Robust Design of Active Control Systems

Computational Engineering & Design Centre

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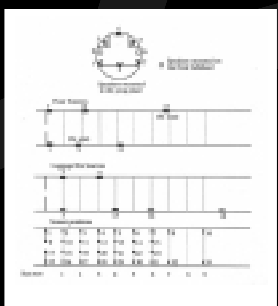
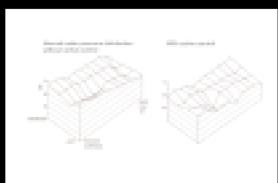
Active Control of Sound is a technique used to reduce the noise within an enclosure. It has advantages over conventional noise reduction methods where size and weight is a problem, especially more so at low frequencies. One application is to reduce the interference from an identified primary sound source such as the propeller noise within an aircraft cabin or the engine noise within a car interior. This is achieved using loudspeakers (secondary sources) to produce a sound field which destructively interferes with that from the primary source in order to reduce the noise. Microphones (error sensors) are used throughout the enclosure to provide a measure of the average sound field reduction. This is used to continually adapt an array of control filters which drive the secondary sources in order to achieve the best noise reduction.

In order to optimise these systems the positioning of the secondary sources (and errors sensors) is important. In order to find the best positions within an enclosure (adhering to practical constraints) it is necessary to make measurements between a large number of candidate positions and choose the combination with the desired number of loudspeakers which produces the best attenuation.



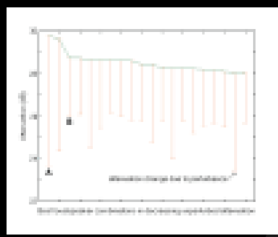
Finding the best combination of secondary sources and error sensor positions is a large combinatorial problem. As an example, choosing the best combination of 8 loudspeakers from 32 candidiates involves evaluating over 10 million combinations - in many instances the number of candidate positions is much greater.

The use of evolutionary algorithms is an efficient method for finding near-optimal solutions in large and difficult search spaces in which conventional gradient-based or deterministic algorithms fail. They are guided random search methods which are capable of finding an optimal combination without needing to evaluate every single combination, whilst being resistant to converging on local sub-maxima or sub-minima.



For ‘robust’ design the optimum combination of loudspeakers additionally needs to perform in a near-optimal way when small changes (perturbances) occur to the system under control, such as people moving around the enclosure. These changing conditions should have little effect on the attenuation achieved.

Therefore the best optimum ‘robust’ solution is not simply the solution which gives the best attenuation in an enclosure with no perturbances, but one which may give a slightly lower unperturbed attenuation and be more ‘robust’ when perturbances occur. This is a more practical solution.



For the loudspeaker combinations shown above solution B is more ‘robust’ than A, even though it gives a slightly lower unperturbed attenuation.

This poster may be viewed at http://www.soton.ac.uk/~cedc

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