Loudspeakers and Space (a.k.a Spatialization)

David Adamcyk

Advanced Mixed Music Composition
“The presence of spatialization can be recognized in every situation in which spatial extensions, positions (directions and distances) of the sound sources as well as the acoustic quality of the performance space are given compositional significance.” – Maris Anna Harley

1) Main Challenges
2) Different Approaches
1) Main Challenges: Localization

Knowles Electronics Mannequin for Acoustics Research (KEMAR) for Head Related Transfer Functions measurements

1) Main Challenges: Localization

We determine the **angular position** of sound using three types of aural cues:

1) **Interaural Time Differences (ITD)**

Mostly contribute between 270Hz and 1400Hz (dominates between 270Hz and 500Hz)

2) **Inter-aural Intensity Differences (IID)**

Mostly contribute between 500Hz and higher (dominate above 1400Hz)

3) **Head Related Related Filtering**

Filtering caused by the shape of our ears

* Note that ITDs and IIDts have very little to no effect on our perception of sounds lower than 270Hz

1) Main Challenges: Localization

We determine **distance** of sound using three types of aural cues:

1) Intensity of a sound

2) Ratio of reverberated to direct sound (R/D ratio) in a given space

   \[ \text{Critical Distance} \rightarrow R/D = 1 \]

3) The amount of high frequency in a sound

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1) Main Challenges: Localization

Resolution of spatial hearing:

In sum:
- We hear very well in front of us
- We hear very well at head level on the horizontal plane

1) Main Challenges: Localization

Other issue: *Precedence Effect*

“A listener receiving the same sound from multiple sources locates it at the closest source, not at a point between them, unless the separation time is less that about a millisecond.”

1) Main Challenges: Source Bonding

**Source Bonding**: “The natural tendency to relate sounds to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins.”

1) Main Challenges
2) Different Approaches
2) Different Approaches: Classification

- Typical Loud-speakers
- Non-typical loud-speakers

- Standard
- Non-standard

- Mobile sources
- Fixed sources

- Sound is in a virtual space (or at least the impression of one)
- Sound is in the physical space (speaker as substitute for a performer)
2) Different Approaches: Use of Typical Loudspeakers with **Standard** Configurations

Standard commercial configurations:

- Stereo
- Quad
- 5.1
- 6.1
- 7.1 > Blu-ray (Dolby True-HD, DTS-HD, Linear PCM; all lossless formats)

... and more

These formats all seem very aware of source bonding…

Source: dolby.com
2) Different Approaches: Use of Typical Loudspeakers with **Standard** Configurations

Standard “concert-music” configurations:
- Stereo
- Quad
- Hexaphonic (6 channels)
- Heptaphonic (6 surround channels +1 center channel)
- Octaphonic (8 channels)
- Dome-type configurations
  - BEAST (Birmingham Electro-Acoustic Sound Theatre)
  - Acousmonium (France, related to GRM)
  - Audium (San Francisco)
  - Motus (France)
  - Klangdom (Germany, ZKM)
- WFS (Wave Field Synthesis) ~ not really standard yet

Musical Examples:
- Erin Gee, *Mouthpiece IX*, for amplified voice and orchestra
- Rama Gotfried, Ircam project for cello and WFS
- Haydn Project, re-synthesizing spaces
2) Different Approaches: Use of Typical Loudspeakers with **Standard** Configurations

**Technical advantages** of standard configurations:
- Stereo is commonplace
- Can be cheap (via commercial formats)
- Infrastructure increasingly available in music institutions

**Aesthetic disadvantages** of standard configurations:
- Tends to impose a preferred “sweat spot” for the listener
- Tends to conform to the standard concert protocol
- Tends to impose a common set of tools, most of which have visual interfaces
  - Ex: Spat~, ICST Ambisonics, vbap~, Zirconium, ViMic, OMPrisma, commercial panners (logic, DP, ProTools, etc.)

→ Is it possible to imagine using visuals aids during a concert, to guide the listener?
→ Is space travel possible?
2) Different Approaches: Use of Typical Loudspeakers with **Non-Standard** Configurations

**Fig. 1:** Stereo corridor with 42 speakers (CAD)

**Fig. 2:** Auditory-Channel: stereo corridor setup

**Fig. 3:** Two cone/tree setups (CAD)

**Fig. 4:** Sound-Tree: Cone/Tree setup

2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations

As sound installations:

2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations

As sound installations:
2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations

As concert works which enhance what’s already there
  • extension instrumental properties (i.e., “meta-instrument”)

2) Different Approaches: Use of **Typical** Loudspeakers with **Non-Standard** Configurations AND with **Movement** of the loudspeaker

Less typical loudspeakers…

2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations AND with Movement of the loudspeaker

Less typical loudspeakers… (continued)

• Paul Clift, *With my limbs in the dark* (2008-09)
2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations AND with Movement of the loudspeaker

Less typical loudspeakers… (continued)

• David Adamcyk, *Cheval mémoire* (2011)
2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations AND with Movement of the loudspeaker

Performative installation

2) Different Approaches: Use of Typical Loudspeakers with Non-Standard Configurations AND with Movement of the loudspeaker

A very old idea…

- David Tudor, Bandomeon (a combine!) (1966)
2) Different Approaches: Use of **Non-Typical** Loudspeakers with **Non-Standard** Configurations

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2) Different Approaches: Use of Non-Typical Loudspeakers with Non-Standard Configurations

Postlude: Short survey of “sound tools” used for spatialization

- **Vbap** (2D and 3D panning, for MaxMSP; It’s free! By Vile Pulkki)
  [http://www.acoustics.hut.fi/~ville/](http://www.acoustics.hut.fi/~ville/)
- **ViMic** (Microphone position based spatialization, for MaxMSP, part of Jamoma; It’s free! By Nils Peters)
- **Spat~** (2D and 3D panning with room simulation, for MaxMSP)
  Part of Ircam Forum
- **Sequencer panners** (Logic, DP, ProTools, Cubase, etc.; watch out for pan laws!)
- **Ambisonics** (many different versions, MaxMSP version most versatile, by ICST; It’s free!)
- **Reverbs Units**
  - Algorithmic
    - Kjaerhus Audio Classic Reverb (only VST; It’s free!)
    - Waves True Verb and Renaissance Verb (very good, expensive)
    - Lexicon PCM Native Reverb Bundle (like…crazy expensive)
  - Impulse Response
    - Space Designer (part of Logic, Mainstage, and SoundtrackPro)
    - Altiverb (by Audio Ease, very expensive, industry standard)
    - Knufinke SIR1 (only VST; It’s free!)
    - Waves IR1 (good)
    - Tconvolution (MaxMSP object; it’s free!)