Formulation of Locally Reacting Surfaces in K-DWM Modelling of Acoustic Spaces

Reuben's Ongoing Concerns-With-The-Paper Scratch Space

- so far we've only seen formulations for rectilinear grids and planes
  - will this work for other topologies
  - especially if we need to find velocity components normal to the surface nodes

FDTD

- sound propagation governed by
  - conservation of mass
  - conservation of momentum
- wave equation is given by eliminating particle velocity
  - giving an equation for change in acoustic pressure against time (?)
- equations for the discretized wave equations on rectilinear regular grids are given
- Courant number is cT / X where
  - c is the speed of sound
  - T is the time step
  - X is the grid spacing
- in the 3D case, the courant number (stability condition) is Courant number <= 1 / sqrt(3)
  - to minimize dispersion, the Courant number cT/X should be set to the stability limit
- dispersion equations are given for rectilinear regular grids
- boundary formulations are derived by combining the discretized wave equation with a discretized boundary condition
  - updating boundary nodes using the resulting boundary update equation

Locally Reacting Surfaces

- In a locally reacting surface, the normal component of the particle velocity at the wall surface depends on the sound pressure in front of the wall.
  - this holds for surfaces that can't propagate waves parallel to the boundary surface
- reflectance / planar wave coefficient is given by
  - (g cos(theta) - 1) / (g cos(theta) + 1) where
    * g is the normalized wall impedance Z / rho c where
      · Z is the boundary impedance
      · rho is the air density
      · c is the speed of sound
  - see H. Kuttruff, Room Acoustics p. 38
- this models only locally reacting surfaces (I think) which are the exception rather than the rule - most surfaces in fact DO propagate waves parallel to the surface
- can't really model anechoic boundaries with this model

Frequency Independent Boundaries

- by substituting centred finite difference operators into the continuous boundary condition equation, we get an equation which can be written to describe a 'ghost point' which lies outside the modelled space
- this equation can be used to eliminate the ghost point in the discretized wave equation
  - giving us an update equation for the boundary
- to find an update equation for the corner, recognize that the corner boundary must satisfy the boundary conditions of the two joining edges simultaneously
  - we find two ghost point equations
  - then eliminate the ghost points in the discretized wave equation
  - this gives us the corner update equation

Frequency Dependent Boundaries

- replace real-valued wall impedance with complex-valued frequency-dependent impedance
- combining impedance equations for mass-like and spring-like boundaries gives a single general boundary impedance equation
- insert the impedance equation into the continuous wave equation
  - then use finite difference operators to produce a discretized equation
- the continuous equation includes a second-order derivative and an integral
  - versions of the bilinear transform are used to remove these
- now we use the discretized boundary equation to eliminate the ghost point in the discretized wave equation