General-purpose Ambisonic playback systems for electroacoustic concerts

A practical approach

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So you are organizing a concert with contemporary electro-acoustic works?

Great!

Let's publish that call for music, and wait for contributions.
Hmm.
This quadraphonic piece would fit right in!
Hmm. This quadrephonic piece would fit right in!

This is great, too. Oh, it's 5.1!
Hmm.
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This is great, too.
Oh, it's 5.1!

We got to have this one.
Oops – eight speakers at irregular angles and distances?
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Whee! This one needs six speakers in a regular hexagon.
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Hmm.

Whee! This one needs six speakers in a regular hexagon.

Two speakers in the front, and one in the back? Well...
Ambisonic playback systems – Jörn Nettingsmeier <nettings@stackingdwarves.net>
Half the show we'll be watching the crew move speakers around...
Wish I had „virtual speakers“!
...well, you do!

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It also scales nicely to include height.

(And as a bonus, you will be able to reproduce native Ambisonic compositions at their very best.)
Components:
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A speaker array suitable for 3rd-order Ambisonic reproduction (horizontal-only here, for the sake of simplicity)
Components:

**Components:**

- Artist-supplied ADAT signals
- Live electronics/microphones
- A Linux rendering PC (or MacOS, or maybe even Windows), with ADAT I/O, using free software

Diagram:
- ARTIST-SUPPLIED ADAT SIGNALS
- LIVE ELECTRONICS / MICROPHONES
- A Linux rendering PC with ADAT I/O
- Using free software
- Components:
  - Audio PC with ADAT I/O
  - Audio file player
  - Ambisonic panning plugins (encoders)
  - Ambisonic decoder
  - Mixer inputs
  - Mixer outputs

Legend:
- ADAT
- Analog audio
Components:

- ARTIST-SUPPLIED ADAT SIGNALS
- LIVE ELECTRONICS / MICROPHONES

Components:

- (optionally) a digital mixer, for convenience and safety, with additional ADAT I/O
- AUDIO PC WITH ADAT I/O
  - AUDIO FILE PLAYER
  - AMBISONIC PANNING PLUGINS (ENCODERS)
  - AMBISONIC DECODER

ADAT
ANALOG AUDIO

2nd International Symposium on Ambisonics and Spherical Acoustics – IRCAM, Paris/France
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You can do without, but consider this: If your PC gets stuck („motorboating“) or there is a sync problem, you'll get loud digital noise, and no means to turn it off.
Components:

That means you're utterly hosed.
Components:

So don't be cheap, get that mixer.
Virtual speakers:

Inside the PC, Ambisonic encoders (a.k.a. panners) will take the discrete input signals, position them at azimuth and elevation angles of your choice, and route them to a third-order Ambi master bus.
Virtual speakers:

An Ambisonic decoder will then generate speaker signals for the physical speaker layout you have chosen.
Virtual speakers:

The speaker signals are routed back through the mixer, where you can calibrate each one for equal loudness, and control the master volume.
Process different sources:
Process different sources:

“tape pieces“ from harddisk
Process different sources:

- ARTIST-SUPPLIED ADAT SIGNALS
- LIVE ELECTRONICS / MICROPHONES

Live electronics or microphones

MIXER INPUTS

MIXER OUTPUTS

AUDIO PC WITH ADAT I/O

AUDIO FILE PLAYER

AMBISONIC PANNING PLUGINS (ENCODERS)

AMBISONIC DECODER

ADAT
ANALOG
Process different sources:

artist-supplied ADAT signals (for material rendered in real-time)
The software stack:

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  (Paul Davis et al., native on Linux and MacOSX)
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- Hosting of plugins, signal routing, tape playback: **Ardour 2.8** (Paul Davis et al., native on Linux and MacOSX)
- Ambisonic decoding: **AmbDec** (Fons Adriaensen)
- Putting it all together: **JACK** Audio Connection Kit (Davis, Letz, Hohn et al.)
Mission control:
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AMB plugins in Ardour
Mission control:

AMB panners in Ardour

Panners accessible via generic MIDI control surface
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AMB panners in Ardour

Panners accessible via generic MIDI control surface

Ganged output faders for volume adjustment; optionally ganged EQ for tone correction.
The paper contains detailed setup information.
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- Accommodate arbitrary speaker layout requirements
- Improve the concert experience by avoiding disruptive speaker rearrangement breaks
- No errors and malfunctions caused by in-flight rewiring and reconfiguration
- Provide the performer with positional control, as an additional degree of freedom in sound diffusion
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  - Acoustically dry venues will emphasize HF phasing effects which must be corrected by other means.
  - Signals susceptible to comb-filtering may suffer.
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Artefacts may have different effects and severity, depending on the compositional approach.
So where's the catch?

While artefacts may be evident in A/B comparison, they need not pose a problem in actual practice.
Genres unsuitable for Ambi playback:

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- Pathological signals with large amounts of negative correlation
- The dialogue channel(s) of movie sound tracks (workaround: use a discrete speaker for the center)
Practical experience

- Past deployments of Ambisonic concert systems have met with general approval, both by audience and performers:
  - LAC 2009 concert system, Auditorium Paganini, Parma
    Eight full-range QSC speakers driven in 3rd order, implemented by Fons Adriaensen
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  • DEGEM 2009 concert system, musikFabrik, Köln Twelve K+H O108TV speakers driven in 3\textsuperscript{rd} order, plus two Genelec subs driven with W/Y, implemented by the author
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    Twelve K+H O108TV speakers driven in 3rd order, plus two Genelec subs driven with W/Y, implemented by the author
  - CCRMA lecturer Fernando Lopez-Lezcano has reported very pleasant results in several concerts (one open-air) with a similar eight-channel 3rd order rig
Listening tests

Practical deployments were always successful.

But how does the system fare in a direct A/B comparison?
Listening tests

- Two informal listening tests have been conducted in spring 2010:
  - Kunsthochschule für Medien, Köln, with film and media artists, using direct A/B comparisons between interspersed 5.0 and 3rd-order horizontal Ambisonics rigs.
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  • Kunsthochschule für Medien, Köln, with film and media artists, using direct A/B comparisons between interspersed 5.0 and 3rd-order horizontal Ambisonics rigs
  
  • ICEM, Folkwang Universität der Künste Essen, with electronic composers, using a 3rd-order horizontal rig, A/B-ing between Ambi and quad reproduction
Listening tests

Test setup:

5.0 or 4.0 content was played back over a virtual Ambisonic rig in 3rd order, and compared with native reproduction over 5 and 4 speakers.

Evil! It is clear that Ambi can't outperform the original. Rather, it will combine the defects of both discrete and Ambisonic playback.

Does it work? Is it a good compromise?
Listening tests – film artists

• absolute position of C is mandatory
• focus and stability over correctness and homogeneity
• no advantage in coverage area
• phasing artefacts evident in typical cinema acoustics

For film, not too impressed. For music, ok.
Listening tests – Film artists

Conjecture:

Does Ambisonic listening require training or habituation?

If so, maybe their verdict would improve over time?

But also: can it be that „us Ambi professionals“ routinely over-estimate the impact on casual (i.e. non-habituated) listeners?
Listening tests – Electronic composers

- shortcomings inobtrusive
- often no clear preference (very good!), but large individual deviations
- no advantage in coverage area
- subjects prefer being able to pinpoint speaker locations over homogeneity
“In the context of electro-acoustic music, any reproduction is interpretation.

Ambisonic reproduction is a valid form of interpretation (except for a few very particular works).”

- a test participant
Thank you for your attention!

I'll be happy to address your questions.