Time Domain Sound Field Analysis Using the Finite Element Method and the Fast Multipole Boundary Element Method

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Noise is one of the seven major types of pollution in Japan, and it leads to the highest number of complaints according to a survey published by the Ministry of Internal Affairs and Communications in December 2021. Especially in urban areas, the evaluation of noise has been an urgent issue for planning and designing various constructions, such as roads, railways, and airports. Several evaluation methods for traffic noise simulation have been utilized. Based on the frame of reference used, those methods can be classified into two categories: 1) Methods based on the geometrical acoustic theory and 2) Methods based on acoustic wave theory. Both methods have advantages and disadvantages. For geometrical acoustic theory methods, the CPU time is very short but the numerical accuracy is comparatively low. Acoustic wave theory methods, on the other hand, provide accurate solutions but large-scale simulations.

This paper presents a noise evaluation system based on acoustic wave theory. This paper utilizes two methods – the finite element method [1] and the boundary element method using a fast multipole method [2], which are employed for the discretization of unsteady wave equation – and compares the numerical results of the benchmark problem. In addition, we show the results using the analytical model of the complex shape based on standard specifications of noise barriers and discuss the difference of the numerical results and auralization results between the two methods.

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