Flat 3D microphones: Binaural

As a flat 3D array can produce a higher-order ambisonic signal and methods for rendering this as a binaural signal are well known, this presents an obvious path towards the use of such arrays as binaural recording devices with three degrees of freedom.

However, it is possible to achieve even higher spatial resolution by foregoing the ambisonic encoding / decoding and instead encoding the array output directly as a binaural signal.

The following diagrams shows the results of beamforming, using the HRTFs of the Neumann KU-100 as the target beamforms. These were downloaded from the SADIE database.

In each case, the beamforming aims to reproduce both the amplitude and phase of the measured HRTFs up to a frequency of 1500 Hz. Above this frequency, gradually less emphasis is placed on matching the phase in order to better match the amplitude of the HRTFs. The beamforming is based on 1153 measured directions. The diagrams show the HRTF amplitudes across the audible spectrum for a horizontal slice through the data set. This includes 72 of the 1153 directions.

The diagrams compare the result for ambisonic signals of 3rd, 5th and 7th order to the result of directly beamforming the output of an 84-channel, 17 cm diameter double-sided, baffled array.


There is an inherent trade-off to be done between the accuracy of the beamforming and the amount of noise in the output signal. For the ambisonic beamformers, this has been ignored, and the signals are assumed to be noise-free. For the array beamformer, the actual noise curve of the IM-69D130 microphones has been used, and the beamforming has been constrained to produce the same noise level as the KU-100: 29 dB / CCIR-468. The figures on the next page, as well as the numerical error norm, shows that the array beamformer performs on par with a theoretical, ideal 5th order ambisonic system, even when the array beamformer is subject to a noise constraint, and the ambisonic one is not.
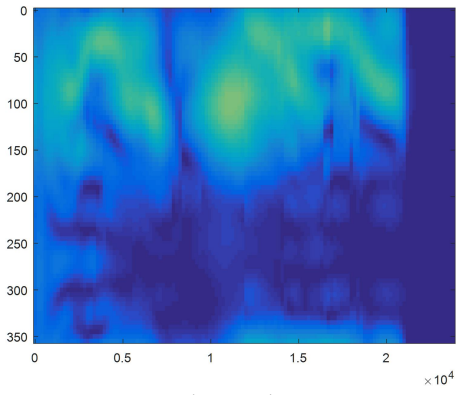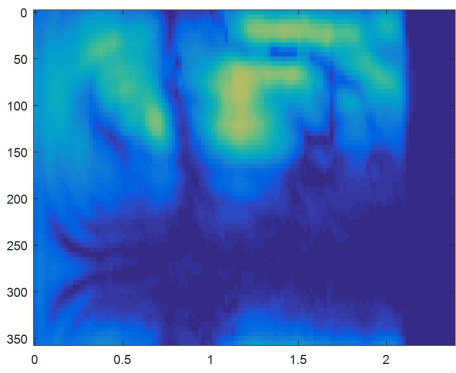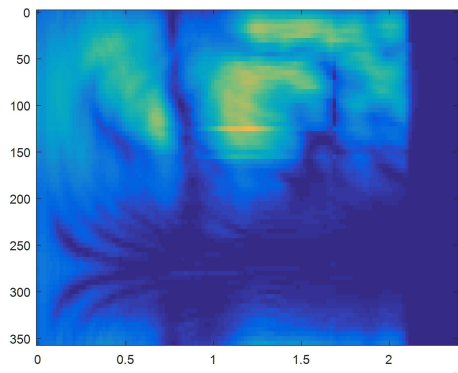
3rd order ambisonics
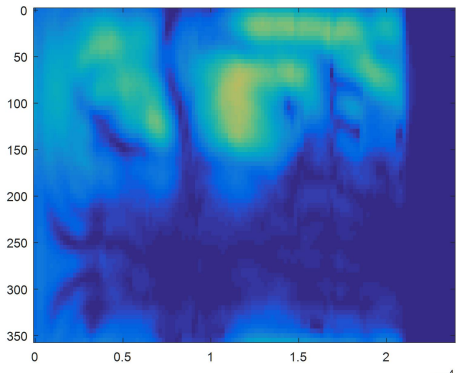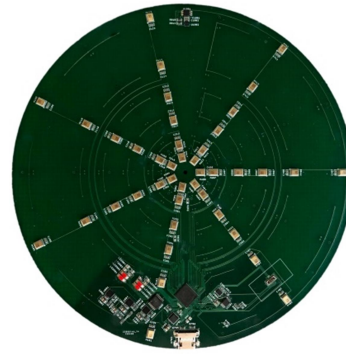
5th order ambisonics
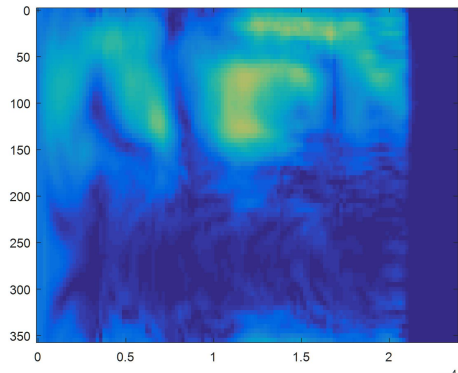
84-microphone array

7th order ambisonics

Target response, KU-100
(SADIE database)