Stereo recording in 3D: Concepts and Examples

Helmut Wittek
hauptmikrofon.de
SCHÖEPS GmbH
Abstract:

- Stereophonic 3D-Audio formats offer great chances for sound engineers to deliver the full spatial and timbral fidelity of a performance to the listener. Recording principles based on stereophonic rules and experiences can perform even better now as the limitations of stereophony are further minimized.

The advantages of the stereophonic 3D-Audio format over WFS and Ambisonics can be quite apparent, e.g. with regard to spatial perception and channel efficiency. However, there are pitfalls, as well. More loudspeakers don`t automatically create a better sound.

Examples of setups and recordings from ambience recording, sports and music recording are presented.
Contents:

- Stereophony Basics
  - 4 Spatial Sound reproduction principles
  - Psychoacoustics of Stereo
- Stereophonic Imaging for 3D
  - Directional Image
  - Room Image
- Array design for 3D-Audio
  - $\Delta t$ and/or $\Delta L$
  - ORTF-3D
Spatial sound reproduction techniques:

- Real sources
- Stereophony
- Sound field reconstruction
- Binaural
Spatial sound reproduction techniques:

- **Real sources**
- Stereophony
- Sound field reconstruction
- Binaural
Spatial sound reproduction techniques:

- Real sources
- **Stereophony**
- Sound field reconstruction
- Binaural
Spatial sound reproduction techniques:

- Real sources
- Stereophony
- **Sound field reconstruction**
- Binaural

* The term „Sound field reconstruction” includes techniques like WFS or HOA
Spatial sound reproduction techniques:

- Real sources
- Stereophony
- Sound field reconstruction
- Binaural
Localization and perception model:

- **Real source** = **Sound field reconstruction** = **Binaural**
Localization and perception model:

- **Stereophony unexplained!** Summing localization with strong comb filtering

Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo
Stereo Imaging
Array design for 3D-Audio
Stereophony unexplained!

- Interaural Cross Correlation

ΔL = 7dB
Δt = 0 ms

ΔL = 0dB
Δt = 0.4 ms

Real source, +15°

Phantom Source, perceived +15°

Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging
Array design for 3D-Audio
Localization and perception model:

- **Stereophony** after the “Association model” of Theile

---

Spatial sound reproduction techniques:

- *Multichannel* Stereophony??
Spatial sound reproduction techniques:

- *Multichannel* Stereophony??

Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging
Array design for 3D-Audio
Spatial sound reproduction techniques:

- **Multichannel** Stereophony??

Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo
Stereo Imaging
Array design for 3D-Audio
Spatial sound reproduction techniques:

- *Multichannel* Stereophony
Basics
Stereo Imaging
- Directional Image
- Room Image
Array design for 3D-Audio

Spatial impression

- Direction
- Distance, Depth, Spaciousness
- Envelopment
- Reverberance

© Theile

0 ms 30 ms t
• The Recording angle

\[ \Delta t, \Delta L \]

between microphones

\[ \Delta t, \Delta L \]

between loudspeakers
• The Recording angle
• The Recording angle

 Demo Recording Angle: Cedric 4 Stereofoniepaare “Schulhof” oder “Enten”
• Localisation Curve

- RecAngle 75%: 24°
- RecAngle 100%: 35°
- Left-Right

Basics
Stereo Imaging
• Directional Image
• Room Image

Array design for 3D-Audio
• SCHOEPS-App “Image Assistant”: [www.ima.schoeps.de](http://www.ima.schoeps.de)

Basics
Stereo Imaging
• Directional Image
• Room Image
Array design for 3D-Audio

Demo App „Image Assistant“, Demo Cedric 4 Stereopaare mit Screenshots IMA3
• Panning/Stereophonic Imaging between vertical loudspeaker pairs (Demo Vertical Shaker)

REF Jim Barbour, AES
• Panning/Stereophonic Imaging between vertical loudspeaker pairs: X/Y microphone configuration for vertical imaging
Basics
Stereo Imaging
- Directional Image
- Room Image
Array design for 3D-Audio

Spatial impression

- Direction
- Distance, Depth, Spaciousness
- Envelopment Reverberance

© Theile
Diffuse sound in the recording room → diffuse sound in the reproduction room

Basics
Stereo Imaging
• Directional Image
• Room Image
Array design for 3D-Audio
Diffuse sound in the recording room $\rightarrow$ diffuse sound in the reproduction room

$\rightarrow$ different diffuse signals
$=\text{decorrelated in the diffuse field}$
• The larger the distance, the more independent the signals

○ ○ ○ ○ ○ ○ ○ ○

• The larger the directivity, the more independent the signals

○ ○ ○ ○ ○ ○ ○ ○

• The larger the opening angle, the more independent the signals

○ ○ ○ ○ ○ ○ ○ ○
Diffuse field correlation (DFC): coincident setups
- is dependent on the distance, angle and directivity
- is dependent on the frequency (wave length)
• Diffuse field correlation (DFC): coincident setups

DFC = Correlation coefficient

Opening Angle (°)

Acht (a=0)
Hyperniere (a=0.25)
Superniere (a=0.36)
Niere (a=0.5)
breite Niere (a=0.65)
Kugel (a=1)

Basics
Stereo Imaging
• Directional Image
• Room Image
Array design for 3D-Audio
- Diffuse field correlation (DFC): spaced setups

![Diffuse field correlation (DFC)](image)

**DFC**

- **Blue:** A/B 10cm
- **Green:** A/B 50cm
- **Red:** XY Cardioids
- **Turquoise:** ORTF

from: [Riekehof et al., TMT 2010]
• Coherence function calculated by the Image Assistant v3

Demo Diffusfeld:
HdM Diffusfeld Koinzidenz;
Cédric 2 Stereophoniepaare mit Umschalten der Screenshots DFC, Bahnhofshalle
• Image Assistant v3

• Simulation of the DFC and proper Auralisation
- Correlation between vertical loudspeaker pairs
- Live demo: X/Y vs. A/B

→ In the vertical domain correlation plays a different role
• „Diffuse Field Listening Area“

5ch Total power sum
• „Diffuse Field Listening Area”

2 ch Diffuse Field Listening Area

Blue Zone:
No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers

Basics
Stereo Imaging
• Directional Image
• Room Image
Array design for 3D-Audio
• „Diffuse Field Listening Area“

5 ch Diffuse Field Listening Area

Blue Zone:
No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers
• "Diffuse Field Listening Area"

Blue Zone:
No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers
Spatial impression

Direction
Distance, Depth, Spaciousness
Envelopment Reverberance

0 ms 30 ms t
• Distribution of reflections
• Hypothesis: Less coloration and better perception of depth/distance through better separation

Basics
Stereo Imaging
• Directional Image
• Room Image
Array design for 3D-Audio

Demo Galaxy Modern 9 <-> 5
Klavier 9 <-> 5
• Array design for 3D-Audio (= Stereo + height)

• Two recording principles with different priorities:

**ORTF-like recording techniques**
- Closely spaced, directive microphones
- Typical properties:
  - proportional and clear directional imaging
  - natural spatial impression
- Application: chamber music, drama, sports, ambience

**Wide a/b-like recording techniques**
- Widely spaced, omni-directional microphones
- Typical properties:
  - stable, but not proportional directional imaging
  - enhanced spatial impression
- Application: music, film music
• Array design for 3D-Audio (= Stereo + height)

• Two recording principles with different priorities:
  - Δt and/or ΔL
  - ORTF-3D
“OCT 9” for 9.1 Surround
- lower plane: OCT Surround
- upper plane: + 100cm, 4 supercardioids pointing upwards

Basics
Stereo Imaging
Array design for 3D-Audio
- $\Delta t$ and/or $\Delta L$
- ORTF-3D
“Omni Array” for 9.1 Surround
• 9 Omnis

Basics
Stereo Imaging
Array design for 3D-Audio
• Δt and/or ΔL
• ORTF-3D
• Test recordings in the Galaxy Studios, Belgium
• OCT 9
• Omni array

Basics
Stereo Imaging
Array design for 3D-Audio
• Δt and/or ΔL
• ORTF-3D
ORTF-3D regular

- 8 * Supercardioid on the edges of a cube with $d = 10-20$ cm

Basics
Stereo Imaging
Array design for 3D-Audio

- $\Delta t$ and/or $\Delta L$
- ORTF-3D
ORTF-3D „FLAT“ (NEW)

- 8 * Supercardioid on the edges of a rectangle/square with d = 10-20 cm
- Coincident X/Y microphone pairs for each vertical loudspeaker pair
- Orientation of the XY pair: +60° (height layer) / -30° (ground layer)

Basics
Stereo Imaging
Array design for 3D-Audio
- $\Delta t$ and/or $\Delta L$
- ORTF-3D

Demo Worldcup
Demos ORFT-3D Ambience
Infos, Powerpoints, Papers, Audio demos on
www.hauptmikrofon.de (new launch in Oct 2015)

wittek@schoeps.de