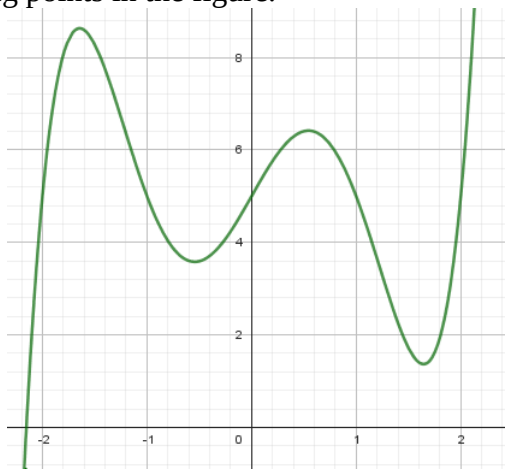
List of Time Series - 2024-2

1) Define what the following points in a time series are:
a) Outliers
b) Turning points
c) Change points

2) Identify the turning points in the figure.



3) What is forecasting?

4) When does collinearity occur between two or more variables?

5) What is the difference between homoscedasticity and heteroscedasticity?

6) Why does correlation not imply causation?

7) What is the difference between a random time series and a deterministic time series? Which of the two is easier to predict? Why?

8) What are the conditions for a series to be weakly stationary?

9) What is the condition for a series to be ergodic? Give an example of an ergodic process and one that is not ergodic.

10) Can a series be ergodic and not be stationary? And the opposite: can it be stationary and not be ergodic?

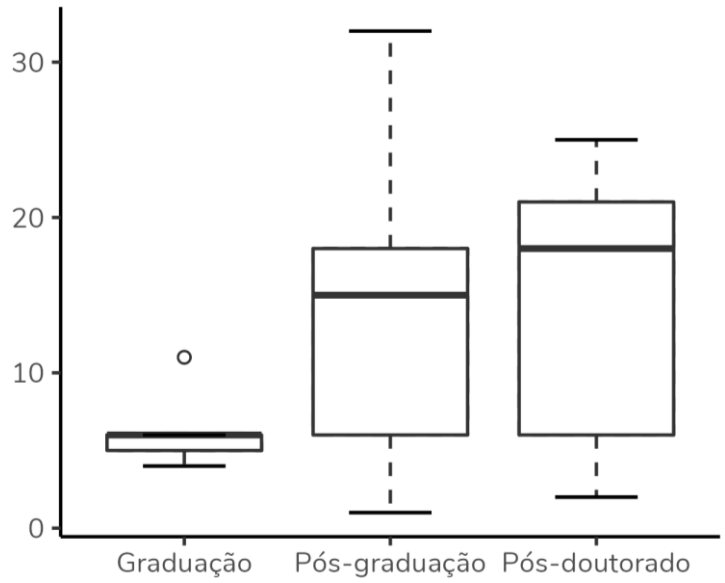
11) Define:
a) Trend
b) Seasonality
c) Cycles

12) Let f be a time series, calculate:
$f[0] = 1;\ f[1] = 3;\ f[2] = 4;\ f[3] = 2;\ f[4] = 10;\ f[5] = 89;\ f[6] = 1$
a) Mean

b) Median
c) Standard deviation
d) Variance
e) Range
f) Coefficient of variation
g) Absolute average deviation
h) Median absolute deviation

13) From the previous question, try to identify outliers using:
a) Mean and ± 3 standard deviations
b) Three scaled median absolute deviation (consider $b = 1.4826$)

14) From boxplots below, estimate:
a) First quartile
b) Third quartile
c) Median
d) Potential outliers
e) Are the distributions symmetric or not?



15) What is the difference between autocorrelation and partial correlation?

16) Compute the autocorrelation of x:
$x[0] = 3;\ x[1] = 2;\ x[2] = 1;\ x[3] = 0;\ x[4] = -1;\ x[5] = -2;\ x[6] = -3$

17) What is cross-correlation?

18) What is white noise? And what is colored noise?

19) What is Nyquist frequency? What happens to the signal if it is sampled below twice the Nyquist frequency?

20) What are the possible problems that can occur in data collection when a sensor is not working properly?

21) Name three methods that can be used to treat missing data and explain them.

22) Explain what the null hypothesis is in a statistical test. If in a test the null hypothesis is maintained, does this mean that it is true? Why?

23) In a statistical test, what is the difference between type 1 error and type 2 error?

24) Consider that someone used the Kolmogorov-Smirnov test on a data set and obtained a p-value of 0.03. Given that a significance level of 0.05 is being considered, should the person discard the null hypothesis or not? Why?

25) What is the difference between a parametric test and a nonparametric test?

26) What is the use of the Granger causality test? And what is its limitation?

27) Apply difference function in the signal from question 16. Did the signal lose trend?

$$\Delta x[k] = x[k] - x[k-1]$$

28) List some advantages of analyzing a signal in the frequency domain.

29) Why can we only use Discrete Fourier Transform on computers? What are the assumptions that must be considered to apply the DFT to a signal?

30) If a signal is sampled and aperiodic in time, how will it be represented in the frequency domain? What if the signal is continuous and periodic in time?

31) Compute DFT of four samples from a discrete signal obtained at intervals ΔT:

$$f[0] = 2;\ f[1] = 1;\ f[2] = 5;\ f[3] = 0$$

32) What is aliasing? What can be done to avoid it (or at least reduce it)?

33) What is the property of the DFT that allows us to add two signals in the frequency domain and its inverse transform returns the sum of the signals in the time domain?

34) According to slide 42 of chapter 3, draw the amplitude spectrum for a signal sampled at $f_s = 140$ Hz given by the equation:

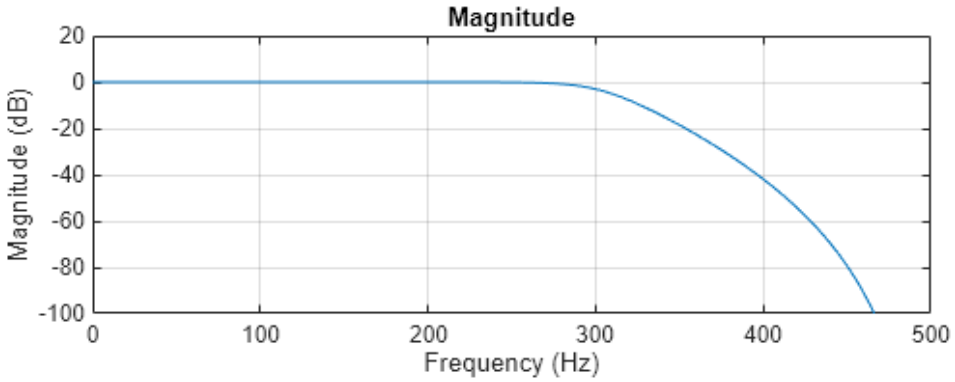
$$x[n] = 5\cos(20\pi n) + 2\sin(60\pi n) + 0.5$$

35) Explain what filters are

a) Low-pass filters
b) High-pass filters
c) Band-pass filters
d) Band-reject filters

36) For the filter with the profile below, answer:

a) What type of filter is it (low-pass, high-pass, etc.)
b) What is the cutoff frequency (estimated value)? Why is it this value?



37) What does the convolution theorem say? Why is it important?

38) Let x be the signal below:
$x[0] = 4;\ x[1] = 2;\ x[2] = 0;\ x[3] = 2;\ x[4] = 15;\ x[5] = 5;\ x[6] = 3$
Consider that you want to apply the filter h in the time domain:

$$h[z] = \frac{1}{1 - 0.3z^{-1}}$$

Calculate the result of the filtering.

39) Let x be the signal below:
$x[0] = 4;\ x[1] = 2;\ x[2] = 0;\ x[3] = 2;\ x[4] = 15;\ x[5] = 5;\ x[6] = 3$

Calculate the result of the filtering using:
a) A moving average filter of order $N = 5$
b) An exponential moving average filter with $\lambda = 0.2$
Use zero padding to get an output the same size as the input

40) Briefly explain how STFT works. What is the advantage of STFT over the Fourier transform?

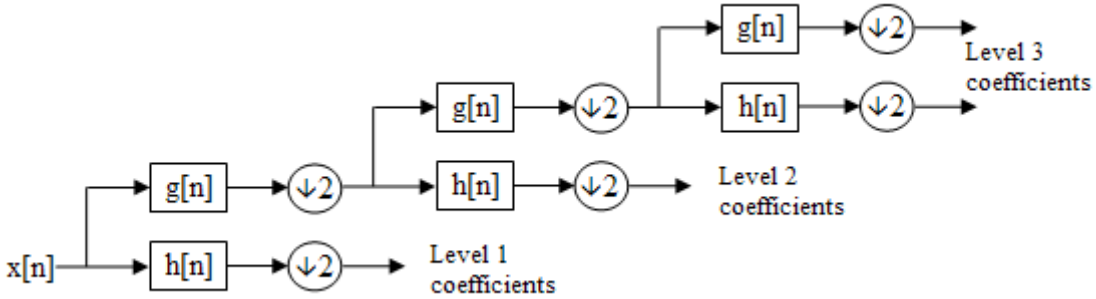
41) What is spectral leakage and why can it be problematic in STFT?

42) What is the trade-off between time location and frequency resolution in STFT?

43) Mention at least one advantage that wavelet transform has over STFT.

44) Mention the two basic changes that occur when we stop using the STFT and use the wavelet transform.

45) Consider that the signal x has a maximum frequency of 1000 Hz. What are the frequency ranges of each wavelet decomposition coefficient shown in the figure below? Consider that h is a high-pass filter and g is a low-pass filter.



46) What is the difference between an additive decomposition and a multiplicative decomposition?

47) Given the figure below, draw the trend and seasonality components of the time series.