Time-Domain Simulation of Multi-Physics Sound Propagation in Complex Media and Environments

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With the advent of computing power in recent decades, time-domain (TD) simulation of acoustic propagation has become practically feasible. Because TD simulation is based on conservation laws in the physical domain (both time and space), the primary advantage is its ability to accommodate a wide spectrum of realistic physics in the ambient of acoustic propagation, including complex geometries, media, and environmental conditions. The simulation can include effects such as terrain, trees and bushes, vegetation, and buildings in the way of sound propagation. It can represent refraction and diffraction in the atmosphere and from obstacles. Other properties such as interface between different acoustic propagation media can be effectively modeled. Furthermore, it enables investigation of transient signal propagation with moving sources or receivers, particularly for long-distance sound propagation by using the zonal moving-frame technique.

In this presentation, details of the mathematical formulation and numerical algorithm for a TD simulation package developed by our group will be explained, followed by several examples of simulation including sound propagation with background shear and vortex flow, propagation around arbitrary-shaped porous barriers and around trees, noise from unmanned aerial vehicles, diffractions near buildings, array arrangements in sonic crystals in both two and three dimensions, and acoustic wave interactions at the air/porous-ground interface. During the course of the presentation, it will also be demonstrated that the simulation results are verified/validated by comparisons to the analytical solutions and measured data in the literature.