Spatially Fixed and Moving Virtual Sensing Methods for Active Noise Control

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Abstract

Local active noise control systems generate a zone of quiet at the physical error sensor location. While significant attenuation is achieved at the error sensor, local noise control is not without its problems, chiefly that the zone of quiet is generally small and impractically sized. It may be inconvenient to place the error sensor at the desired location of attenuation, such as near an observer's ear, preventing the small zone of quiet from being centered there. To overcome the problems encountered in local active noise control, virtual acoustic sensors have been developed to shift the zone of quiet away from the physical sensor position to a spatially fixed desired location.

The general aim of the research presented in this thesis is to improve and extend the spatially fixed and moving virtual sensing algorithms developed for active noise control thus far and hence increase the scope and application of local active noise control systems. To achieve this research aim, a number of novel spatially fixed and moving virtual sensing algorithms are presented for local active noise control.

In this thesis, a spatially fixed virtual sensing technique named the Stochastically Optimal Tonal Diffuse Field (SOTDF) virtual sensing method is developed specifically for use in pure tone diffuse sound fields. The SOTDF virtual sensing method is a fixed gain virtual sensing method that does not require a preliminary identification stage nor models of the complex transfer functions between the error sensors and the sources. SOTDF virtual microphones and virtual energy density sensors that use both pressure and pressure gradient sensors are developed using the SOTDF virtual sensing method. The performance of these SOTDF virtual sensors is investigated in numerical simulations and using experimental measurements made in a reverberation chamber. SOTDF virtual sensors are shown to accurately estimate the pressure and pressure gradient at a virtual location and to effectively shift the zone of quiet away from the physical sensors to the virtual location. In numerically simulated and post-processed experimental control, both virtual microphones and virtual energy density sensors achieve higher attenuation at the virtual

location than conventional control strategies employing their physical counterpart.

As it is likely that the desired location of attenuation is not spatially fixed, a number of moving virtual sensing algorithms are also developed in this thesis. These moving virtual sensing algorithms generate a virtual microphone that tracks the desired location of attenuation as it moves through a three-dimensional sound field. To determine the level of attenuation that can be expected at the ear of a seated observer in practice, the performance of the moving virtual sensing algorithms in generating a moving zone of quiet at the single ear of a rotating artificial head is investigated in real-time experiments conducted in a modally dense three-dimensional cavity. Results of real-time experiments demonstrate that moving virtual sensors provide improved attenuation at the moving virtual location compared to either fixed virtual sensors or fixed physical sensors.

As an acoustic energy density cost function spatially extends the zone of quiet generated at the sensor location, a fixed three-dimensional virtual acoustic energy density sensing method is also developed for use in a modally dense three-dimensional sound field. The size of the localised zone of quiet achieved by minimising either the acoustic energy density or the squared pressure at the virtual location with the active noise control system is compared in real-time experiments conduced in a modally dense three-dimensional cavity. Experimental results demonstrate that minimising the virtual acoustic energy density provides improved attenuation in the sound field and a larger 10 dB zone of quiet at the virtual location than virtual microphones.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Danielle Moreau and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Contents

List of Figures

List of Tables