Homework 1 (Due: 26th Sept.)

(1) Which of the following applications are the proper applications of the short -time Fourier transform? Also illustrate the reasons. (a) Filter design. (b) convolution computation; (c) image analysis.

(10 scores)

(2) If $x(t)$ requires N sampling points, which of the following functions require more than N sampling points? (a) $x(2t)$, (b) $x(t-2)$, (c) $x^2(t)$, (d) $x(t)*x(t)$ where * means convolution, (e) $\exp(j2\pi t)x(t)$? Also illustrate the reasons.

(10 scores)

(3) Why the wavelet transform is suitable for (i) compression and (ii) edge detection? (10 scores)

(4) If $x(t)=\sin\left(1400\pi t+200\pi t^2\right)+\sin\left(600\pi t\right)+\cos\left(2000\pi t\right),\quad 0\le t\le 3,$

how do we perform adaptive sampling for $x(t)$ if the sampling interval changes per second? Also, determine the lower bound of sampling points. (15 scores)

(5) Suppose that

$$x(t) = 1 \text{ for } -1 < t < 1, \quad x(t) = 0 \text{ otherwise.}$$

Also suppose that the window of the rec-STFT is $w(t) = 1$ for $|t| < B$, $w(t) = 0$ otherwise. Determine the rec-STFT of $x(t)$ if (a) $B = 1$ and (b) $0 < B < 1$. In (b), shows the solutions in terms of B. (15 scores)

(6) (a) What is the spectrogram? (b) Why sometimes it is better to use the STFT with an asymmetric window instead of a symmetric one? (c) What is the relation between a rectangular function and a Gaussian function? (d) Why better time-frequency analysis result can be obtained if one uses the Gaussian window instead of the rectangular window? (20 scores)

(7) Write a Matlab or Python program that can generate a *.wav file whose instantaneous frequency is $\pm(at^2 + bt + c)$ Hz, the length of the file is T second, and the sampling frequency is Fs Hz.

gwave (a, b, c, T, Fs)

The code should be handed out by NTUCool together with homework.

(20 scores)

(Extra): Answer the questions according to your student ID number.

(ended with 0, 1, 2, 3, 5, 6, 7, 8)