AMATH 482: HOMEWORK 1

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Abstract. In this report, we have been tasked to locate a submarine that is moving in the Puget Sound. The submarine emits an unknown acoustic frequency that we need to detect. Using broad spectrum recording of acoustics pressure data, we will analyze the data to locate the submarine. The data is noisy and contains measurements of acoustic pressure taken over 24 hours. The measurements are 3D and taken on a uniform grid of size 64 x 64 x 64. We will visualize the data and define the physical scales of the problem to locate the submarine.

Your goal in this homework is to locate a submarine that is moving in the Puget Sound. We do not know much about this submarine as it is a new technology that emits an unknown acoustic frequency that you need to detect. Broad spectrum recording of acoustics pressure data obtained over 24 hours in half-hour increments is available to you. You can download the data using the Google drive links on Canvas; either of the data files subdata.npy for Python users, subdata.mat for MATLAB users or subdata.csv in text format if the previous two formats are insufficient. The data file contains a matrix with 49 columns of data corresponding to the measurements of acoustic pressure taken over 24 hours. These measurements are noisy (which is typically the case). The measurements themselves are 3D and taken on a uniform grid of size $64 \times 64 \times 64$. The provided (hwhelper) notebook will visualize this data for you and define the physical scales of the problem Your report should contain a brief, 100 word abstract describing what is contained inthe document and what you did. **Don't forget 6 pages max**.

1. Introduction and Overview

Here you will give a brief introduction to the problem you solved. Including some discussion of relevant literature and background. Make sure you use the correct citation commands (i.e., `\cite`) to keys from your bib file like this [**?**]. If you want to cite more than one reference simply use [**?**, **?**]. You can grab latex citations from Google Scholar. Just keep in mind that they often need to be cleaned up.

2. Theoretical Background

You dedicate this section to the theoretical background of the methods and frameworks that you used in your homework. This is not meant to reproduce material from the lectures or references you used but rather to demonstrate your understanding of the mathematical foundations of the methods and algorithms. You can create equations like this

$$f(x) = \int_A \sin(\pi x) dx.$$

You do not need to label your equations unless they are referenced in the text. In that case simply use

$$-\frac{\partial^2 u}{\partial x^2} = \sin(\pi x). \tag{1}$$

Date: January 26, 2025.

Also look up the `align` or `aligned` environments if you want multi- line equations. You can then reference your equations in text using the \ textteqref command as such (**??**).

3. Algorithm Implementation and Development

Here you discuss the algorithms and software packages that you used. Not much to it. Just make sure you cite the packages properly and avoid including code. You are welcome to use LaTeXpackages that are specifically designed to show algorithms such as this, but it is not always worth the effort and real estate.

4. Computational Results

This is perhaps the most important section of your report. You want to dedicate more space here and present your numerical results in a clear, concise and meaningful way. Also include a discussion of your numerics. Think hard about how you can use your space most efficiently. For example, include subplots and multiple error curves on the same plot etc. Ask us for advice when the time comes. You will most definitely need tables and figures. So here is an example. Make sure

row 1	column 1	column 2
row 2	column 1	column 2
row 3	column 1	column 2

Table 1. Don't forget to include a caption for your table. Say a few words about what is being shown.

your table is labeled and referenced withing the text using \ textttref as such Table **??**. In fact, you can use `\ref` to cite anything else in the document such as sections (ex. Section **??**). This will create hyperlinks in your pdf after compilation and automatically update the numbers and tags whenever you change anything. Figures are very similar to tables. Here's an example:

Figure 1. Include a descriptive caption for your figure. Also make sure all legends, axis labels, and titles are large enough to be readable. You might have to reproduce the plots from Python or MATLAB with larger fonts for this purpose. It can be annoying the first time you do it but it is crucial.

Once again, make sure all your figures are referenced like Figure reffig:meaningful-label or Figure **??** in the text body of the report and discussed in detail. This is where you will make

observations about your results and we will look at these very closely. Also note, I am using PDF figures. These give you the best looking graphs but PNG works well too. I advise staying away from JPG as it always looks weird and low quality.] Both Python and MATLAB can output figures in PDF or PNG.

5. Summary and Conclusions

Wrap up your report with a brief summary of what you did and what you discovered. Finish with some conclusions and possibly future directions if any.

Acknowledgements

The author is thankful to Professor Frank for providing me with the materials and resources needed to complete this assignment. The author is also thankful to the peers Eric Ye and Chenab for discussion and implementation of visualization techniques in Python. corresponding document. You also have to maintain your references in the .bib file