Homework 3: Frequency analysis

Do not listen to the wav-files sound1.wav to sound5.wav in advance, before examining your answer to Exercise 3!

Exercise 1 Chirp signals (4 Points)

Plase run the script `specom_homework_3_1.py`. This file generates a chirp signal `chirp1.wav` which increases its frequency from 100Hz to 1000Hz in 6 seconds. A second audio `chirp2.wav` is also generated.

Compare the two audios `chirp1.wav` and `chirp2.wav` aurally and via the displayed spectrograms. Please answer these questions.

- Why do `chirp1.wav` and `chirp2.wav` sound different?
- What can you see in the spectrograms?
- What is the name of this effect and where does it come from?
- What could you do to avoid this effect?

(Of course, you can take a look at the Python code to understand the difference of both signals.)

Exercise 2 Histogram of a speech signal (2 Points)

Please run the script `specom_homework_3_2.py`.

It uses `matplotlibs` `Axes.hist(…)` method to create a histogram with an array which defines the limits of the contiguous histogram bins. The histogram shows the distribution of sample values in the time domain.

After looking at the histogram, answer the following questions.

- What does this plot tell you about the signal?
- What should you keep in mind when you quantize a speech signal?

Exercise 3 Vowel identification with formants (2 Points)

This exercise will be using and explaining Praat to extract formants from the speech signals but you can use any other tool to your availability on your own. Praat should be available for popular package managers.

As you have learned in the lecture, one attempt at identifing a vowel at a time uses the first two formants.

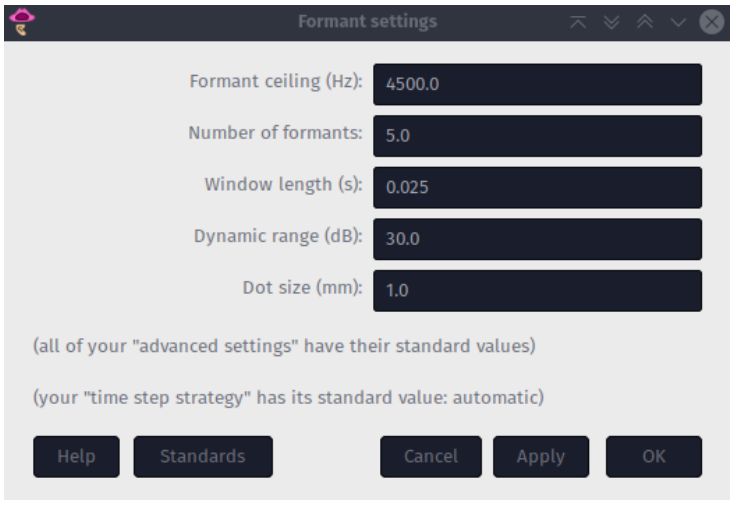
Start Praat and open `sound{1..5}.wav` with CTRL+O (you can select and open multiple files at once).

The formants can be found in the spectrogram view of a file. Open this view by selecting one sound file object in the list and then click on “View & Edit” on the right side, see Figure 1.

Figure 1: Screenshot of Praat, open the spectrogram view of `sound1.wav`

Inside the spectrogram view, you can show the formants over time by checking `Formants` → `Show formants` from the window menu bar.

Before you read them out, please make sure, your formants are computed with the parameters as shown in Figure 2.



setting name	value
Formant ceiling (Hz)	4500
Number of formants	5.0
Window length (s)	0.025
Dynamic range (dB)	30.0
Dot size (mm)	1.0

Figure 2: Desired formant settings in Praat

After applying the settings, click at a place in the spectrogram which looks like representing the average of the signal. Display the formants at that time with `Formants` → `Formant listing`.

Use PRAAT to get the values for F1 and F2. Then use the formant maps on page 51 (German script)/ page 53 (English script) of the script to identify the vowels.

Create a table with five columns. The first colum for the file name, two for the values of formant F1 and formant F2. The third column should be for the vowel or phoneme you would guess by using the formant maps as depicted in the lecture script, see Figure 3.

When you filled out the first four columns, listen to the wav files and insert the actual vowel into the remaining last column.

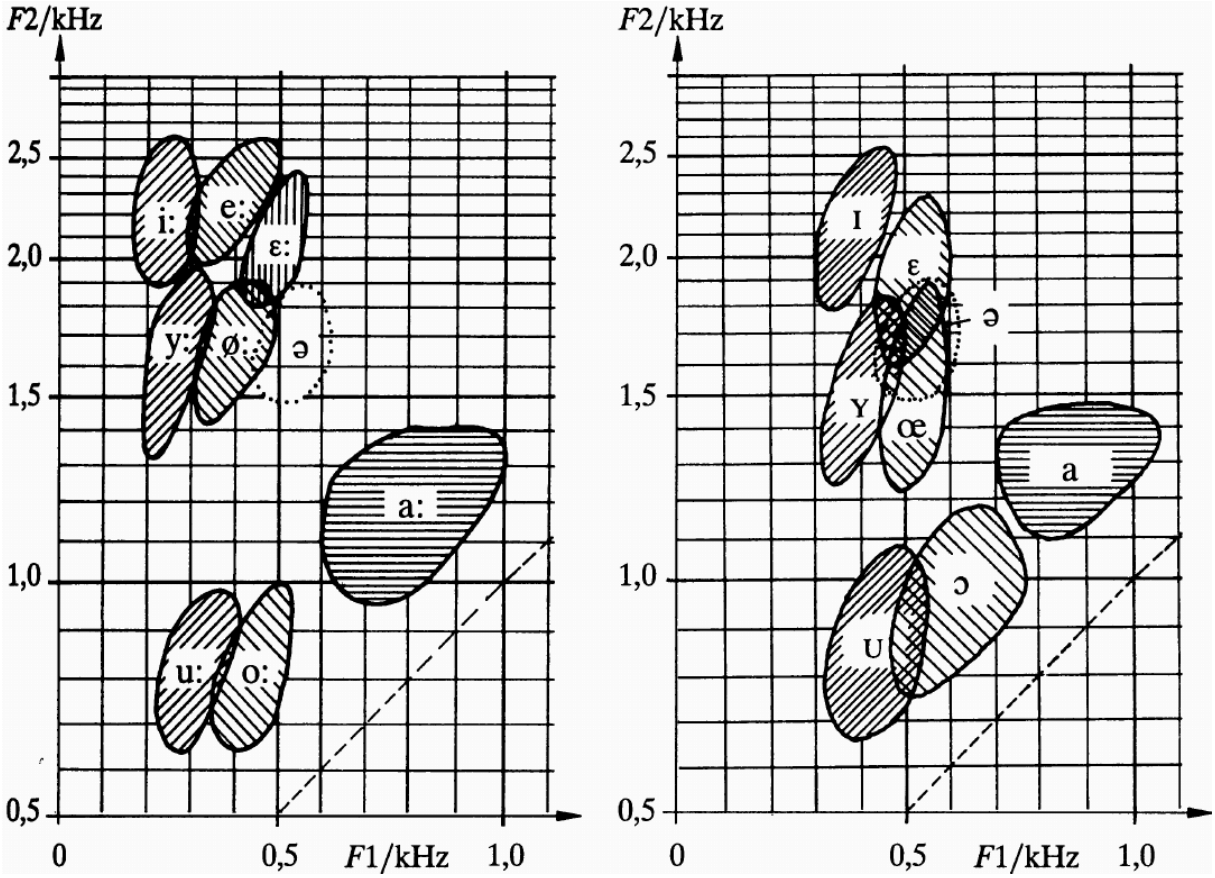


Figure 3: German formant maps from the German lecture script, page 50
left: long vowels, right: short vowels

Exercise 4 Phonetic consonant taxonomy (3 Points)

When humans produce sound, it happens at different places inside their vocal tract. Based on the place of articulation, a phoneme can be labial, dental, alveolar, palatal, or velar for example. A second dimension describes how air passes through the vocal tract so that consonants can be plosives (stops), approximants, laterals or fricatives for example.

Consonants are classified by these places of articulation and their mode of excitation (voiced, unvoiced).

Create a table and name a voiced and unvoiced consonant for each of the above mentioned place of articulation.

Also specify an example word where the sound occurs as a demonstration. German words allowed.

Note: Your solution should look like Table 1:

place of articulation	voicing	example
Labial (lips)	voiced	sound “w” in “wind”
	unvoiced	sound “f” in “foot”

Table 1: proposed table scheme as exercise solution