Homework 3 (EAS 8803: OBS SEISMOLOGY - SPRING SEMESTER 2011)

Total points: 100. Due 03/28/2011

1. Reproduce Figure 6.5-2 in the Stein book: "Results of drawing N samples from a Gaussian parent distribution with mean zero and a unit standard deviation". Please plot the results for N = 100, 1000, 10000, and the corresponding mean. Note: the shape might be slightly different from the book due to random distribution of the input (15 point).

2. Write your own code to add random noise to the following time series. Next, generate 100 new time series with random noises (e.g., 20% of the maximum amplitude of the time series). Then stack them together. Plot the 100 new time series together with the original and stacked trace. Comment on the improvement of signal to noise ratio before and after stacking around *P* wave (5 s) and head waves (4.8 s) (15 point).
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/CCO.19940820152624.EHZ.SAC

3. Please read the Fletcher et al. (BSSA, 2006) paper first (included in the tar file below). Then follow the steps described in "Data and Method" section, and write your own array analysis code to perform the following analysis (70 points).

   0). Please download the tar file from the following website:
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/UPSAR_PKD_ObsSeis_HW3.tar.gz

   Use the following command to extract the data:

   tar zxvf UPSAR_PKD_ObsSeis_HW3.tar.gz

   The tar file contains the Fletcher et al. (BSSA, 2006) paper, the three component acceleration data in SAC format, station geometry, and site delays. See the readme.txt for details.

   1). Preprocessing the data: Take the two horizontal-component data for each station, cut the data between 28 and 42 s, rotate the data to fault parallel and normal component (the strike of the San Andreas fault is 140 deg clockwise from north), and apply a 0.2 to 15 Hz band-pass filter to the fault parallel data. Plot the fault-parallel component for each station together with the direct sum of the each component (10 points).

   2). According to the Table 2 of the Fletcher et al. (BSSA, 2006) paper, the best-fitting apparent velocity C_{app} and back-azimuth θ for the following time window [34.1 – 34.6] s (the time window corresponds to data at the center station P06) is: C_{app} = 2.75 km/s, θ = 225 deg. Please use these numbers to compute the slowness component in the east (S_E) and north (S_N) directions (5 points).

3). Using the obtained slowness component in 2), compute the time shift relative to the center of the array (station P06). Apply the time shift to the fault-parallel component data, and stack them together. You need to correct for the effect of elevation difference using $S_Z = \sqrt{1/c^2 - S_E^2 - S_N^2}$ as given in the paper. You should also correct for site delays using the table UPSAR_site_delays.dat. If a delay in (s) is positive, it means that the *S* wave arrives later than it should, because (for example) the shear wave speed under the station is lower than average. Plot the results and compare with those from step 1). Comment on the improvement of signal around the time window of [34.1 – 34.6] s (15 points).

4). Perform a grid-search of slowness component in the east (S_E) and north (S_N) directions in the range of [–0.7 – 0.7] s/km, with a step of 0.01 s/km. Compute the cross-correlation coefficient (CCC) using equation 1 in the paper after correcting for the time lag, and average the CCC values for all possible pairs corresponding to each set of slowness. Plot the average CCC values as a function of slowness for time window [34.1 – 34.6] s. If everything works out well, your results should be similar to those shown in Figure 3 (bottom right panel). Compute your best-fitting apparent velocity and back-azimuth with those given in 2) (40 points).

Note:

1. Your code can be written in any scientific languages (e.g., Fortran, C, Matlab). Please make sure that the code can be compiled under standard Linux machine. Please submit your code electronically to zpeng@gatech.edu, and submit a write-up that includes all the figures and answers to all questions.

2. The MatSAC package can be downloaded from the following link:
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/SAC_Tutorial/MatSAC.tar.gz
Use fget_sac to read the SAC binary format data into Matlab.
Alternatively, you can use sacdump program to extract data from SAC into two column ASCII output.