Signals and Systems

Lab 2: Signal analysis with DFT

Problem 15: "What's in a name?"

Preparation

```
!apt install libasound2-dev portaudio19-dev libportaudio2 libportaudiocpp0 ffmpeg
!pip install pyaudio
!git clone --recursive https://github.com/Atellas23/sis_files
import numpy as np
import matplotlib.pyplot as plt
from scipy.fftpack import fft, ifft
from scipy.signal import hamming, convolve
from scipy.io import wavfile
import pyaudio
```

```
fig_size = plt.rcParams["figure.figsize"]
fig_size[0] = 6*1.5
fig_size[1] = 4*1.5
plt.rcParams["figure.figsize"] = fig_size
```

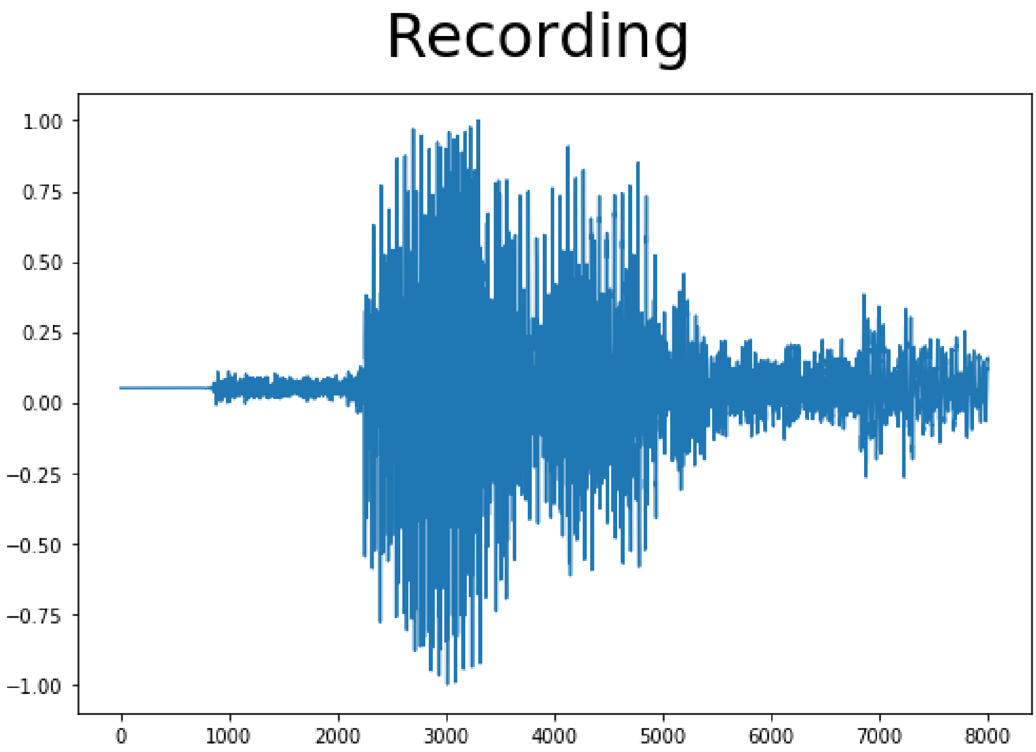
Voice recording

We recorded the sound with an auxiliar program and then saved it as a `.wav` file in a Github repository, s anywhere. Now we load it, so we can use it for our analysis.

Saving...

```
is_files/lab2/aleix.wav')

fig = plt.figure(1)
plt.plot(data)
plt.suptitle("Recording", fontsize=32)
fig.show()
```

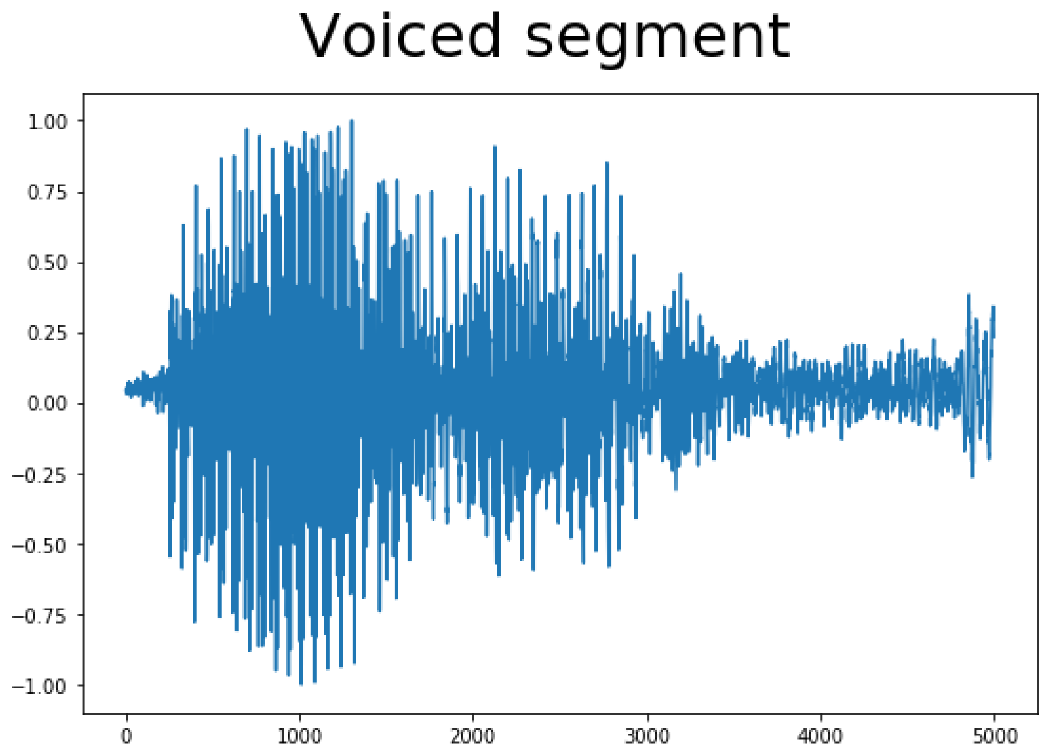


Studying the voiced segment

First of all, we distinguish the voiced segment from the noise segment. Therefore, the following plot sho
"Aleix".

```
idx1 = 2000
idx2 = 7000
x = data[idx1:idx2] #Segment that contains the vowel.
fig = plt.figure(2)
plt.plot(x)
ize=32)
```

Saving...



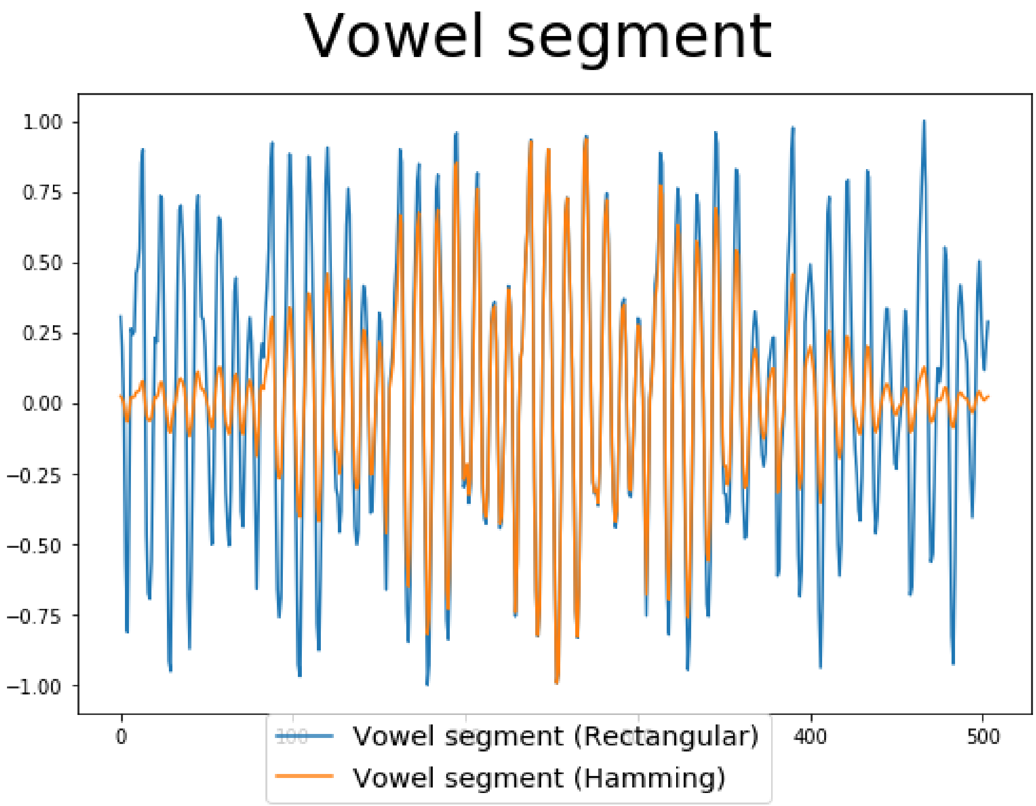
Now, from this part of the recording we will take the first part, where we think the 'A' is. We also window
Hamming window.

```
i1 = 835
i2 = 1842
i3 = 1339
x2 = x[i1:i3]
wx2 = x2*hamming(i3-i1)
```

Here we can see both the windowing with a rectangular window and the windowing with the Hamming v

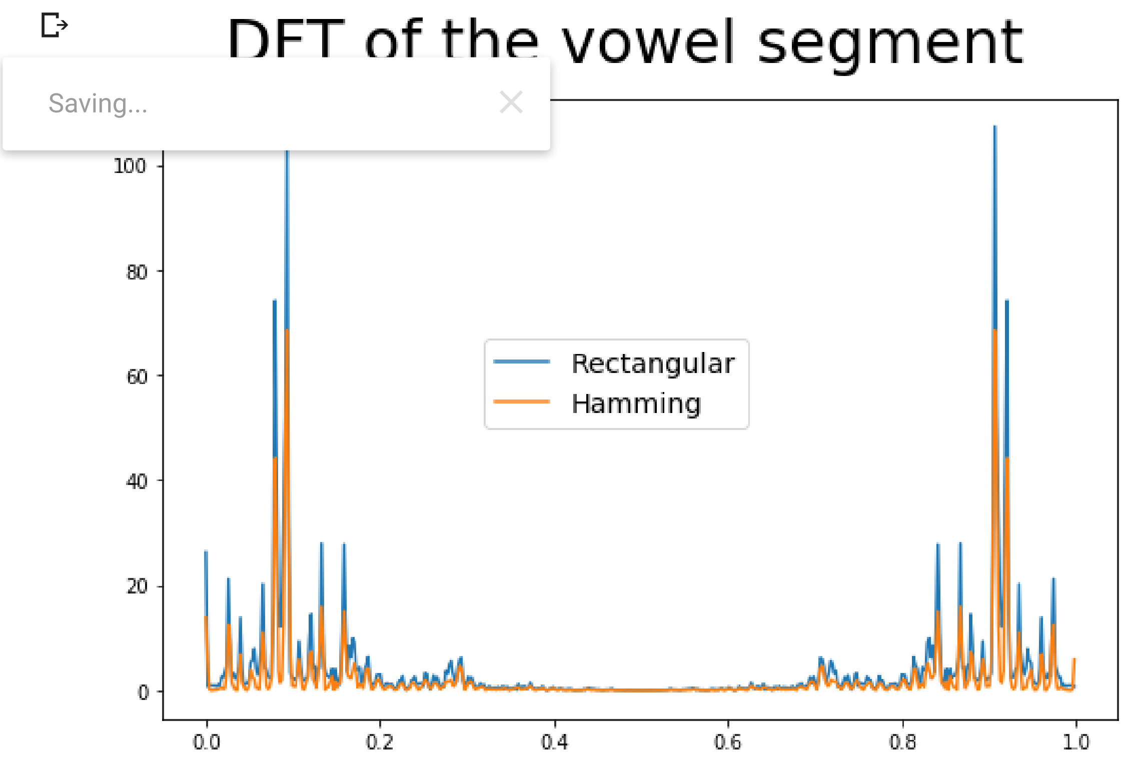
Saving...

```
ectangular)")
plt.plot(wx2, label="Vowel segment (Hamming)")
plt.suptitle("Vowel segment", fontsize=32)
legend = fig.legend(loc="lower center", fontsize="x-large")
fig.show()
```



Now, we compute the DFT of 504 samples of both the rectangular and the Hamming windowed signals.

```
fig = plt.figure(5)
plt.plot(np.arange(504)/504, abs(fft(x2)), label = "Rectangular")
plt.plot(np.arange(504)/504, abs(fft(wx2)), label = "Hamming")
plt.suptitle("DFT of the vowel segment", fontsize=32)
legend = fig.legend(loc="center", fontsize="x-large")
fig.show()
```

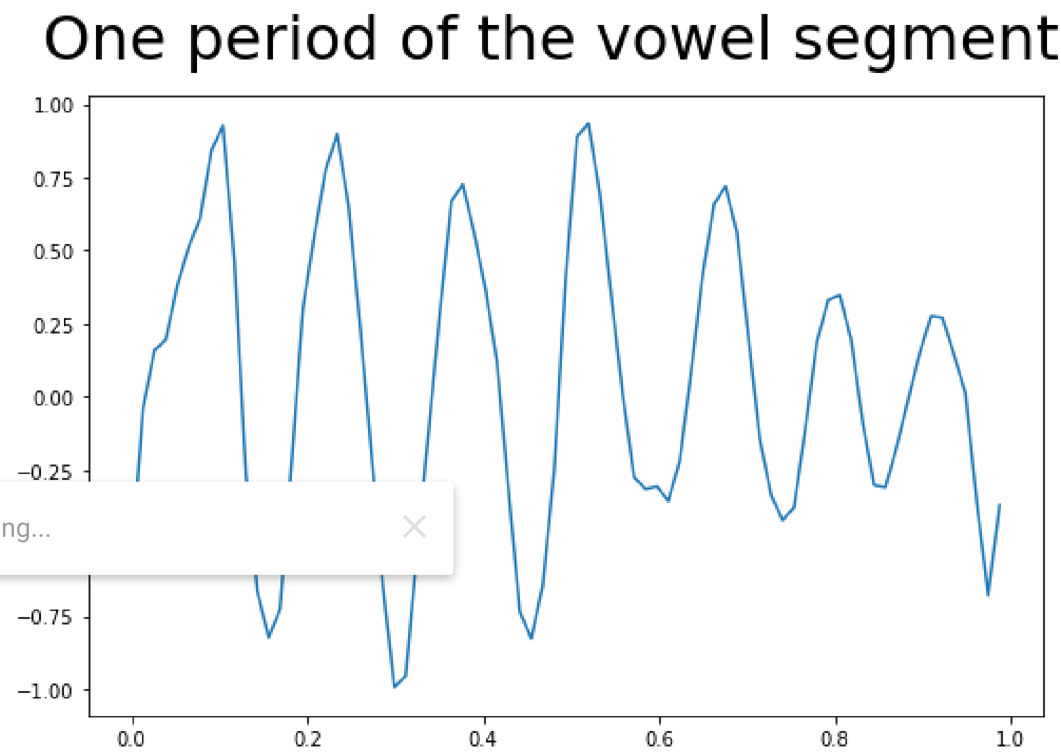


From this graph, we can estimate the formant and fundamental frequencies:

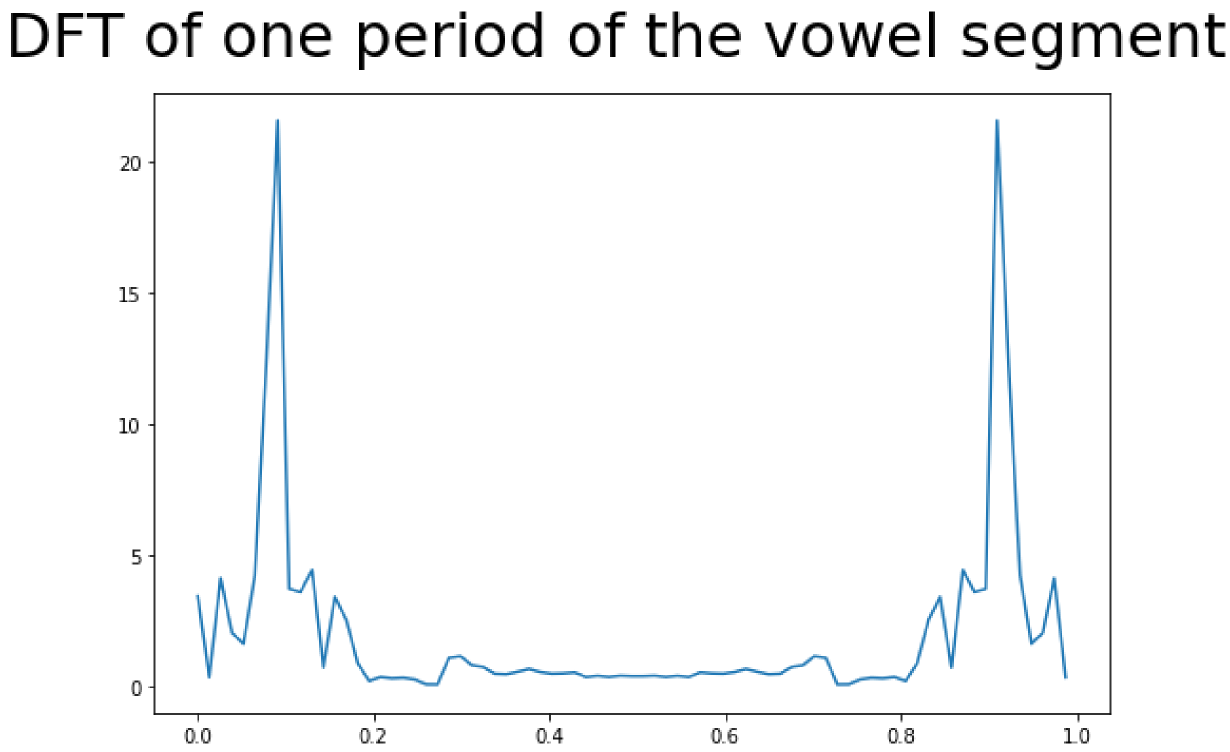
- The fundamental frequency is calculated dividing the sampling frequency by the period of the sigr and the sampling frequency is $f_s = 8000$. Then,
$$f_f = \frac{f_s}{P} = \frac{8000}{75} \approx 107 \text{ Hz}.$$
So, the speaker is (unsurprisingly, as we already knew) more likely to be a man.
- The formant frequencies are the two most important peaks times the sampling frequency; the mo $f_1 = f_s \cdot 0.0932... \approx 745.6 \text{ Hz}$, and the second formant is $f_2 = f_s \cdot 0.1587... \approx 1269.6$ Hz an 'A'.

We can also study one period of the 'A' signal, where the formant peaks are more clearly distinguishable

```
i4 = 230
i5 = 307
period = wx2[i4:i5]
fig = plt.figure(7)
plt.plot(np.arange(i5-i4)/(i5-i4), period, label = "One period")
plt.suptitle("One period of the vowel segment", fontsize=32)
fig.show()
```




```
fig = plt.figure(8)
plt.plot(np.arange(i5-i4)/(i5-i4), abs(fft(period)), label = "DFT of one period")
plt.suptitle("DFT of one period of the vowel segment", fontsize=32)
fig.show()
```



Now, the formant frequencies can be more clearly calculated, as the two most prominent peaks are at (
are $f_1 = 8000 \cdot 0.0879 \approx 703.2$ and $f_2 = 8000 \cdot 0.1558 \approx 1246.4$.

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