ICE503 DSP-Homework#10

1. Suppose we have two four-point sequences $x[n]$ and $h[n]$ as follow:

$$x[n] = \sin\left(\frac{\pi n}{2}\right), n = 0,1,2,3$$

$$h[n] = 2^n, \qquad n = 0,1,2,3$$

   (a) Calculate the four-point DFT $X[k]$.

   (b) Calculate the four-point DFT $H[k]$.

   (c) Calculate $y[n] = x[n]$ ④ $h[n]$ by doing the circular convolution directly.

   (d) Calculate $y[n]$ of Part (c) by multiplying the DFTs of $x[n]$ and $h[n]$ and performing an inverse DFT.

2. MATLAB simulation:

   The idea of a spectrogram is plotting a sequence of short DFTs of the input signal using overlapping windows. If the signal is real, then one typically plots only the positive frequencies $k = 0,1,\ldots,\frac{N}{2} - 1$.

   (a) Download guitar4.wav from cyber university（網路大學）and use audioread function to obtain the sampled data $x[n]$ and the sample rate F_s.

   (b) Create a Hann window as the overlapping window

$$w[n] = \frac{1}{2}\left(1 - \cos\left(\frac{2\pi n}{N}\right)\right), n = 0,1,\ldots,N-1$$

   where N is the DFT length. Here you need to choose a suitable $N = 2^m$ so that the bandwidth of the DFT frequency bins is around 20Hz. Plot $w[n]$.

   (c) Let $M = \frac{N}{4}$ be the number of samples to shift after each DFT. The energy in the k-th frequency bin of the i-th window is given by

$$X_i[k] = \left| \sum_{n=0}^{N-1} x[iM+n]w[n]e^{-\frac{j2\pi k}{N}} \right|^2, k = 0,1,\dots,N-1$$

Write a MATLAB function "myspectrogram.m" that computes the short DFTs of the input signal for each window.

```
X = myspectrogram(x,N,w,M)

% x is the sampled data x[n]

% N is the DFT point

% w is the overlapping window

% M the number of samples to shift after each DFT
```

(d) Use the following code to plot the spectrogram

```
image(t,f,X(1:floor(N/2),:));  % t is time and f is frequency
colormap(hot(256));
colorbar;
```