Improving Beamforming for Distant Speech Recognition Using a Genetic Algorithm for Planar Array Synthesis

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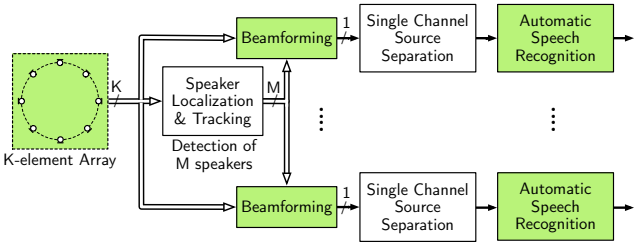
Abstract

- Beamformer's (BF) spatial filtering performance depends on microphone array (MA) geometry
- **Uniform circular array** (UCA) introduces
  + **directivity pattern stability** around array plane
  – **high sensitivity** to reflections from ceiling and floor
- Reduce this kind of sensitivity by using genetic algorithm (GA) for planar array synthesis without loosing directivity pattern stability and without suffering from significant performance degradations
- Alternative method presented

1. Problem Statement & Distant Speech Recognition

Given distant speech recognition system with fixed source localization/tracking, source separation, and automatic speech recognition system, its performance depends on

- **microphone array geometry**
- **beamformer**: delay&sum, convex-optimization based



UCA with or without center microphone (CM)

+ **directivity pattern stability** around array plane
– **high sensitivity** to reflections from ceiling and floor

Optimize MA to reduce sensitivity to reflections from ceiling and floor without suffering from significant performance degradations and without loosing directivity pattern stability around array plane

2. Multi-Objective Genetic Algorithm

Given GA based on binary coding and

- non-dominated **sorting**
- crowded tournament **selection**
- random multi-point **crossover** and **mutation**

optimizing set of m randomly initialized MAs **considering**

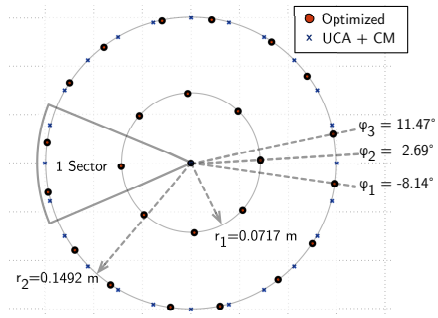
- beamformer
- multiple objective measures as fitness measures
  - main-to-side-lobe ratio (MSR)
  - 3dB-beamwidth (3dB-BW)
  - directivity index (DI)

  } 3-dim. measures
- symmetry constraint: optimize microphone positions within single disc sector and add rotated copies to remaining disc

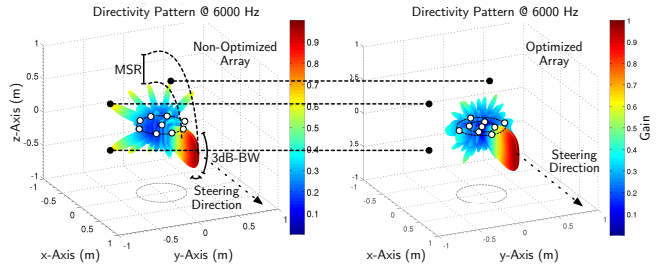
3. The Evolved Microphone Array

Given delay&sum BF and 25 microphones

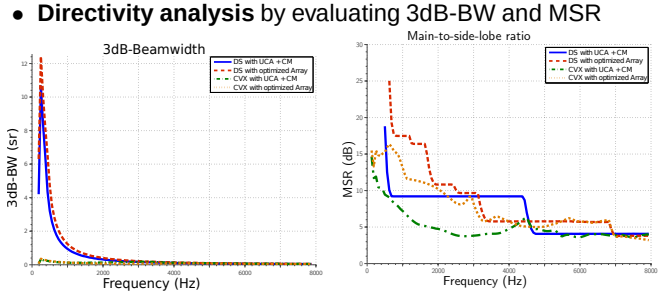
- **First-ranked 25 microphone individual** of last generation



- **Improvement in directivity** (not optimized / optimized)

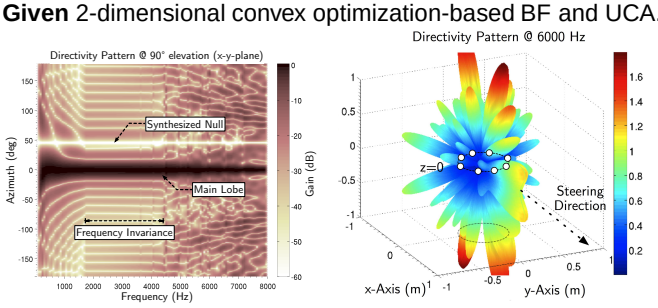


- **Directivity analysis** by evaluating 3dB-BW and MSR



4. Optimization Using Convex Optimization-based BF

Given 2-dimensional convex optimization-based BF and UCA.



3-dimensional optimization allows directivity control outside plane of interest, which yields similar optimized directivity as shown above.

5. Conclusion

Improving beamforming by using **GA** for **planar array synthesis** or by using **BF optimized to 3 dimensions** to **decrease high sensitivity to reflections from ceiling and floor** by at least 3.194 dB **without** suffering from **significant performance degradations**.

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