Homework 3 (Due: Dec. 2nd)

(1) (a) Compared to the original STFT, what is the advantage of the S transform? (b) Compared to the original spectrogram, what is the advantage of the generalized spectrogram? (c) Compared to the Fourier series, what is the advantage of the 3-parameter atom? (15 scores)

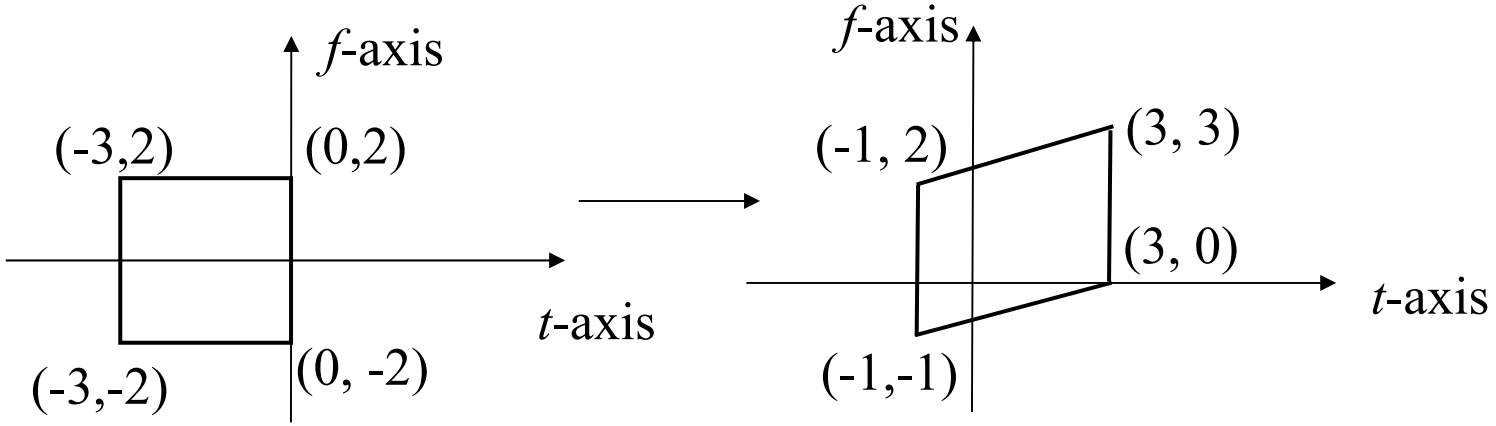
(2) Which of the following function is most suitable to be the window function of the S transform? Why?

(a) $w(t) = f^2 \exp\left[-\pi t^2 f^4\right]$ (b) $w(t) = |\cos(f)| \exp\left[-\pi t^2 \cos^2(f)\right]$

(c) $w(t) = \left|(1+\sqrt{|f|}/10)\right| \exp\left[-\pi t^2 (1+\sqrt{|f|}/10)^2\right]$ (10 scores)

(3) Why (a) the LCT and (b) the generalized modulation are useful for filter design? (10 scores)

(4) Suppose that the time-frequency distribution of $x(t)$ is as the left figure. How do we change the time-frequency distribution into the right figure with scaling, shifting, and chirp multiplication? (15 scores)



(5) Suppose that $X(t, f)$ is the STFT of $x(t)$ and $X(t, f)$ > threshold for

$$(2t+3f - 5)^2 + 4(3t-2f -1)^2 < 144.$$

If $x(t)$ is interfered by white noise, how do we use two filters designed by the FrFTs to reduce the effect of noise?

(15 scores)

(6) Write a Matlab or a Python program for the Wigner distribution function when the input function has a finite duration.

y = wdf(x, t, f) (35 scores)

x: input, *t*: samples on *t*-axis, *f*: samples on *f*-axis

(i) The code should be handed out by NTUCool， (ii) 用 function 的指令寫成函式，(iii) 自己選一個 input *x*， 用你們的程式將 output *y* 算出來並畫出來，(iv) 用 tic 和 toc 的指令來計算程式的 running time，(v) 程式執行的時間，越短越好 (使用 unbalanced form 有額外加分)

Ex:

```
del_t = 0.0125;    del_f = 0.025;
t = -9:del_t:9;      f = -4:del_f:4;
x = exp(j*t.^2/10-j*3*t).*((t>=-9)&(t<=1))+exp(j*t.^2/2+j*6*t).*exp(-(t-4).^2/10);
tic
y=wdf (x,t,f);
toc
```

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

(ended with 0, 1, 3, 4, 5, 6, 8, 9)