CMSC 715: Wireless and Mobile Systems for the IoT

Assignment - I

Fall 2021 Due: September 29th, 2021 11:59 pm

Instructions

1. This assignment is due on September 29th, 2021 at 11:59 PM.
2. There are total 150 points to score and additional 40 points as extra credit.
3. Please submit an electronic copy of your answer sheet through ELMS-Canvas. Contact the TA if you face any technical difficulties in submitting the assignment.
4. Your report should contain plots, source code, along with short description of the operation for each part separately.
5. You may discuss ideas with others in the class, but your solutions and presentation must be your own. Do not look at others' solutions or copy from anywhere.

Assignment description

The goal of this assignment is to get familiarized with the time-domain to frequency-domain conversion through simple programming tasks. Here you will be plotting the Short-term Fourier Transform (STFT) of a given sound signal to visualize the time varying frequencies in it. You can use any programming platform for this assignment, however the instructor and the TA will provide programming specific help for Matlab only.

Task 1: Warming-up [20 points]

Read the sound file and plot the signal.

(a) You are provided with a data folder containing sound files. The names of the files are in numbers. If the last digit of your UID is 'x', then use the file 'x.wav' from the data folder. You will be using signal from this file for this entire assignment. [0 Points]

(b) Read the sound signal with your program and store it in a variable. Find out the sample rate of the recording. Play the file using an audio player and listen to the sound. [0 Points]

(c) Plot the time domain signal. The vertical axis should show the amplitude and horizontal axis should show time (NOT the sample numbers). Use proper labels and units for the axes. [10 Points]

(d) Plot the STFT or the spectrogram of the signal using a standard library function. For Matlab, you can use the 'spectrogram' function. [10 Points]

Task 2: Home-grown STFT [50+20 points]

Plot STFT of the signal using your own DFT matrix. You can not use standard function to generate the DFT matrix for this task. You should use equations discussed in the class to calculate the values of this matrix.

(a) Create a 1024 point DFT matrix. Plot the real and imaginary components of that matrix in two separate 2-dimension image plots. [20 Points]

(b) Use your DFT matrix to find the Short-time Fourier Transform (STFT) of the signal. Here the time-window (or FFT-points, same as the number of rows/columns of the DFT matrix) should be 1024 and the time-windows should not have any overlap between them. Plot the STFT as a 2-dimensional plot. The vertical axis should show frequency and horizontal axis should show time. Use proper tick values and labels for the axes. [30 Points]

(c) Get the same STFT as in the previous question but using exactly one matrix multiplication. Plot the real part of the matrix you used. [20 Bonus Points]

Task 3: Home-grown STFT with Overlaps [30+20 points]

Same as Task 2, but this time you should use overlapping time-windows for the STFT.

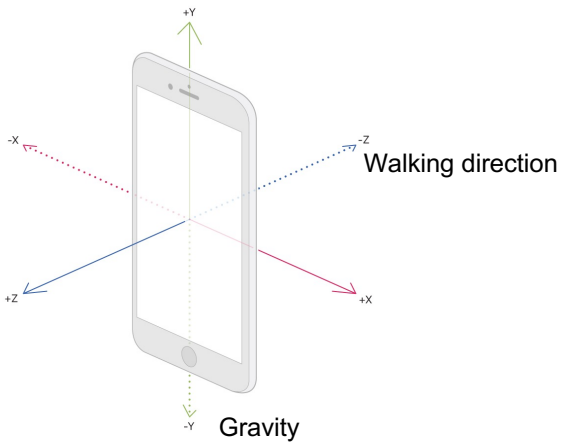

Figure 1: Task4: Orientation of smartphone and accelerometer axis. The direction of walking is along the Z axis.

(a) Use your DFT matrix to find the Short-time Fourier Transform (STFT) of the signal. Here the time-window should be 1024 and the time-windows should have 512 point overlap between them. Plot the STFT as a 2-dimensional plot. The vertical axis should show frequency and horizontal axis should show time. Use proper tick values and labels for the axes. [30 Points]

(b) Get the same STFT as in the previous question but using exactly one matrix multiplication. Plot the real part of the matrix you used. [20 Bonus Points]

Task 4: How fast do I walk? [50 points]

In person classes are finally back. Your first class is from 12:30-1:45PM in the Brendan Iribe building and the next class is from 2:00-3:15 PM in the Chemistry building. You do not want to reach late to the second class, so you decide to calculate the time it will take you reach the Chemistry building. You know the shortest distance between the buildings is 480meters, but you do not know your walking speed. You hack into your smartphone and collect the accelerometer data for the previous day when you walked to the class. Assuming your walking speed to be constant, you have to use the provided accelerometer data to calculate the frequency of your steps and calculate time it will take to reach the building. You are provided with a data folder containing accelerometer data for X, Y and Z axis. The names of the files are in number. If the last digit of your UID is *'x'*, then use the *'sensorlog_x.mat'*.

(a) Read the accelerometer data from the '.mat' file and plot the time domain signal for X, Y and Z axis. [20 Points]

(b) Use fast fourier transform (FFT) to calculate the frequency of your steps. You can use the inbuilt functions for this. Plot the amplitude spectrum of the FFT result. Calculate the time it will take you to reach the building. Use stride length for one step as 0.5meter and the walking direction to be parallel to the Z axis of the accelerometer axis. Figure 1 shows the orientation of the smartphone while walking. [30 Points]

What to submit

Please submit a single document file (.pdf format is preferable) containing the following:

(a) Your name and UID

(b) The answers/output/results/plots etc. for each of the questions above.

(c) The source code or scripts you used for this programming assignment.

Late Policy

The late assignments will be penalized 10% per day after the due date. Maximum of 5 late days are allowed.

List of Matlab functions useful for this assignment

Use 'help ⟨ function-name ⟩' on the Matlab console to get information about the input/outputs of these functions.

(a) audioread

(b) spectrogram

(c) exp

(d) imagesc

(e) transpose

(f) kron

(g) reshape

(h) circshift

(i) fftshift

(j) load