

Homework 4 (Due: 23rd Dec.)

(1) Suppose that there are 6 signals. Their time length are all 10 seconds and their frequencies are all from $-2000\text{Hz} \sim 2000\text{Hz}$. Also suppose that the channel is almost full except for $f \in [200000 - 200t, 210000 - 200t]$ and $f \in [-210000 + 200t, -200000 + 200t]$, $0 < t < 12$. How do we transmit the 6 signals by the channel? (15 scores)

(2) Suppose that $x(t)$ is a stationary random process. Which of the following functions are also stationary random processes? Why?

(i) $\exp(j10\pi t)x(t)$; (ii) $\exp(j10\pi t^2)x(t)$; (iii) FrFT of $x(t)$; (iv) the Fresnel transform of $x(t)$. (10 scores)

(3) What are the two main differences between the IMF and a sinusoid function?

(b) Which function is an IMF? Why? (i) $(2+\cos(10\pi t))\cos(2\pi t)$; (ii) $\cos(\pi t^3)$. (10 scores)

(4) Among the Gabor transform, the WDF, the HHT, and the wavelet transform, which one is better for the applications of (a) signal modulation, (b) random process analysis, (c) climate data analysis, and (d) signal sampling? Also illustrate the reasons. (15 scores)

(5) (a) What is the most important advantage of the Haar transform nowadays?
(b) Write the 7th row of the 16-point Haar transform. (10 scores)

(6) (a) What is the role of the vanish moment in the wavelet transform?
(b) Suppose that $x(t) = 1 + at + bt^2$ for $-2 < t < 2$, $x(t) = 0$ otherwise.
If $x(t)$ has the vanish moment of 2, determine a and b . (10 scores)

(7) Write a Matlab or Python program of the Hilbert-Huang transform.

$y = \text{hht}(x, t, \text{thr})$

x: input, y: output (each row of y is one of the IMFs of x), t: samples on the t -axis, thr : the threshold used in Step 7.

In Step 8, the number of non-boundary extremes can be no more than 3.

Step 9 is not required. The code should be handed out by NTUCool.

(30 scores)

Example: $t = [0: 0.01: 10];$

$x = 0.2*t + \cos(2*\pi*t) + 0.4*\cos(10*\pi*t);$

thr = 0.2;

$y = \text{hht}(x, t, \text{thr});$

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

(ended with 0, 2, 3, 4, 5, 7, 8, 9)