Abstract

Active noise cancelling (ANC) of acoustic noises is becoming a common feature of consumer headphones. The active suppression of unwanted noises in special environments, such as the air conditioning vents of concert halls can be more efficient than passive isolation. However all of the market available solutions operate under strictly controlled acoustic conditions, such as the specially designed earmuffs of headphones.

This thesis presents an approach and a software simulation tool for investigating the behaviour and operating efficiency of active noise cancelling systems under arbitrarily chosen conditions. Special attention is given to environments described by typical conditions of room acoustics, which are generally unfavourable for active noise cancelling efforts. The efficiency of the feedforward noise cancelling structure utilizing multiple reference microphones is investigated under such conditions using finite-difference time-domain simulations. The results are evaluated in comparison with real-life measurement data. Based on the simulated and experimental results best practices and the outline of future investigations are identified.

The thesis briefly investigates the active noise cancelling problem, and presents the feedforward structure capable of suppressing wideband stochastic noises. The ELMS noise cancelling algorithm is also reviewed, which has been implemented on both the real-life and simulated ANC systems.

A brief overview of various acoustic field modelling techniques, and a detailed discussion of the finite-difference time-domain (FDTD) method is given. The techniques of locally reacting surfaces (LRS) and perfectly matched layer (PML) are also presented, which allow the simulation of arbitrary frequency dependent surfaces and anechoic conditions. As part of a simulation software these methods are implemented using the OpenCL language, allowing the efficient utilization of high-performance general purpose graphical processing units (GPGPU). The software has been integrated with a 3D modeller tool and Matlab to allow the easy description of acoustic environments and simple evaluation of simulation data.

Using the implemented simulation software a set of cornerstone ANC situations in reflective environments are simulated and the behaviour of the ANC system is investigated in comparison with real-life experiences.