Homework 3 Sample Solution

Exercise 1 Chirp signals (4 Points)

- **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?**

`chirp1.wav` and `chirp2.wav` are basically the same signals. However, `chirp1.wav` has a sampling frequency of 10kHz while `chirp2.wav` only has a sampling frequency of 1kHz. Thus, the frequency spectrum of `chirp2.wav` can only consist of frequencies as high as 500Hz (Shannon/Nyquist theorem).

The sinus sweep starts at a frequency of 100Hz and goes up to 1000Hz. In `chirp1.wav` this does not lead to any problems. But since `chirp2.wav` has a fs of 1kHz it can only contain frequencies up to 500Hz. Thus, the spectrogram of `chirp2.wav` shows distortions at the time where `chirp1.wav` has a frequency of over 500Hz. These distortions are called Aliasing.

If you listen to the signals you can hear that in the second part of `chirp2.wav` the frequency of the signal goes down after it reached 500Hz.

To avoid this effect you could either increase fs to double the value of the highest frequency in `chirp2.wav` or you could use a low-pass filter to get rid of frequency above 500Hz.

Exercise 2 Histogram of a speech signal (2 Points)

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

The python file creates a histogram of the input speech signal. In the plot you can see the frequency of different amplitude values in the signal. The histogram shows that low amplitudes (around zero) occur much more often in speech than amplitudes of a medium or high value. Thus, if you want to quantize a speech signal you should quantize low amplitude values more accurately than higher values.

Exercise 3 Vowel identification with formants (2 Points)

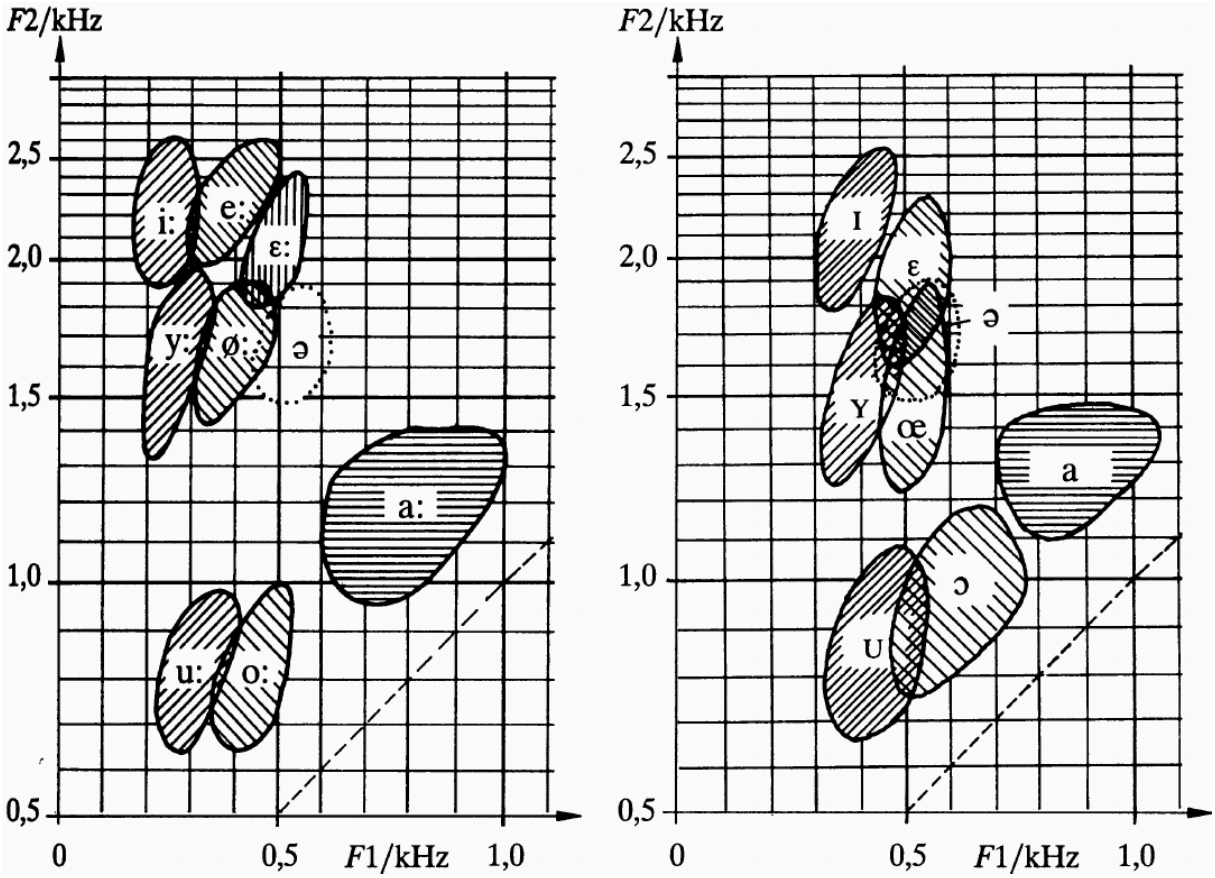

Figure 1: Formant Map of German Vowels from German Lecture Script page 50

file name	formant 1 [Hz]	formant 2 [Hz]	guessed vowel	actual vowel
sound1.wav	248.114	666.959	uː	“oo”, /uː/
sound2.wav	387.437	576.888	oː	“o”, /oː/
sound3.wav	411.138	2116.903	ɪ	moves between /ɛ/ and /e/, like German “ey”
sound4.wav	827.908	1324.670	aː	“uh”, /aː/
sound5.wav	240.054	2301.635	iː	“ee”, /iː/

Exercise 4 Phonetic consonant taxonomy (3 Points)

The first adjective of a word describes the place of artificulation, the 2nd term describes how air is passing through the vocal tract.

place of articulation	voicing	example
Labial (lips)	Voiced	[b] bilabialer plosive e.g. "Bun"
	Unvoiced	[p] bilabialer plosive e.g. "Pun"
Dental (teeth)	Voiced	[v] labiodental fricative e.g. "Vine"
	Unvoiced	[f] labiodental fricative e.g. "Foe"
Alveolar (adjacent to teeth)	Voiced	[l] alveolar lateral e.g. "Luck"
	Unvoiced	[t] alveolar plosive e.g. "Tee"
Palatal (at hard palate)	Voiced	[j] palatal approximant e.g. "You"
	Unvoiced	[ç] palatal fricative e.g. "Hue"
Velar (back tongue)	Voiced	[g] velar plosive e.g. "Good"
	Unvoiced	[k] velar plosive e.g. "Key"

Table 2:

place of articulation	voicing	example
Labial (lips)	Voiced	[b] bilabialer plosive e.g. "Bein"
	Unvoiced	[p] bilabialer plosive e.g. "Pein"
Dental (teeth)	Voiced	[v] labiodental fricative e.g. "Wein"
	Unvoiced	[f] labiodental fricative e.g. "fein"
Alveolar (adjacent to teeth)	Voiced	[l] alveolar lateral e.g. "nein"
	Unvoiced	[t] alveolar plosive e.g. "Laus"
Palatal (at hard palate)	Voiced	[j] palatal approximant e.g. "Jäger"
	Unvoiced	[ç] palatal fricative e.g. "ich"
Velar (back tongue)	Voiced	[g] velar plosive e.g. "ganz"
	Unvoiced	[k] velar plosive e.g. "kein"

Table 3:

You could take a look at the table of the International Phonetic Alphabet (IPA) to solve this exercise.

https://en.wikipedia.org/wiki/Help:IPA

Another useful quick tutorial about phonetic technical terms.