Efficient grid generation implementation for acoustic modelling

To date, there is a lack of a detailed 3D acoustic propagation method for the detailed reproduction of the indoor and urban sound environment, both due to the computational burden as well as due to the absence of an easy accessible software interface. In the acoustics group of the department of the built environment (TU/e), an open-source software of the Pseudo-Spectral Time-Domain method (openPSTD) is currently being developed: a full-fledged software tool, accessible for academic research purposes, which enables to efficiently and in detail compute outdoor as well as indoor sound propagation (see figure 2). To achieve this, the computational method behind the tool will be further developed. Within the project, the software tool will also be implemented and applied to e.g. studying reduction of urban noise and to support the positive sound environment, the latter amongst others directed to train the blind in the auditory perception of the environment through aurализation.

The computational architecture of openPSTD is as follows: a geometry is drawn in the software Blender, a computational grid is generated related to the geometry, the grid data is processed to Python, and computations are carried out by a Python code. The computational architecture is designed such that the geometry is decomposed into rectangles (see figure 1(b) below), and the acoustic equations are solved per rectangle (per cuboid in 3D). Each rectangle or cuboid consists of an equidistantly spaced grid. Also, a calculation mode will be made available in which non-rectangular boundaries are captured by a mapping from rectangular ones, i.e. the curvilinear approach, on which the actual equations are solved. The grid on which the equations are solved is not equidistant any longer, see figure 1(a) below.

Currently, the subdomains are drawn directly in Blender. This is not the most useful approach. For arbitrary geometries, a grid generation algorithm is desired within the openPSTD framework that generates a grid based on a geometry provided by Blender.

Purpose
The purpose of this project is to couple a designed (indoor or outdoor) building environment geometry in Blender with the acoustic propagation algorithm of PSTD in Python by a grid generator. The grid generator decomposes the environment into a geometry confined block structure.

Tasks
1. Get acquainted with the openPSTD software framework and the numerical PSTD code
2. Define rules and strategies for the desired grid decomposition algorithm, both for the rectangular decomposition as for the curvilinear decomposition.
3. Explore the languages that can be used to generate the grid in the framework of the openPSTD project with the existing Blender-Python interface (we search for an open source language)
4. Implementation of the grid generation algorithm to translate the designed geometry in Blender into a grid that can be solved by PSTD in Python.
5. Tests of the algorithm for a variety of geometries.

Supervision
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Figure 1. a) Conformal map of a Cartesian grid on a rectangular domain onto a grid with deformed boundary\(^1\), b) voxelization of a bounded domain (thick line) with internal grid cells (green) and boundary grid cells (gray).

Figure 2. Screen-shot of the Blender OpenPSTD interface that allows for easily creating geometries and interactively visualising both simulated wavefronts and receiver impulse responses

\(^1\) (generated with Schwarz-Christoffel toolbox for MATLAB, http://www.math.udel.edu/~driscoll/SC/)