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A Python library for Multichannel Acoustic Signal Processing

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ABSTRACT

The programming language Python is receiving increasing attention among the audio research community, partially motivated by the growth of data science and machine learning fields, and its potential applications. In this work we present a Python library for acoustic simulation and microphone array processing, with a special focus on spherical geometries. More specifically, the library provides a shoebox impulse response generator, a microphone array response simulator with arbitrary geometries and sensor directivities, and a set of methods for signal dependent and independent processing in the spherical harmonic domain.

1 Introduction

Python is nowadays becoming one of the most popular programming languages [1, 2]. Its popularity is also widespread among scientists and engineers, being for example the most chosen language for the arising Machine Learning field [3].

The existence of libraries oriented to scientific programming is therefore of interest for the research community. Specifically, there is a general lack of packages oriented to the acoustic signal processing and microphone array fields. To the best of the authors' knowledge, the only exception is the *pyroomacoustics* library [4], which features an extensive set of options for (but not limited to) room acoustic simulations.
However, we consider that there is still room for improvement, especially regarding microphone arrays with spherical geometries and the related signal processing methods.

2 Implementation

Accordingly, we present the *Multichannel Acoustic Signal Processing* (*MASP*) library for Python, which is a transcoding from several Matlab libraries by one of the authors [5, 6]. *MASP* is open source, and the code can be accessed at the project repository [7]. Furthermore, it can be installed using the *pip* package installer.

The library implements a variety of methods for the simulation and analysis of reverberant acoustic scenes, with emphasis on microphone arrays with spherical geometries.

More specifically, *MASP* is structured in submodules, having the following structure :

- *Array Response Simulator:* Simulation of spherical microphone arrays.
    - Rigid/open configurations.
    - Scattering simulation.
    - Arbitrary capsule distances, positions and directivities.

- *Shoebox Room Model*: fast implementation of the Image Source Method [8].
    - Convex 3D rooms.
    - Arbitrary number of sources and receivers, with arbitrary positions, orientations and directivities.
    - ISM expansion limited by order or time.
    - Frequency-dependent wall absorption.
    - RIR spherical harmonic expansion.
- *Spherical Harmonic Transform*:
    - Mathematical convenience tools.
- *Spherical Array Processing*: methods for the transformation and analysis of signals measured with a spherical microphone array:
    - A2B conversion with theoretical or measured filters.
    - Signal-independent beamforming.
    - Signal-dependent and adaptive beamforming.
    - Direction of Arrival estimation.
    - Diffuseness estimation.

The library implements a Unit Testing system, which assesses numerically the validity of the methods. More specifically, for each function, the equivalent Matlab code is called in the background. The Matlab result is then sent back to Python, where it is evaluated against the own result.

3 Conclusions

This paper introduces *MASP*, an open-source Python library for acoustic simulations and spherical microphone array methods.

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