LAB 1 – Stochastic Processes

Part A (Week 1):

1. Generate 3 random sequences (i.e. '**white noise**') each at least 200'000 samples (*Hint:* in Matlab use function "randn", but you may use also Python or 'R' for your assignment).

2. Use these sequences to generate accumulated noise also called **'random walk'**.

3. Use previously generated random sequences to generate 1st order **Gauss-Markov** process (i.e. in your notes this process is called 'exponentially correlated random variable') for two correlation times (e.g. T_1=2000 and T_2=500 samples). *Hint*: in Matalb use 'exp()'.

Save all realizations into a text file in a column format per stochastic process, 8 digits after 0.

Part B (Week 2):

4. Compute the noise characteristics for each sequence by a: **autocorrelation** (AC) function; b: **power-spectral-density** (PSD); c: (optional apart IC or Adv. SatPos. students) **Allan** (*or Wavelet*) **Variance**

5. Verify **graphically the changes** of these characteristics for each type of noise (suggestion: make a common plot for each type of noise while toggling the colors between the sequences)

6. Compare your findings with the values determined by the online tool for noise characterization via GMWM[1]. It is sufficient to upload one sequence for each noise.

Report content:

1. Answers to the following questions[2]:
   a. How does the shape of the empirically determined autocorrelation function **correspond** to the theoretical ones in all cases? Explain differences.
   b. How do the *empirically* determined values of **standard deviation** (i.e. calculated from all realizations) and **correlation length** (derived from the plot) **deviate** from the *true* values (i.e. those used in simulation)?
   c. Which computed characteristics identified best the underlying process?
   d. [option: How does the real values compare to those estimated by GMWM]?
2. Plots of associated characteristics (AC, PSD, [AV/WV]) for all type of noises.
3. Your code, i.e. main file + written (not provided) functions.

Lab weight:	3%
Distributed:	Week 1
Deadline without penalty:	2 weeks after distribution (i.e. lecture of week 3)

[1] https://rstudio.aws.science.psu.edu:3838/rum415/gui4gmwm/

[2] The answers and the comments should be relevant, short and consistent as would be expected during an oral exam. In other words, large number of pages does not prove that you well understood the subject.

HINT on useful Matlab routines (in Signal Processing Toolbox):

Autocorrelation:
xcorr.m

Power Spectral Density (PSD):
spectrum.m (*note: to define estimator first – recommended: h* = spectrum.welch)
psd.m e.g. psd(h, signal, 'Fs', Fs).
hanning.m
check_order.m
psdchk.m
nargchk.m