Psychoacoustics-based 3D Microphone Array Design

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Stereo microphone technique design

- Microphone angle and spacing → Trade-off between interchannel time and level differences for phantom image positioning → Stereo Recording Angle (SRA)

![Image](image_url)

Interchannel Time Difference (ICTD) in ms

Interchannel Level Difference (ICLD) in dB

Image shift (%)
Stereo microphone technique design

- Object-oriented mic technique design tool (Lee, Johnson and Mironovs 2017).

- Based on the time-level trade-off functions

Flexible object and mic array positioning on a virtual stage

Predicted positions of sources btw. speakers

Mic array configuration

ICTD & ICLD
Surround microphone technique design

- Main microphone array: OCT, ICA, Fukada Tree, etc.
  - Similar principles to the stereo technique design, but only for the front and rear.
  - Unstable side imaging.

- Ambience array: Hamasaki square, etc.
  - For envelopment.
  - Interchannel decorrelation is the key! (horizontal microphone spacing)

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3D microphone array design

- A surround mic array is augmented with a height layer.

- Psychoacoustic factors to consider.
  
  1. Vertical interchannel crosstalk.
  
  2. Vertical level and time differences.
  
  3. Vertical microphone spacing (decorrelation).
**Vertical Interchannel Time Difference**

- Interchannel time difference (ICTD) is a very unstable cue for vertical localisation (Wallis and Lee 2015).
- The precedence effect does NOT operate vertically.

• To avoid upwards image shift, direct sound in the height channel should be attenuated by at least 7dB.

Vertical Microphone Spacing

- The effect of vertical microphone spacing on spatial impression (Lee and Gribben 2014)

Vertical Microphone Spacing

Vertical Microphone Spacing

- Vertical microphone spacing has NO significant effect on perceived spatial impression.

PCMA-3D Microphone Array

- Horizontally spaced, vertically coincident design for 3D sound capture.
- Compact.
- No comb-filtering in downmixing.

Application of PCMA for 3D capture (Lee and Gribben 2014)

- $d$ depends on the desired diffuseness of the rear channels: For maximum diffuseness, beyond critical distance recommended.
- The upper cardioids can be angled directly towards the ceiling: this still allows enough suppression of the vertical interchannel crosstalk.

Microphones used: Schoeps CCM4 (main) and CCM41 (height).
ESMA-3D for 360 audio capture

- Equal Segment Microphone Array for 360 recording (for VR).
- 50cm x 50cm square, ideal size for accurate localisation in a quadraphonic reproduction (Lee 2016).
- Vertically coincident (Cardioid main + supercardioid height.)