The localisation performances of three multi-channel systems are studied through a formal listening test. Second-order Ambisonics is compared with two circularly symmetric microphone array systems: Johnston’s perceptual sound field reconstruction scheme [1] and its modification which we recently proposed [2,3]. It is found that the employed second-order Ambisonics decoder renders auditory images that are contracted around the mid-point between the two frontal loudspeakers and that our recently proposed system delivers a more uniform localisation performance.

Considered Multi-Channel Systems

- Perceptual sound field reconstruction systems
  - Circular array of five microphones situated at vertices of a regular pentagon in the horizontal plane. Reproduction using five loudspeakers in the same regular configuration. Each microphone drives the corresponding loudspeaker.
  - Johnston/Lam version
    - The microphone directivity has the primary lobe down by 3 dB at 72° and down to effectively zero at 144°. The diameter of the array is 31 cm. [1]
  - Recently proposed version (TI pan)
    - The microphone directivity design is established within the framework of time-intensity stereophony [2]. The diameter is set so as to deliver more “natural” and mutually consistent ILD and ITD cues [3].
- Second-order Ambisonics
  - The B-Format signals are encoded via the Furse-Malham 2nd-order coefficients (FMH-Format) and decoded using the in-phase coefficients. The CDP Multi-Channel software toolkit available at [4] has been used. The employed loudspeaker layout is pentagon.

Listening Test Setup

- Audio booth with walls and ceiling almost completely absorbent. \( T_{60} = 230 \text{ms} \)
- Room dimensions: \( W = 4.5 \text{ m}, L = 6 \text{ m} \) and \( H = 2.2 \text{ m} \)
- Six subjects (5 males and 1 female).
- Subjects positioned in the centre of the loudspeaker array.
- Three different seating orientations - see Figure 3.

Methodology and Stimuli

- Stimulus: White Gaussian noise of 100 ms duration tapered with a Tukey window (30% taper-to-constant ratio).
- For each of the 3 systems, the microphone recordings were simulated for 8 different directions corresponding to the directions of the acoustic pointers - see Figure 3 (free field).
- The subjects’ task was to listen to the five-channel system stimuli and respond by listening to and selecting the acoustic pointer which is closest to the perceived direction of the auditory image.
- At each seating direction, each system-direction pair was repeated 15 times and with fully randomised presentation order (total 1080 trials per subject).

Results

- Front-looking orientation (Figure 4a)
  - 2nd-order Ambisonics, the average responses lie within \((-15°, 15°)\)
  - TI pan system provides more uniform subjective localisation performance.
  - Johnston/Lam performs better than Ambisonics but worse than TI pan.

- Side-looking orientation (Figure 4b)
  - Between 44° and 68° the performance of all the systems perform equally bad, possibly due to the sparsity of the surround system and the poor localisation accuracy of the auditory system for side angles.
  - Beyond 68° TI pan delivers the best performance.

- Back-looking orientation (Figure 4c)
  - The above observations hold for this orientation too.

References


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