Homework 4 (Due: 5th Dec.)

- (1) Suppose that x(t) is a white noise and (i) $y_1(t) = 2x(3t)$, (ii) $y_2(t) = x(t) * \Pi(t)$ where * means convolution; (iii) $y_3(t) = \exp(-|t|)x(t)$; (iv) $y_4(t) = FT[x(t)]$. Among $y_1(t)$, $y_2(t)$, $y_3(t)$, and $y_4(t)$, (a) which signals are also white noise? (b) Which signals are also stationary random process? Also illustrate the reasons. (15 scores)
- (2) Suppose that there are 2 signals. Their time length are all 15 seconds and their frequencies are all from -1000Hz ~ 1000 Hz. Also suppose that the channel is almost full except for $f \in [100000 100t, 110000 100t] \ 0 < t < 3$, and $f \in [-110000 + 100t, -100000 + 100t], \ 0 < t < 3$. How do we transmit the 2 signals by the channel? (10 scores)
- (3) Suppose that $x(t) = \sin(20 \pi t) + \sin(40 \pi t)$. (a) What are the true instantaneous frequencies of x(t)? (b) What is the instantaneous frequency of x(t) determined by the Hilbert transform without decomposition? (10 scores)

(Continued)

- (4) (a) What are the <u>two main differences</u> between the IMF and a sinusoid function?
 (b) Which function is an IMF? Why? (i) sin(πt³); (ii) (3+cos(20πt))cos(2πt²); (10 scores)
- (5) (a) What is the most important advantage of the Haar transform nowadays?
 (b) Write the 11th row of the 32-point Haar transform. (10 scores)
- (6) (a) What are the roles of <u>the vanish moment</u> for the wavelet transform design?
 (b) What is the vanish moment of xexp(-2|x|)?
 (c) What is the vanish moment of <u>d⁵</u>/_{dx⁵} exp(-πx²)? (15 scores)

(Continued)

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

y = hht(x, t, 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. Just write Steps 1~8 and Step 9 is unnecessary.

The Matlab or Python 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 = hht(x, t, thr);

(Extra): Answer the questions according to your student ID number. (ended with 0, 2, 3, 4, 5, 7, 8, 9)