MIR: Music Information Retrieval/Research

- Introduction,
- Applications,
- What is “digital sound”?
- Code for **demonstrative** purposes
  - *Code samples to give a sense of what researchers create*

https://www.youtube.com/watch?v=YgYV-7-ohxQ

MIR: Music Information Retrieval/Research
Müzik Bilgi Erişim

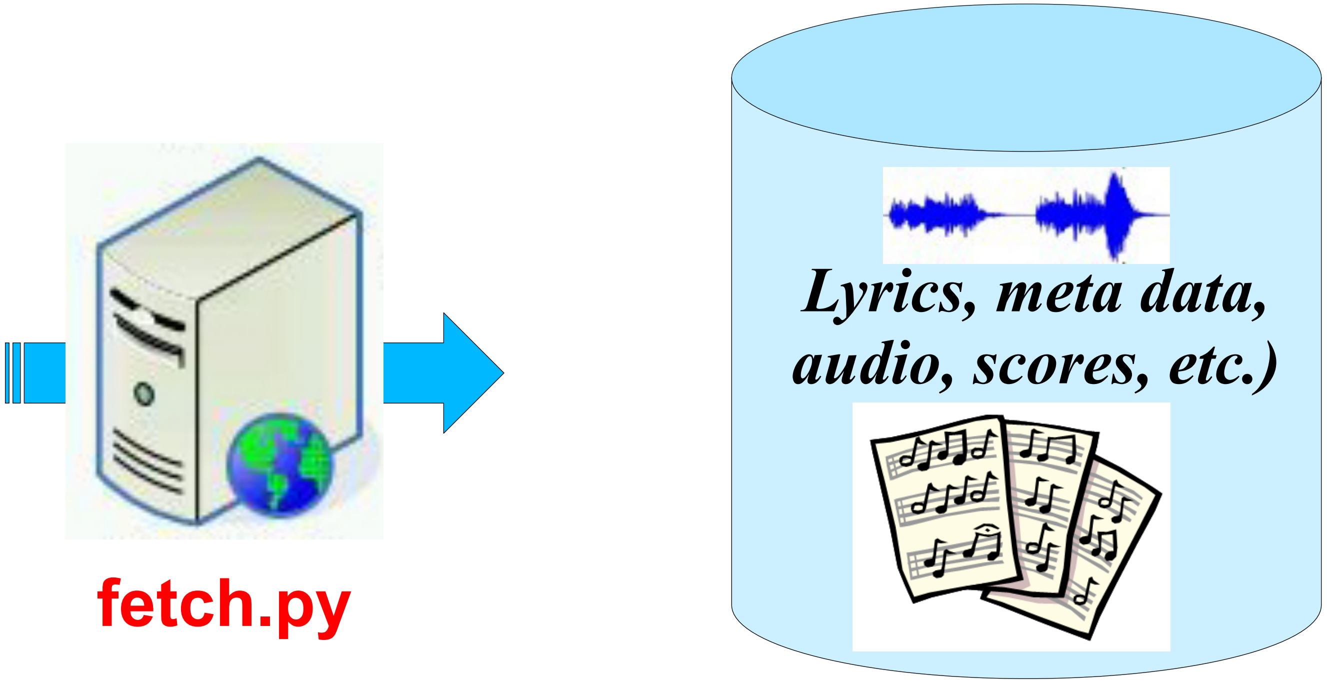
Developing computer based tools for:

- Extracting, accessing, representing, … information from music data

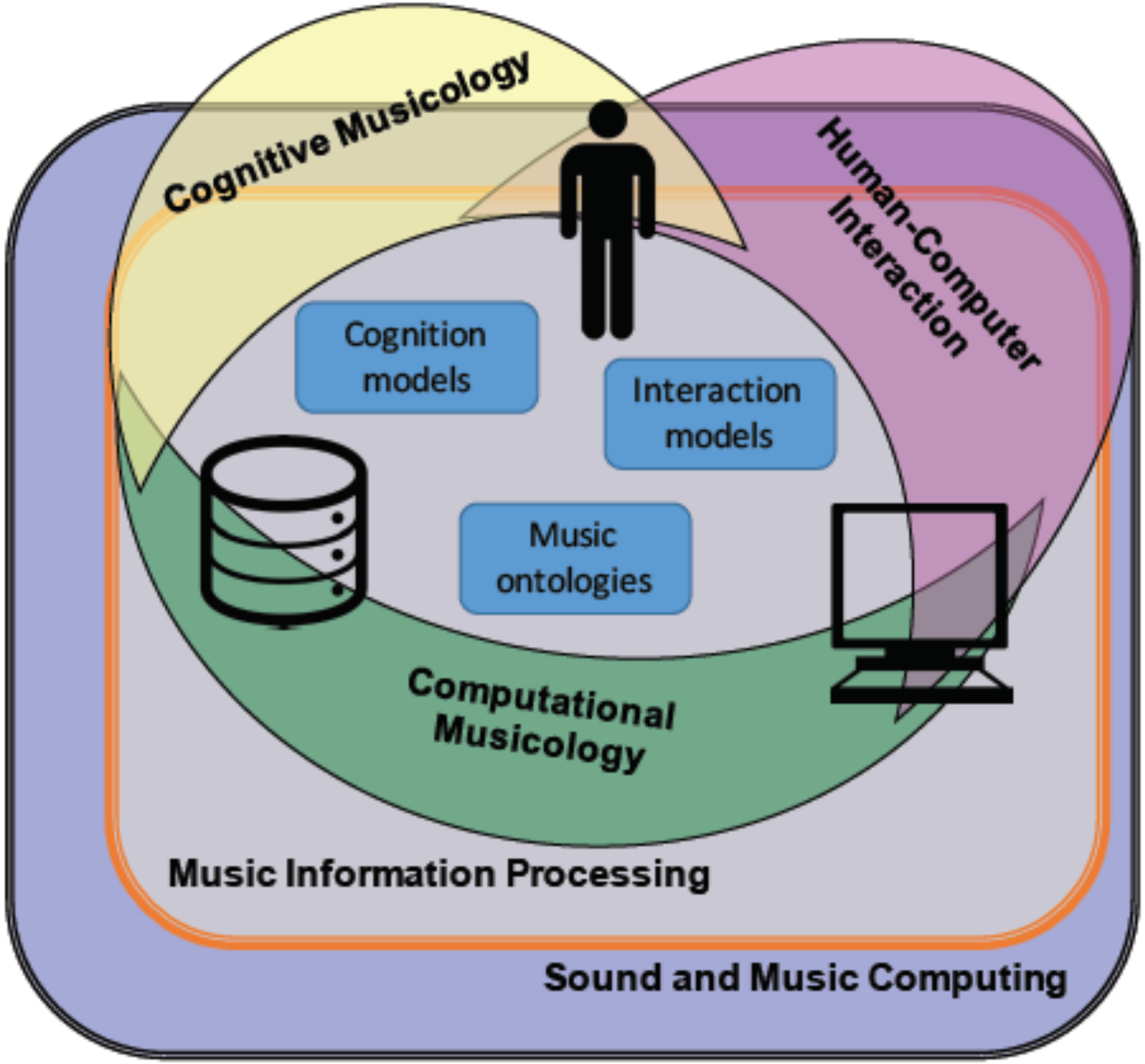
- Facilitating query of items in large databases.

User query interface:

- **Text**
- **Humming/singing**
- **Recording example**
- **Notation**
- **…**



MIR is a multi-disciplinary field



Pattern recognition

Musicology

Signal processing

Music perception and cognition

Hardware (recording, interfaces, etc.)

Computing, programming

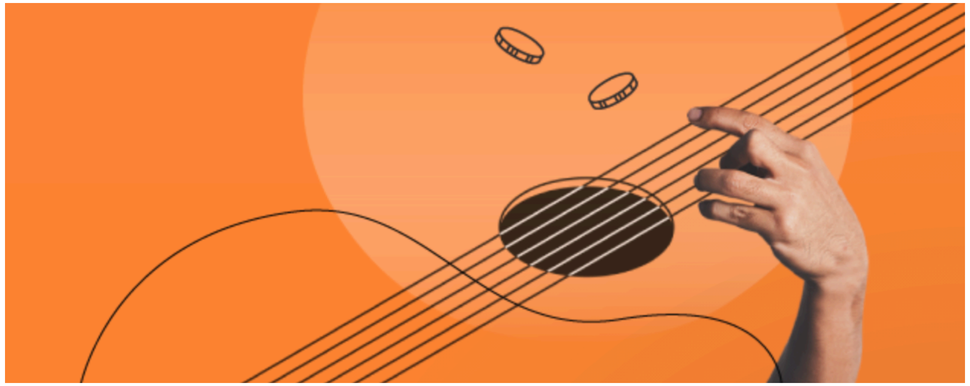
Popular MIR Applications

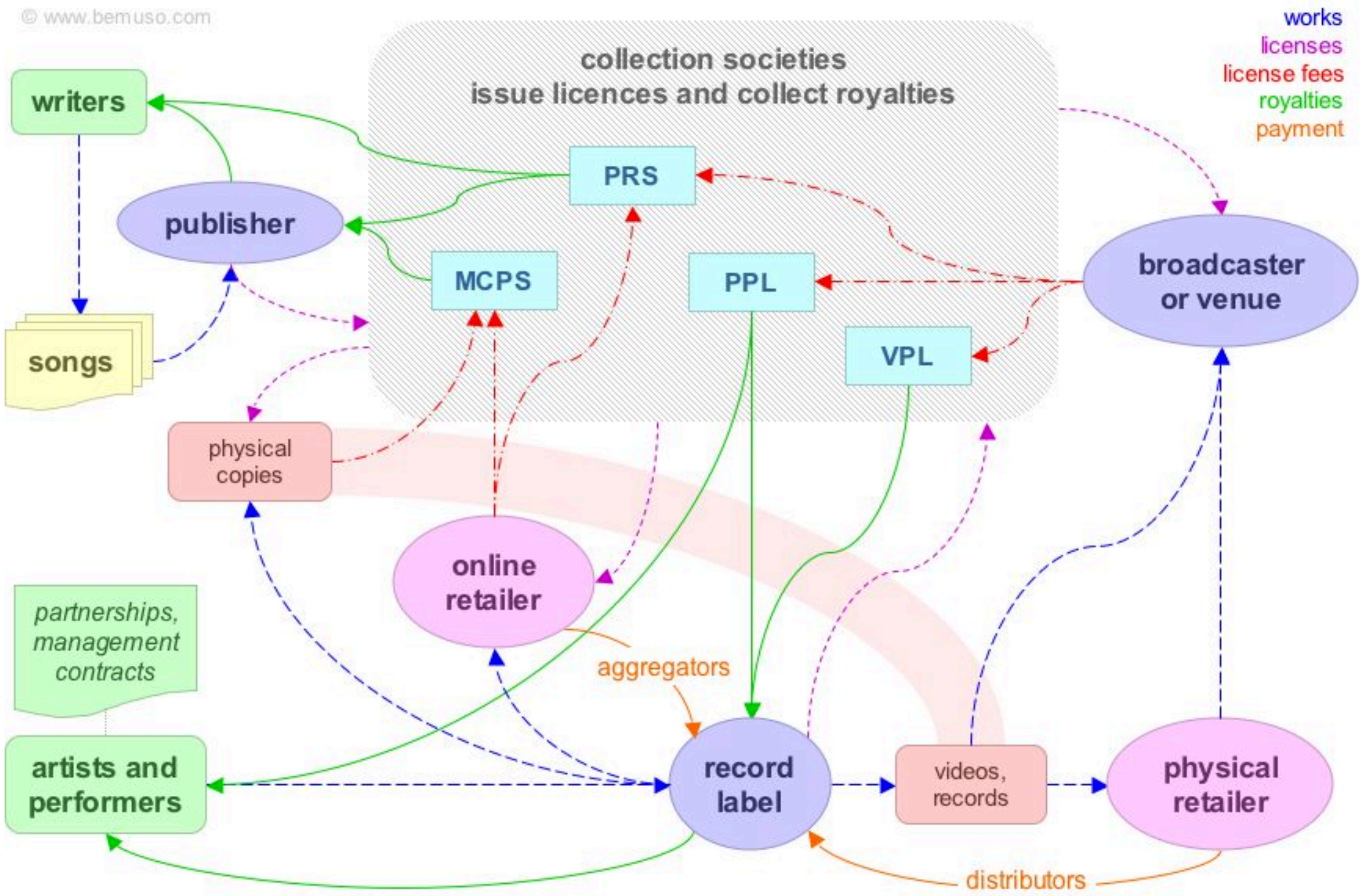
- **Royalty rights tracking**
  - ***Monitoring broadcast***

bmat MUSIC INNOVATORS

kahuna.com.tr

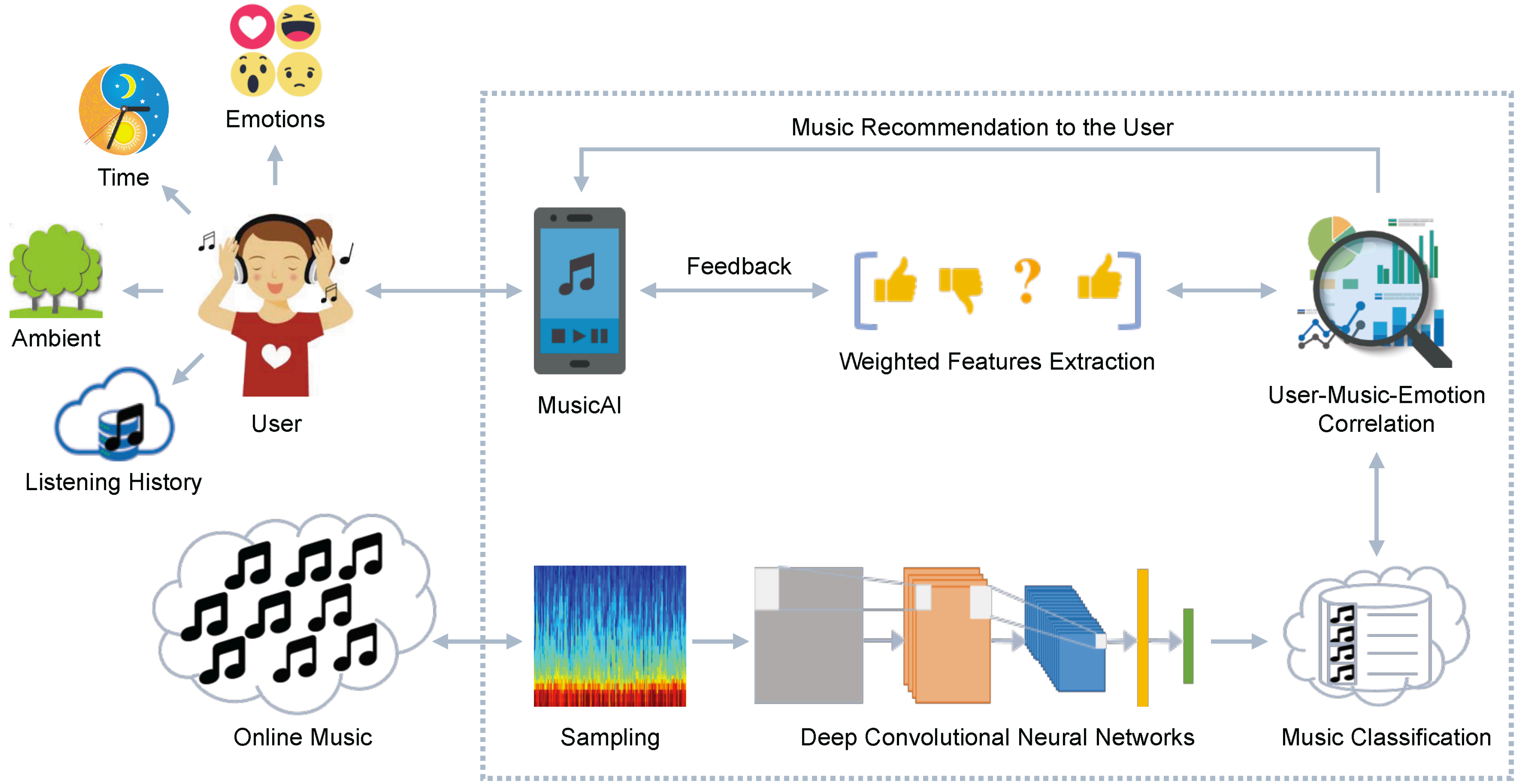
KAHUNA





Popular MIR Applications

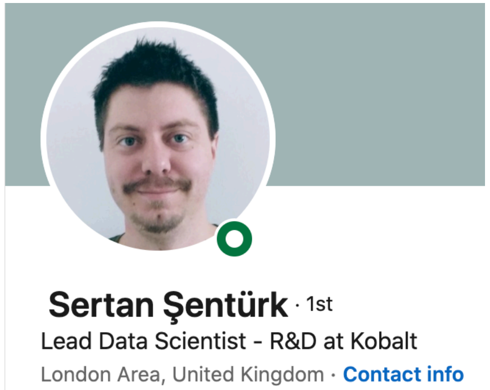
- **Recommendation systems**
- **Music discovery**



https://www.mdpi.com/2076-3417/8/7/1103

Popular MIR Applications

- **Audio-score alignment, score following**

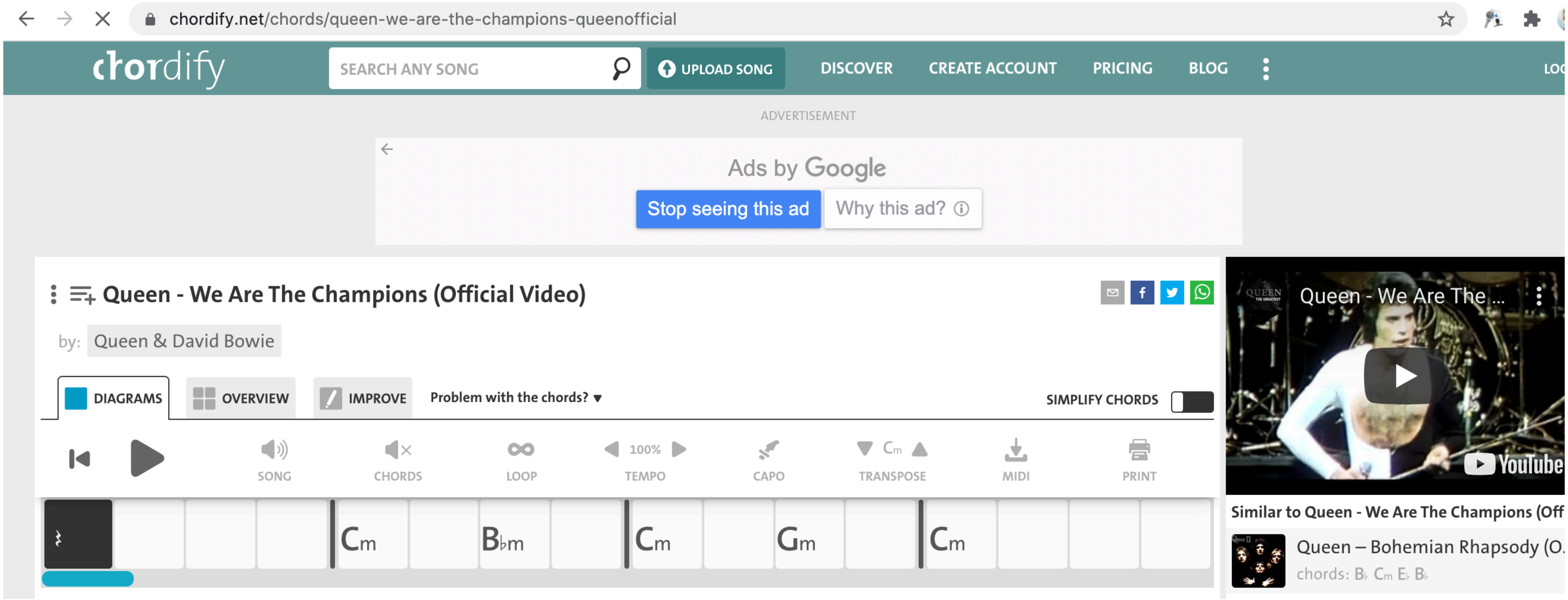


Phd, 2017
@MTG-UPF, Barcelona

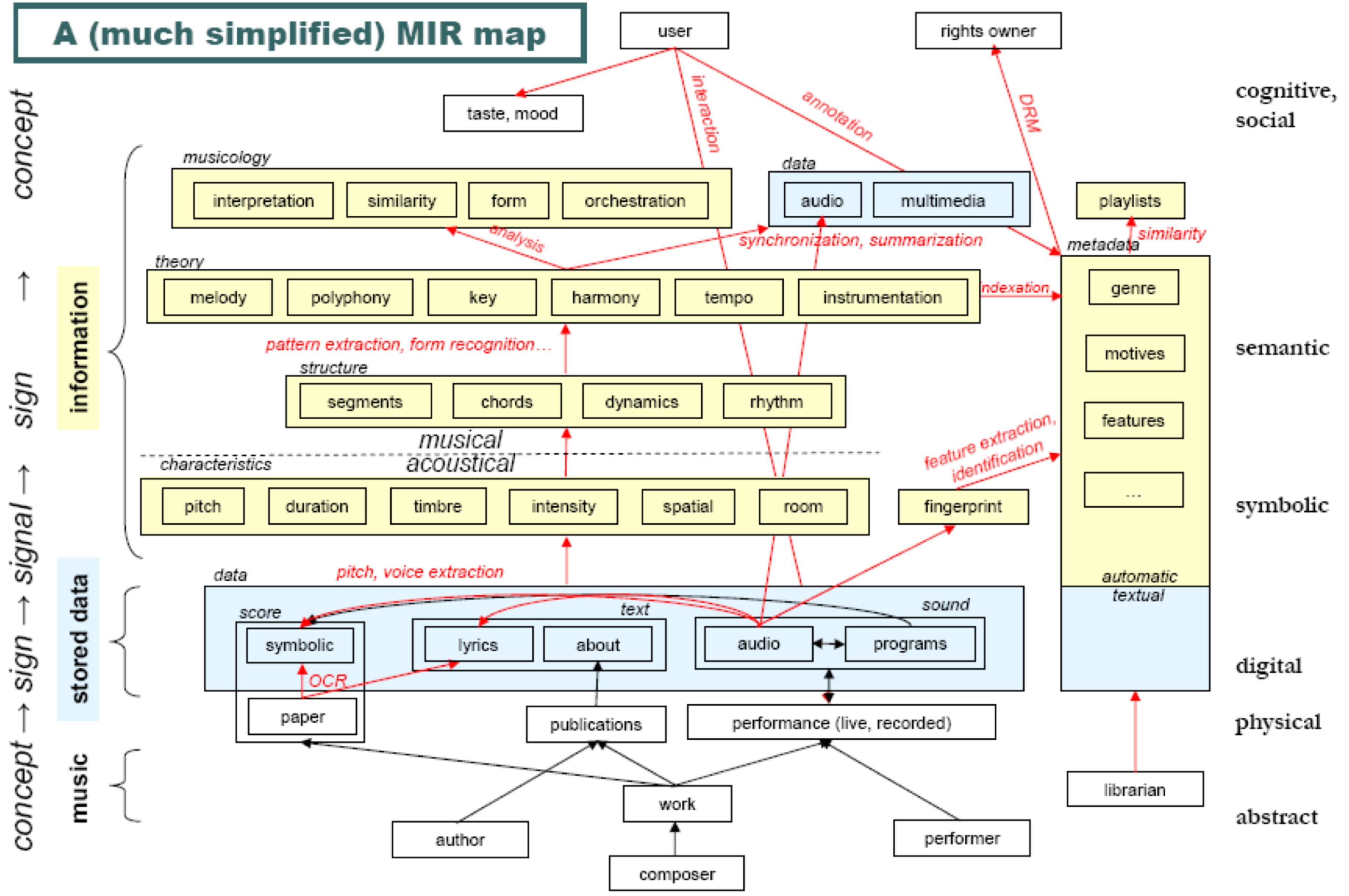
https://sertansenturk.com/work-research/phd-thesis/

Popular MIR Applications

- **Automatic chord detection**

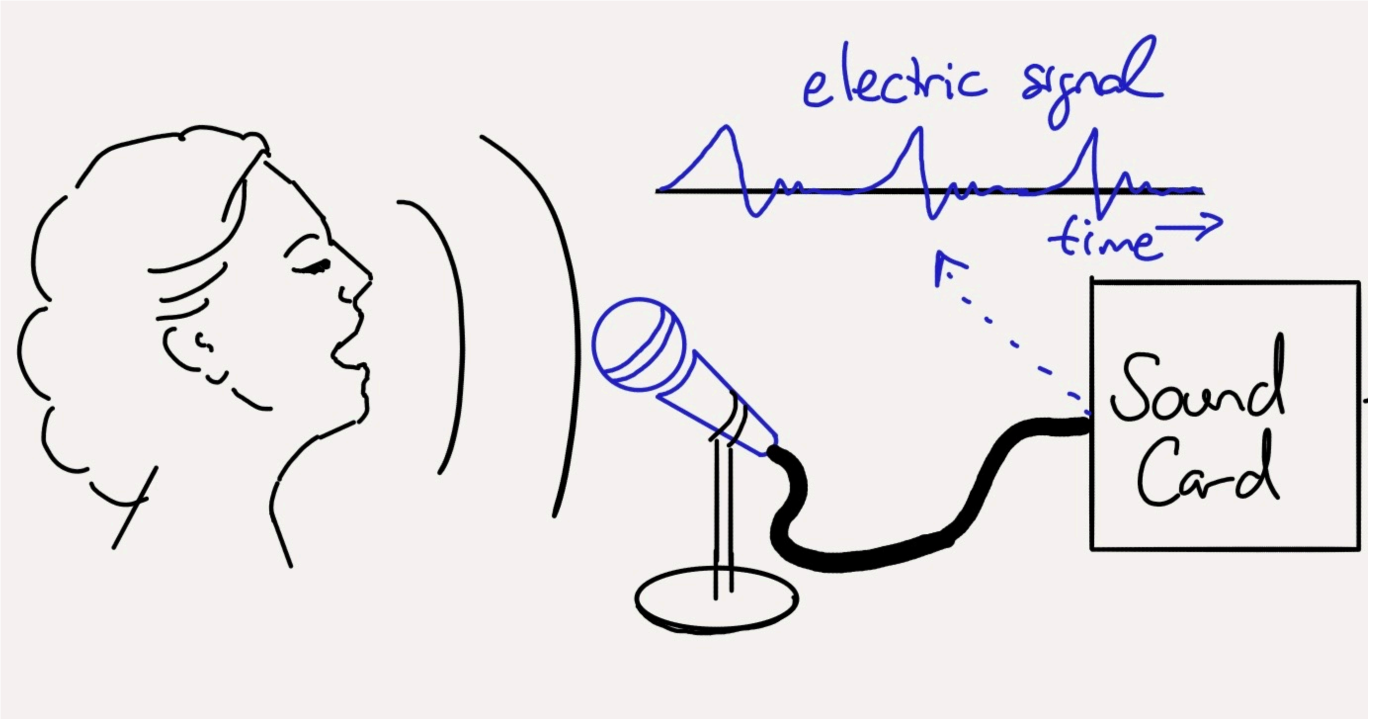


https://chordify.net/

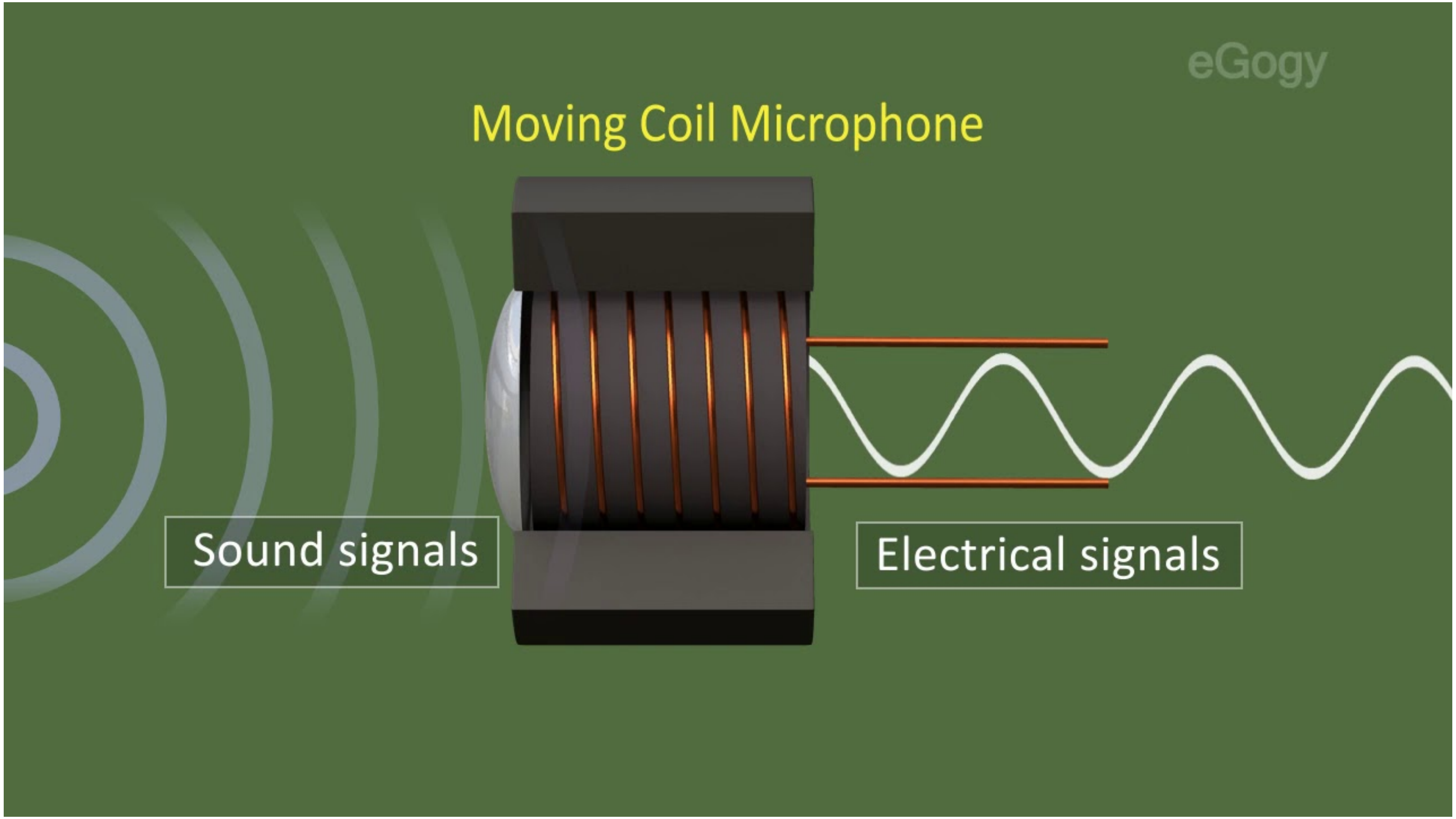


[Fingerhut, 2004]()

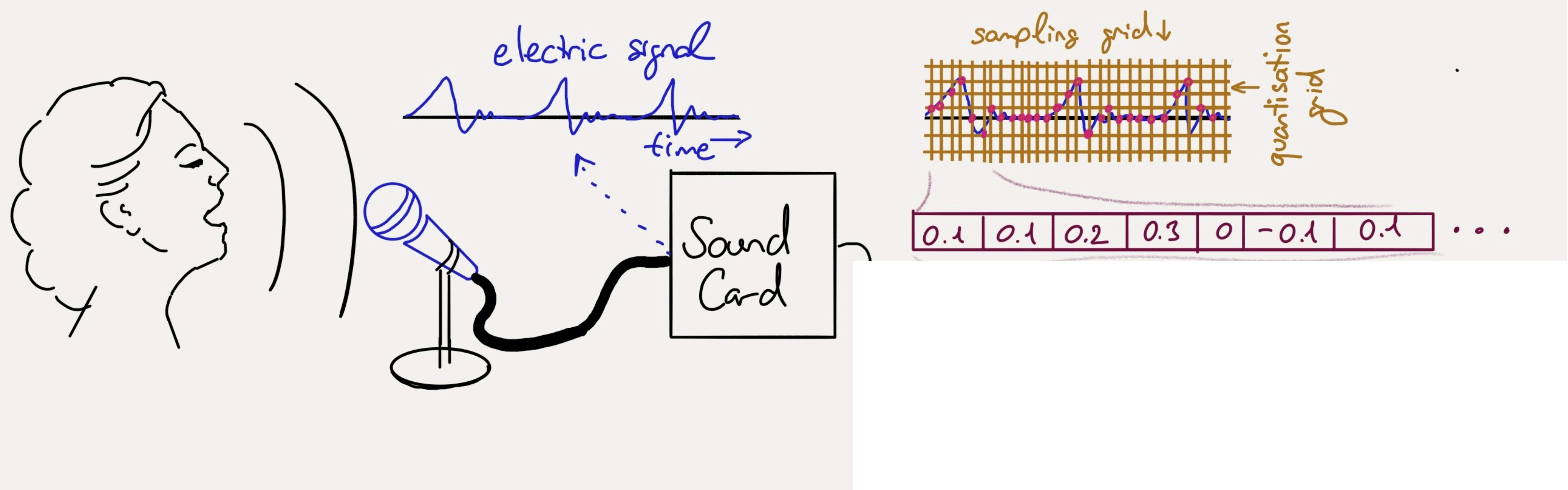
Baby steps towards audio signal processing in Python


electric signal
time
Sound Card

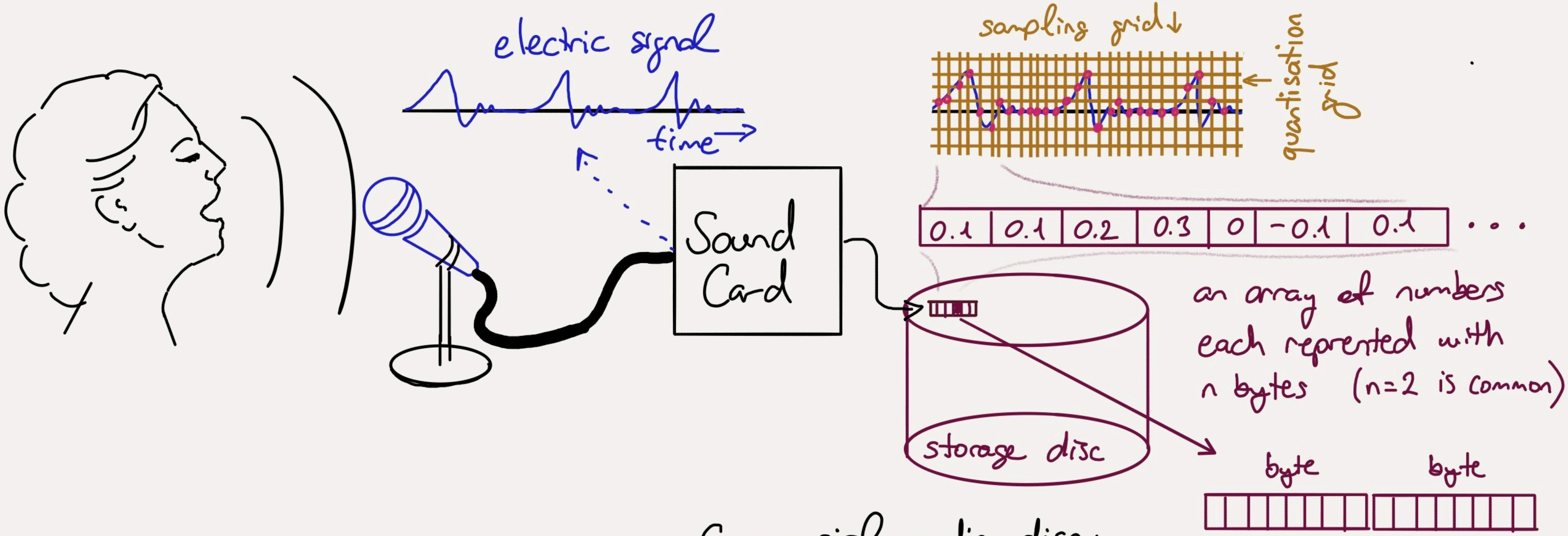
Microphones, loudspeakers; how do they work?



https://www.youtube.com/watch?v=Y585z2XRFFs&list=RDecPUTGDX5cw&index=10



electric signal
time
Sound Card
sampling grid
quantisation grid
0.1
0.1
0.2
0.3
0
-0.1
0.1
. . .

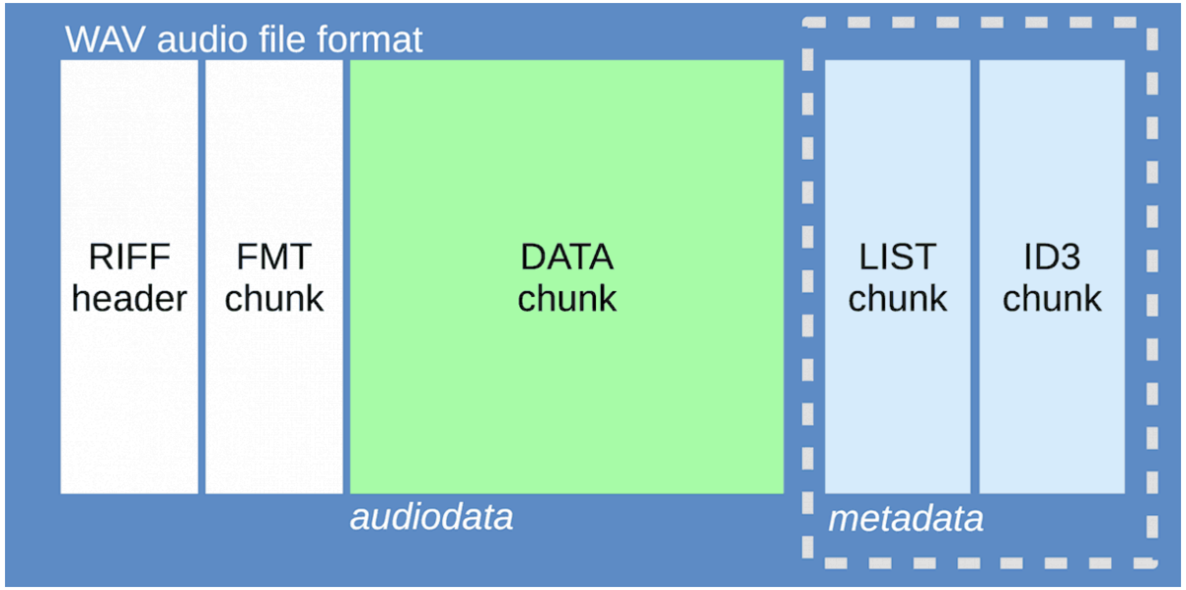


Commercial audio disc:

44100 samples / second

2 bytes / sample

Storing audio data(series of numbers) in files



To read audio data from audio files,
we need functions designed for that specific format

Let's see some sample code

DigitalAudio_sampleCode.ipynb

File Edit View Insert Runtime Tools Help All changes saved

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RAM Disk Editing

Reading digital audio files

Audio file reading functions are available in various libraries. This example uses Sms-tools, the accompying code resource for Xavier Serra's Coursera course. We would first need to clone the repo to start using it.

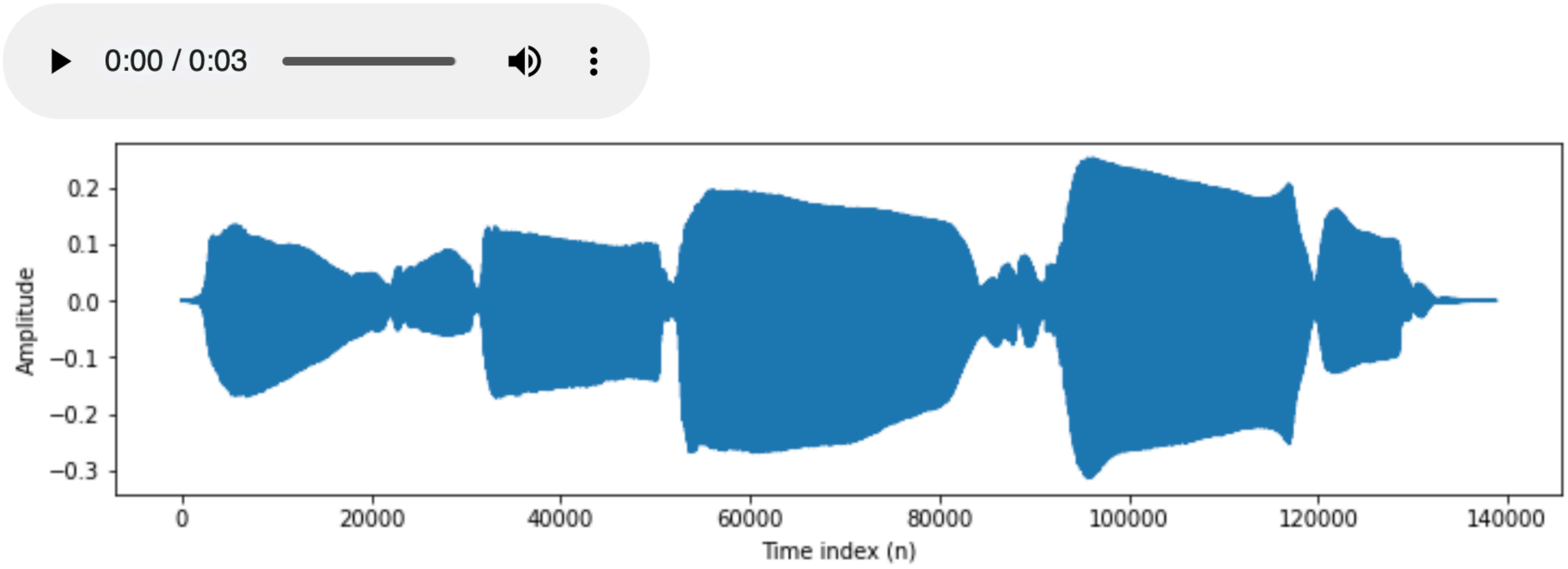
```
#We need to clone the repo to start using it.
!git clone https://github.com/MTG/sms-tools.git
import sys
import os
import numpy as np
import matplotlib.pyplot as plt
import IPython

sys.path.append('sms-tools/software/models/')
from utilFunctions import wavread, wavwrite
```

https://drive.google.com/file/d/1iyV5KTUWx4p68ByDoXjA1sn97XjgKkGD/view?usp=sharing

Let’s see some sample code

Reading an audio file and ploting the signal loaded

```
fs, x = wavread('sms-tools/sounds/sax-phrase-short.wav')
fig = plt.figure(figsize=(12,3))
plt.plot(x)
plt.xlabel('Time index (n)'); plt.ylabel('Amplitude');
IPython.display.Audio(x, rate=fs)
```



https://drive.google.com/file/d/1iyV5KTUWx4p68ByDoXjA1sn97XjgKkGD/view?usp=sharing

Let's see some sample code

Print a few elements of the audio

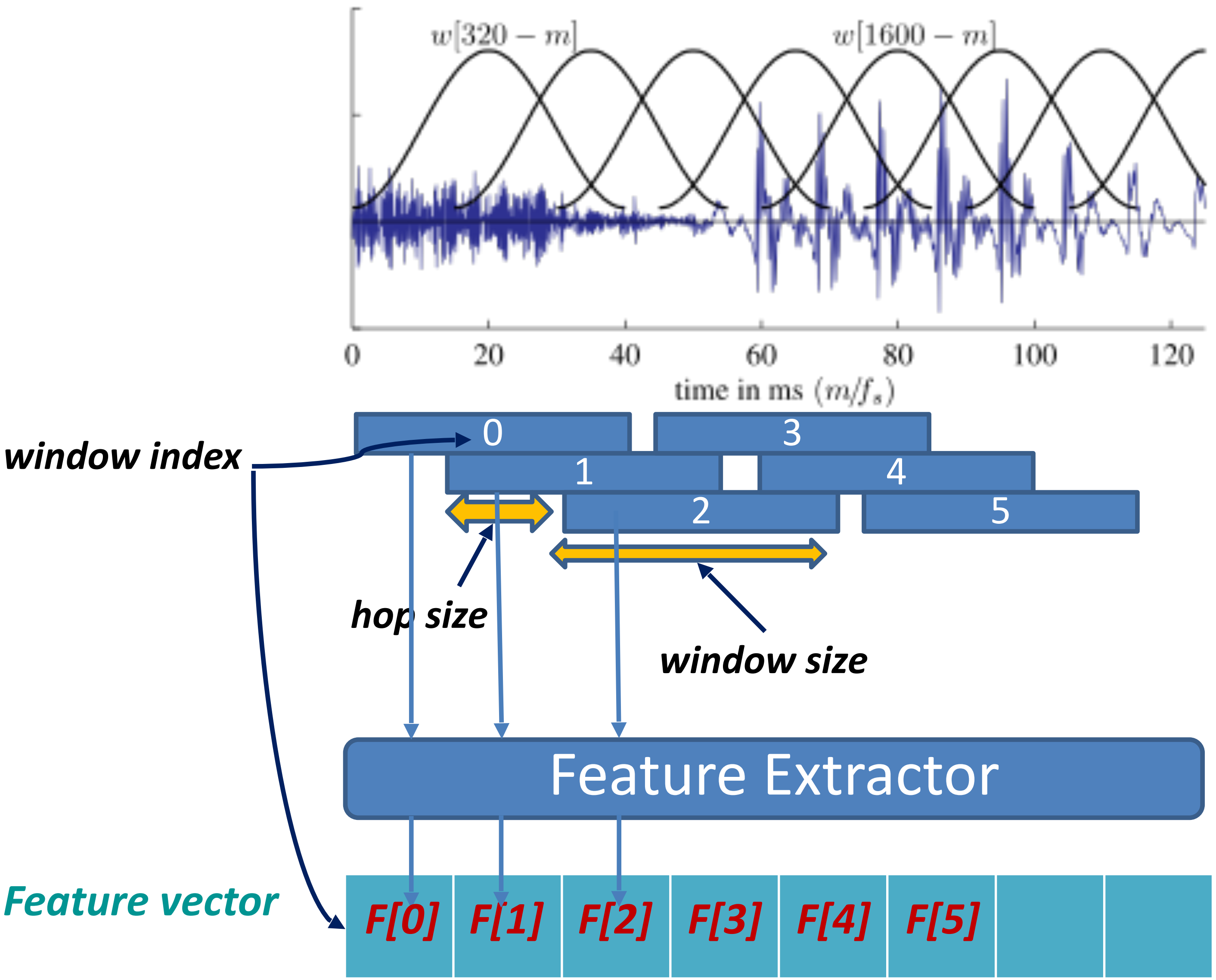
start stop

```
[17] print(x[50000:50020])

[-0.12344737 -0.10858486 -0.09179968 -0.07345805 -0.05505539 -0.03827021
 -0.02462844 -0.01327555 -0.00412     0.00332652  0.00900296  0.01361126
  0.02035585  0.0283517   0.03482162  0.03927732  0.04412977  0.0516068
  0.05865658  0.06576739]
```

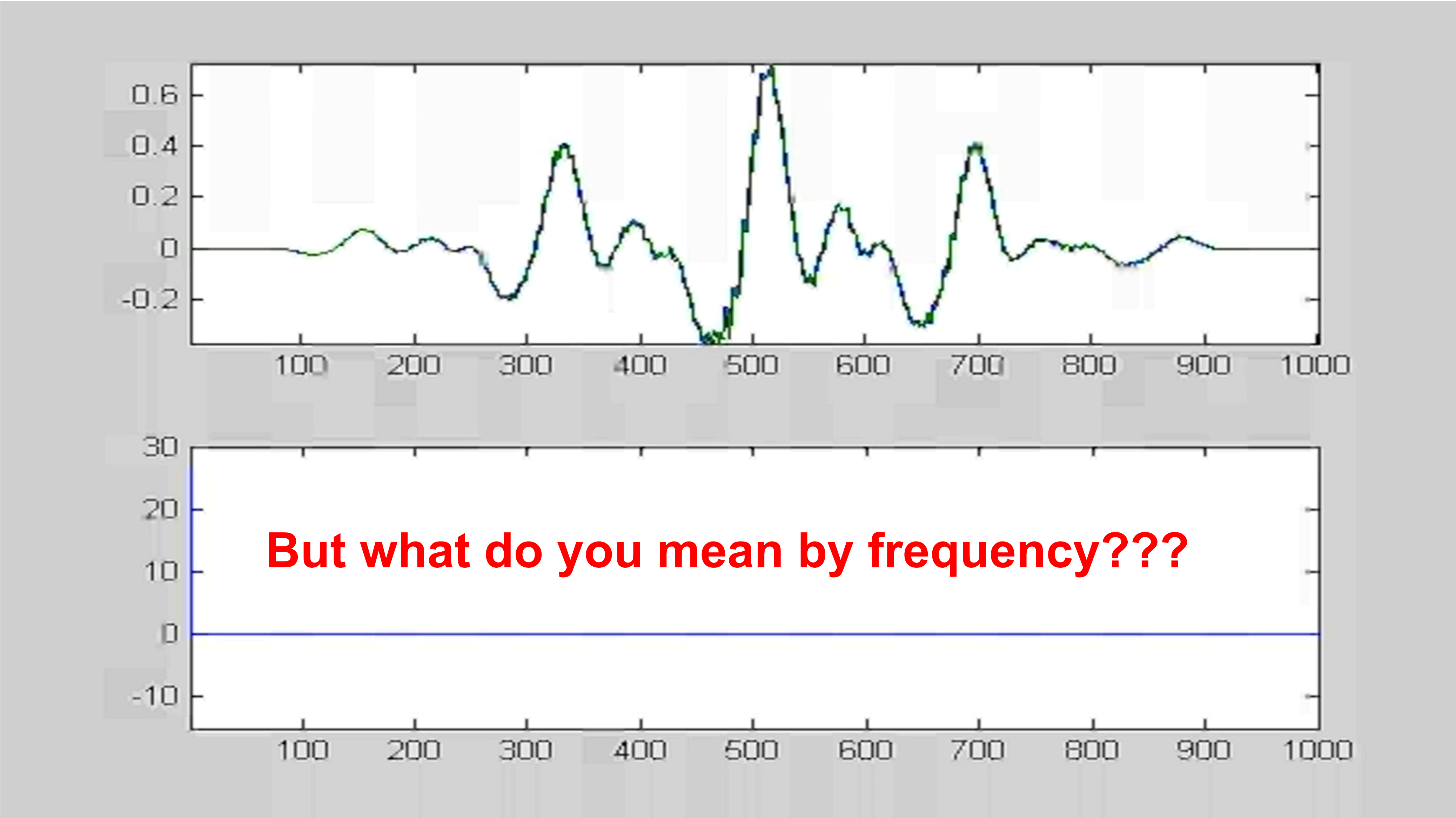
OK, fine,

But how do we extract any information from these series of numbers?

Chopping signal into frames and extracting information



Autocorrelation based fundamental frequency/period estimation



Frequency (of a signal) : the number of repetitions in 1 second duration.

Fundamental frequency extraction using the autocorrelation

The function below performs an auto-correlation based fundamental frequency estimation as explained in the lecture.

The autocorrelation , r_k, of a signal x at lag k is defined as:

$$r_k = \sum_n x[n]x[n+k]$$

which is basically a dot product of the signal with its shifted version

```
def estimateF0_autoCorr(x_win, fs, minF0, maxF0):
    '''F0 detection on a single frame using autocorrelation
    Parameters
    ----------
    x_win : numpy.array
        Windowed signal frame
    fs,minF0,maxF0 : int
        Sampling rate, minimum and maximum F0 limits

    Returns
    -------
    f0 : float
        Estimated f0 in Hz
    '''
```

Fundamental frequency extraction using the autocorrelation

```
def estimateF0_autoCorr(x_win, fs, minF0, maxF0):

    f0 = 0
    minT0 = int(fs/maxF0)
    maxT0 = int(fs/minF0)
    maxValAC = -1;T0 = -1
    for k in range(minT0, maxT0):
        x_win_shifted = np.hstack((np.zeros(k),x_win[:-k]))
        autoCorr = np.dot(x_win,x_win_shifted)
        if autoCorr > maxValAC:
            T0 = k
            maxValAC = autoCorr
    f0 = float(fs) / T0
    return f0
```

Fundamental frequency extraction using the autocorrelation

```
from scipy.signal import get_window

# Analysis parameters
minF0 = 50 #in Hz
maxF0 = 2000 #in Hz
windowSize = 4096
hopSize = 1024

w = get_window('blackman', windowSize)
startIndexes = np.arange(0, x.size - windowSize, hopSize, dtype = int)
numWindows = startIndexes.size
```

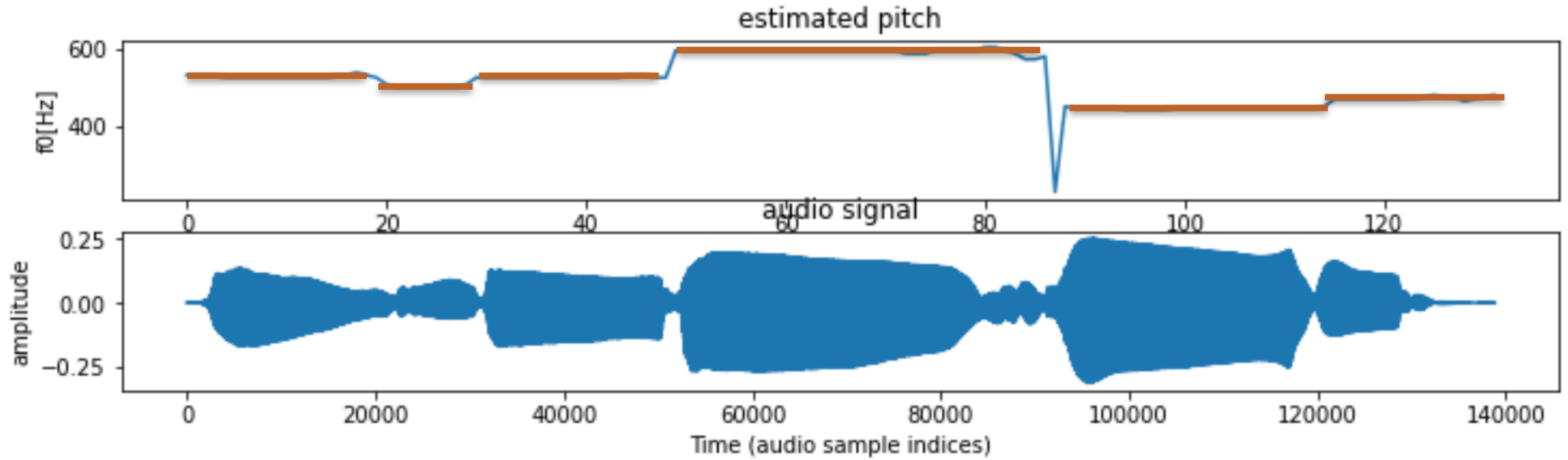
```
#F0 estimation for each window
f0 = []
for k in range(numWindows):#framing/windowing
    x_win = x[startIndexes[k] : startIndexes[k] + windowSize] * w#window applied here
    f0.append(estimateF0_autoCorr(x_win, fs, minF0, maxF0))
f0 = np.array(f0)
```

Fundamental frequency extraction using the autocorrelation

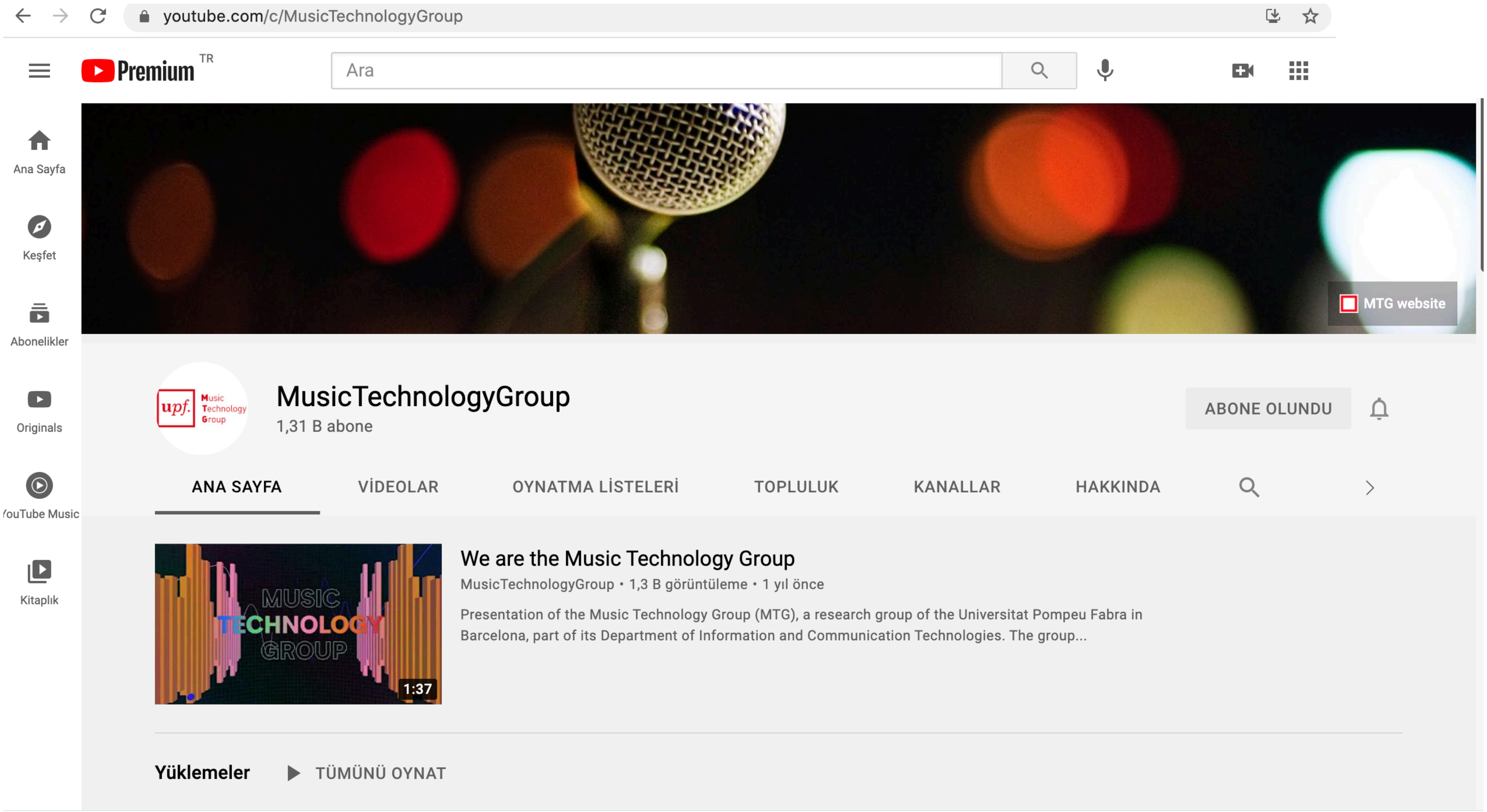
```
fig = plt.figure(figsize=(12,3))
plt.subplot(2,1,1)
plt.plot(f0)
plt.title('estimated pitch')
plt.ylabel('f0[Hz]')
plt.xlabel('Time (frame indices)')
plt.subplot(2,1,2)
plt.plot(x)
plt.title('audio signal')
plt.ylabel('amplitude')
plt.xlabel('Time (audio sample indices)')
```

```
Text(0.5, 0, 'Time (audio sample indices)')
```

One potential next step is to estimates the notes played in this recording: automatic transcription



Looks interesting, where do I find more material?



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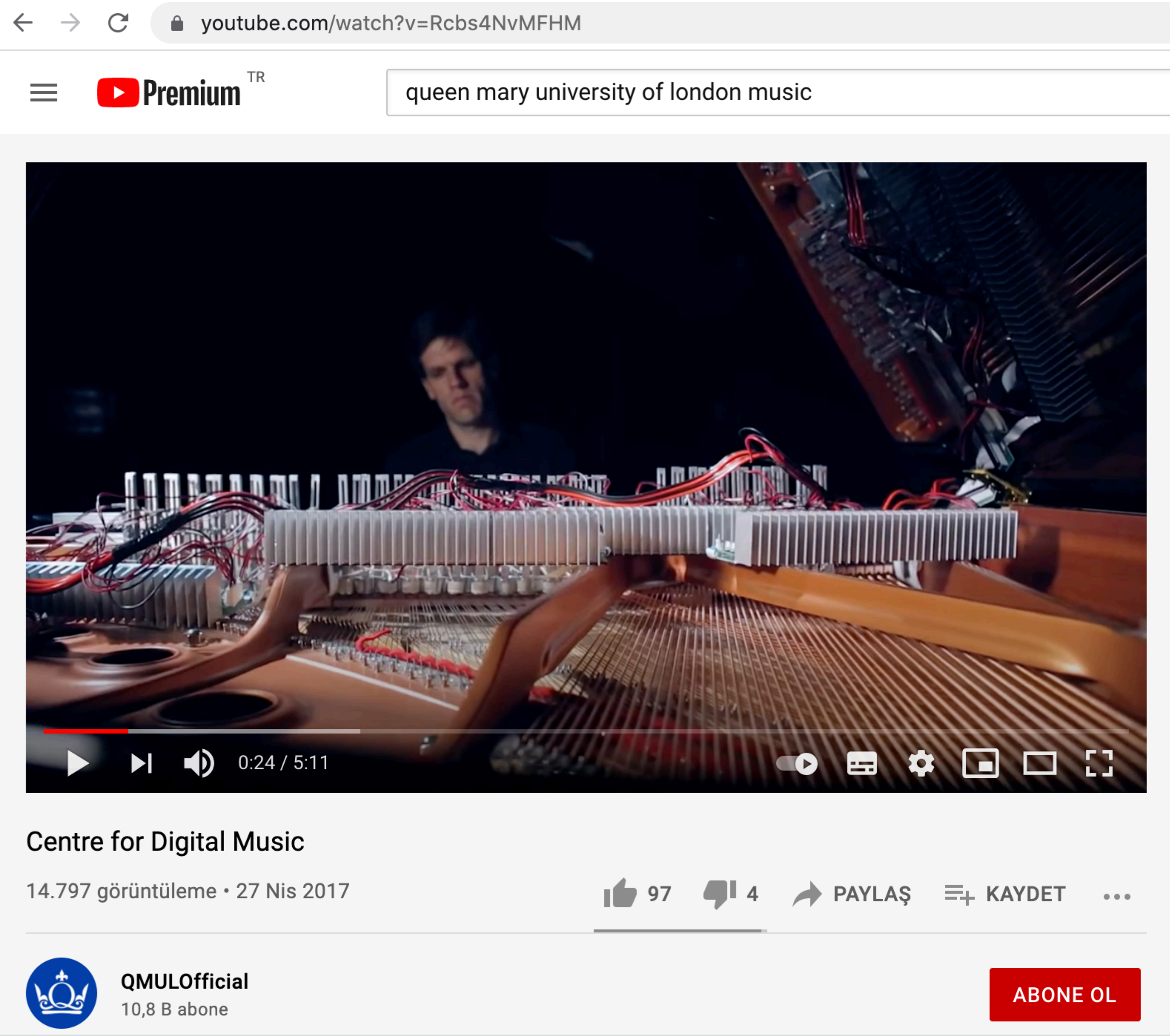
https://ccrma.stanford.edu/



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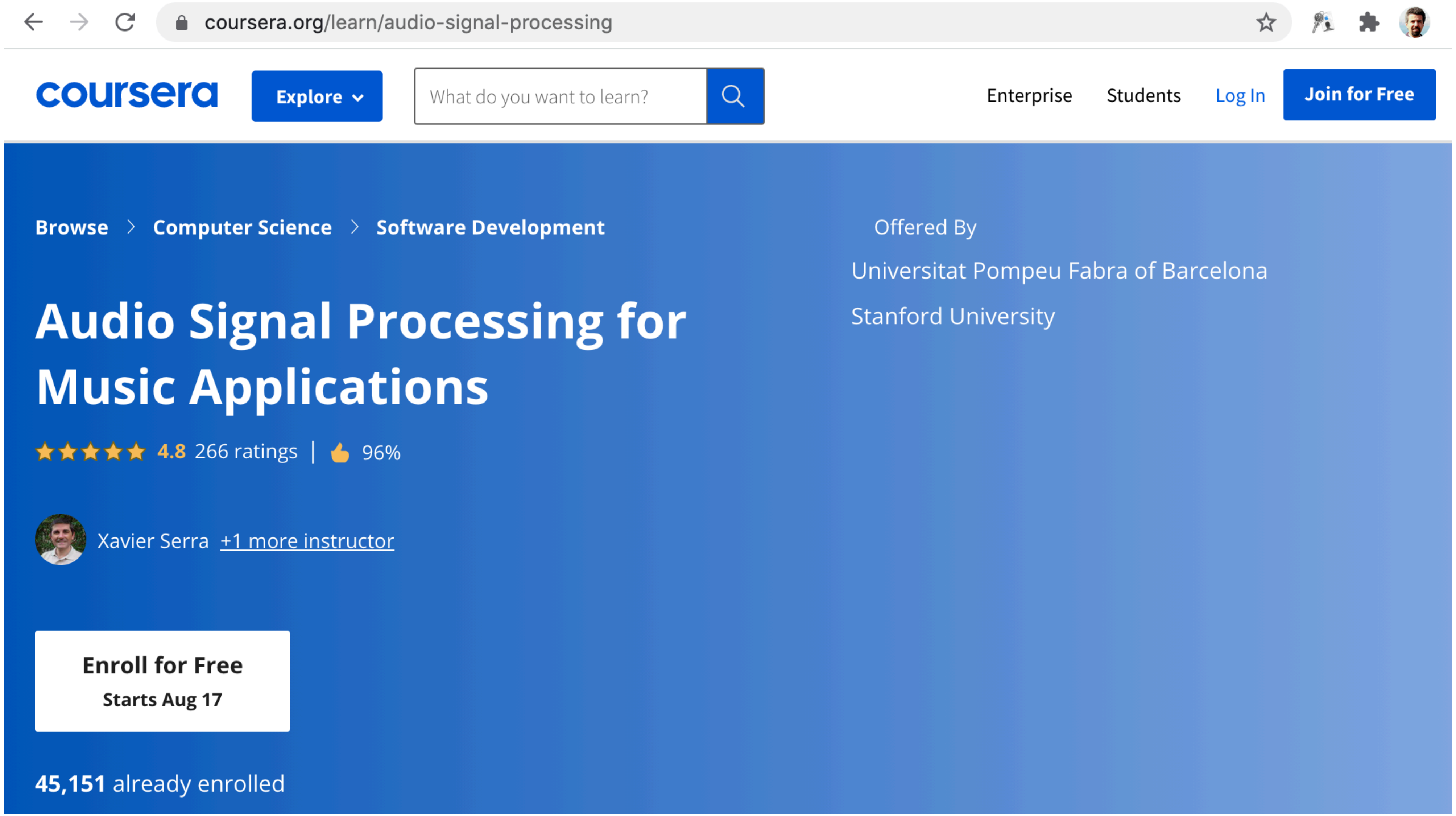

https://www.coursera.org/learn/audio-signal-processing