SEVEN YEARS OF ICST AMBISONICS TOOLS FOR MAXMSP - A BRIEF REPORT

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ABSTRACT

A brief overview of the practice and developments in Ambisonics at the ICST in the last decade is given. The paper traces the evolution of the ICST tools for MaxMSP and a number projects using them in concerts and installations is shown. Finally the current state of the software and the newly available features and implementations are discussed.

1. INTRODUCTION

The ICST Ambisonics tools are the fruit of practice-based experience and developments with Ambisonics that took place in Zurich since the late 1990's. These activities were first held at the Swiss Center for Computer Music (SZCM), a private foundation, and from 2005 at the Institute for Computer Music and Sound Technology (ICST), the music technology research institute for the Music Department of the Zurich University of the Arts. Originally the usage of Ambisonics was focused on concert performances of spatialized electro-acoustic music, but this practice has since expanded to interactive installations and even music production.

2. FIRST STEPS WITH AMBISONICS

Close contact between Gerald Bennett in Zurich and Dave Malham at York University during the late 1990`s led to a transfer of knowledge that set the foundation for all further work with Ambisonics. D. Malham was commissioned a piece of software that would enable Ambisonic processes in DAWs in the form of a set of VST Plug-ins. [1] These Plug-ins never reached maturity and would fall victim to the transitions to different generations of operating systems and host software but were one of the first viable options for 1st order Ambisonic work. They also formed some of the code base for future tools. The idea of having a set of DAW Plug-ins seemed compelling, a fact, which still holds true until today, but still, isn't available in a satisfactory way. In 2004 Gerzonic's Christian Schneider took a step in the same direction and made the next generation of VST Plug-ins, but this time coupled with a commercial interest. [2] Most of the composition work in the SZCM at that time was done in Csound, but MaxMSP was increasingly used for concert performances. The implementations of Ambisonics were done in patcher format, which proved a valuable pedagogical tool but suffered from severe performance issues, especially at higher orders with a large number of input voices and speakers.

3. THE MAX MSP EXTERNALS

The author became involved when the need for more versatile and optimized implementations became apparent. The very first version of MaxMSP externals (the compiled extensions written in C) were created in 2002-2003 and set the basis for the ICST tool-set.

3.1. The DSP Externals

This very first version implemented the 1st order Furse-Malham full 3D encoding/decoding for an arbitrary number of inputs or outputs with the full set of Ambisonics spherical component signals between the two boxes, The next iteration added the 3rd order Furse-Malham full 3D encoding/decoding capabilities, which had been intended for the VST Plug-Ins. The formulas were provided again by D. Malham himself and this first public release of the two externals *ambiencode~* and *ambidecode~* was realized in close collaboration and with his support. Since the algorithms and part of the source code was inherited from other projects it was decided to publish them under an open source license (LGPL), so that other people could profit not just from the finished tools but also the algorithms and formulas used in their making.

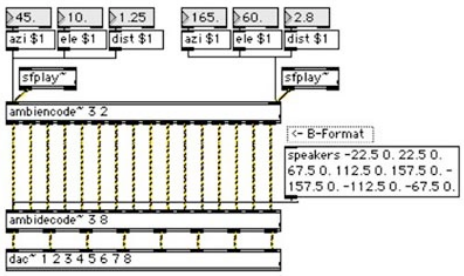

Figure 1. The first version of the MaxMSP externals in 2003.

3.2. The Graphical User Interface and Point Control

Philippe Kocher, one of the composers active in the SZCM at that time, had been programming graphical tools using MaxMSP in its patcher format. Based on the experience and the features developed over the course of several years for composition and concert performances, he designed what would become the second half of the ICST tool-set, a graphical user interface extension called *ambimonitor* and controller extension called *ambicontrol*. In 2006 the full set of objects was

released in a 1.0 version for both Macintosh and Windows and a paper was published in the ICMC proceedings. [3]

4. INTEROPERABILITY AND LIMITATIONS

At that point in time a number of decisions were taken, that would affect the interoperability with other Ambisonics contents and tools for some time and which have only recently been addressed and corrected. With the advent of a graphical user interface offering the possibility to control source placement with mouse-actions – immediately visualized on the screen – one issue became very apparent.

4.1. Coordinate System

The main problem was which coordinate system to use when setting source and speaker positions. It was decided to implement a strictly navigational coordinate system, where zero degrees azimuth are due front, the y-axis points to the front, the x-axis to the right, the z-axis upwards, horizontal angles rotate in a clockwise fashion and vertical angles increase from the horizontal plane. This coordinate system is commonly used in electro-acoustic composition tools, most notably in IRCAM`s Spat [4] and has recently become one of the supported coordinate system of SpatDIF [5]. The reasoning behind this decision was to favor the composer, who couldn't or wouldn't want to understand the intricacies of spherical harmonics mathematics. This had the unfortunate side effect of inverting the sense of rotation and the orientation in a recording such as the ones originating from a Soundfield microphone. Of course this contradicts the mathematical basis of Ambisonics and leads to an altered B-format stream and much confusion.

4.2. Distance Attenuation

Distance encoding of virtual sources upstream of the encoder was the next issue, something that isn't described in the pure Ambisonics theory. D. Malham's method was adopted. It describes the distance attenuation outside of the unit circle in terms of dB per unit. Inside the unit circle the zero-th component becomes more dominant the closer to the origin a source is placed. At the absolute center a sound is completely monophonic, which not something that can happen nature, of course. This solution does not address any other distance cues, such as air absorption. Nor does it deal with the question where the very abstract unit circle is located.

5. DAW-PLUGINS USING CYCLING74'S PLUGGO

In 2007 the ICST externals were used to produce the "ambiplugins", a series of plug-ins for Ambisonics encoding/decoding and source/speaker control in DAWs. These were built using Pluggo, Cycling74's (now defunct) Plug-in wrapper, which made MaxMSP patches accessible to a host in the VST, RTAS (Pro-Tools) and MAS (Motu Digital Performer) plug-in formats. The Ambisonic plug-ins generated independent full 3D 3rd order 16 channel busses exchanging the signals behind the host's back, so to speak, and were capable of generating either discrete speaker-feeds or new B-format streams to be used later in the work-flow. A large-scale radiophonic piece, "Die Wunschmachinen" was produced by Swiss electronic musician Marcus Maeder. He used the 3rd order encoding/decoding of virtual sources mixed together with source materials recorded using a variety of discrete microphone and Soundfield-Microphone techniques to build sonic environments where actors theatrically performed scenes from the play. The main drawback was the limit in file size, which for 16 channel files means a relatively short file-length. The other limitations were double dependencies (Pluggo and the host) and the fact that the Ambisonic busses were basically a hack of the host's DSP engine, which caused a number of irreconcilable problems, not the least being very high CPU processing cost and a fundamental incompatibility with multiprocessing due to the segmentation of the signal chain into several plug-ins.

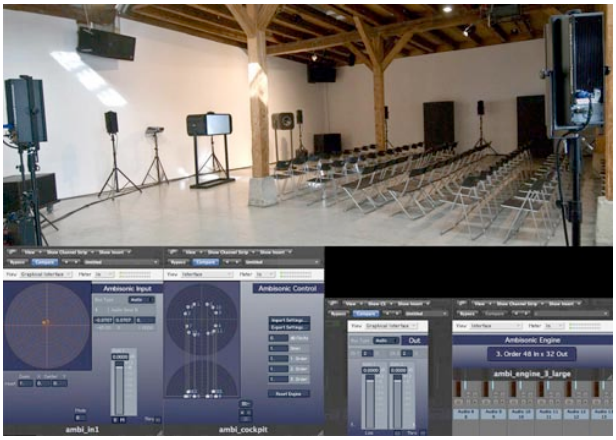

Figure 2. Performance situation and Pluggo-based plug-ins for the radiophonic piece "Die Wunschmaschinen" by Marcus Maeder in 2007.

6. ICST AMBISONIC TOOLS APPLIED

Judging from the number of feature requests and the feedback we received over the years, the ICST tools are useful in a number of contexts and regularly get deployed by a fair number of musicians.

The team at ICST uses the externals in suite of software dubbed the "ambitools" on a frequent basis, with concerts in halls of varying sizes. The Mobile Ambisonic Equipment is used to rapidly set up to 50 speakers and is used to diffuse multichannel audio in Ambisonics and other formats. [6]

The following is a selection of projects where the author himself applied the ICST Ambisonics tools:

- 2005: World Fair, Aichi, Japan, French Pavilion, "ce qui nous regarde", interactive audio-visual installation, by Thierry Fournier, le troisième Pôle. 12 + 36 channel Ambisonic setup.
- 2005: "codespace-tag", <>tag gallery, den Haag, the Netherlands. Interactive audiovisual installation with Ambisonic surround sound.
- 2007-2009: ISO Interactive Swarm Orchestra; Research project at ICST - on display at ICMC Belfast, August 2008.

- 2009: Flow-Space, with Daniel Bisig, "Milieu Sonore"-Exhibition at Walcheturm Gallery, Zurich. Interactive audiovisual installation.
- 2009: "Codespace", at Medienkunstlabor, Kunsthaus Graz. Interactive audiovisual installation.

Figure 3. FlowSpace, an interactive audio-visual installation, using Ambisonics in a dodecahedral speaker array to sonify swarm simulations. Walcheturm Gallery, Zurich 2009.

7. AMBIPANNING

In 2007 Martin Neukom, mathematician and musicologist at ICST, published some findings about 5.1 and in-phase decoding. [7] He developed an Ambisonic Equivalent Panning method, which bypasses the B-Format representation and expresses the speaker feeds in a relatively simple formula, which basically just needs the angle between a speaker and the sound source and a continuous Ambisonic order factor to calculate the signal. [8] This method was implemented in an external for MaxMSP named *ambipanning~* and was integrated into the ICST toolset. [9] It offers an alternative for musical applications, where the intermediate B-Format is superfluous. The method compares nicely with Ville Pulkki's VBAP [10], and DBAP [11], a panning algorithm useful for non-circular speaker arrays. One of the main advantages of the equivalent panning algorithms is its continuous non-discrete order factor which allows for example panning at 55.5th order, without incurring the computational cost of a spherical harmonic decomposition at that order (one which is impossible, needless to say). Ambipanning along with the rest of the ICST tool-set is also being integrated into the Jamoma project [12], where one of the declared goals for spatialisation modules is the ability to exchange different algorithms seamlessly and thus gain valuable comparative experience of the sound and performance of each algorithm in varying contexts.

8. CURRENT STATE

In 2008/2009 a major overhaul of the externals was started, prompted by a new version of MaxMSP, which forced us to do a complete rewrite of the graphical user interface external *ambimonitor* and its sibling *ambicontrol*. The DSP externals were also reworked, mainly to correct the earlier errors, but also to extend them to be more interoperable and add higher order capabilities. Experience had shown that connecting a B-format feed coming from the ICST-tools to, for example, the IEM cube-mixer [13] requires a transformation matrix to adapt the two channel sequences and different weights of the components.
The externals are now in the final stages of beta testing for a release of the proper version 2.0 later this year.

8.1. New Features

The new version of the DSP externals now implements the correct Furse-Malham encoding/decoding up to 3rd order and additionally gives the users the option to transcode with either the ***N3D*** or the ***SN3D*** weightings. These formulas are made available online by the Ambisonic association under the guidance of Michael Chapman. In the ICST Ambisonic tools they are implemented up to 11th order. This can generate a B-format with up to 144 components, which are ordered using the published Ambisonic channel numbering scheme ACN [14].
A new distance attenuation algorithm is implemented in *ambiencode~* and *ambipanning~* giving much finer control over the curves inside and outside the unit circle. The option of omitting distance coding altogether is added.
A choice of coordinate systems is now present, ranging from navigation, mathematical, acoustic coordinate systems (as described by Blauert/Gerzon etc.) to the one used in computer graphics such as OpenGL. Internally all coordinates are now converted to the ambisonically correct orientation and rotation.
The syntax for the setting of any parameter is unified across all externals and some older syntax was dropped in favor of a more concise set of methods. Functionalities for reading and writing to file of the complete internal state of the DSP objects are now available as well as direct access to the signal matrices coefficients via input methods or file-imports. All of these files use a structured XML-format, which in the future should help establish a good SpatDIF compatibility, not just for storing and transmitting the scene description present in the graphical user interfaces but also to describe and exchange the settings of the encoder/decoder matrices or the variables describing them.

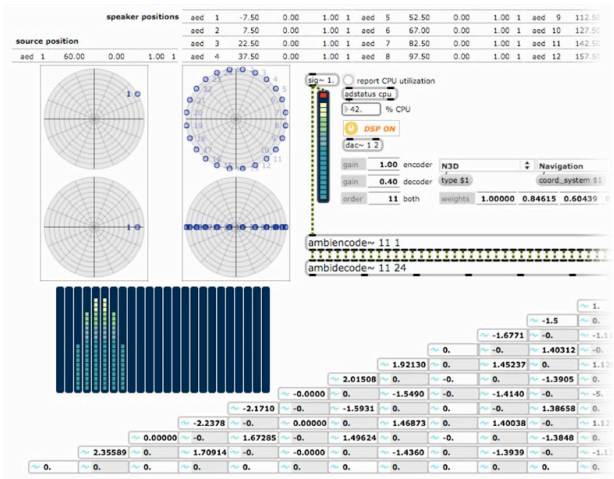

Figure 4. The current version of the ICST MaxMSP externals in Max5 in a debugging setup: a unity signal is spatialized to 24 speakers using 11th order N3D Ambisonics.

8.2. Availability

The current version of the ICST Ambisonics Externals for MaxMSP is available for download at http://www.icst.net.

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