TTT4180 - Simulation assignment

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1 Introduction

The Transmission Line Matrix (TLM for short) method is a general purpose time-domain simulation technique that originates from electromagnetism but that can be used in acoustics also. It has been discussed in class and is also well explained in references like the one by Kagawa, uploaded in Blackboard. In this assignment you will first implement your own TLM in 2D and simulate wave propoagation in a pipe. Second you will use the TLMfig software program to study some more complex problems. The purpose of the assignment is to get introduced to numerical methods in acoustics and to observe some acoustic phenomena, TLMfig simulates sound propagation in a 2-dimensional environment. The program has a graphical user interface in Matlab. You have access to the microphone pressure values by doing the following:

- click on the GUI window,
- go to the command window and write " data = guidata(gcf)", the pressures can now be found by writing "p = data.pmic".
- choose 200 by 200 size grids and take the cell size to be 0.1 · 0.1m.

2 Sound propagation in a pipe

In the language of your choice, implement a 2D TLM to simulate sound propagation in a horizontal rigid pipe. The length of the pipe is 2 m, its width is 0.2 m. The maximum frequency considered is 2 kHz. The simulations should be carried out with at least 10 mesh points per wavelength. The left termination of the pipe is rigid. The right termination is defined by a reflection factor $R = 1$, unless otherwise specified.

- Place a harmonic point source at the lower left corner at 500 Hz and illustrate the response of the pipe along its axis at well chosen instants.

- What happens if $R = 0.1$?
- Generate a single pulse of amplitude 1/4 in all the branches of the node at the lower left corner, record the response at the lower right corner and find the resonance frequencies. Compare with theory.

3 Propagation in free space and above ground using TLMfig

3.1 Sound pressure as function of distance from source

Put a source close to the middle of one of the sides, and a row of microphones away from the source on a common line. Note where the source and microphones are. Make a plot of the sound pressure level as a function of distance from the source.

3.2 Reflection from a surface

A surface can in the program be hard ($R = 1.0$), or partly absorbing ($R \neq 1.0$). The reflection factor given in the program is defined for plane waves normally incident to a surface. The surface is considered locally reacting. You will study the effect of a ground underneath a source. The ground can for instance be put at the height 20, and the source at height 80. Again we put in a row of microphones in a line through the source and parallel to the ground. Use a gauss type of source with around 40 cells per wavelength. Note the positions of the source and microphones. Note the amplitudes of the direct and ground reflected waves. Change the ground to one having a reflection factor of $R = 0.5$, note the amplitudes of the reflected waves. Comparing the reflections with hard and partly absorbing grounds gives information on the reflection factors at different angles of incidence. Illustrate the findings by a graph.

3.3 Effect of noise screen

Consider a flat ground having a reflection factor of 0.95. A sound source is placed 0.5m above ground. A 3m high screen is put up between the source and possibly annoyed people. The screen is 4m away from the source. Discuss the noise reducing effect of the screen on people walking on the quiet side by putting microphones 1.5m above the ground for some distances up to 10m. This is best done by calculating the insertion loss in decibels. The insertion loss is the difference in sound pressure level with and without the screen in place. Use a high and a low frequency (for instance around 15 and 45 cells per wavelength), and also the source type: noise).

4 Deliverables (due date: see Blackboard)

The deliverables will be uploaded in Blackboard (Simulation assignment hand-in) as **separate files**.

- A report (English, Norwegian) in 6-10 pages (possible short annexes excluded). It should contain the results, and a discussion of these. Results should be presented by figures rather than tables. Make sure that the legends are readable. Please use LaTeX and the Acta Acustica template[1]. Also, since TLMfig has not yet been fully tested, you should comment on any strange behavior or clear errors you might find.
- Commented code for the 2D TLM modelling of the pipe.

[1](template `http://www.acta-acustica-united-with-acustica.com/for-authors/instructions-for-authors.html`) when writing and typesetting your report. Overleaf makes it straightforward (https://www.overleaf.com/latex/templates search for Acta Acustica template).