CS 6810/7810: Wavelets and Wavelet Algorithms
Assignment 8
Harmonic Recovery and Audio Analysis

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Learning Objectives

1. Harmonic Recovery
2. Discrete Fourier Transform
3. Audio File Analysis

Introduction

In this assignment, you will recover harmonics from data and apply DFT to audio files. This is the last assignment for this semester. I initially thought of splitting it into two weekly assignments but then decided against it and combined them into one assignment due in two weeks. I hope this works out better for all of us.

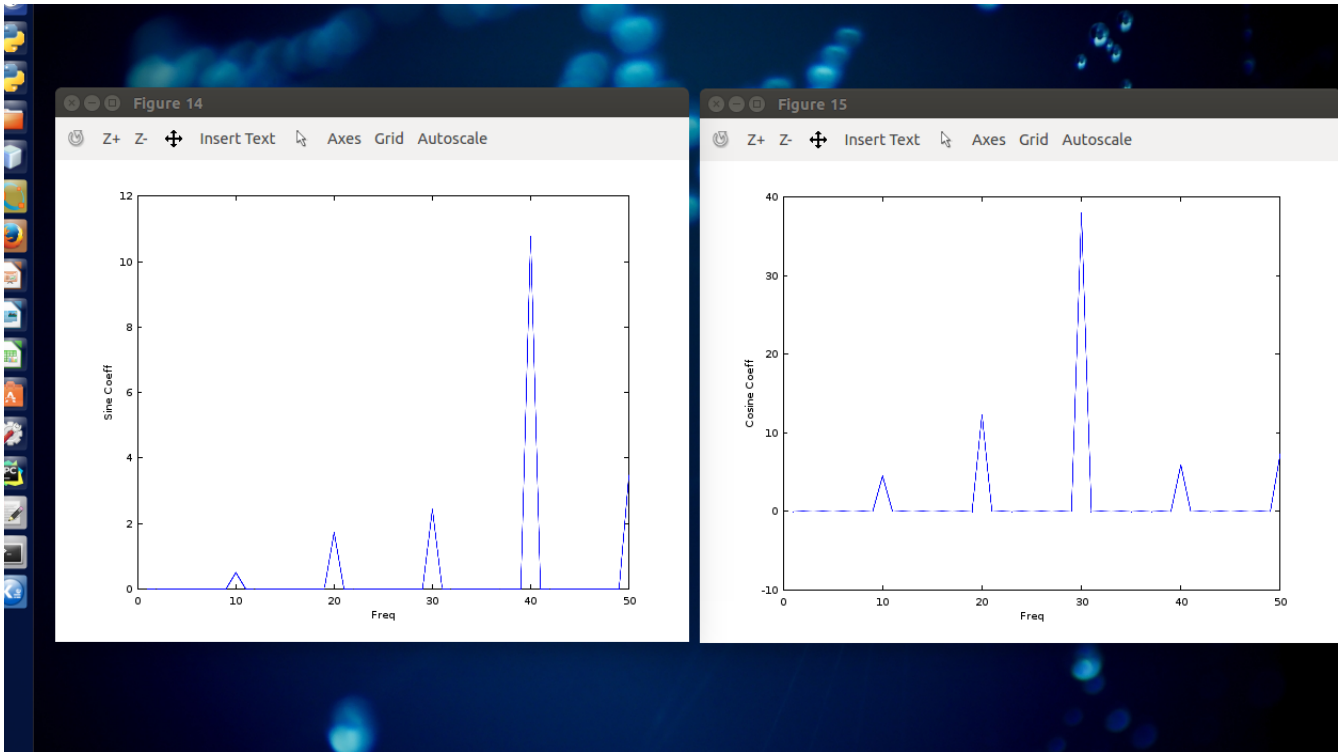

Figure 1: Sample coefficient vs. frequency plots; sine coefficients vs. frequecy (left); cosine coefficients vs. frequency (right)

Problem 1

The zip archive for this assignment contains `data.txt` with 6,284 real numbers generate by some function unknown to you. Apply the harmonic recovery analysis to it to recover the harmonics in the frequency range from 0 to 150 and plot

their coefficients. The plots in Figure 1 show two sample plots. Note that the plots are not the plots for this problem. They are just examples. Your plots will have a similar appearance but different values. For example, suppose that you have recovered the values of a_0, a_{10}, b_{10}, a_{40}, and b_{40}, i.e., the 0-th, 10-th, and 40-th harmonics are present. Here is a sample output that your code may produce.

```
a0 = 1.784
a10 = 0.56996
b10 = 1.898
a40 = 29.18
b40 = 7.9209
```

To do harmonic recovery, you will need a threshold to determine if the sine or cosine coefficient of a harmonic is present. I implemented my solution in Octave and used a threshold of 0.03.

Problem 2

In this problem, you will perform the DFT analysis of musical audio files. The zip archive contains three audio files: `ODE_TO_JOY_RIGHT_HAND.wav`, `ODE_TO_JOY_BOTH_HANDS.wav`, and `ODE_TO_JOY_ORCHESTRA.wav`. All three files record the famous segment from Beethoven's Ode to Joy. The file `ODE_TO_JOY_RIGHT_HAND.wav` records me playing the notes on my piano with my right hand. The file `ODE_TO_JOY_BOTH_HANDS.wav` records me playing the same segment with both hands. Finally, the file `ODE_TO_JOY_ORCHESTRA.wav` is a recording of the segment by an Austrian choir and orchestra. I recorded these wav files with a five-dollar microphone so there is some background noise in all three recordings. But it is manageable. So, do the DFT analysis of the three files the way we did in Lecture 12. Specifically,

1. Plot the spectrum analysis of each audio file;
2. Identify the top five frequencies in each audio file;
3. Use `https://en.wikipedia.org/wiki/Piano_key_frequencies` to identify the corresponding musical notes.

What To Submit

You can do this assignment in Octave, Python, or Java. If you do it in Octave, save your solution in `HW08.m`. If you do it in Python, save it in `HW08.py`. If you do it in Java, save it in `HW08.java`. If you do it in Java and use third-party jars, please submit them along with your `HW08.java`. In your source file, define the function/method `problem_01()` with your source code for Problem 1 and the function/method `problem_02()` with your source code for Problem 2.

Enjoy!