SATFD - lab 01 report

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1 Wave

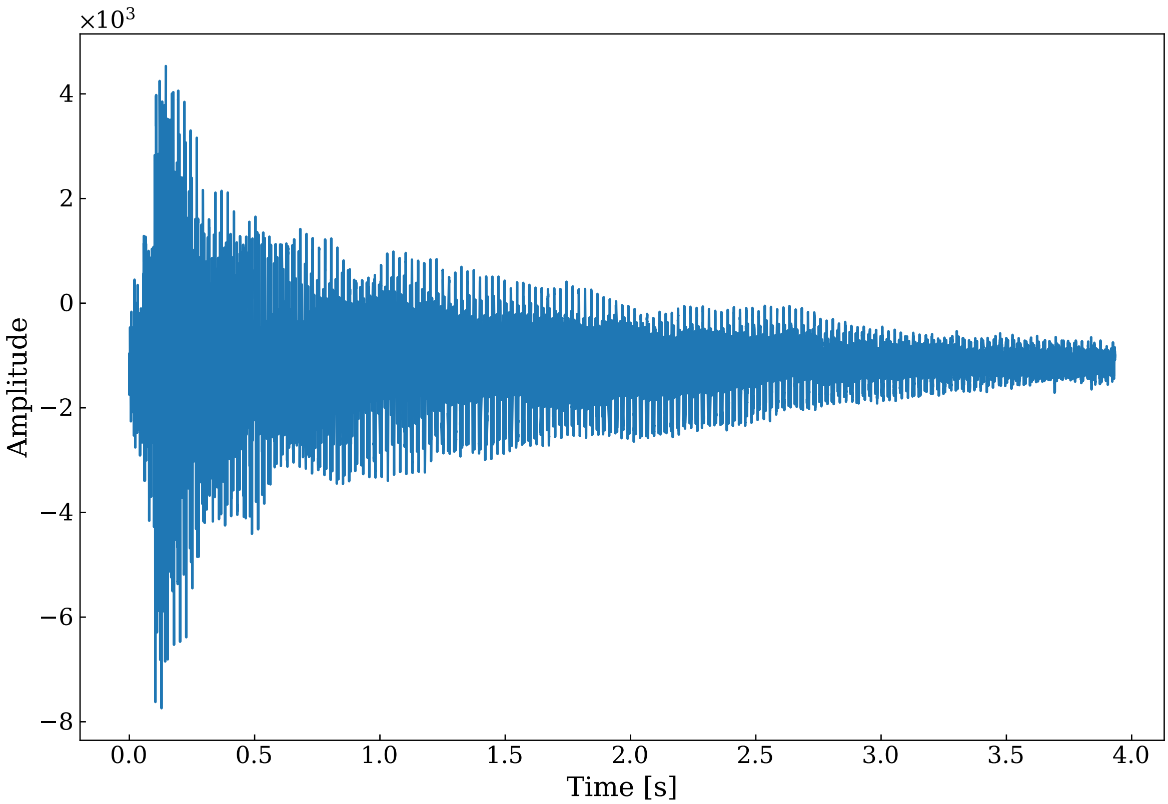
The task during lab 01 involves determining the highest peaks in the spectrum of a sound file and identifying what guitar chord has been recorded.

The available file, `chord.wav`, is a recording of a guitar playing some chord. The signal is a 44100 [Hz] sample rate and was cut to 4 seconds of data.

Listing 1: **Code snippet for loading the initial signal.**

```
sample_rate, wave = scipy.io.wavfile.read("./data/chord.wav")
time = np.arange(wave.size) / sample_rate
```

Figure 1: **Wave from 'chord.wav'.**



2 Fourier transform and the power spectrum

To determine the tones in the recorded accord, a Fourier transform was performed using the function `np.fft.fft()`. The power spectrum of the signal was limited to the frequency range of 16 to 4000 [Hz], as suggested in the lab instructions.

Furthermore, the power in dB units is obtained by using the following formula:

$$P(x) = 10 \cdot \log(|H(x)|),$$

where $H(x)$ is a Fourier transform of the initial signal

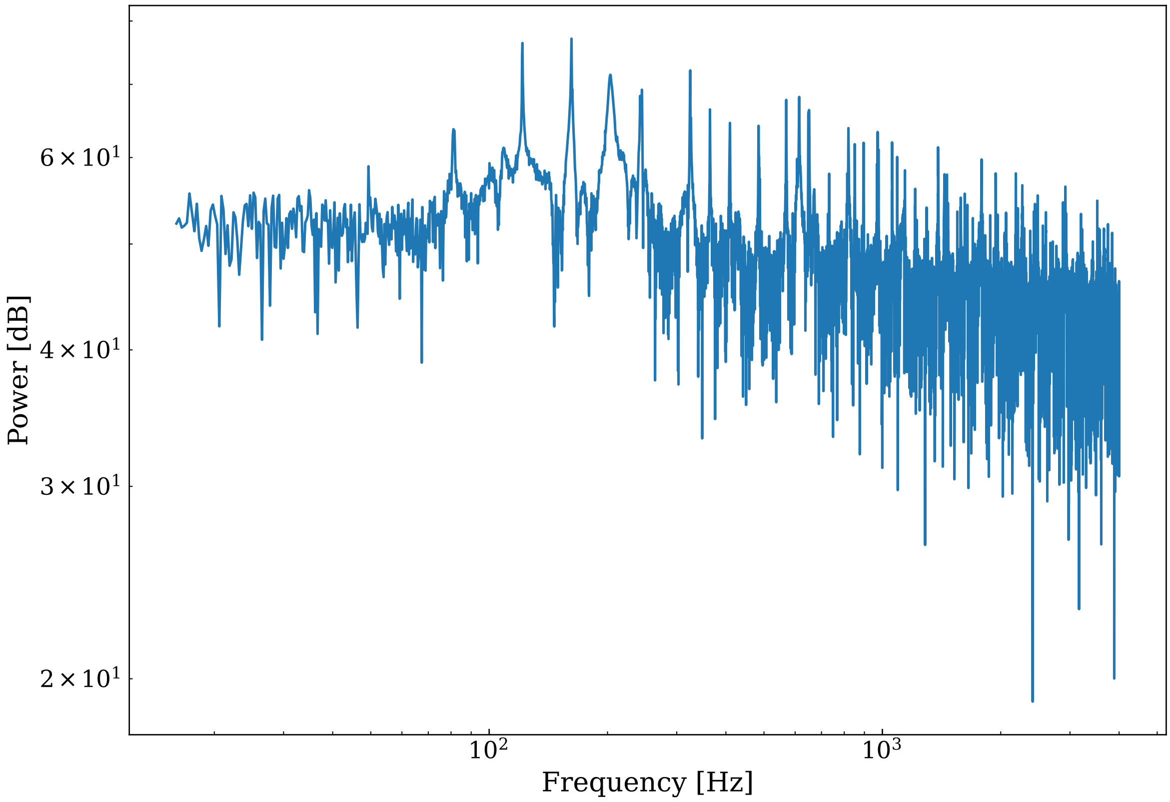
Listing 2: **Code snippet for calculating the power spectrum.**

```
spectrum = np.fft.fft(wave)
freqs = np.fft.fftfreq(wave.size, 1 / sample_rate)

f_range = (freqs >= 16) & (freqs <= 4e3)
freqs = freqs[f_range]
spectrum = spectrum[f_range]

spectrum_db = 10 * np.log10(np.abs(spectrum) + 1e-15)
```

Figure 2: **Power spectrum of 'chord.wav'.**



3 Peak analysis

By using the `scipy.signal.find_peaks()` function, the frequencies corresponding to the highest value of power are found, and only 11 highest are considered for further analysis.

Listing 3: **Code snippet for identifying the semitones, based on the provided MATLAB code.**

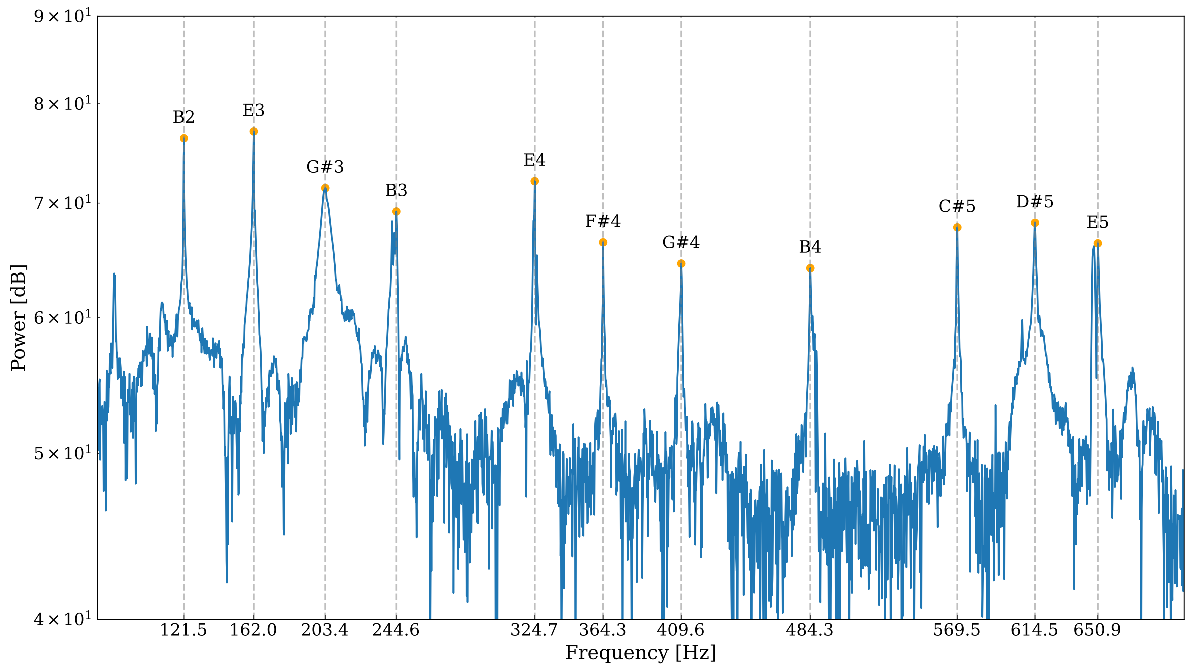
```
peaks, _ = signal.find_peaks(spectrum_db, distance=100)
peaks = peaks[np.argsort(spectrum_db[peaks])[-11:]]

min_note = -57
max_note = 39

base_names = ["C", ..., "B"]

tone_freqs = 440 * np.power(2, np.arange(min_note, max_note + 1) / 12)
tone_names = [
    *[
        f"{base_names[halftone]}{octave}"
        for octave in range(8)
        for halftone in range(12)
    ],
    "C8",
]
```

Figure 3: **The highest peaks and the corresponding semitones.**



The played chord is in the major key, hence one of the possibly played chords could be **E major**. It consists of E, G# and B, which are showing as peaks in the above plot of the power spectrum.

4 Conclusion

By taking a Fourier transform and representing the signal as a power spectrum, I have identified E major as the key of the chord from the provided sound file `chord.wav`.

The entire code for generating the data and plots can be found at:

https://github.com/davkk/signal-analysis/tree/main/sat/lab01