

Chumbi, An Object-Based Paradigm for Higher-Order Ambisonics in The Chuck Programming Language

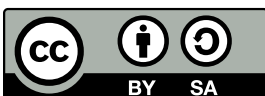
Everett M. Carpenter

School of Humanities, Arts and Social Sciences,
Rensselaer Polytechnic Institute
Troy, USA
carpee2@rpi.edu

Abstract

Chumbi is a collection of unit generators (UGens) encapsulated as a package of 'Chugins' for the Chuck programming language Wang et al. (2015) that provides higher-order ambisonic (HOA) encoding, decoding and calculation of spherical harmonics. Historically, ambisonic processing could be performed within Chuck by utilizing computationally inefficient arrays of UGens acting as gain values for incoming signals. This led to excessive control structures and higher level processing having to handle the calculation of spherical harmonics. Chumbi addresses this by providing a spherical harmonic algorithm for Chuck's builtin math library and a set of UGens which accomplish the encoding and decoding of ambisonics via low level, high performing C++ code. At the same time, Chumbi was designed with the goal of making HOA accessible to computer musicians by abstracting the complex signal processing and mathematics required for ambisonics, so that users can create their own processing schemes. With that goal in mind, Chumbi is easily deconstructed to the basic ambisonic signal processors which make up a system, enabling user created weighting systems to accomplish beamforming, highly personalized decoding schemes for site specific optimization, and pairings with Chuck's AI layer to create gesture driven audio spatialization.

Keywords: Ambisonics; Object-Oriented Programming; Signal Processing;



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1 Methods

Chumbi's interface design was heavily influenced by Object Based Programming (OBP), a method of system design which uses predefined objects operating separately to accomplish some defined goal. OBP was explicitly considered in the design of Chumbi to achieve a space which enables easy construction of systems (Puckette, 1970). As defined in Wegner (1987), languages are object-based if they support objects as a feature, but OBP does not require the use of inheritance, which is precisely why OBP was used when designing Chumbi. By avoiding inheritance, users are not concerned with the creation of new objects, but more so the compounding of pre-existing objects via complex audio routing. ChuckK as a programming language already exhibits object-based paradigms, where users are given a set of predefined audio processors to create any type of audio routing desired. Additionally, ChuckK also provides object-oriented methods which allow users to create their own UGens via three methods, Chugraphs, Chugens, and Chugins, with the latter being a C++ plugin (Salazar and Wang, 2012).

2 Process

Chumbi's highly efficient C++ Chugins handle the calculations of spherical harmonics using a newly authored real valued spherical harmonic algorithm holding to the SN3D normalization standard (Poletti, 2005; Williams, 1999), as well as the audio processing required for ambisonic encoding and decoding. Chumbi's encoder and decoder are built upon C++ template classes able to instantiate ambisonic encoders of any order, allowing a scalable base class to easily stretch to any order. Specific audio processing algorithms for each decoder are then specified in a child class. These design decisions allow Chumbi to support high ambisonic orders such as 12th or 15th. Chumbi's C++ source was wrapped and compiled to a Dynamic Linking Library (DLL) using ChuckK's Chugin framework, resulting in a .chug file that can be read from ChuckK's search path.

3 Final Result

All UGens in Chumbi are scalable, meaning by default they can operate from 1st to 5th order, with higher orders available by modifying and recompiling the MIT licensed package. While Chumbi can operate at higher orders, 5th was settled on as the highest order to be offered due to the exponentially increasing channel count required for HOA. The order of a Chumbi processor is designated via an integer

at the end of the class instantiation, such as Encode4 or SAD1. Due to Chuck's structure, it is easy to instantiate five or fifty five instances of Chumbi's UGens, and control them all with threads running concurrently. A full list of Chumbi's components follows.

- EncodeN: Basic encoder (can operate on either spherical harmonics or angular positioning)
- DecodeN: Basic decoder (operates on spherical harmonics)
- SADN: Sampling decoder (operates on angular positioning)
- OrderGainN: Simple gain control for BFormat signals
- ABFormat: Convert 1st order ambisonic microphones to BFormat signals
- BAFormat: Convert 1st order BFormat signals to AFormat signals

The author is continuing to develop Chumbi, with current goals being the implementation of Mode Matching Ambisonic Decoders and Dual Band Decoders to further optimize decoding performance (Frank. and Zotter, 2020).

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