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A Comparison of Partial Coherence and Singular Value Partial Field Decomposition in the Context of Nearfield Acoustical Holography

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ACOUSTIC HOLOGRAPHIC METHOD

- What's the Acoustic Holography

A Useful Sound Visualization Technique

- Localization of Sources
- 3D Characterization of Radiated Sound Fields

INTRODUCTION

- What's the partial field ?

BASIC IDEAS

- How can we separate partial fields ?

- Unable to directly measure source signals
- Use of references close to sources; strong relation between each source and corresponding reference
- Partial field separation methods
 - Singular value decomposition method
 - Partial coherence method

Residual field method; modified from conventional method

FUNDAMENTALS

- Source/ signal relations

- Decomposed references

2 SOURCE MODELLING

- 2 incoherent sources/ 2 references

- Incoherent sources; $S_{AB}=0$
- Transfer functions: g_{ij} , geometry relation

- simple point source case

$$g_{ij} = \frac{e^{jk r_{ij}}}{r_{ij}} \quad r_{ij} : \text{distance between } i \text{ source \& } j \text{ receiver}$$

- strong source/corresponding reference relation

$$g_{11}, g_{22} \gg g_{12}, g_{21}, g_{1y}, g_{2y}$$

METHODOLOGIES

- **Reference spectral matrix**

reference signals $\mathbf{r} = \mathbf{G}_{\text{ref}} \mathbf{a}$ source amplitudes

TF's from sources to references, geometric relations

$$\mathbf{S}_{\text{ref}} = E \{ \mathbf{r}^* \mathbf{r}^T \} = \mathbf{G}^* \mathbf{S}_s \mathbf{G}$$

- **Partial field separation**

- Singular value decomposition method;
 - depends on the levels of sources & geometrical TFs (g_{ij} , S_{AA} , S_{BB})
 - reordering, singular value swapping
- Partial coherence method;
 - depends on the levels of sources & geometrical TFs (g_{ij} , S_{AA} , S_{BB})
- Residual field method;
 - depends only on the geometrical TF's (g_{ij})
 - easily applicable to general acoustic problems, including structural acoustic problems

INCOHERENT REFS.

- 1-to-1 relation between sources & references

SIMULATION

- Simulation parameters

$N=512$
 $\Delta f=8\text{Hz}$
 $N_{\text{avg}}=250$

SIMULATION

- Estimation of source strengths

- Comparison of separated partial fields

SIMULATION

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EXPERIMENTAL SETUP

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EXPERIMENTAL RESULTS

(1 KHz)

SVD

Partial Coh.

Residual Field

1st partial field

2nd partial field

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CONCLUSION

- **Partial field separation methods**
 - Use of as many references as sources, and place them close to incoherent sources
 - SVD, Partial coherence techniques
 - depend on source levels as well as geometries of sources & refs.
 - reordering of references & partial fields
 - A useful alternative: ***Residual Field Technique***
 - modified from partial coherence technique
 - depends only on the geometries of source & refs.
 - simple extraction of partial field related to each reference
- **Applicable to the structural acoustic problems**

APPENDIX

- In case of 1-to-1 measurement**

$$\mathbf{S}_{\text{ref}} = \begin{bmatrix} |g_{11}|^2 S_{AA} & 0 \\ 0 & |g_{22}|^2 S_{BB} \end{bmatrix}$$

$$S_{11} = |g_{11}|^2 S_{AA}, S_{22} = |g_{22}|^2 S_{BB}$$

$$H_{1y} = \frac{g_{1y}}{g_{11}}, H_{2y} = \frac{g_{2y}}{g_{22}}$$

$$\lambda_1 = \max\{|g_{11}|^2 S_{AA}, |g_{22}|^2 S_{BB}\},$$

$$H_{1y} = \frac{g_{1y}}{g_{11}}, H_{2y} = \frac{g_{2y}}{g_{22}} \quad \text{if } |g_{11}|^2 S_{AA} > |g_{22}|^2 S_{BB}$$

$$\lambda_2 = \min\{|g_{11}|^2 S_{AA}, |g_{22}|^2 S_{BB}\}$$

$$H_{1y} = \frac{g_{2y}}{g_{22}}, H_{2y} = \frac{g_{1y}}{g_{11}} \quad \text{if } |g_{11}|^2 S_{AA} < |g_{22}|^2 S_{BB}$$

- Cross-relations between sources/references**

$$|g_{11}|^2 S_{AA}, |g_{22}|^2 S_{BB} \gg |g_{12}|^2 S_{AA}, |g_{21}|^2 S_{BB} \quad S_{AA} \approx S_{BB} \quad \text{source level relation}$$

$$|g_{11}|, |g_{22}| \gg |g_{12}|, |g_{21}|, |g_{1y}|, |g_{2y}| \quad \text{geometric relation}$$