Novel sensing and actuating systems for active control of sound radiated by vibrating surfaces

The active control of noise radiated from vibrating structures asks for sensors and actuators at optimal locations which are not always accessible. The project focuses on design, placement and shaping of spatially distributed sensors as used for smart adaptive systems. A novel type of virtual sensors has been investigated, and a new technique was found for placement of modal acoustical sensors to be used with low order, robust, high performance control systems.

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The poor sound insulation properties in the low frequency range of lightweight constructions may be improved by active control. The present work expands knowledge from work on the "active window". Vibrating structures radiate sound below the material dependent coincidence frequency for diverse classes of structural modes with different radiation efficiencies. The control of sound radiation may be optimized using an array of virtual sensors and/or modal sensors. The virtual sensors are a class of mathematical functions predicted or identified for a real structure for sensing the sound radiated from vibrating surfaces into a coupled cavity. This method is aimed at overcoming observability problems associated with traditional error sensors such as microphones and accelerometers. The new virtual sensor approaches are based on estimating the disturbing sound field by Kalman filters or measurement of the acoustic pressure transfer function between a permanently placed remote microphone and a microphone temporarily located at the inaccessible observer location. With the temporary microphone subsequently removed, the signal from the permanent microphone can be modified with the transfer function to create a mathematical virtual microphone at the inaccessible location. In this project, we realized a prototype of virtual sensors by an array of conventional microphones. Together with piezo fiber based patches, a novel array of collocated pairs of virtual sensors and actuators for acoustic duct was constructed.

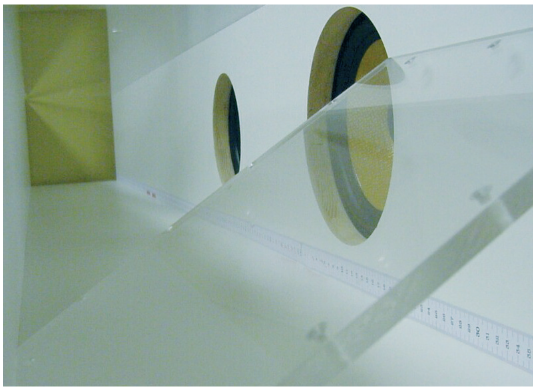

Fig. 1: *Acoustic duct with to loudspeakers for testing virtual sensors.*

Within the project, we also investigated another class of sensors, the "modal radiation filters". A prototype of radiation mode sensor was built, based on the theory that the radiation of acoustic modes can be estimated by weighting the output signals of a grid of discrete velocity sensors. The problem of frequency dependence of the radiation modes was overcome by estimating the amplitude of the frequency independent elementary radiation shapes. A spatial filter was realized in analog hardware as presented in Figure 2. This allowed realizing a simple, robust system for control of sound radiated by vibrating surfaces from a beam.

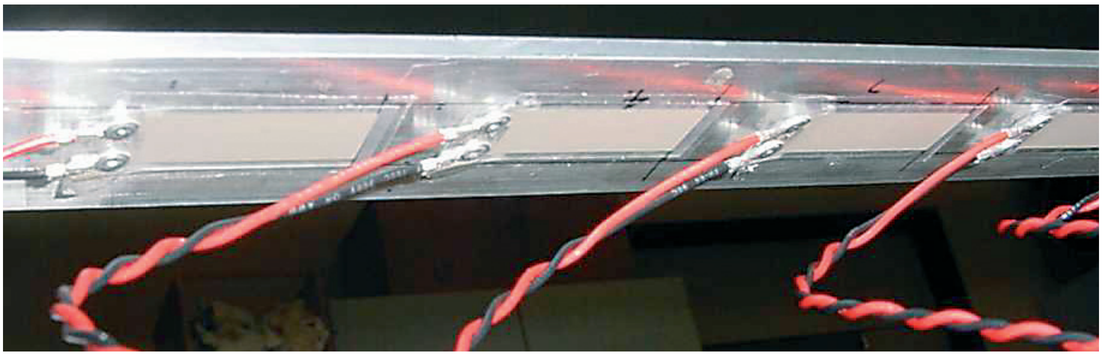

Fig. 2: *Prototype of radiation mode sensor (detail).*

Links: www.empa.ch/akustik

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References:
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