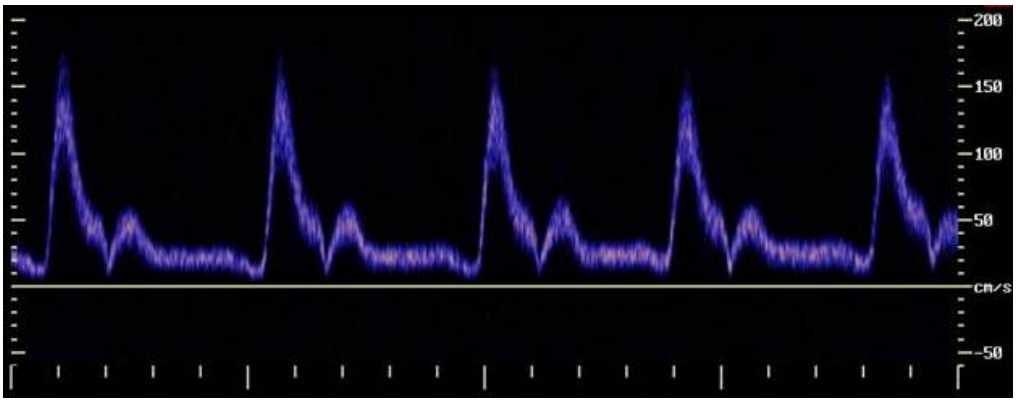
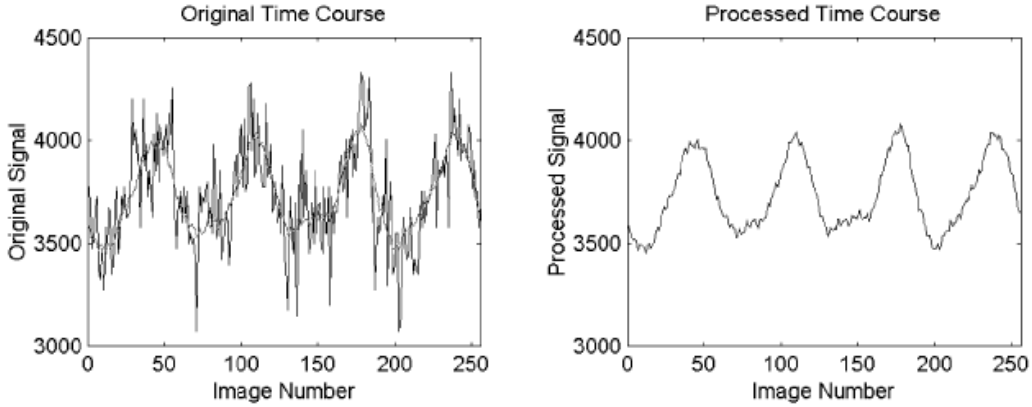
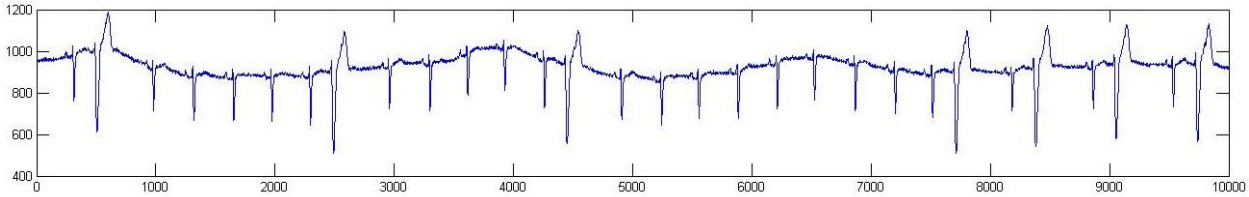
1. In spectral Doppler ultrasound, the received ultrasound signal is shifted in frequency depending on the speed of blood flow in the imaged region. Since the speed of blood flow changes with time, it is desired to display the so called "spectrogram" as the one below with the x-axis representing time while the y axis represents the spectrum at a given time. Provide the steps that allow you to do that given the received ultrasound signal.



2. In event-related functional magnetic resonance imaging (fMRI), it is desired to obtain the response time course signals of different regions in the brain to a particular stimulus (called event). Unfortunately, such signals are very noisy as show below. From your experience, what type of noise is present in these signals? Describe one method that allows you to remove such noise to obtain the desired signal shown.



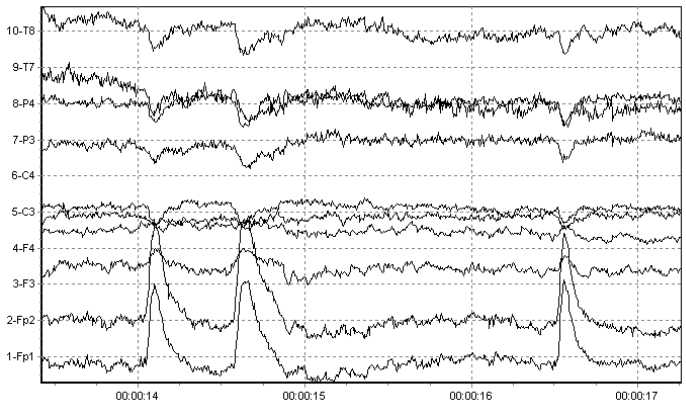
3. Given the shown ECG signal, what kind of signal problem do you see? Describe how you can design a signal processing method that allows removing such artifact and provide the exact specifications to be used. Assume the sampling rate of the signal to be 300 Sa/s.



4. What is meant by the term “zero-phase filter”? Show an example of a case where such filter is used to illustrate its performance.

5. In your opinion, for practical physiological signal filtering problems, which type of filter (FIR vs. IIR) would provide a better performance? Explain your answer.

6. Given the shown EEG signals, what kind of signal problem do you see? Describe how you can design a signal processing method that allows removing such artifact and provide the exact specifications to be used. Note that the x-axis scale shown is in seconds.



7. How do you simulate a 5D random data set with means [100, 150, -50, 0, 200] and standard deviations [20, 30, 10, 10, 20]?

8. If you are to face a biomedical classification problem where the distributions of the different classes significantly overlap, which classifier you would try first and why? Which classifier you would never consider for this problem and why?

9. You are given the data set for a binary classification problem (e.g., normal/abnormal) that includes 14 different measurements taken for 100 cases. How can you make sure that a particular measurement (for example, body weight) is relevant to the classification? Provide the steps to allow you to confirm the result.

10. In proteomics, protein sequences of enzymes used in the biological matter as well as in pharmaceutical drugs are expressed in terms of a number of basic proteins (20 basic proteins). For example, one such enzyme starts with the sequence:

    “MERCGWVSQDPLYIAYHDNEWGVPETDSKKLFEMICLEGQQAGLSWITVL …”

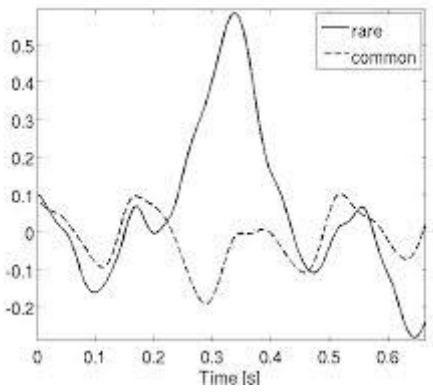
    How can you compare an unknown enzyme sequence with a set of known sequences and determine its type?

11. It is desired to compare two signals sampled at different rates of 500 and 860 Sa/s. What should be done to enable direct comparison?

12. Given the confusion matrix of a cancer diagnosis system as below, determine the following:
    a. Overall Accuracy
    b. Sensitivity
    c. Specificity
    d. PPV
    e. NPV
    f. Positive likelihood ratio
    g. Negative likelihood ratio

    Which of the above metrics measure the pre-test performance and which measure the post-test performance?

13. Consider the two signals shown below. Mention a few signal features that you think will help discriminate between the two signals and justify your answers.



14. You are given a signal of length 4096 point. Describe the steps you can do to obtain its spectrum in the form of 32 points representing average of frequency domain bands covering the whole frequency scale.

15. Where can you find physiological signals to download for your research? Describe one such resource and briefly mention a few of the available signals there.

16. Describe briefly 3 different methods to compare the genome of two organisms. Which method do you prefer and why?