Introducing the Open Ambisonics Toolkit

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1. INTRODUCTION

As a result of the recent extension of the fields of application of spatial audio in the entertainment industries, an increasing number of academic institutions are renewing their interest in the subject, adding it to their curricula. However, the plethora of techniques and practices, together with the relative novelty of them, has resulted in a lack of a methodology for teaching these technologies. This served as a motivation for our team to develop the Open Ambisonics Toolkit (OAT): a modular educational method for institutions and individuals alike, offering a standardised and gradual theoretical introduction and promoting a democratisation of spatial audio through a DIY approach. This introduction describes the overall project design of OAT, focussing on the first phase of its development and future possibilities.

With the diffusion of AR and VR, more and more content creators, musicians, artists, engineers and sound designers are turning their attention to spatial audio, with Dolby Atmos and Ambisonics sharing the lead in terms of diffusion [1]. But while the first one is a patented technology, primarily used in the film industry and the mainstream music sector, Ambisonics is an open source, free alternative that generally offers a wider range of applications. This consideration led to the idea that Ambisonics could be the ideal spatial audio format for higher education institutions, due to its versatility, relative affordability and the potential for many interdisciplinary applications that exceed the use in the entertainment industry.

OAT started to be developed at SoundLab, School of Creative Media (SMC), thanks to a Teaching Start-up Grant. Hong Kong has experienced considerable progress in the field of sound art over the past decade, and witnessed the rise of a new generation of sonic art practitioners, but there is no large institution for sonic arts at any of the nine universities in Hong Kong [2]. In this context, SCM well reflects the profile of the city, offering very diverse and often interconnected programs. The grant conditions have emphasised the purpose of hardware-software development towards pragmatic and pedagogically useful solutions that needed to be specific but also versatile to match the needs of a wider range of practitioners willing to use Ambisonics for different applications, in accordance to the diversity of the profiles of the students at SMC.

2. OAT: A MODULAR APPROACH

The primary objective of the toolkit is to develop a spatial sound pedagogy supported by a hardware-software toolkit for undergraduate students. We provide the necessary theoretical background, while designing, presenting, and documenting software and hardware solutions that would allow students to use Ambisonics in a variety of contexts. We have therefore designed OAT as three main interconnected modules focusing on as many aspects of the subject: 1) a hardware module, in which we describe solutions to build inexpensive diffusion setups for Ambisonics; 2) a software module, where we present software tools available for Ambisonics work with a specific focus on free/open source software compatible with Linux and Raspberry Pi; 3) a theory module that explains Ambisonics in detail and provides documentation, producing and filtering existing information.

In the first phase of the project, we have tried various hardware options. We settled on a car speaker system and used it in combination with a Raspberry Pi, to ensure a good audio quality while overcoming the significant upfront cost in equipment that often represent a road-block against equality of opportunity in the production of sound art. For these reasons we imagined that building a small, portable, and relatively inexpensive multi-channel loudspeaker setup could become an asset for students and artists who want to emancipate their workflow. This resulted in the design of an eight-speaker (plus one subwoofer) setup that was configured in three different ways: 4.4.1 skewed cuboid, 5.3.1 hemispherical dome, and 8.1 ring.

In the software module we have decided to only employ free software with a distinct preference for open-source programs. As we chose to work on Raspberry Pi, we needed to utilise software that would be compatible with its ARM processors and work on Linux. To facilitate access to these tools for all students, we also favoured software that was available for download and installation directly from the APT. Both Pure Data and Super Collider provide the necessary features to work with Ambisonics on Raspberry Pi [3, 4]. We have chosen Pure Data partly because it is closer to Max which is what most students at the School of Creative Media are already acquainted with. We have also explored three dedicated Pure Data libraries for Ambisonics [5, 6, 7], as well as the possibilities offered by the Ambisonics Decoder Toolbox [8] and AmbDec [9].

In the final module we focused on the development of a theoretical method that can help the students to navigate the wide range of commonly accessible and extremely diversified learning resources on Ambisonics. In our research we have outlined three types of available information:

- Tool-specific materials: The instructions, tutorials, and documentation provided with specific software packages and hardware. They usually provide some theoretical contextualisation, though often arbitrary.
- Academic papers: The core of Ambisonics knowledge covering scientific aspects of the technology. They are of fundamental importance but often too advanced for beginners and not necessarily relevant for end users.
- Independent/informal divulgation: tutorials on YouTube or other platforms. Some of this information can be pedagogically useful, though not subject to fact-checking or peer-review, which can lend imprecise information

Our work was to map and filter them by accuracy, relevance and depth, creating a coherent pedagogical path. Parallelly we will produce an independent document in which these pieces of information will converge to convey the theory behind Ambisonics, with the specific aim of tuning this knowledge for the work of sound designers and composers specifically, explaining its main concepts and processes while focusing on its practical applications.

3. TESTS AND FURTHER DEVELOPMENTS

The first stage of our research has mainly been concerned with the design of the toolkit, the choice of the software tools, and development of the necessary patches and scripts. This process was followed by an assessment of the hardware materials to be sourced and the evaluations of the loudspeakers through listening tests aimed at comparing their frequency responses as well as their perceived quality in comparison with a reference high-grade studio monitor [10]. We adopted the spatial audio quality inventory [11] to our needs and conducted two perceptual tests with experienced listeners (both N = 8) following our previous methodology [12]. The first test led us to decide which loudspeakers to use. In the second, we compare three different spatial configurations with a range of spatial music materials encoded in HOA 2D and 3D. These experiences allowed us to establish boundary conditions for achieving the best possible spatial sound with a truly low-cost DIY Ambisonics system.

In the next phase of the project, we will stimulate students to develop practical and pedagogical applications using OAT. We will evaluate how the toolkit can support the learning process. Wanting to provide necessary tools to use Ambisonics in DIY projects but also to formalise a pedagogy, we have convened that the design of a decoder that will allow the students to play back an Ambisonics file would be an effective final goal for an introductory course in music technology. Focusing on Ambisonics decoding is a sensible choice because it provides a good level of challenge, touching a wide range of relevant aspects both theoretical and practical, such as Ambisonics conventions, orders and irregular arrays, all crucial aspects in the design of a listening space.

Through the practical experience of building their own setups, corroborated by solid theoretical knowledge, students will acquire the necessary skills to effectively work with multimedia design, sound art, music, and VR/AR applications with an innovative and critical-thinking mindset.

4. REFERENCES

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