

Digital Signal Processing - Laboratory Report 3

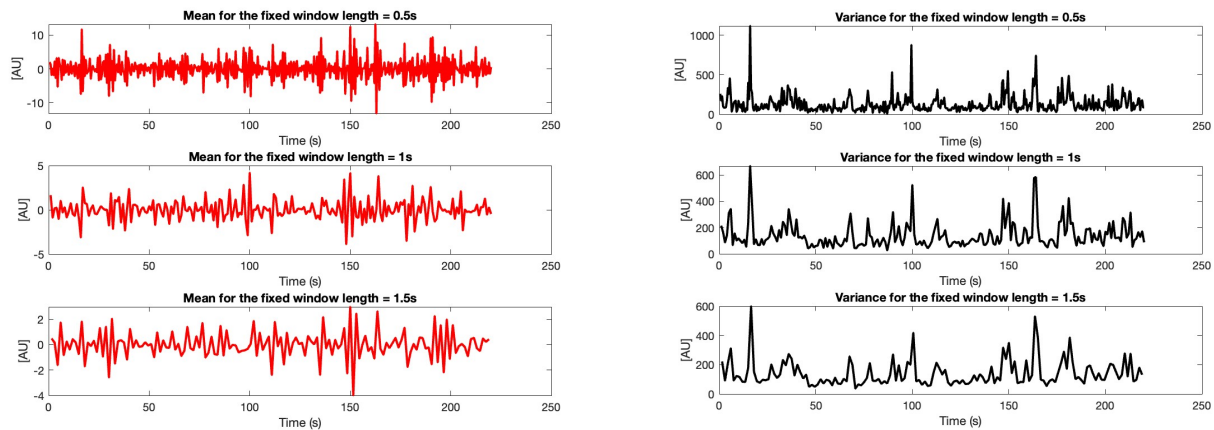
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1. Laboratory 7

1.1. Task A

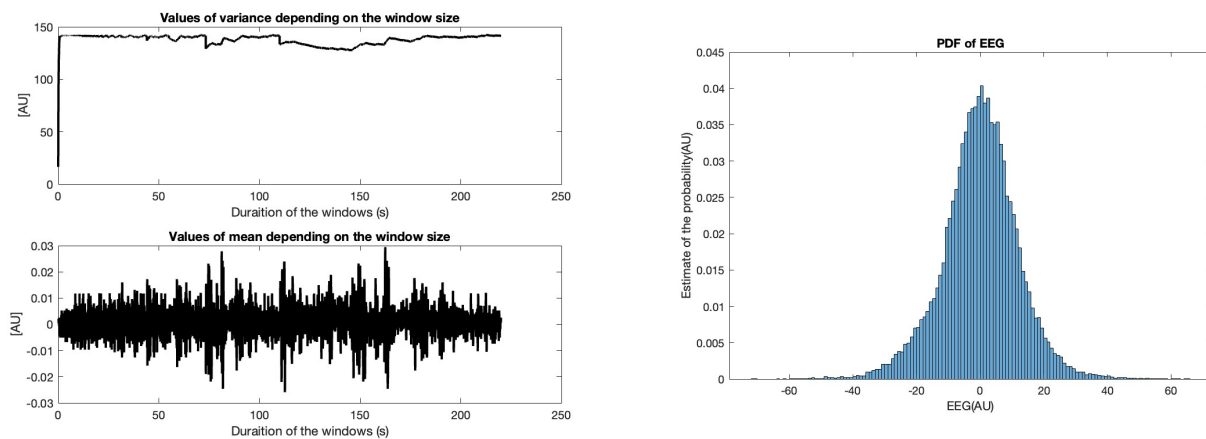
The estimates of the mean and variance against time of an EEG signal for window lengths of 0.5, 1, and 1.5 seconds are shown below.



Comment: As the window duration increase, the magnitude of mean and variance decrease. The reason for the magnitude decrease is because longer time duration can include more data point which will average certain small duration with extreme high value (decrease mean) or some small duration with values change very fast (decrease variance.)

Window Length(s)	Variability of Variance	Variability of Mean
0.5	12615.04	10.93
1	9656.58	1.47
1.5	8073.51	1.16

1.2. Task B and C



The left figure above shows the average values of variance and mean against the duration of window. The right figure above shows the estimates of probability density function (PDF) for the EEG signal.

2. Laboratory 8

2.1. Task A

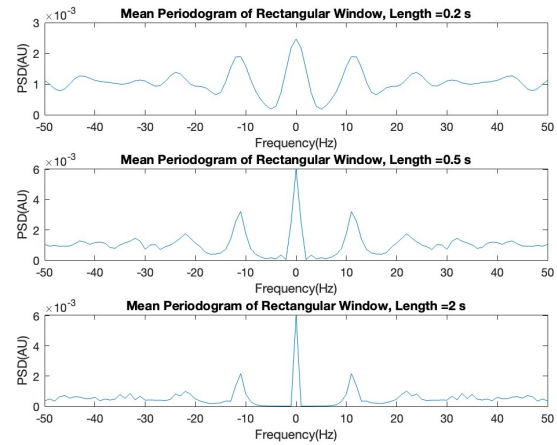
The figure at the left side is the mean periodogram applying the rectangular window with the window size at 0.2, 0.5 and 2s.

2.2. Task B

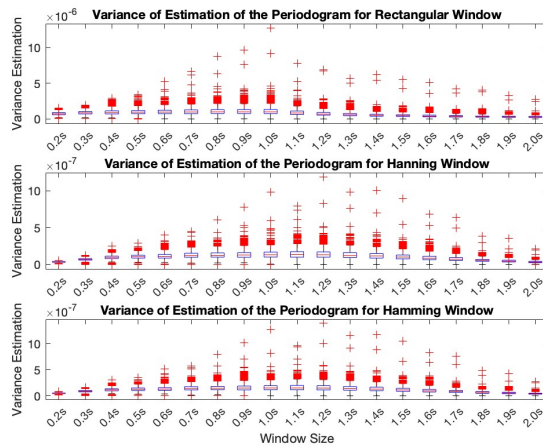
Window Length(s)	0.2	0.5	2
Bias	4.8186	2.0074	1.0311

The table above is the estimates' bias of the rectangular window with different length.

Comment: The decrease in bias with an increase in window length can be explained by the fact that applying a rectangular window in the time domain is equivalent to convolving with a sinc function in the frequency domain, where the PSD is calculated. A wider time window results in a sinc function with a narrower main peak, which ideally isolates a certain frequency and more accurately identifies its power. Therefore, as the window length increases, the bias decreases.



2.3. Task C



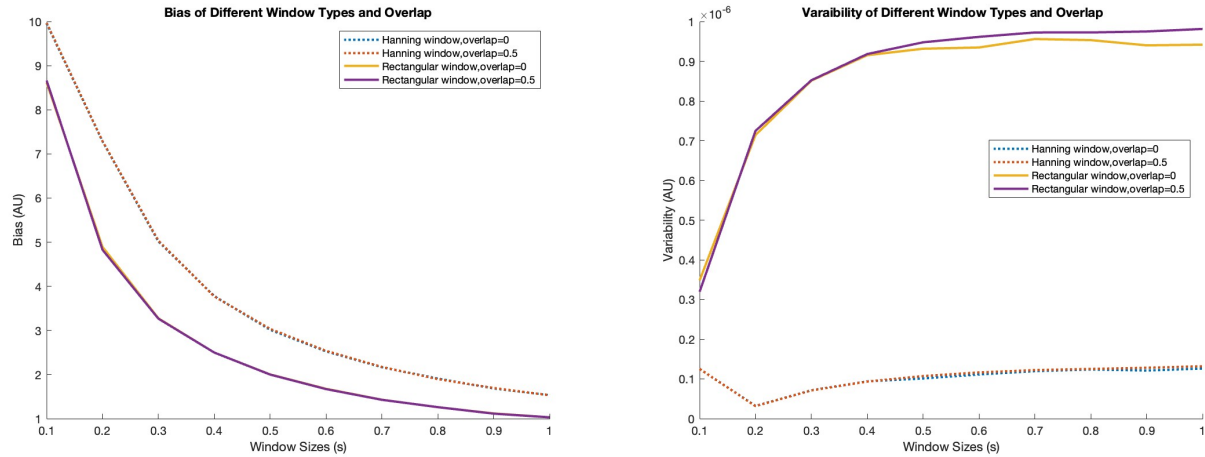
The figure at the left side is the estimate of the variance of the periodogram against the window length for 3 different types of window (Rectangular, Hanning and Hamming).

Comment: When the window length is between approximately 0.7 and 1.7 seconds, the power at certain frequencies shows a high degree of variability across 35 observations. This may be explained by the fact that different neural activity is captured within this range of window lengths, resulting in a pronounced variability in power for these frequencies. High variance for particular frequency on the PSD, implying some observations have very high power that frequencies, while the others might have low power. This is expected, since there is a random variability of discharge around the average discharge time, which is stated in the question. With window lengths shorter than this range, the signal might be divided in such a manner that each part contains less variability, as the segmentation could miss capturing the more active periods of neural activity. On the other hand, when the window length is longer, it includes more samples with less pronounced neural activity. This additional data can dilute the variability, leading to a more even distribution of power among the frequencies.

Furthermore, the Hanning and Hamming windows display smaller variances compared to the rectangular window. This reduction in variance is likely due to the decreased edge discontinuity associated with these windows, as opposed to the sharp discontinuities introduced by the rectangular window.

3. Laboratory 9

3.1. Task A



The two figure above illustrate the bias and variability of the PSD estimate against the window length. Each plot shows the effect of different window type(rectangular and hanning) with different overlap factor(0 and 0.5).

Comment: Overlap factors (0 and 0.5) do not significantly affect either bias or variability, regardless of the window type or length. As the figures illustrate, lines representing different overlap factors show negligible differences for both bias and variability when using rectangular and Hanning windows.

Concerning bias (as depicted in the left figure), it decreases as the time window widens. This can be attributed to the fact that employing a window (both hanning and rectangular) in the time domain corresponds to a sinc function (for hanning, it's something looks like sinc with less other peaks) convolution in the frequency domain. The broader the window, the more narrow the main peak of the sinc function becomes, which in turn reduces bias. Moreover, the Hanning window tends to exhibit greater bias compared to the rectangular window. This might be due to the sharper discontinuities at the edges of the rectangular window as opposed to the smoother edges of the Hanning window.

Regarding variability(right figure), it generally increases with longer window lengths. A shorter window permits the generation of more window samples, and a larger number of samples can reduce variance. The rectangular window demonstrates higher variability compared to the Hanning window; this is likely due to the reduced spectral leakage in the Hanning window, which implies that less power from other frequencies is included when calculating the power of a specific frequency. The leakage effect is more pronounced for the rectangular window because it has multiple peaks aside from the main lobe, capturing power from frequencies unrelated to the one being measured, which results in increased variability.

3.2. Task B

3.2.1. WINDOW LENGTH CHANGE

When the window length is increased, bias tends to decrease due to a narrower sinc function main peak in frequency domain analysis, while variability increases because of the reduced number of windowed segments.

3.2.2. OVERLAP FACTOR CHANGE

Variations in the overlap factor, at 0.5, have negligible effects on bias and variability. This suggests that the expected increase in sample count from overlapping does not significantly reduce variability.

3.2.3. WINDOW TYPE CHANGE

Comparatively, the Hanning window results in lower variance and higher bias than the rectangular window. The wider main peak and reduced side peaks of the Hanning window's frequency response, explain its lower variance and higher bias.