Numerical Acoustics – Spring 2025

Exercise 4: Introduction to the Boundary Element Method

A simplified implementation of the BEM in 2D is distributed with this exercise. It is part of the Matlab-based research package OpenBEM. Start Matlab on the *2DBEM_Exercise_4* folder and run the file *run_me.m*. All functions will then be included in the Matlab path. Remain in this root folder. The objectives of the exercise are:

- understanding the implementation,
- comparing the formulation with the theory,
- verifying it with a test case (scattering of a plane wave by a cylinder), and
- running some examples of your choice.

This simplified implementation will be a base for some of the course exercises. A full BEM implementation will be provided later for its use in the project.

1. Open the Matlab functions contained in the package. Study the functions *bem2d.m*, *fieldpoints.m* and *intF1.m* in the *kernel* folder. Try to match the calculations in the files with the theory on the slides (slide 18 and following).
    a. *bem2d.m*: Calculates the coefficients of the BEM system of equations for the discretized matrices after collocation.
    b. *fieldpoints.m*: Calculates new coefficients for points on the domain away from boundaries. This calculation is done after solving on the boundary.
    c. *intF1.m*: Performs the numerical integrals needed for the calculation of the matrix coefficients. Used by the two previous functions.

2. The package contains a mesh generator called *nodegen*. A script is provided (*TestScatCyl*) where the mesh for an infinite cylinder is generated using *nodegen*. Study it. Run the mesh generation section (up to line 26) and identify the geometry matrices and their structure.

3. Some parts related to the BEM calculation are missing. Write the Matlab sentences to calculate the scattered pressure by an infinite cylinder, the same problem that was solved in exercise 1 with an analytical expression. You may use today's lecture slides and the reference conference paper that comes with the package for guidance.

4. Compare the BEM results on the cylinder surface and on the domain with the analytical solution. There should be a match.

5. Define other object shapes of your choice and calculate the scattered sound field around them at different frequencies. You may also include multiple scattering objects. You can be inspired by real objects like room acoustics diffusers, microphones, loudspeaker boxes, etc. (all in 2D). Be careful not to define too lengthy calculations and follow the "six nodes per wavelength" rule of thumb.

You may compare the BEM and analytical solutions for the cylinder in your short explanation to the other students. You may also come up with results for other shapes of your own.

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