FREQUENCY-BASED CUSTOMIZATION OF MULTIZONE SOUND SYSTEM DESIGN

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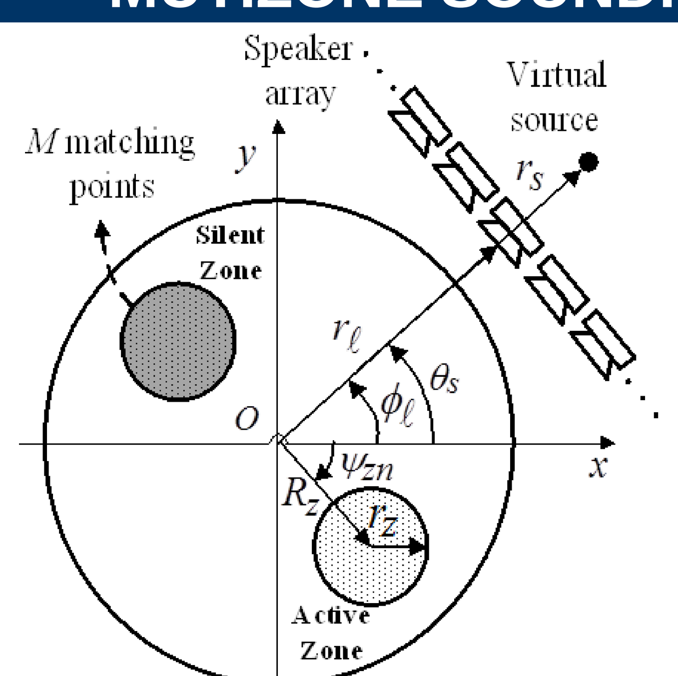
INTRODUCTION

- Control of both the speakers' locations and their weights using Lasso-LS optimization allows multizone sound reproduction with a limited number of speakers [1].
- A time dependent dictionary was suggested in [2] to reduce the complexity of subset selection by applying the optimization only over previously unselected vectors.
- Employment of a novel frequency dependent dictionary in Lasso-LS optimization reduces the computational complexity of loudspeakers' location search [3].
- The frequency contents should be adjusted for customization of multizone sound system design.

MUTIZONE SOUNDFIELD REPRODUCTION



- Generate S isolated sound fields in N zones
- Use a Linear array of L speakers
- Use a pressure matching approach to calculate speaker weights

$$\boldsymbol{D}_{s,q} = \boldsymbol{H}_q \boldsymbol{W}_{s,q}$$

where $\boldsymbol{H}_q$ is the Green's function matrix, $\boldsymbol{W}_{s,q}$ is the vector of speaker weights and $\boldsymbol{D}_{s,q}$ is the vector of desired matrix, sound pressures at the matching points.

Single Stage LS Weight Estimation

The speaker weights can be determined by:

$$\hat{\mathbf{W}}_{s,q} := \arg\min_{\mathbf{W}_{s,q}} \left[\|\mathbf{H}_q \mathbf{W}_{s,q} - \mathbf{D}_{s,q}\|_2^2 + \delta \|\mathbf{W}_{s,q}\|_2^2 \right]$$

where $\|.\|_2$ is the ℓ_2-norm and δ is the LS penalty parameter.

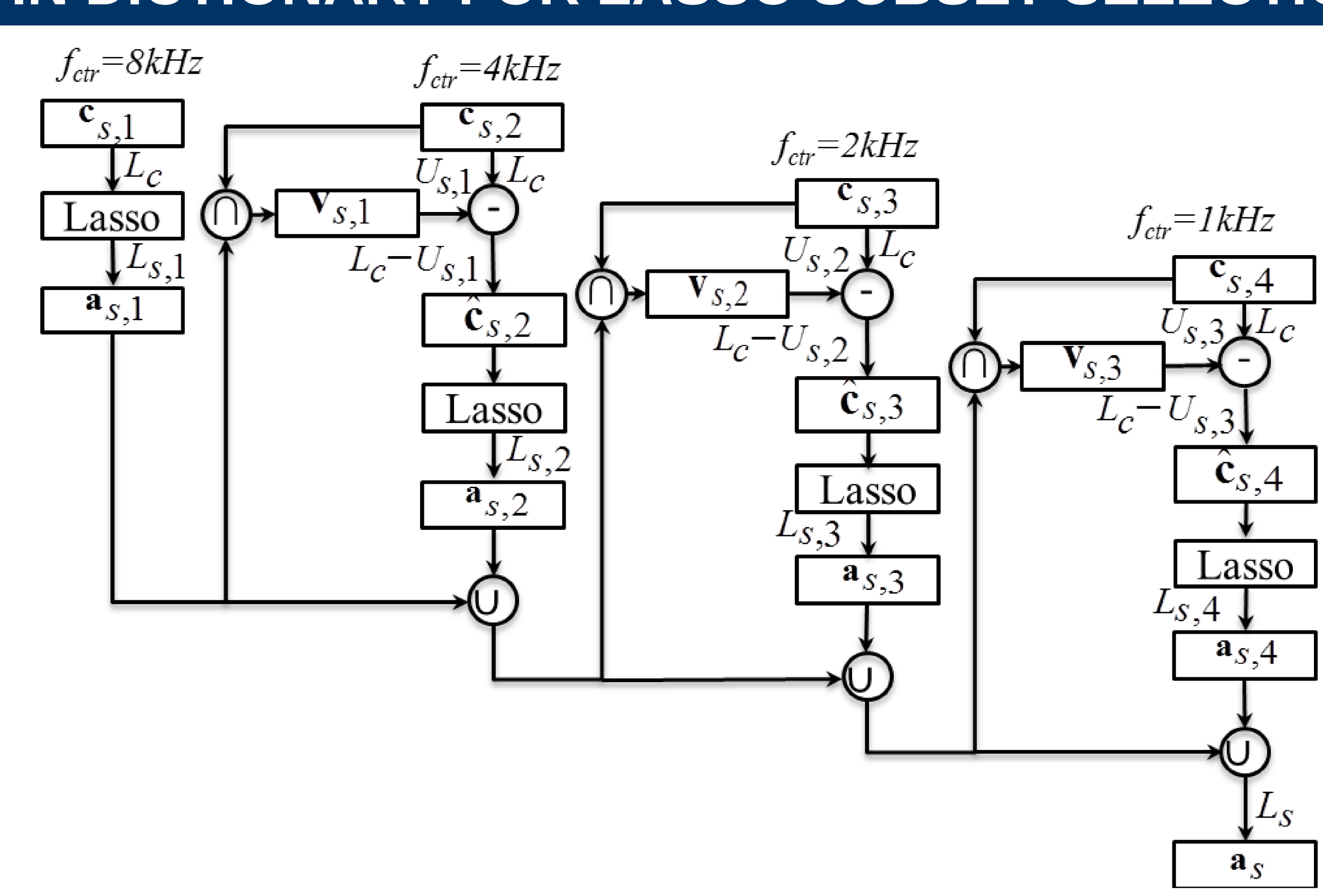
Single Stage Lasso Weight Estimation

The speaker weights can be calculated from:

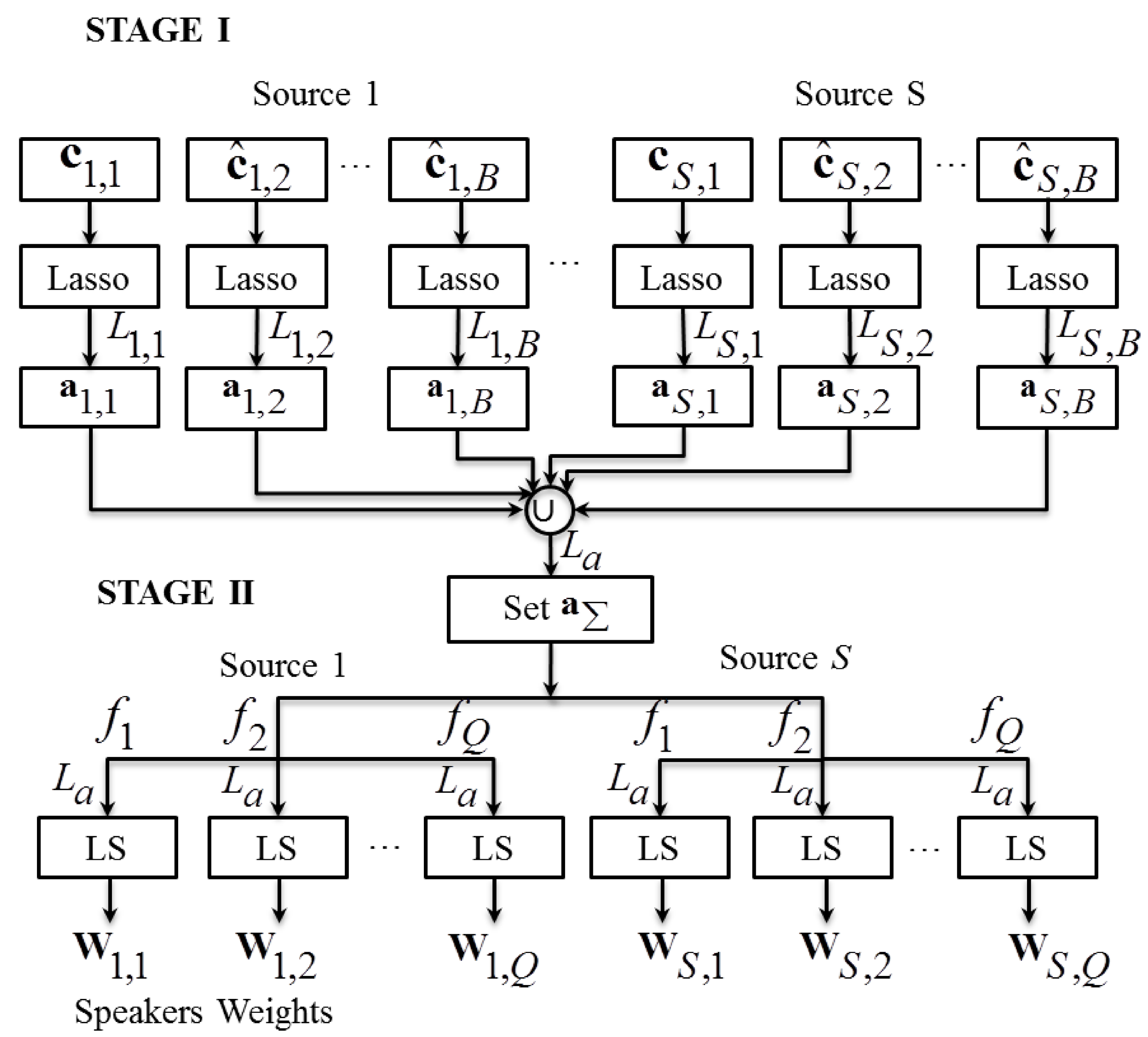
$$\hat{\mathbf{W}}_{s,q} := \arg\min_{\mathbf{W}_{s,q}} \left[\frac{1}{2} \|\mathbf{H}_q \mathbf{W}_{s,q} - \mathbf{D}_{s,q}\|_2^2 + \lambda \|\mathbf{W}_{s,q}\|_1 \right]$$

where $\|.\|_1$ is the ℓ_1-norm and λ is the Lasso penalty parameter.

EHN DICTIONARY FOR LASSO SUBSET SELECTION



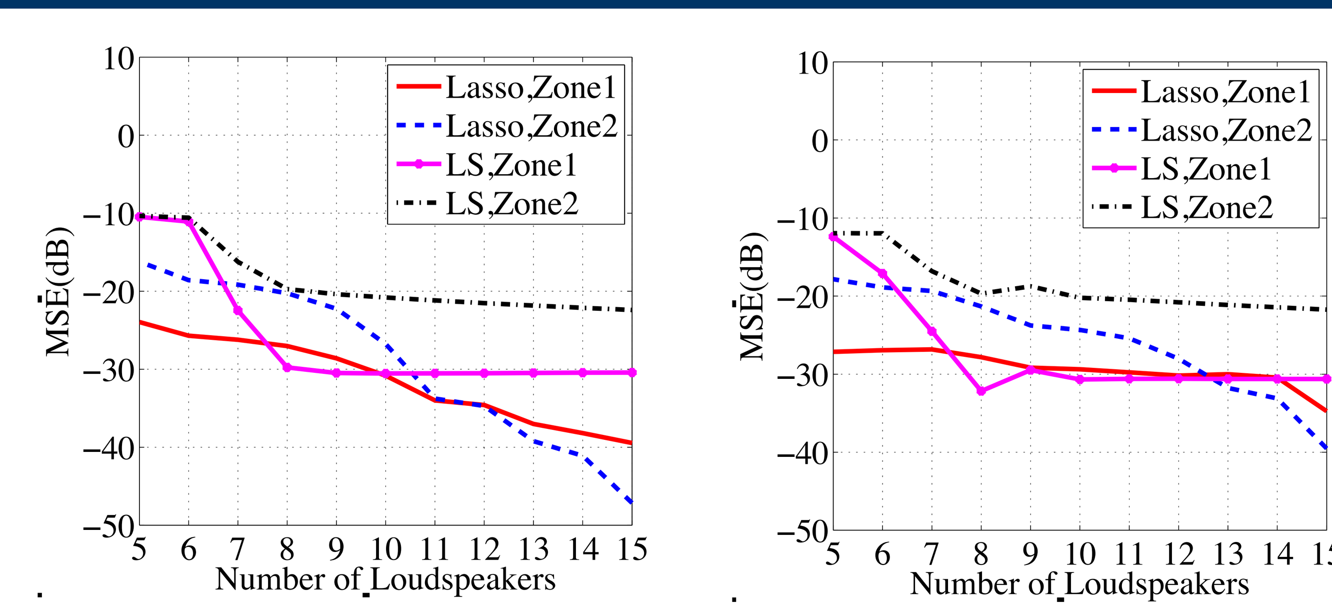
A LASSO-LS OPTIMIZATION ALGORITHM WITH AN EHN DICTIONARY



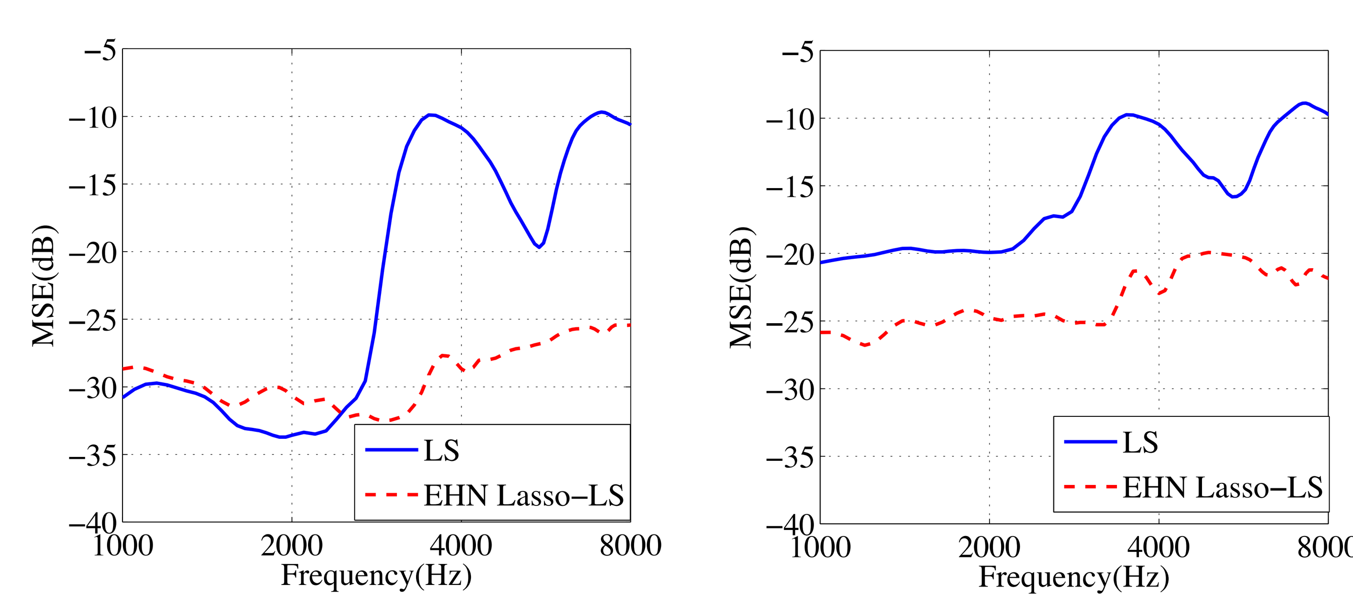
The *b*th set of loudspeakers' weight corresponding to source *s* is calculated from:

$$\hat{\mathbf{W}}_{\mathbf{c}_{s,b}} := \arg\min_{\mathbf{W}_{\mathbf{c}_{s,b}}} \left[\frac{1}{2} \|\mathbf{H}_{\mathbf{c}_{s,b}} \mathbf{W}_{\mathbf{c}_{s,b}} - \mathbf{D}_{s,b}\|_2^2 + \lambda_b \|\mathbf{W}_{\hat{\mathbf{c}}_{s,b}}\|_1 \right]$$

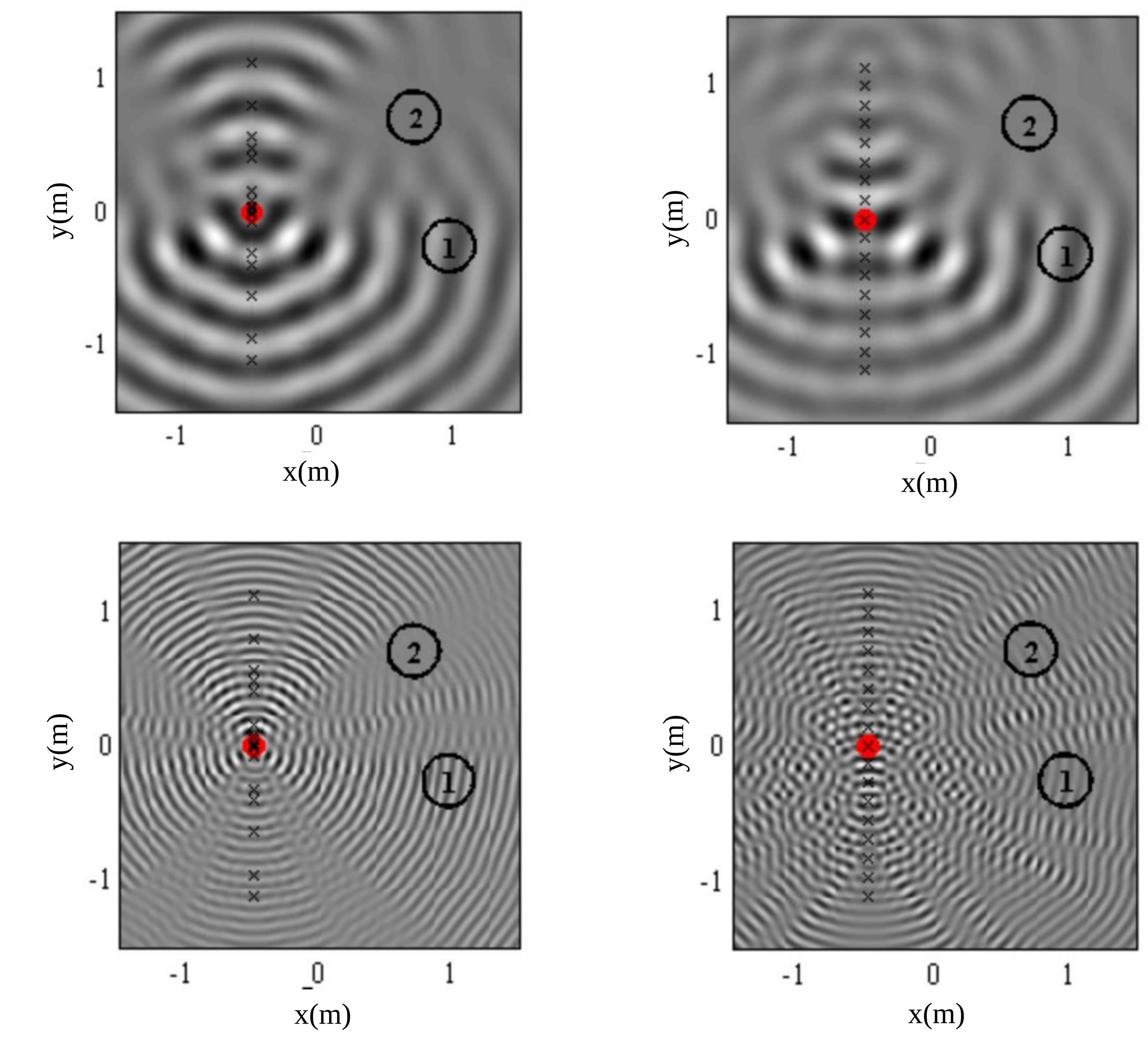
SIMULATION RESULTS



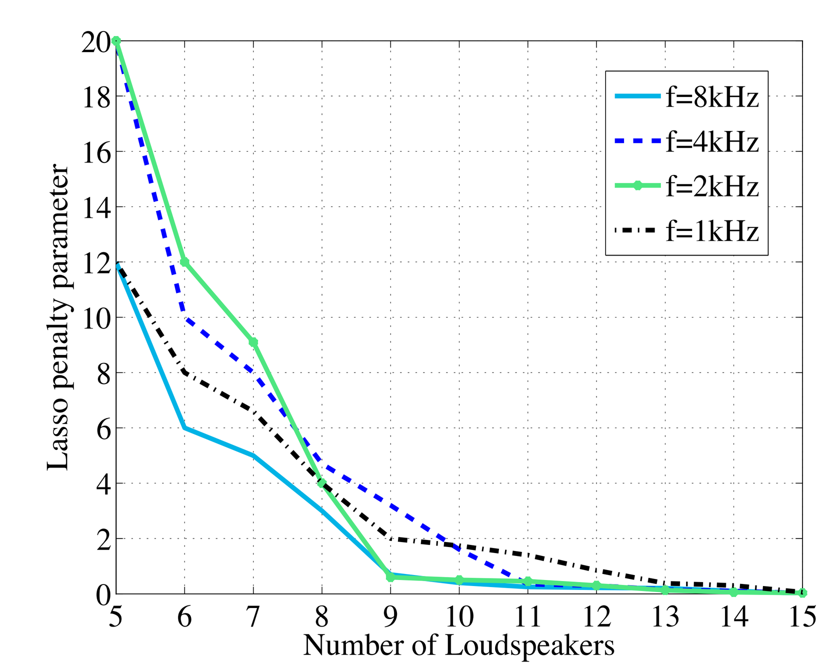
The MSE vs. the number of active speakers.



The MSE vs. frequency. A larger number of speakers selected for sound reproduction at frequencies under 3kHz.



Sound field visualization and speaker locations.



Lasso Penalty Parameter vs. the number of speakers.

CONCLUSIONS

- An efficient harmonic nested Lasso-LS algorithm was employed for multizone wideband sound field generation.
- The ability of this approach in adjusting the performance of sound system across frequency was investigated.
- Up to 24dB improvement in the MSE was achieved over a single-stage LS optimization for multizone sound reproduction using e.g. 17 speakers.

SELECTED REFERENCES

[1] N. Radmanesh and I.S. Burnett, "Generation of Isolated Wideband Sound Fields Using a Combined Two-stage Lasso-LS Algorithm," IEEE Audio, Speech, Language Process., vol. 21, no. 2, pp. 378-387, Feb 2013.

[2] S F Cotter, B D Rao, K Kreutz-Delgado, and J Adler, "Forward sequential algorithms for best basis selection," IEE Proceedings-Vision, Image and Signal Processing, vol. 146, no. 5, pp. 235–244, 1999.

[3] N Radmanesh, I S Burnett and Bhaskar D. Rao, "A Lasso-LS Optimization with a Frequency Variable Dictionary in a Multizone Sound System," *Audio, Speech, and Language Processing, IEEE Transactions on*, vol. 24, no. 3, pp. 583-593, Mar 2016.