Norwegian University of Science and Technology
Department of Electronics and Telecommunications

TTT4185 Speech Technology
Compulsory computer exercise 1: Speech Analysis

The problem set presupposes knowledge on short-tme spectrum estimation by FFT and AR modelling (LP analysis) as well as cepstral analysis. You also should know the meaning of the terms fundamental frequency and formant frequencies.

A headset will be needed.

Problem 1

(a) Download the speech file **stry.wav** from the homepage. It represents the last part of the English word "tapestry". Load the speech signal into Matlab using the following command:

```
>> [signal,Fs,nbits,opts] = wavread('stry.wav');
```

- Plot the signal and listen to it.
- What is characteristic for the waveform of the speech sounds (/s/,/t/,/r/ og /iy/)?
- Take a 40 ms section in the middle of the vowel/iy/. Plot the excerpt.
- Find the fundamental frequency F_0 of the vowel.

Useful Matlab-commands: `wavplay`, `plot`, `axis`.

(b)
- Estimate the spectrum of the vowel from the excerpt by using an 1024 point FFT. Plot the log-spekctrum as a function of frequency (in Hz).
- Multiply the speech excerpt by a Hamming window and repeat the previous item.
- Explain the difference between the two spectra.
- Estimate the fundamental frequency F_0 and compare with the estimate from subproblem a).
- Estimate thte two first formant frequencies and compare with Table 2.5 in the textbook (page 39).

Useful Matlab commands: `fft`, `abs`, `hamming`.

(c)
- Compute the coefficients of AR models of order 4,8,16 and 50 based on the speech excerpt.
- Estimate the spectrum for each model order. Plot the log spectrum as a function of frequency (in Hz).
- Compare with the spectrum from subproblem b. Which model order gives the best spectral envelope? What happens if the model order is too low or too high?
- Why is it not possible to estimate the fundamental frequency from the AR spectra??

Useful Matlab commands: `lpc`, `freqz`.

(d) Download the Matlab function **spektrogram2.m** from the homepage and use it to make a spectrogram of the entire speech signal. Ues e.g. the commands:

```
[array,t_axis,f_axis]=spectrogram2(signal,128,8,4);
imagesc(t_axis,f_axis,array); %plotter
handle=gca;
set(handle,'Yticklabel',8000:-1000:1000); %snur frekvens-aksen
```

Which characteristic features ot the speech sounds (/s/,/t/,/r/ og /iy/) kcan be observed from the spectrogram?

Problem 2

This problem concerns cepstrum and deconvolution.

(a) Show that the computation of the real cepstrum is a homomorphic operation.

(b)
- Compute and plot the cepstrum of the speech excerpt from Porblem 1.
- Use the cepstrum to estimate the fundamental frequency, F_0. Compare with the estimates from Problem 1.

(c) In this subproblem you will use .the cepstrum to estimate the spectral envelope

- Use liftering to extract the part of the cepstrum that represents the spectral envelope.
- Compute the spectrum envelope by the use of FFT. Plot it as a function of frequency (in Hz) and compare with the log spectra based on FFT and AR modeling.

Hint 1: Remember that the cepstrum is symmetric and that a lifter thus has to be constructed to include sampes frm both sides of the cepstrum.

Hint 2: The FFT of a real symmetric signal is real. However, Matlab often produces small imaginary components due to numerical round-off errors. These can be removed by using the command `real` when plotting.