Assignment 2

Digital Signal processing

FIR filters

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Form groups of 3-4 people.

The task of this assignment is to filter an ECG with FIR filters and to detect the R peaks. In contrast to the FFT assignment we write filter code which can be used for realtime processing. This means that the FIR filter needs to be implemented with the help of delay lines and the impulse response is truncated.

ECG filtering

Record an ECG in the lab. Book a time slot and record it (see instructions on moodle how to record it and complying with the ethics by signing the consent sheet). Alternatively, use an ECG from moodle matching the last digit of your matriculation number. Biomedical students or those with a strong interest in biosignals should record their own ECG as it's an important part of their training.

1. Create two functions which calculate and return the FIR filter coefficients *numerically* (= using python's IFFT command) for a
   a) highpass filter and
   b) a bandstop filter.
   Name these functions "highpassDesign" and "bandstopDesign".
   Both functions should automatically decide how many coefficients are required. The function arguments should be the sampling rate and the cutoff frequencies (and any other optional arguments you like to provide). Feel free to put both functions in a class. **[25%]**

2. Create a Python FIR filter class which implements an FIR filter which has a method of the form value dofilter(self,value) where both the value argument and return value are *scalars* and not vectors (!) so that it can be used in a realtime system. The constructor of the class takes the coefficients as its input:

```
class FIRfilter:
def __init__(self,_coefficients):
# your code here
def dofilter(self,v):
# your code here
```

```
    return result
```

Filter your ECG with the above FIR filter class using the coefficients from 1. by removing the 50Hz interference and the baseline wander with the highpass. Decide which cutoff frequencies are needed and provide explanations by referring to the spectra and/or fundamental frequencies of the ECG. Simulate realtime processing by feeding the ECG sample by sample into your FIR filter class. Make sure that the ECG looks intact and that it is not distorted (PQRST intact). Provide appropriate plots. **[25%]**

3. Instead of using a bandstop filter to remove the 50Hz use an adaptive LMS filter by providing it with a 50Hz sine wave as the reference noise. Add an adaptive LMS filter command to your FIR filter class and name it: "doFilterAdaptive(self,signal,noise,learningRate)" which returns the cleaned up ECG. As before also this function must receive only scalars (i.e. sample by sample) and return a scalar. Plot and compare the result from the adaptive filter and that from the FIR filter design. **[25%]**

4. ECG heartbeat detection The task is to detect R-peaks in your ECG. Write a matched filter which uses a *wavelet* as your R-peak template because wavelets look pretty much like R-peaks. Make sure the wavelet has the correct duration and shape that it matches your R-peaks. It's important in the report that you show a plot of a real R peak and the wavelet side by side. Plot the momentary heartrate (i.e. inverse intervals between R-peaks) against time. **[25%]**

Every report must be based on a different ECG recording or on the recoding matching your matriculation number. Please keep it short but it should make clear what you have done and why you have done it. Include the complete Python code as well as plots of the ECGs (timedomain) and their frequency representation (with proper labels). If necessary annotate the plots with InkScape, Corel Draw or Illustrator by labelling the ECG peaks and remember to use vector based image formats, for example EPS, SVG, PDF or EMF and not pixel based formats for the report. These figures need to be in the report at the correct place and not attached separately. Also, show zoomed in ECG traces of one heartbeat so that it is possible to identify the different parts of a single heartbeat and that it's possible to check if it's still intact.

No high level Python functions except of FFT/IFFT and the window functions are allowed. Any use of "lfilter", "firwin", "conv", "correl" and any a-causal processing (i.e. data array in and array out) commands will result in zero or very low marks. As before submit a zip file containing all files and test the zip before submission by unzipping it and then running python from the command-line in a terminal (not spyder). Also check that all plots are generated when running the script from the commandline. See moodle for the exact filename conventions.

Deadline is 15th November, 3pm.