論文の内容の要旨

Thesis title: ***Inverse sound rendering***: In-situ estimation of surface acoustic impedance for acoustic simulation and design of real indoor environments

論文題目： インバースサウンドレンダリング： 内部空間の表面の音響特性推定を目的とした音響逆問題解析

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Abstract

When acoustic engineers do simulations of sound propagation with numerical algorithms, they use the acoustic properties of the objects to describe the behavior of a material when a sound wave hits its surface. In other words, the acoustic properties of a material determine the characteristics of the reflected wave and sound absorbed by that material. In the present work, of particular interest is the development of a method to measure an acoustic property called "normal acoustic impedance" of the surfaces (it will be referred here as to simply "impedance"). Furthermore, the measurement of the impedance is to be preformed in a real interior environment (in-situ) by using *the geometry of the place, the position and strength of a sound source (a speaker), and a set of sound samples measured at random positions in the acoustic field. Having these measured data as input, the estimation of the impedances at each surface is achieved by stating an inverse propagation model that leads to an ill-posed non-linear problem that has to be solved with special regularization techniques.*

When the impedances of the surfaces inside the space are known, we can now use them to make predictions of the sound response of that space (a room for example) by employing numerical algorithms. Moreover, since the 3D model of the room is assumed to be available, we may use it together with the measured impedances to simulate modifications of the room by inserting new objects (with known impedance), or changing the materials of the existing walls, or placing a carpet on the floor, to predict the sound response that we would hear if we did the actual modifications in the real room. This is important for example in the design of concert halls, seminar rooms, audio studios, etc. where an optimum acoustic design should be determined in advance before making costly expenses. The process of acquiring the acoustic properties of the materials in a room has been named as "*inverse sound rendering*". There are other methods for the estimation of acoustic properties of materials, however, inverse sound rendering differs in that the acoustic properties of all surfaces within the room are obtained in one time by using only one microphone, while existent methods have to measure each individual object with expensive microphone arrays. Computer simulations with this method have shown the applicability of the method, and validation experiments are presented in this dissertation.