

Audio Files with Librosa

Code and audio for this article can be found here:

<https://git.arts.ac.uk/ipavlov/WikiMisc/blob/main/AudioProcessing.ipynb>

Documentaion for Librosa can be found here:

<https://librosa.org/doc/main/index.html>

Loading audio files

Librosa is a Python libray created for working with audio data. It's both easy to understand and has an extensive feature list.

By default Librosa supports all the popular audio file extensions, like WAV, OGG, MP3, and FLAC.

```
import librosa
import librosa.display

filename = librosa.ex('trumpet') #Loads sample audio file
y, sr = librosa.load(filename)
```

y — is a NumPy matrix that contains audio time series. If audio file is mono it will be one-dimensional vector, if audio file is stereo it will be two-dimensional, and so on.

sr — is audio file's sampling rate.

Playing audio in Jupyter notebook

Using the code bellow you will be able to play audio inside of your notebook. The player is very basic, but will be enough for simpler projects.

```
from IPython.display import Audio

Audio(data=y, rate=sr)
```

Vizualising audio files

To vizualise our audio files we can use Matplotlib.

```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 4))
```

```
librosa.display.waveshow(y, sr=sr) #This functions will display audio file's waveform.  
plt.show()
```



You can use code bellow to visualize audio file's spectrogram. Please refer to Librosa's documentation for explanation for each function used in the code bellow:

<https://librosa.org/doc/main/index.html>

```
fig, ax = plt.subplots()  
  
S = librosa.feature.melspectrogram(y=y, sr=sr, n_mels=128,  
                                   fmax=8000)  
  
S_dB = librosa.power_to_db(S, ref=np.max)  
img = librosa.display.specshow(S_dB, x_axis='time',  
                                y_axis='mel', sr=sr,  
                                fmax=8000, ax=ax)  
fig.colorbar(img, ax=ax, format='%+2.0f dB')  
ax.set(title='Mel-frequency spectrogram')
```



Working with multiple audio files

You can work multiple audio files. Just assign the time series for each file to a different variable or create a list of audio time series.

The code bellow looks at all .wav files in a given folder.

```
from glob import glob  
  
audio_filepaths = []  
  
for filename in glob('./audio/*.wav'):  
    audio_filepaths += [filename]  
  
audio_filepaths
```

Often times for AI&ML applications audio data needs to be of uniform length. To do this we can pad them.

```
padded_audio_files = []

max_allowed_length = 32000

for audio_filepath in audio_filepaths:

    y_voice, sr_voice = librosa.load(audio_filepath)

    if len(y_voice) > max_allowed_length:
        raise ValueError("data length cannot exceed padding length.")
    elif len(y_voice) < max_allowed_length:
        embedded_data = np.zeros(max_allowed_length)
        offset = max_allowed_length - len(y_voice)
        embedded_data[offset:offset+len(y_voice)] = y_voice
    elif len(y_voice) == max_allowed_length:
        embedded_data = y_voice

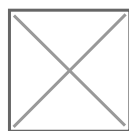
    padded_audio_files += [embedded_data]

padded_audio_files = np.array(padded_audio_files)

padded_audio_files.shape
```

You can also append multiple audio files together. Let's do it with our padded files.

```
long_number = padded_audio_files.flatten()
long_number.shape
```



The waveform of a new audio will look like this:

Note: Keep track of audio file shapes, especially along the 2nd axis.

Advanced Audio Analysis

Librosa has a wide range of tools for audio analyses. Some examples are included bellow.
Short-time Fourier transform:

```
S = np.abs(librosa.stft(y))
```

```
S.shape
```

Decibel analysis:

```
D = librosa.amplitude_to_db(librosa.stft(y), ref=np.max)
```

```
D.shape
```

Spectral flux:

```
#This code was taken from here: https://librosa.org/doc/main/generated/librosa.onset.onset\_strength.html
```

```
S = np.abs(librosa.stft(y))
```

```
times = librosa.times_like(S)
```

```
fig, ax = plt.subplots(nrows=2, sharex=True)
```

```
librosa.display.specshow(librosa.amplitude_to_db(S, ref=np.max),
```

```
                        y_axis='log', x_axis='time', ax=ax[0])
```

```
ax[0].set(title='Power spectrogram')
```

```
ax[0].label_outer()
```

```
onset_env = librosa.onset.onset_strength(y=y, sr=sr)
```

```
ax[1].plot(times, 2 + onset_env / onset_env.max(), alpha=0.8,
```

```
          label='Mean (mel)')
```

```
onset_env = librosa.onset.onset_strength(y=y, sr=sr,
```

```
                        aggregate=np.median,
```

```
                        fmax=8000, n_mels=256)
```

```
ax[1].plot(times, 1 + onset_env / onset_env.max(), alpha=0.8,
```

```
          label='Median (custom mel)')
```

```
C = np.abs(librosa.cqt(y=y, sr=sr))
```

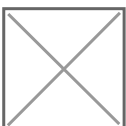
```
onset_env = librosa.onset.onset_strength(sr=sr, S=librosa.amplitude_to_db(C, ref=np.max))
```

```
ax[1].plot(times, onset_env / onset_env.max(), alpha=0.8,
```

```
          label='Mean (CQT)')
```

```
ax[1].legend()
```

```
ax[1].set(ylabel='Normalized strength', yticks=[])
```



Filters As with all Python libraries, to unlock the full potential of librosa they need to be

used with other libraries. The code bellow shows you how to apply a butter filter to audio signal, with a help of SciPy. ``python scipy.signal.butter

```
fig, ax = plt.subplots(nrows=2, figsize=(12, 4), constrained_layout=True)
```

```
ax[0].set(title='Normal waveform')
```

```
librosa.display.waveshow(y, sr=sr, ax=ax[0])
```

```
sos = signal.butter(17, 150, 'hp', fs=1000, output='sos') filtered = signal.sosfilt(sos, y)
```

```
ax[1].set(title='Filtered waveform')
```

```
librosa.display.waveshow(filtered, sr=sr, ax=ax[1])
```

```
filtered = filtered - 0.25 # Hearing protection
```

```

```

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