Biomedical Signal Processing

Master on Biomedical Engineering

2nd Semester 2020/21 – Lab06 – May 4th 2021 – for Evaluation – deadline May 18th

Empirical Mode Decomposition (EMD) – EEMD - CEMD - rParabEmd_L.m (R&U)

This lab illustrates the application of EMD for noise reduction and features extraction. Different versions of EMD are studied and compared. Introduction to Hilbert-Huang transform (HHT). Comparison of trend removal by Moving Average and EMD. Tools and functions to perform the exercises are available in Matlab functions or source code provided under current directory.

Note: The **emdoptimset.m** function set the options for the respective **emd.m**, both in directory EMD

a. 10% Load 'ecg' signal from ecg.mat with sampling frequency of 128Hz, extract a section of 4 seconds of your choice from the ecg signal into **x**, make sure that x contains at least 3 recognizable QRS complex). Add to **x** a noise component with zero mean and 0.4 SD into **xn** and plot in the same figure 1, **x** and **xn**. Implement a function to calculate the signal to noise ratio (SNR)

b. 15% Perform an EMD decomposition of **xn** with a limit of 500 iterations for the sifting, propose and justify an error margin for the mean envelope. Record the processing time, giving especial attention to the sifting part. Plot the **xn**, IMFs and residue in figure 2. Reduce the noise of **xn** into **xnf** and compare it to the original **x** signal, plot the **x**, **xn**, **xnf** and error=**x**-**xnf** in figure 3, print also the mean square error in figure 3 near the error curve. Print the estimated SNR of **xnf**. (use/modify plotimf.m and plotimfd.m)

c. 15% Plots the HHT of xn using **plot_hht.m**. Implement an alternative function (**my_pHHT.m**) to plot the HHT of a signal and describe its advantages and limitations.

d. 10% Repeat **b.** using **xn2** obtained by adding noise with N(1,sd=0.8) to **x**. Plot the results in figure 4 and report the processing time, compare the results obtained with the ones in **b**. Comment the main differences found if any.

e. 15% Repeat **d**. using 100 (plot figure 5) and 1000 (figure 6) iterations limit for the sifting. For iterations the error margin use `[0.005,0.05,0.001]`. Illustrate and comment on the differences if any.

f. 15% Instead of noise add a linear ramp r(0) =-1 to r(4s)=2 to the **x** signal into **xr**. Try to remove it using moving average of length 50 into **xrma**. Perform this removal using EMD into **xremd**. Plot the **x**, **xr**, errma=**x**-**xrma**, erremd=**x**-**xremd** in figure 7, print the MSE of the error signals and conclude.

g. 10% Repeat **b.** using EEMD instead of EMD and plot the results in figure 8. Compare the MSEs and processing times and provide relevant comments. Compare the MSEs and processing times and provide relevant comments, namely any speedup.

h. 10% Repeat **g.** using iCEEMD instead of EEMD. Additionally, compare the FFT and boxplot of the IMFs of the 2 methods. (p_IMF2PFFT)

i. 15% (optional) In all EMD exercises explore the function rParabEmd_L.m instead of the basic EMD. Comment your findings.