High Accuracy ESPRIT Without Left-right Ambiguity Using An Acoustic Vector Sensor Array

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Aim

- Existing ESPRIT DOA estimation based on Acoustic Vector Sensor Array (AVSA) can be divided into two categories:
  - Divided the AVSA into two sub-arrays according to the array spatial structure, called ESPRIT-S. With high accuracy, but multivalued angles for arccos function
  - Using the relationship between the sound pressure and analytic velocity, called ESPRIT-A. Without ambiguous angle, but lower accuracy
- High accuracy and without ambiguous in this paper.

Results

1) Two signals stand on the same broadside of the AVSA

Two unrelated narrowband signals from 80° and 90°, center frequency 2000Hz and bandwidth 200Hz, receive array is 5 elements AVSA. Snapshots 3000, sampling frequency 6000Hz. SNR from -15dB to 6dB with 3dB interval. Symbol “S1” and “S2” represent the two signals respectively

2) Two signals stand on different broadside of the AVSA

Two unrelated narrowband signals from 80° and 240°, center frequency 2000Hz and bandwidth 200Hz, receive array is 5 elements AVSA. Snapshots 3000, sampling frequency 6000Hz. SNR from -15dB to 6dB with 3dB interval. Symbol “S1” and “S2” represent the two signals respectively

Methods

Azimuth angle estimation using ESPRIT-OH based on AVSA:

- $K$ signals angle estimated by ESPRIT-S are put into two groups, $K_1$ signals in $(0, \pi]$, $K_2$ signals in $(\pi, 2\pi]$;
- average cross-covariance matrix $R_1$ and $R_2$ as:

\[
R_1 = \frac{1}{N} \sum_{n=1}^{N} x[n-k] y[n-k]^T
\]

\[
R_2 = \frac{1}{N} \sum_{n=1}^{N} x[n-k] y[n-k]^T
\]

- $K_1$ and $K_2$ signal angles estimated by general ESPRIT

\[
\hat{\theta} = \hat{\theta}_1, \cdots, \hat{\theta}_1, 2\pi - \hat{\theta}_2, \cdots, 2\pi - \hat{\theta}_2, \cdots
\]

Discussion

Why the ESPRIT-OH method has higher accuracy than ESPRIT-A method, and moving left-right ambiguousness?

Conclusions

- Conventional ESPRIT-S algorithm based on AVSA has better performance than pressure array;
- The ESPRIT-S can only get estimation angle within the range of 0° ~ 180°;
- The ESPRIT-A can estimate the omnibearing angle, but has no high accuracy;
- The ESPRIT-OH has high accuracy and moving left-right ambiguity.