13.1 Example of Frequency Domain Manipulations: Denoising

This short example shows how one can easily identify noise components in the frequency domain while a similar task is very difficult in the time domain. This is not a homework task, so the only purpose is to help you understand what is happening. Proceed as follows (**if you copy-paste, you might have to change the quote signs ' in matlab**):

i) Download handeln.wav from the course website (under additional material).

ii) Open Matlab, move to the adequate directory and read in the handeln.wav file. Subsequently, play the sound:

```
[datan,fs]=wavread('handeln.wav');
soundsc(datan,fs);
```

iii) Plot the 500 first sample of `datan`

```
plot(datan(1:500))
```

It seems very difficult to distinguish the music and the annoying noise!

iv) Fortunately, all hope is not lost. Let's have a look at what happens in the frequency domain by calculating the DFT (fft is an algorithm allowing you to compute the DFT in a very efficient way, you will learn more on that in upcoming lectures...) of `datan`:

```
XN=fft(datan);
plot((1:length(XN))/length(XN),abs(XN(1:end)))
xlabel('normalized f')
ylabel('|XN(f)|')
```

The plot you just created is a function of $f = \frac{F}{F_s} = \frac{\omega}{2\pi}$. The lowest possible sampling frequency F_s to avoid aliasing is $2max(F)$. Hence, high frequencies are represented close to 0.5. Also note that the spectrum is 1-periodic, so values $0.5 + \epsilon$ correspond to values $-0.5 + \epsilon$ (so also high frequencies)

v) We can see that there are three high frequency components which look different from the rest of the signal, mainly concentrated in the low frequencies. Let us simply set values close to 0.5 to zero (remove high frequencies) and see what happens in the frequency domain first.

```
xm=(1+73113)/2;
inter=[xm-7000:xm+7000];
```

```
X=XN;
X(inter)=zeros(1,length(inter));
plot((1:length(X))/length(X),abs(X(1:end)))
```

Obviously we have removed the suspicious high frequency components, but unfortunately also a part of the signal, even though there was little energy in the high frequencies.

vi) Let's listen to what we obtained in the time domain

```
data=ifft(X);
soundsc(real(data),fs)
```