Homework 2 (Due: 4/8)

(1) Write a Matlab or Python program that uses the frequency sampling method to design a $(2k+1)$-point discrete Hilbert transform filter (k is an input parameter and can be any integer). (25 scores)

The transition band can be assigned to reduce the error (unnecessary to optimize). The frequency response (DTFT of $r[n]$, see pages 111 and 112, show the imaginary part) and the impulse response of the designed filter should be shown. The Matlab or Python code should be handed out by NTUCool.

(2) (a) What are the two main advantages of the minimal phase filter compared to other IIR filters? (b) What is the advantage of the Wiener filter compared to other lowpass / highpass filters for noise removal? (c) What are the two advantages of the cepstrum compared to the equalizer for multipath problems? (15 scores)

(3) Suppose that an IIR filter is $H(z)=\dfrac{2z^3+4z^2+z+2}{2z^2+z+1}$

(a) Find its cepstrum.

(b) Convert the IIR filter into the minimum phase filter. (15 scores)

(4) (a) Which of the following filters are always even symmetric? (b) Which of the following always filters are odd symmetric? (i) Notch filters; (ii) smoothers; (iii) edge detectors; (iv) particle filters; (v) 3 times of integrals; (vi) 2 times of differentiations. (10 scores)

(5) Suppose that $y[n]=\alpha_1 x[n]+\alpha_2 x[n-30]+\alpha_3 x[n-40]+\alpha_4 x[n-50]$

How do we use the cepstrum and the lifter to recover $x[n]$ from $y[n]$? (10 scores)

(6) Why the Mel-frequency cepstrum is more suitable for dealing with the acoustic signal than the original cepstrum? (10 scores)

(7) Why we rarely use $x[n] \xrightarrow{\text{DFT}} X[m] \longrightarrow Y[m]=X[m]H[m] \xrightarrow{\text{IDFT}} y[n]$

for digital filter design in practice? (5 scores)

(8) (a) Which of the following vocal signal sounds louder? (b) Which of the following vocal signal propagates longer?

(i) $\cos(200\pi t)$, (ii) $\sin(600\pi t)$, (iii) $\cos(1800\pi t)$. (10 scores)

(Extra): Answer the questions according to your student ID number.
(ended with (4, 9), (0, 5), (1, 6), (2, 7))