Enabling road noise engineering methods to model complex objects

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Context

Engineering methods are important but limited

> Engineering methods quickly approximate average noise levels for simple geometries

> Governments, city planners, consultants, and researchers use engineering methods to
- Evaluate current noise exposure
- Predict the impact of infrastructure changes
- Mitigate excessive noise

> Engineering methods cannot accurately model complex objects, so the potential benefits of complex objects are often ignored

Objective

To augment engineering method capabilities

> To develop a hybrid method that efficiently models complex shapes and surfaces more accurately

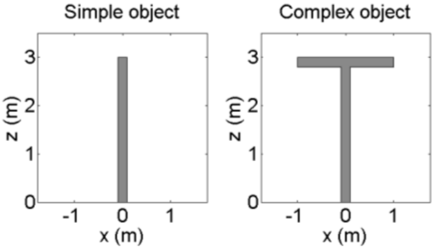

Figure 1: Engineering methods can model the simple object but not the complex object. The hybrid method models both.

Approach

Add a correction to the engineering method

> Model the complex object and a simple object using a detailed method (e.g. the boundary element method)

> Store the differences in a table based on source and receiver positions and frequency (six input variables)

> Model the urban scene using an engineering method with an additional attenuation term for the complex object

Complexities

Obtaining the true correction is difficult to do efficiently

> Interpolating a discrete set of points must accurately represent a very large domain where the number of points is severely restricted by the available computer memory

> The interpolation is 5 dimensional

> Reflections and diffractions are simplified to changes in the source and receiver locations

> For efficiency, the engineering methods assume that different sources of attenuation are independent. The limits of this approximation must be investigated for complex objects.

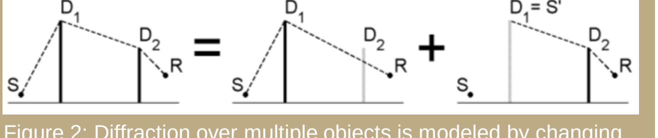

Figure 2: Diffraction over multiple objects is modeled by changing the source or receiver position based on which object has the largest path length difference

Results

Using the hybrid method reduces the error

> For a T-barrier next to two buildings, the hybrid method is closer than the engineering method to the exact results

> The hybrid method predicts a higher overall sound level than the exact method for a T-barrier because the engineering method predicts similarly for a straight barrier

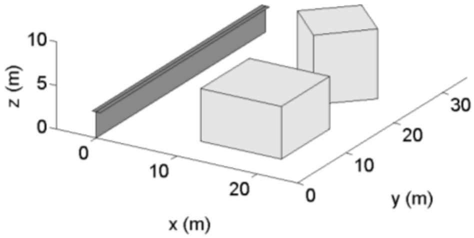

Figure 3: The geometry of the test case

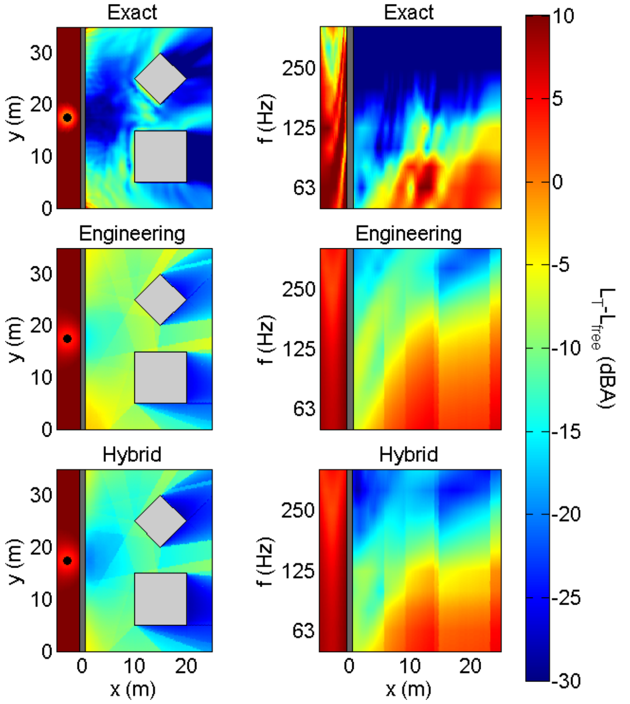

Figure 4: The left-hand plots illustrate the sound levels *spatial* dependence for 50-400 Hz (A-weighted) and the right-hand plots show the *frequency* dependence on the y = 17.5 m line. The engineering and hybrid plots should look like the exact plots.

Conclusion

The hybrid method

> yields more accurate results than the engineering method for complex objects

> requires further validation using additional urban scenes and higher frequencies

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