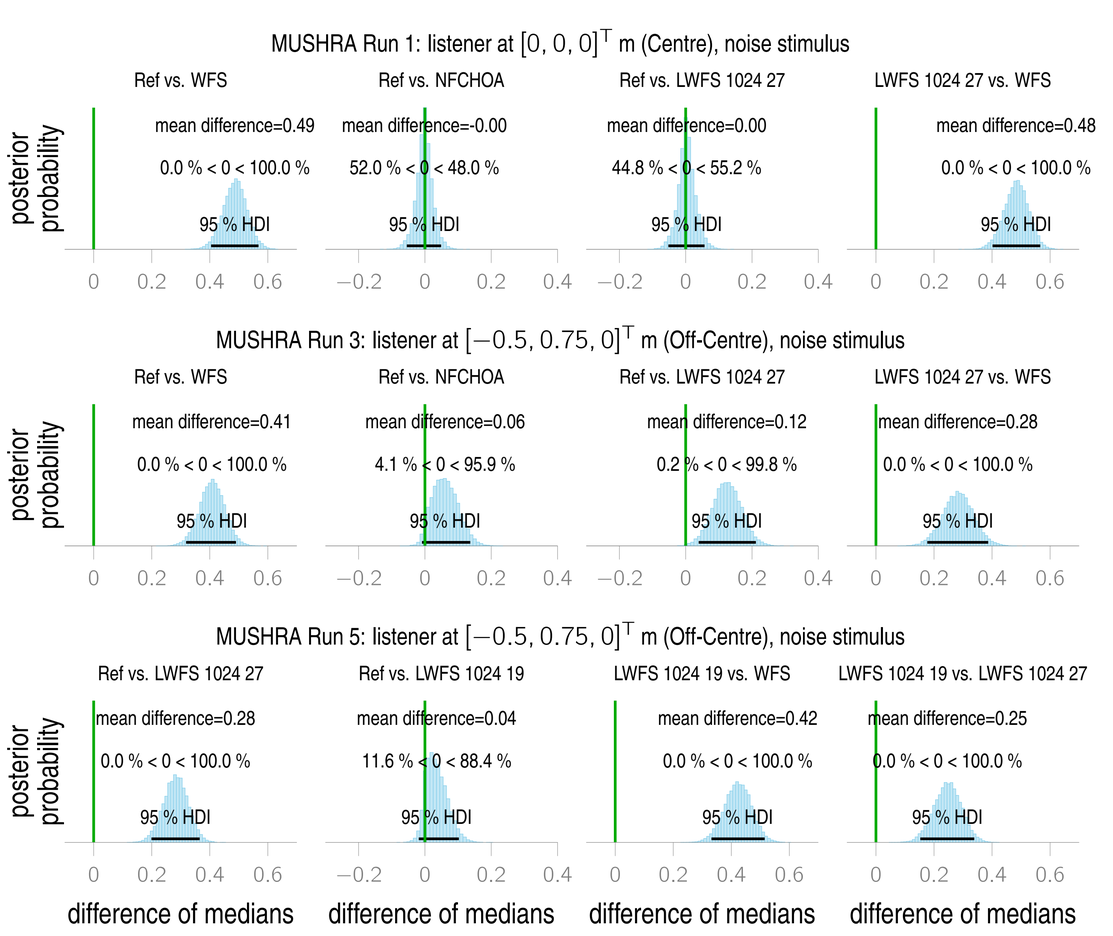
- circular array with radius $R_0 = 1.5$ m and 56 equiangularly spaced loudspeakers
- array was binaurally simulated using anechoic HRTFs
- virtual point source at $\mathbf{x}_{\text{ps}} = [0, 2.5, 0]^{\text{T}}$ m
- two source signals (pink noise pulses and speech)
- two listening positions (Centre and Off-Centre)
- in LWFS, centre of local region is adjusted to listening position
- Multiple Stimulus with Hidden Reference and Anchor (MUSHRA)
- 5 runs à 10 conditions (including reference and anchor)
- 20 listeners



Results



Bayesian Data Analysis



Conclusion

- LWFS is able to decrease perceived colouration compared to conventional WFS
- for the investigated off-centre listening position, colouration is likely to be perceived for all parametrisations of LWFS

Reproducible Research

The Local Wave Field Synthesis approach is implemented in the Sound Field Synthesis Toolbox, Version 2.4.1, which is freely available under the MIT license. The data of the listening experiment is published under Creative Commons Attribution 4.0.

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