

Plug-in Suite for Mastering the Production and Playback in Surround Sound and Ambisonics

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The cross-platform audio plug-ins presented here largely simplify the creation and playback of surround sound productions by providing user-friendly access to Ambisonic techniques taken from the most recent research. Hereby, sound designers and composers, the essential end users, can easily employ the newest ways to create, manipulate, and play back Ambisonic recordings in variable spatial resolutions. Additionally, the multichannel plug-

in suite provides frequently-used equalization features such as levels, delays, and convolution filters to an arbitrary number of channels within one Digital Audio Workstation.

The plug-in suite has already been successfully employed in several performances with various spherical playback facilities, in the technical support of computer musicians, and in the production of Ambisonic surround recordings.

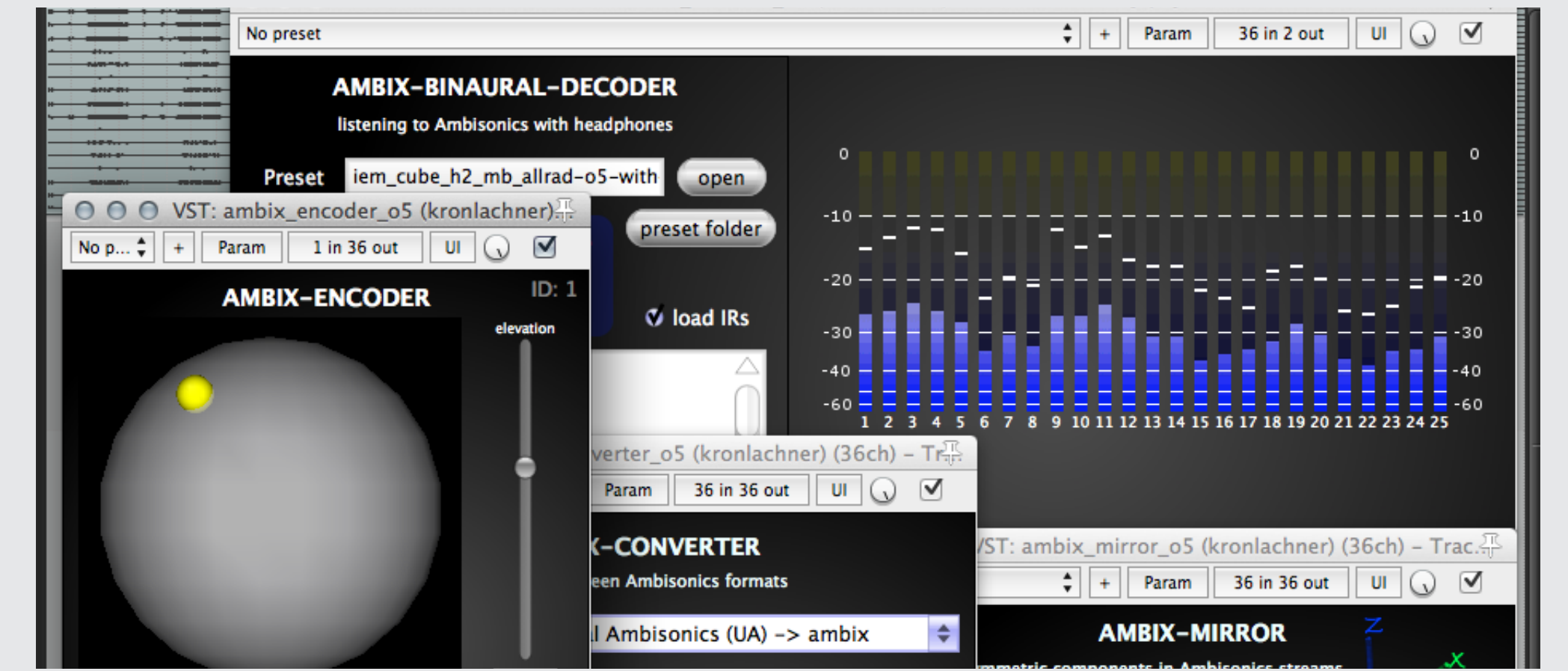


Figure 1: Screenshot of *ambix* surround plug-ins within the DAW Reaper.

Introduction

Spatial audio has not only been a hot research topic but an integral part of cinema sound for many years. The new generation of cinema sound technologies include loudspeakers on different elevation levels thus allow for the playback of full periphonic surround content. While in private homes such extensive loudspeaker installations are still rare a major amount of music and movies is nowadays consumed through headphones. This work addresses this topic by not only providing monitoring of surround sound over loudspeakers but also through headphones.

For several years research institutions have been experimenting with loudspeaker arrays in two- and three-dimensional setups. Many individual software solutions were developed that support the creation of content for these loudspeaker arrangements. While most Digital Audio Workstations (DAWs) provide tools to produce for standard surround setups such as 5.1 only, more extensive loudspeaker setups (eg. Fig. 4) clearly require tools for a more flexible channel routing. To overcome the limitation of DAWs, most

Digital Audio Workstation

provides mixing/editing and export functionality

add multichannel *mcfx* and Ambisonic *ambix* plug-ins:

- | | | |
|--|--|-------------------------------|
| + Encoders (Panner) for mono/stereo/... | + Spatial effects (Reverb, Widening,...) | + Multichannel Metering |
| + Encoders for microphone arrays (Sounfield, Eigenmike, ...) | + Ambisonic Format Converters | + Multichannel Equalizer |
| + Manipulators (Rotation, Dominance,...) | + Decoders for Loudspeakers | + Multichannel Convolver |
| | + Decoders for Headphones | + Multichannel Delay and Gain |

toolkits for spatial audio were developed in graphical programming environments, such as Pure Data and MaxMSP, which basically have no restriction concerning the number of channels and offer quick development and maintenance cycles.

However, not only is the integration of such external spatialization toolboxes into a DAW challenging for the developer, these toolboxes are often also challenging to use for non-experts. Audio channels and control data have to be sent between the applications and complex routing scenarios need to be re-established everytime. This frequently causes difficulties when sharing projects and due to the loss of the ability to render audio tracks offline.

This plug-in suite is meant to get rid of the above-mentioned difficulties. It has been developed as an open source project in C++ using the *JUCE* framework which supports building audio plug-ins in all major formats and standalone audio applications for Windows, MacOS and Linux. Currently the software is provided as VST and standalone binaries for Windows and MacOS.

Using flexible DAWs such as Reaper or Ardour allows for a single software controlling the entire production cycle starting from panning the source signals, mixing microphone array recordings until decoding the playback signals and adjusting the loudspeaker signals.

Ambisonics

Ambisonics can be used to create spatial audio productions for circular or spherical loudspeaker arrangements. In contrast to channel-based standards in surround sound such, as 5.1, it offers flexibility regarding the loudspeaker setup around the listening area. This makes the production stage largely independent of the loudspeaker arrangement. Furthermore, Ambisonic content can be recorded using its classical and new main microphone array technology.

Ambisonics is based on the expansion of the surround signal into spherical harmonics up to the order N that defines the angular resolution. A full periphonic (3D) Ambisonic signal set of order N results in $(N+1)^2$ channels.

The maximum Ambisonic order N for all ambix plug-ins can be defined at compile time and is only limited by the maximum number of channels per track of the host.

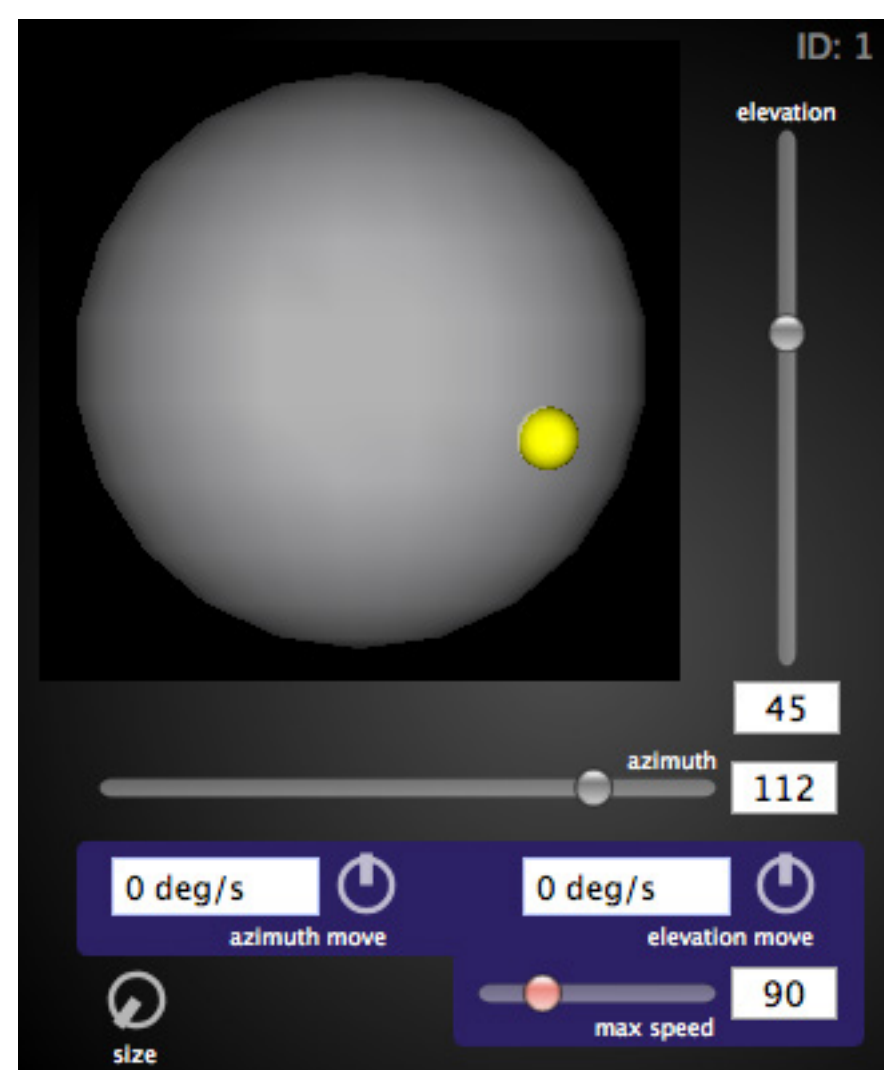


Figure 2: *ambix_encoder* is used for panning mono or multichannel sound sources on a surface of a sphere.

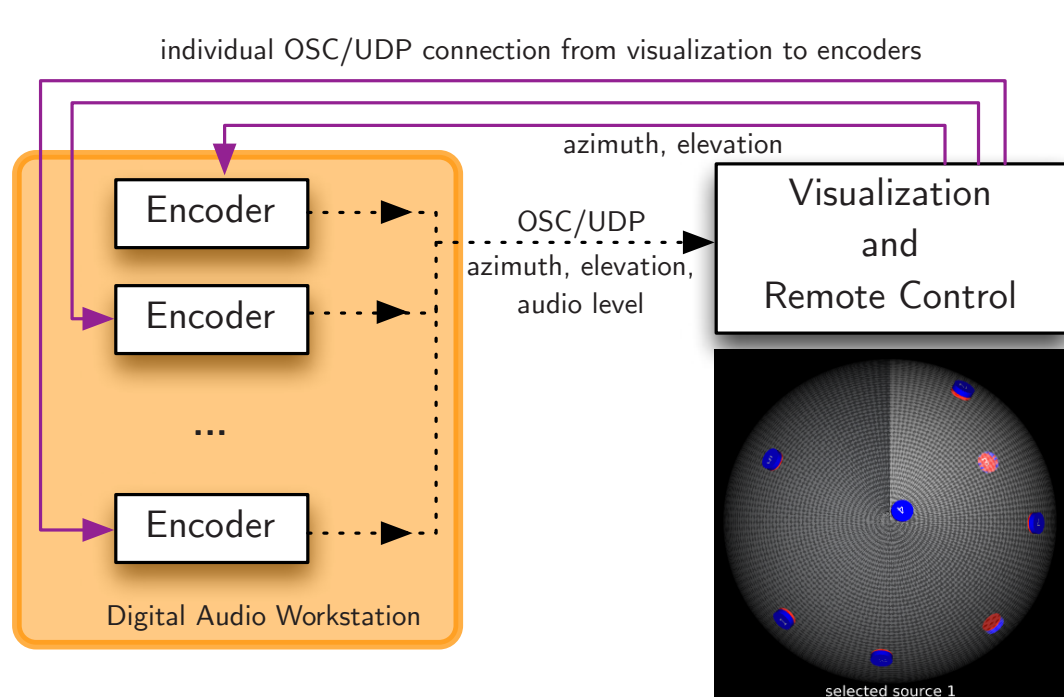


Figure 3: Built in OSC layer for monitoring and controlling multiple encoders from one central point, this application may run on the same computer or on a different device connected via network.

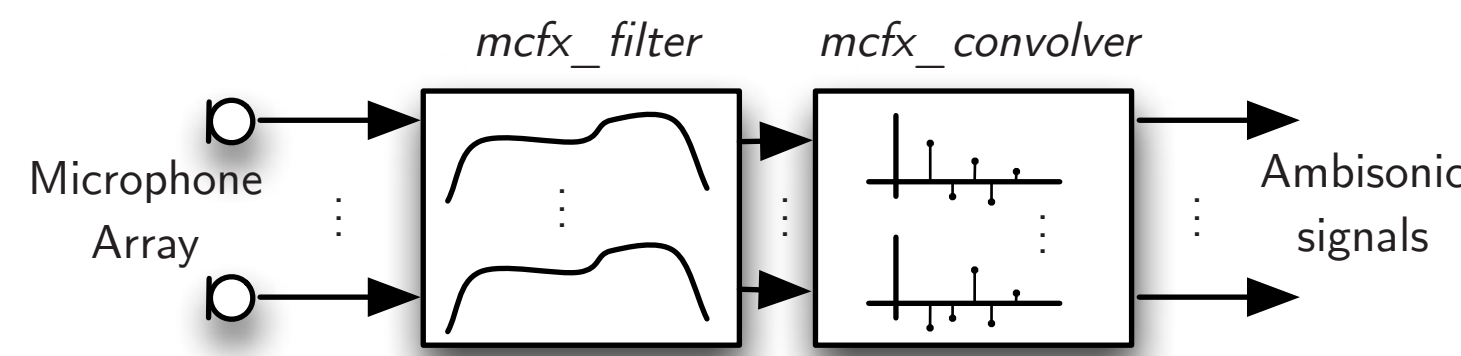


Figure 4: Adjusting the sonic characteristics of microphone array recordings and converting to Ambisonics.



Figure 5: Example microphone arrays that have been used: (a) 32 channel mh acoustics Eigenmike [1] and 4 channel (b) Soundfield and (c) Coresound Tetramic.

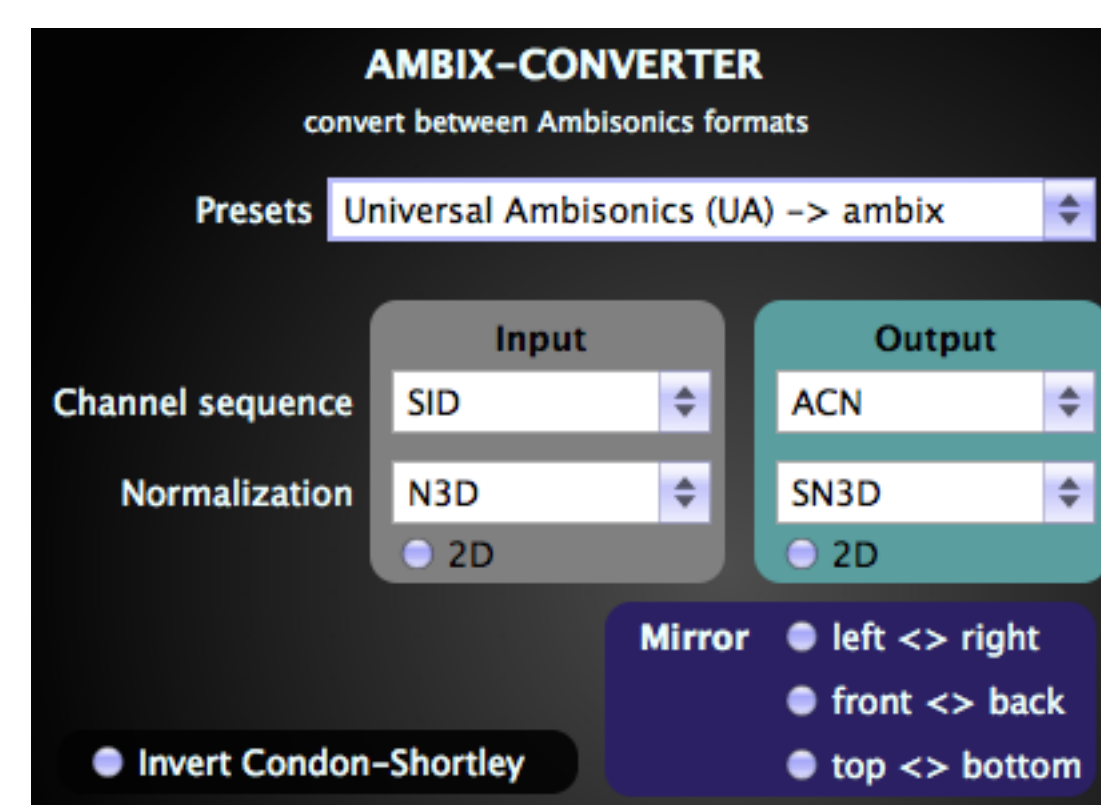


Figure 6: *ambix_converter* allows to convert between different Ambisonic formats.

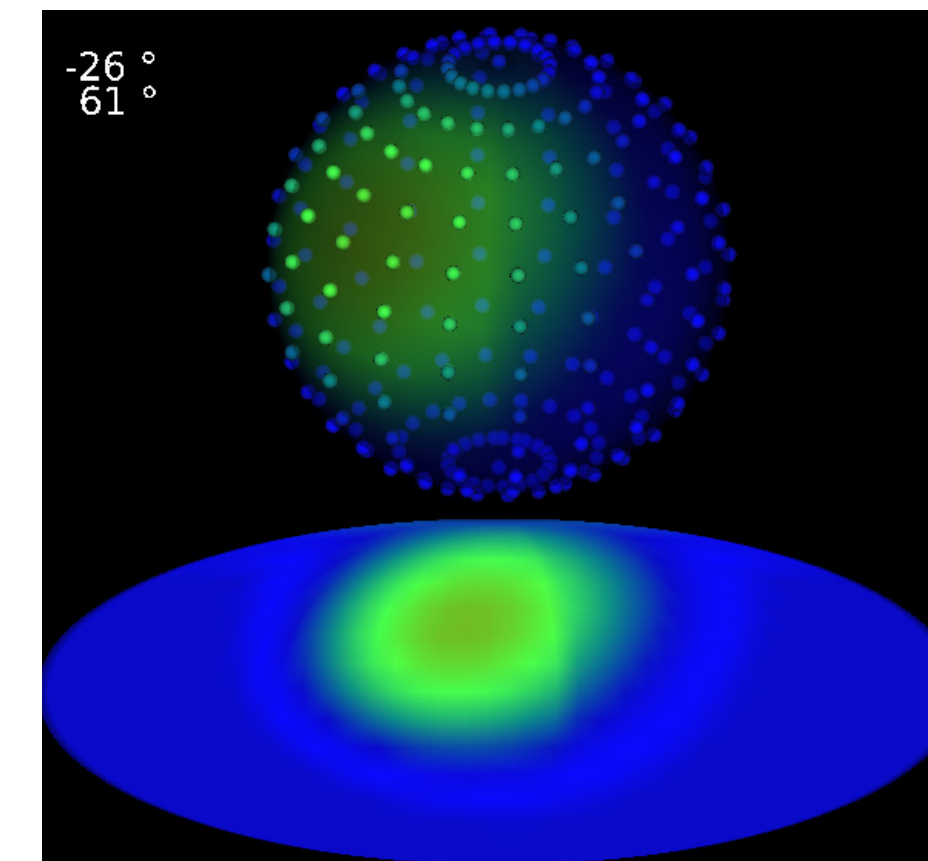


Figure 7: Ambisonic metering, RMS and peak meters distributed on the surface of a sphere.

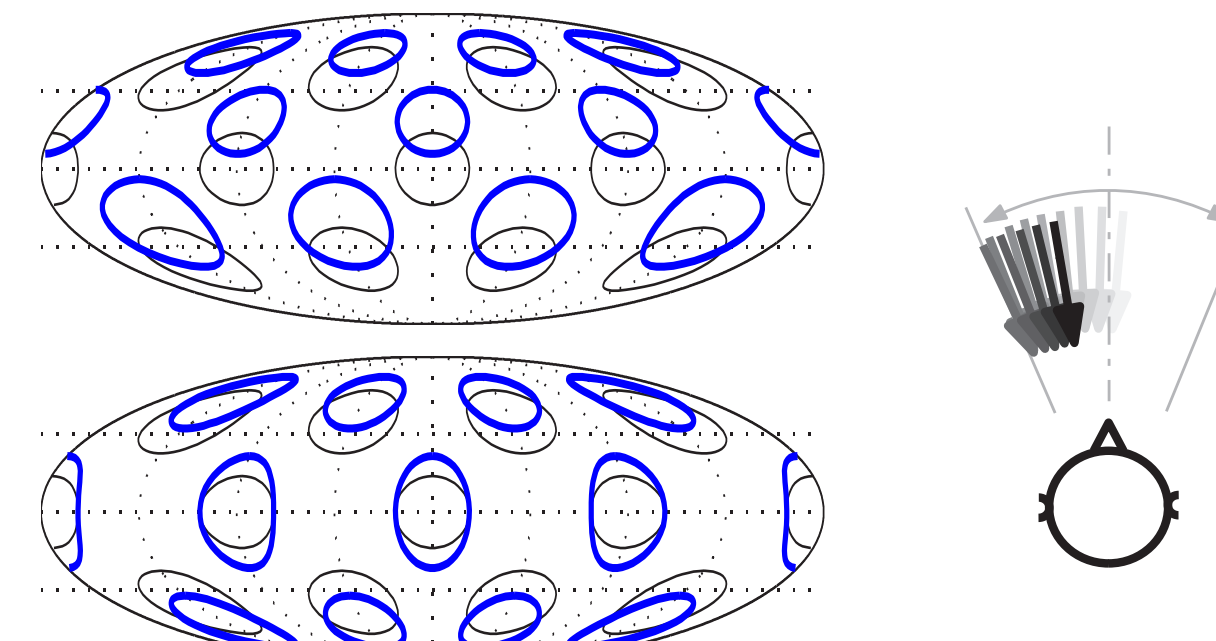


Figure 8a: *ambix_warp* allows to adjust the spatial perspective of the surround mix. Thin lines indicates unmodified surround image, upper scheme: warping towards the northpole lower scheme: warping away from equator [2].

Figure 8b: *ambix_widening* performs a frequency dependent z-rotation and can be used to widen the source or synthesize early reflections [3].

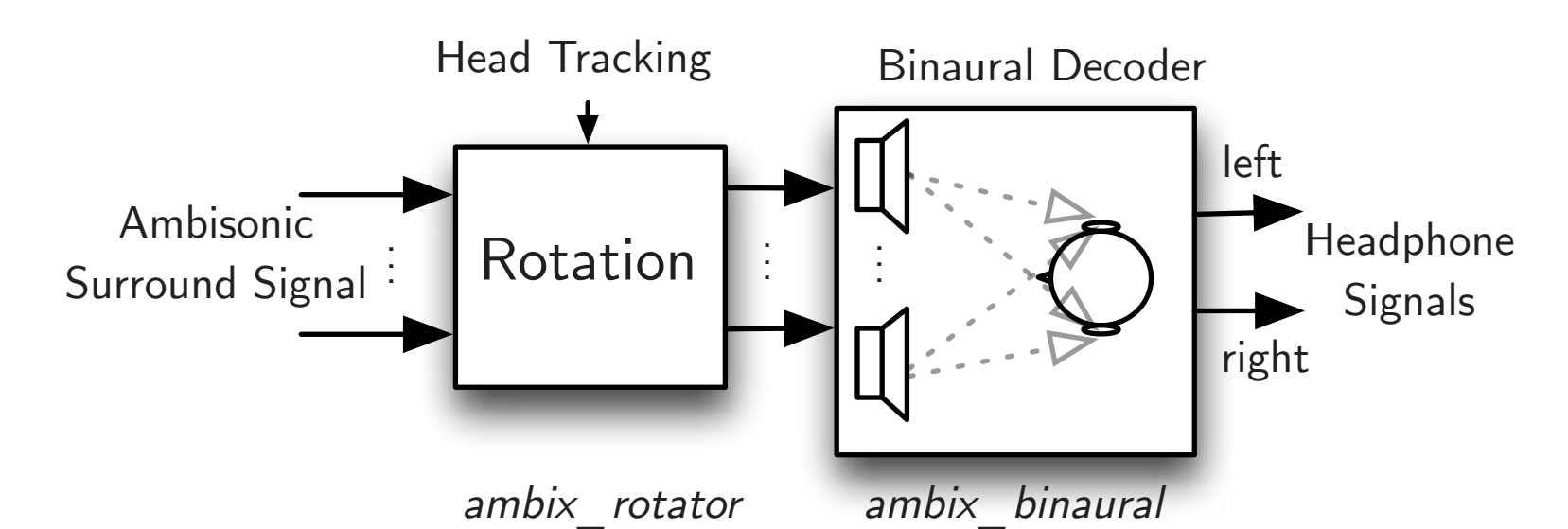


Figure 9: Listening to Ambisonic recordings using virtual loudspeakers and binaural loudspeaker impulse responses, head-tracking controls the rotator for a stable surround image. Decoder matrices are obtained using the AIIRAD method [4].

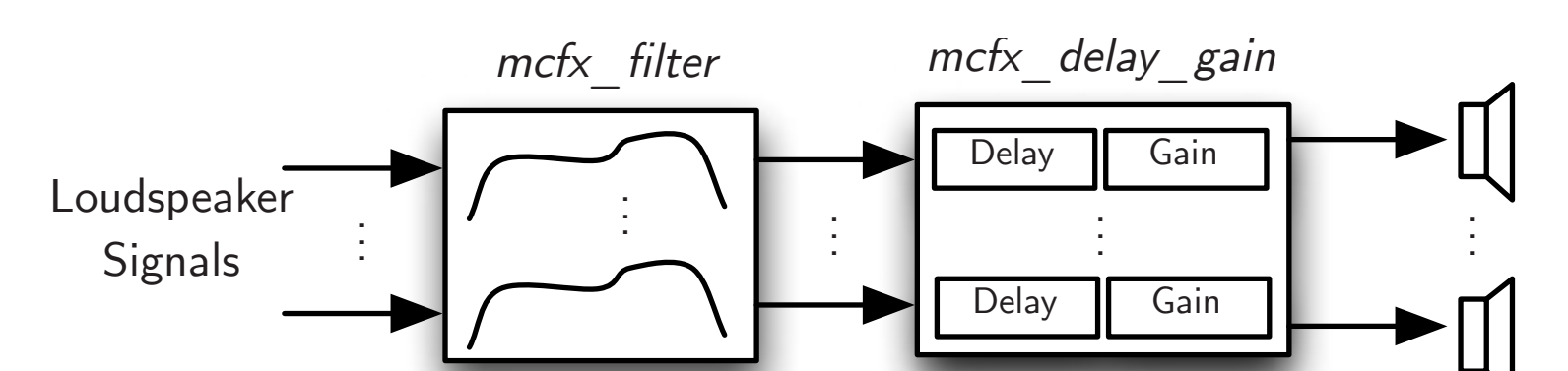


Figure 10: Multichannel filter and delay/gain for adjusting a loudspeaker array on the fly.

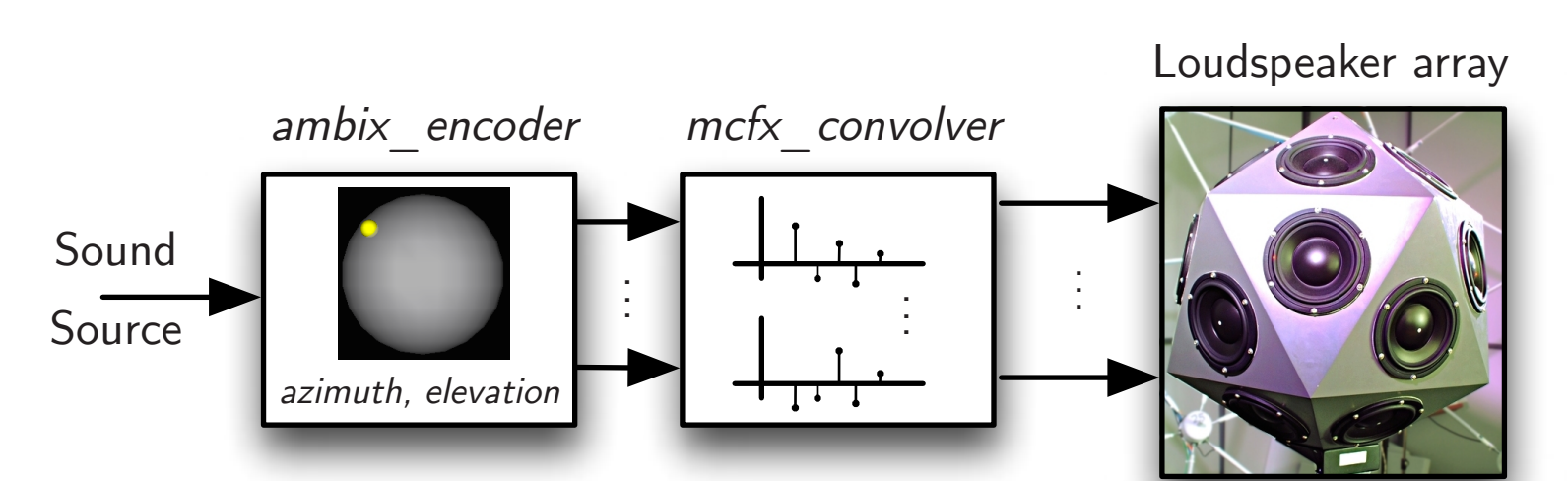
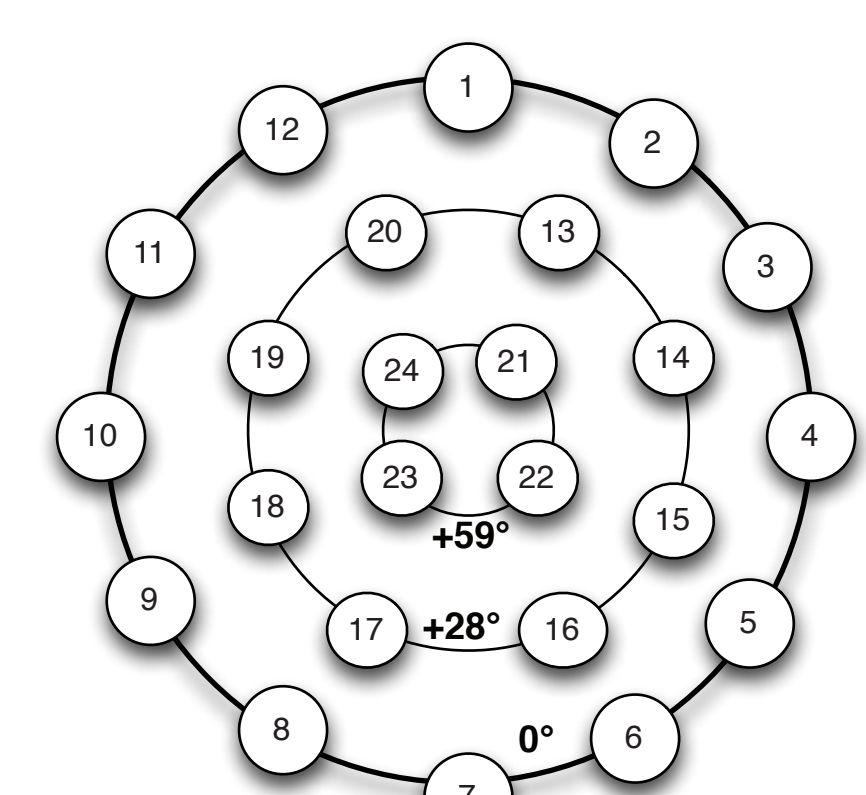


Figure 11: Ambisonics signals can also be used to control the radiation of loudspeaker arrays. This scheme shows the usage for the IEM icosahedron loudspeaker array [5].

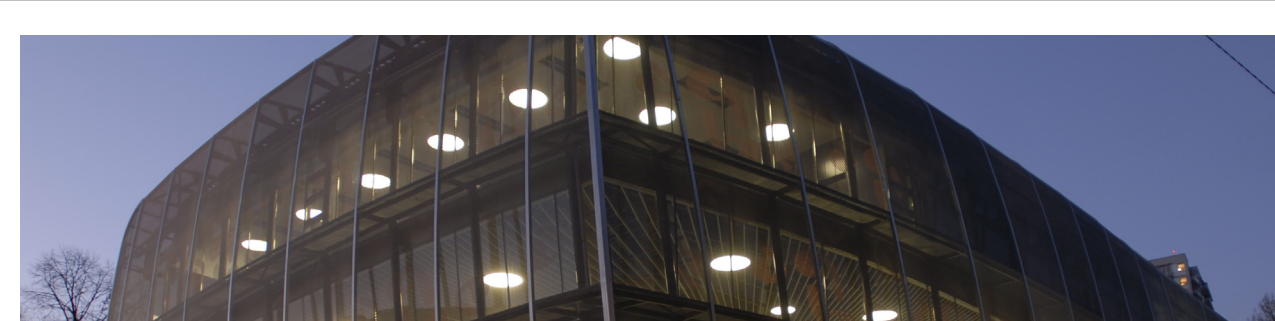
Figure 12: Examples for surround concert venues where the software was already used. *ambix_binaural* comes with binaural loudspeaker impulse responses of the Cube and Mumuth which allows to virtually listen to your surround production within those venues using headphones and head-tracking. The software was used for performances using 4-43 loudspeakers so far.



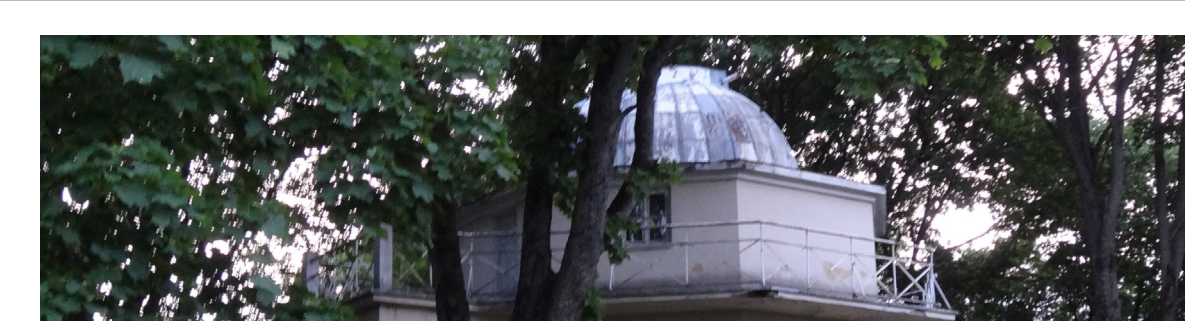
(a) Loudspeaker layout and



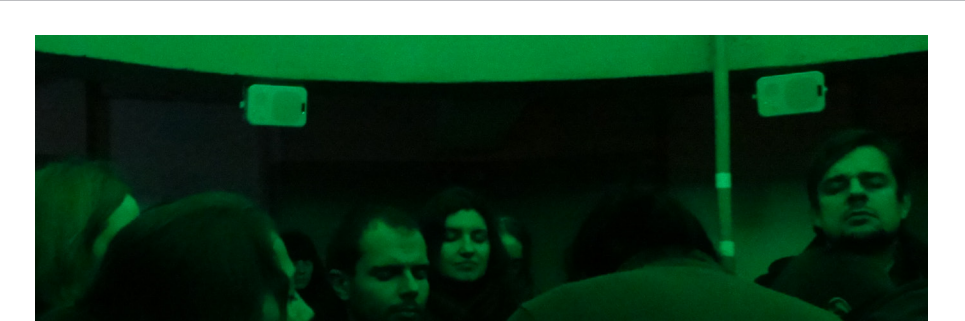
(b) panoramic picture of the IEM CUBE with 24 loudspeakers.



(b) Mumuth, Graz, 29 loudspeaker hemisphere.



(c) Observatory of Vilnius University,



(d) 23 loudspeaker layout.

Conclusion

A suite of cross-platform Ambisonic and multichannel effect plug-ins has been presented. The software allows to use extensive multichannel microphone and loudspeaker arrays within Digital Audio Workstations. By keeping the whole production within one host, the editing and offline rendering functionality of DAWs can be used to efficiently create and share immersive surround productions.

The software has already been successfully used by professionals and students for the production of 3D surround sound and formed an integral part of the concert setup in various venues.

Acknowledgment

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References

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