

Note : You have to keep your internet toggle **ON** to successfully execute all cells of this notebook.

Importing necessary Libraries

```
In [1]: import os
from os.path import isdir, join
from scipy.io import wavfile
from subprocess import check_output
from pathlib import Path
import pandas as pd

# Math
import numpy as np
from scipy.fftpack import fft
from scipy import signal
from scipy.io import wavfile
import librosa

from sklearn.decomposition import PCA

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns
import IPython.display as ipd
import librosa.display

import plotly.offline as py
py.init_notebook_mode(connected=True)
import plotly.graph_objs as go
import plotly.tools as tls
import pandas as pd

%matplotlib inline
```

0. Read the Audio Files

Earlier versions of this kernel could read .7z archive files directly.

But, recently kaggle is not able to read .7z archives directly after their config updates for the Notebook Environment. So, given below is a passage to overcome this hurdle.

We need to extract the 7z archive into a directory and work on it. Later, we need to delete it especially, if no. of files > 500. Read the instruction given below in three steps.

Step 1: Install Python packages in an internet-enabled notebook

```
In [2]: !pip install pyunpack
```

```
!pip install patool
```

Collecting pyunpack

Downloading <https://files.pythonhosted.org/packages/83/29/020436b1d8e96e5f26fa282b9c3c13a3b456a36b9ea2edc87c5fed008369/pyunpack-0.2.2-py2.py3-none-any.whl>

Collecting easyprocess

Downloading <https://files.pythonhosted.org/packages/48/3c/75573613641c90c6d094059ac28adb748560d99bd27ee6f80cce398f404e/EasyProcess-0.3-py2.py3-none-any.whl>

Collecting entryptpoint2

Downloading <https://files.pythonhosted.org/packages/8a/b0/8ef4b1d8be02448d164c52466530059d7f57218655d21309a0c4236d7454/entryptpoint2-0.2.4-py3-none-any.whl>

Installing collected packages: easyprocess, entryptpoint2, pyunpack

Successfully installed easyprocess-0.3 entryptpoint2-0.2.4 pyunpack-0.2.2

Collecting patool

Downloading <https://files.pythonhosted.org/packages/43/94/52243ddff508780dd2d8110964320ab4851134a55ab102285b46e740f76a/patool-1.12-py2.py3-none-any.whl> (77kB)

|██| 81kB 1.0MB/s eta 0:00:011

Installing collected packages: patool

Successfully installed patool-1.12

Step [#2]: Unpack your .7z file

```
In [3]: from pyunpack import Archive
import shutil
if not os.path.exists('/kaggle/working/train/'):
    os.makedirs('/kaggle/working/train/')
Archive('/kaggle/input/train.7z').extractall('/kaggle/working/train/')
for dirname, _, filenames in os.walk('/kaggle/working/train/'):
    for filename in filenames:
        os.path.join(dirname, filename)
#         print(os.path.join(dirname, filename))
```

ALL archived files have been extracted

Step 3: Then after you are finished working with the images you can delete them so that your commit will succeed (max number of files in working directory for a commit = 500)

```
In [4]: shutil.make_archive('train/', 'zip', 'train')
```

```
Out[4]: '/kaggle/working/train.zip'
```

Extracted files zipped again in .zip format (readable for kaggle kernels)

```
In [5]: # deleting unwanted extracted files to avoid memory overflow while committing.
!rm -rf kaggle/working/train/*
```

```
In [6]: # Loading the training Input file.
train_audio_path = "/kaggle/working/train/train/audio"
```

```
In [7]: # Checking to validate the presence of file.
```

```
print(check_output(["ls", "/kaggle/working/train/train/audio"]).decode("utf8"))
print(os.listdir("/kaggle/working/train/train/audio/yes"))
```

```
_background_noise_
bed
bird
cat
dog
down
eight
five
four
go
happy
house
left
marvin
nine
no
off
on
one
right
seven
sheila
six
stop
three
tree
two
up
wow
yes
zero
```

```
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ash_1.wav', 'baeac2ba_nohash_0.wav', 'c0445658_nohash_3.wav', 'afbec28d_nohash_1.wav',
'f17be97f_nohash_1.wav', 'ffd2ba2f_nohash_1.wav', '9db2bfe9_nohash_0.wav', '264f471d_noh
ash_3.wav', '70a00e98_nohash_1.wav', '7b301939_nohash_0.wav', 'dea820ce_nohash_0.wav',
'140a0fdc_nohash_1.wav', 'eb3f7d82_nohash_0.wav', 'da5dad9_nohash_1.wav', 'c1e0e8e3_noh
ash_0.wav', '918a2473_nohash_0.wav', '234ab0fb_nohash_2.wav', 'dd6c6806_nohash_0.wav',
'9b027ecf_nohash_2.wav', '51995cea_nohash_1.wav', '97ae8b25_nohash_1.wav', 'e0315cf6_noh
ash_2.wav', 'c38720cb_nohash_0.wav', '190821dc_nohash_3.wav', '84999496_nohash_0.wav',
'ad63d93c_nohash_3.wav', '76b58705_nohash_1.wav', '6727b579_nohash_3.wav', '8134f43f_noh
ash_2.wav', '84d1e469_nohash_2.wav', 'e7334395_nohash_1.wav', '325a0c39_nohash_0.wav',
'5e3dde6b_nohash_3.wav', 'af405b69_nohash_0.wav', '8830e17f_nohash_2.wav', 'f3cee168_noh
ash_0.wav', '363c6bad_nohash_4.wav', '8a28231e_nohash_3.wav', 'd107dc42_nohash_0.wav',
'069ab0d5_nohash_1.wav', '1d919a90_nohash_0.wav', '2796ac50_nohash_0.wav', 'f8f60f59_noh
ash_4.wav', 'fce65496_nohash_0.wav', '370844f7_nohash_1.wav', '11b1df78_nohash_1.wav',
'6c429c7b_nohash_2.wav', '626e323f_nohash_0.wav', '6b889021_nohash_0.wav', 'f84762e5_noh
ash_0.wav', '712e4d58_nohash_3.wav', '5b09db89_nohash_0.wav', '8eb4a1bf_nohash_4.wav',
'748cb308_nohash_1.wav', 'd9d6559e_nohash_1.wav', 'aac5b7c1_nohash_0.wav', '3209ec42_noh
ash_0.wav', 'cb8f8307_nohash_1.wav', '92e17cc4_nohash_1.wav', 'e54a0f16_nohash_0.wav',

'8830e17f_nohash_3.wav', '3e31dffe_nohash_0.wav', '2197f41c_nohash_2.wav', '70a00e98_nohash_4.wav', '042ea76c_nohash_1.wav', 'e57abea3_nohash_0.wav', '01d22d03_nohash_0.wav', '695c2127_nohash_0.wav', '413bcfe1_nohash_0.wav', 'f17be97f_nohash_3.wav', '06a79a03_nohash_0.wav', '2197f41c_nohash_0.wav', '5d9bb361_nohash_0.wav', '140a0fdc_nohash_0.wav', '1b63157b_nohash_3.wav', 'c2e08f08_nohash_0.wav', '333784b7_nohash_2.wav', 'd8ed3745_nohash_1.wav', 'dca2797e_nohash_1.wav', '5195f0ec_nohash_0.wav', 'ecbd8d66_nohash_0.wav', '4d9e07cf_nohash_0.wav', 'b8897f1c_nohash_0.wav', 'c1d39ce8_nohash_0.wav', '37a3cd33_nohash_0.wav', '01bb6a2a_nohash_4.wav', 'b9f46737_nohash_4.wav', '215699ff_nohash_1.wav', '36de13e1_nohash_0.wav', '59c3a7f2_nohash_0.wav', '28ce0c58_nohash_4.wav', 'b19f7f5f_nohash_0.wav', '042ea76c_nohash_0.wav', '229978fd_nohash_0.wav', '3ae5c04f_nohash_0.wav', 'b9515bf3_nohash_3.wav', 'c93d5e22_nohash_4.wav', '16d41d07_nohash_2.wav', '21832144_nohash_1.wav', '1ecfb537_nohash_2.wav', '62581901_nohash_0.wav', 'ab5ae445_nohash_1.wav', '1aeeef15e_nohash_1.wav', 'dedc7fab_nohash_1.wav', 'd4d898d7_nohash_0.wav', 'b43de700_nohash_0.wav', 'd9e9f554_nohash_1.wav', '9b6c08ba_nohash_1.wav', '3389305e_nohash_1.wav', '22aa3665_nohash_0.wav', '3e3fa7fd_nohash_0.wav', 'c2d15ea5_nohash_3.wav', '72d75d96_nohash_0.wav', '4f256313_nohash_0.wav', '51055bda_nohash_4.wav', '179a61b7_nohash_0.wav', '39a12648_nohash_4.wav', 'ceaadb24_nohash_1.wav', 'bd11a2e7_nohash_1.wav', '8781f4c1_nohash_0.wav', 'e7ea8b76_nohash_2.wav', '4f2ab70c_nohash_1.wav', 'c634a189_nohash_4.wav', 'e900b652_nohash_0.wav', '019fa366_nohash_1.wav', '7eee5973_nohash_0.wav', 'a50a98d2_nohash_0.wav', '96ab6565_nohash_3.wav', '363c6bad_nohash_5.wav', '6a203e0e_nohash_0.wav', '1b63157b_nohash_1.wav', '3f339c33_nohash_0.wav', 'b7a0754f_nohash_2.wav', '15c563d7_nohash_2.wav', 'ee483d85_nohash_1.wav', 'b959cd0c_nohash_1.wav', '30a09789_nohash_1.wav', 'cdfbbe75_nohash_0.wav', '48a8a69d_nohash_0.wav', 'e6db3894_nohash_0.wav', '56f8a100_nohash_0.wav', '692a88e6_nohash_4.wav', 'd197e3ae_nohash_1.wav', '13199b79_nohash_1.wav', '5677ec77_nohash_0.wav', '88a487ce_nohash_0.wav', '76424fa5_nohash_0.wav', '24befdb3_nohash_2.wav', '5e3dde6b_nohash_4.wav', '9c59dd28_nohash_1.wav', 'd069e6ff_nohash_0.wav', '97ae8b25_nohash_0.wav', '7ea032f3_nohash_2.wav', '9f869f70_nohash_2.wav', '96c67073_nohash_0.wav', 'b9db6e42_nohash_0.wav', 'e91d173e_nohash_0.wav', 'f6617a86_nohash_2.wav', '29fb33da_nohash_4.wav', '888a0c49_nohash_0.wav', '5b1db3ee_nohash_0.wav', 'da7689f1_nohash_0.wav', '743edf9d_nohash_1.wav', '41dce6f5_nohash_0.wav', 'c4e1f6e0_nohash_0.wav', '0819edb0_nohash_0.wav', '324210dd_nohash_4.wav', 'fd395b74_nohash_3.wav', 'c948d727_nohash_2.wav', '0f7dc557_nohash_1.wav', '3efa7ec4_nohash_0.wav', '7f74626f_nohash_1.wav', 'ffd2ba2f_nohash_3.wav', 'ac4b3fc3_nohash_0.wav', 'c1d39ce8_nohash_5.wav', '46a153d8_nohash_2.wav', 'e6db3894_nohash_1.wav', 'a827e3a1_nohash_0.wav', '8f4c551f_nohash_2.wav', '2b3f509b_nohash_0.wav', 'e8d562ca_nohash_0.wav', '3fdafe25_nohash_0.wav', 'b97c9f77_nohash_1.wav', '1b459024_nohash_0.wav', 'e900b652_nohash_3.wav', '9a69672b_nohash_4.wav', '72320401_nohash_2.wav', '0ff728b5_nohash_0.wav', 'c1eebc0b_nohash_0.wav', '022cd682_nohash_0.wav', '15574821_nohash_1.wav', 'f5733968_nohash_3.wav', '7e556a2c_nohash_0.wav', 'c53b335a_nohash_0.wav', '5188de0d_nohash_0.wav', '6f1ffef6_nohash_0.wav', '541120c7_nohash_0.wav', '51055bda_nohash_2.wav', '3bc21161_nohash_3.wav', 'f953e1af_nohash_2.wav', '462e1919_nohash_2.wav', '9aa21fa9_nohash_1.wav', '9a4d12fd_nohash_0.wav', '1093c8e7_nohash_0.wav', '90b94017_nohash_0.wav', '21cbe292_nohash_0.wav', 'adc216c5_nohash_1.wav', '10ace7eb_nohash_4.wav', '2c6d3924_nohash_0.wav', '6c0f6493_nohash_1.wav', 'c08585c1_nohash_0.wav', '9c59dd28_nohash_0.wav', 'b84f83d2_nohash_1.wav', 'de040337_nohash_2.wav', '78884794_nohash_0.wav', 'df1d5024_nohash_3.wav', '6982fc2a_nohash_0.wav', '38d78313_nohash_1.wav', '918a2473_nohash_4.wav', 'c0f8f4df_nohash_0.wav', 'bab36420_nohash_1.wav', '3c1e12cf_nohash_0.wav', '60472d26_nohash_0.wav', 'd197e3ae_nohash_2.wav', '1cc80e39_nohash_1.wav', 'd0faf7e4_nohash_6.wav', 'b9fdb9801_nohash_0.wav', 'e102119e_nohash_2.wav', '3df9a3d4_nohash_0.wav', '327289eb_nohash_1.wav', '4a4e28f1_nohash_0.wav', 'a74f3917_nohash_0.wav', '24694eb6_nohash_1.wav', '214ccb20_nohash_0.wav', '28ed6bc9_nohash_0.wav', '39a12648_nohash_3.wav', 'c79159aa_nohash_2.wav', '21832144_nohash_4.wav', '8d8d9855_nohash_0.wav', 'aa753bb9_nohash_2.wav', 'df1d5024_nohash_2.wav', 'e53139ad_nohash_2.wav', 'c1e0e8e3_nohash_2.wav', 'd84829e0_nohash_1.wav', '745a8e32_nohash_1.wav', '763188c4_nohash_1.wav', 'cd85758f_nohash_3.wav', '44f68a83_nohash_0.wav', 'ece1a95a_nohash_0.wav', '9a69672b_nohash_2.wav', 'aef8dcf5_nohash_0.wav', '3847619e_nohash_1.wav', '8dd788d8_nohash_0.wav', '130d9a87_nohash_1.wav', '11860c84_nohash_1.wav', 'f632210f_nohash_0.wav', 'aff582a1_nohash_3.wav', '8931f494_nohash_0.wav', 'fb495c43_nohash_0.wav', '460f2bad_nohash_0.wav', '439c84f4_nohash_3.wav', '06a79a03_nohash_1.wav', '459345ea_nohash_1.wav', '264f471d_nohash_4.wav', '617de221_nohash_0.wav', 'b87bdb22_nohash_3.wav', 'e1469561_nohash_0.wav', 'd312f481_nohash_0.wav', 'db8a3397_nohash_1.wav', '35d1b6ee_nohash_3.wav', '8012c69d_nohash_3.wav', '03cf93b1_nohash_1.wav', '7846fd85_nohash_2.wav', 'aff582a1_nohash_2.wav', 'cb2929ce_nohash_3.wav', 'a9f38bae_nohash_0.wav', '01648c51_nohash_0.wav', '0f7dc557_nohash_0.wav', 'cf68fad2_nohash_1.wav', 'ce9410da_nohash_1.wav', 'b52bd596_nohash_0.wav', '6f5b4d3d_nohash_0.wav', 'ae71797c_nohash_0.wav', '57cb3575_nohash_0.wav',

```
'1ecfb537_nohash_1.wav', '25132942_nohash_2.wav', '24c9f572_nohash_1.wav', '7211390b_nohash_0.wav']
```

```
In [8]: # As an example using this input file here...
filename = '/yes/00f0204f_nohash_0.wav'
```

```
In [9]: dirs = [f for f in os.listdir(train_audio_path) if isdir(join(train_audio_path, f))]
dirs.sort()
print('Number of labels: ' + str(len(dirs)))
```

Number of labels: 31

Audio Features.

```
sample_rate, samples = wavfile.read(str(train_audio_path) + filename)
```

The above code line works fine for everything except **Librosa** library MFCC functionality. So, we'll read wave files using **librosa** only.

We have to read samples in **librosa** format, Otherwise "librosa" error will come:

data must be in floating format

```
In [10]: samples, sample_rate = librosa.load(str(train_audio_path)+filename)
```

1. Visualization

There are two theories of a **human hearing - place** (frequency-based) and **temporal** In speech recognition, I see two main tendencies - to input spectrogram (frequencies), and more sophisticated features MFCC - Mel-Frequency Cepstral Coefficients, PLP. You rarely work with raw, temporal data.

Let's visualize some recordings!

1.1 Spectrogram

Define a function that calculates spectrogram.

Note, that we are taking logarithm of spectrogram values. It will make our plot much more clear, moreover, it is strictly connected to the way people hear. We need to assure that there are no 0 values as input to logarithm.

```
In [11]: def log_specgram(audio, sample_rate, window_size=20,
                        step_size=10, eps=1e-10):
    nperseg = int(round(window_size * sample_rate / 1e3))
    noverlap = int(round(step_size * sample_rate / 1e3))
    freqs, times, spec = signal.spectrogram(audio,
                                             fs=sample_rate,
                                             window='hann',
                                             nperseg=nperseg,
```

```

        noverlap=noverlap,
        detrend=False)
    return freqs, times, np.log(spec.T.astype(np.float32) + eps)

```

Frequencies are in range (0, 8000) according to Nyquist theorem.

Let's plot it:

```

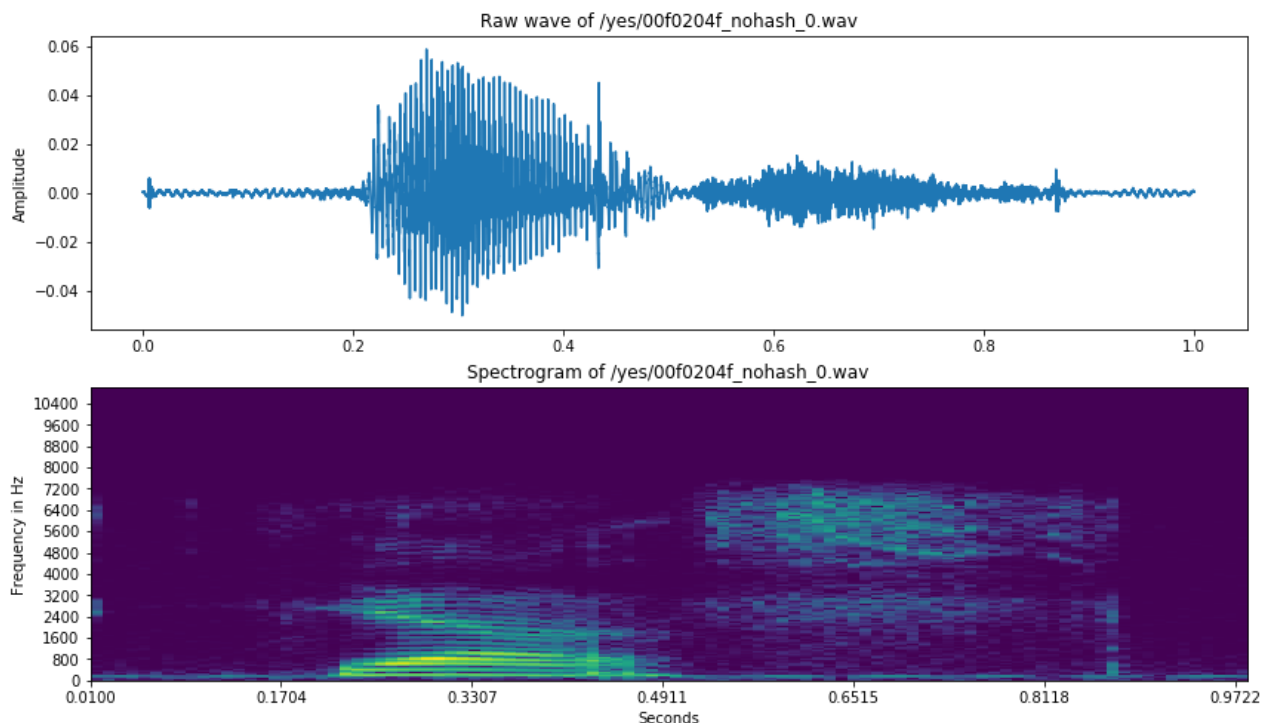
In [17]: freqs, times, spectrogram = log_spectrogram(samples, sample_rate)

fig = plt.figure(figsize=(14, 8))
plot1 = fig.add_subplot(211)
plot1.set_title('Raw wave of ' + filename)
plot1.set_ylabel('Amplitude')
plot1.plot(np.linspace(0, sample_rate/len(samples), sample_rate), samples)

plot2 = fig.add_subplot(212)
plot2.imshow(spectrogram.T, aspect='auto', origin='lower',
             extent=[times.min(), times.max(), freqs.min(), freqs.max()])
plot2.set_yticks(freqs[::16])
plot2.set_xticks(times[::16])
plot2.set_title('Spectrogram of ' + filename)
plot2.set_ylabel('Frequency in Hz')
plot2.set_xlabel('Seconds')

```

Out[17]: Text(0.5, 0, 'Seconds')



Normalizing the audio data, always a good plan if we gonna feed it into NN.

```

In [18]: mean = np.mean(spectrogram, axis=0)
std = np.std(spectrogram, axis=0)
spectrogram = (spectrogram - mean) / std

```

There is an interesting fact to point out. We have ~160 features for each frame, frequencies are

between 0 and 8000. It means, that one feature corresponds to 50 Hz. However, frequency resolution of the ear is 3.6 Hz within the octave of 1000 – 2000 Hz. It means, that people are far more precise and can hear much smaller details than those represented by spectrograms like above.

1.2 MFCC

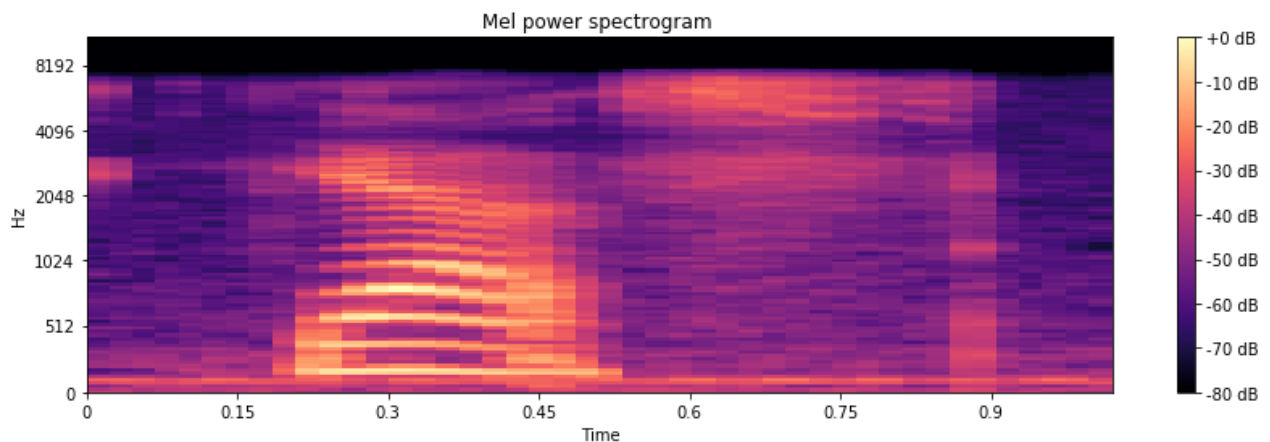
If you want to get to know some details about MFCC take a look at this great tutorial. You can see, that it is well prepared to imitate human hearing properties.

You can calculate Mel power spectrogram and MFCC using for example librosa python package.

```
In [19]: # From this tutorial
# https://github.com/Librosa/Librosa/blob/master/examples/LibROSA%20demo.ipynb
S = librosa.feature.melspectrogram(samples, sr=sample_rate, n_mels=128)

# Convert to Log scale (dB). Using the peak power (max) as reference.
log_S = librosa.power_to_db(S, ref=np.max)

plt.figure(figsize=(12, 4))
librosa.display.specshow(log_S, sr=sample_rate, x_axis='time', y_axis='mel')
plt.title('Mel power spectrogram ')
plt.colorbar(format='%+02.0f dB')
plt.tight_layout()
```

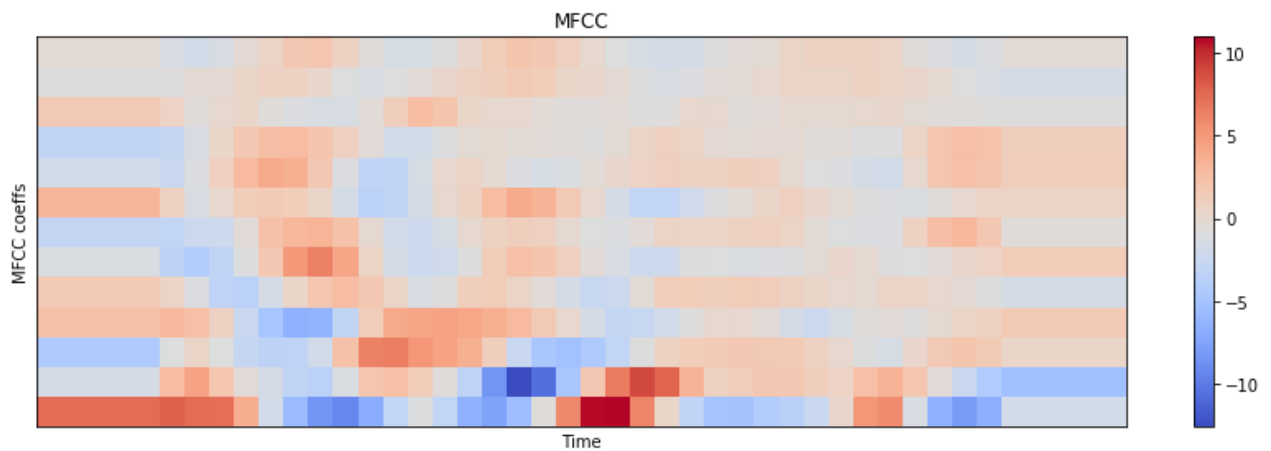


Now delta- mfcc

```
In [20]: mfcc = librosa.feature.mfcc(S=log_S, n_mfcc=13)

# Let's pad on the first and second deltas while we're at it
delta2_mfcc = librosa.feature.delta(mfcc, order=2)

plt.figure(figsize=(12, 4))
librosa.display.specshow(delta2_mfcc)
plt.ylabel('MFCC coeffs')
plt.xlabel('Time')
plt.title('MFCC')
plt.colorbar()
plt.tight_layout()
```

In classical, but still state-of-the-art systems, MFCC or similar features are taken as the input to the system instead of spectrograms.

However, in end-to-end (often neural-network based) systems, the most common input features are probably raw spectrograms, or mel power spectrograms. For example MFCC decorrelates features, but NNs deal with correlated features well. Also, if you'll understand mel filters, you may consider their usage sensible.

It is your decision which to choose!

1.3 Silence Removal

```
In [21]: samples_cut = samples[4000:13000]
         ipd.Audio(samples_cut, rate=sample_rate)
```

```
Out[21]: 0:00 / 0:00
```

We can agree that the entire word can be heard. It is impossible to cut all the files manually and do this basing on the simple plot. But you can use for example webrtcvad package to have a good VAD.

Let's plot it again, together with guessed alignment of 'y' 'e' 's' graphemes

```
In [24]: freqs, times, spectrogram_cut = log_spectrogram(samples_cut, sample_rate)

fig = plt.figure(figsize=(14, 8))
plot1 = fig.add_subplot(211)
plot1.set_title('Raw wave of ' + filename)
plot1.set_ylabel('Amplitude')
plot1.plot(samples_cut)

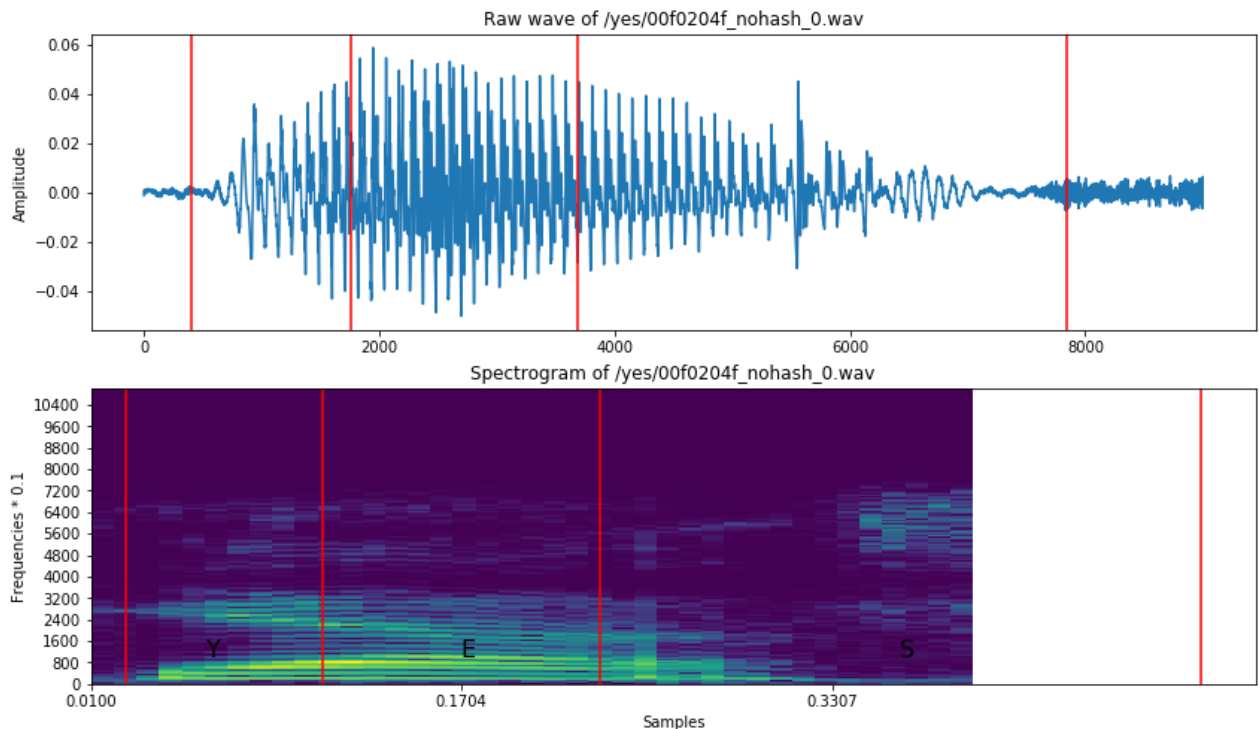
plot2 = fig.add_subplot(212)
plot2.set_title('Spectrogram of ' + filename)
plot2.set_ylabel('Frequencies * 0.1')
plot2.set_xlabel('Samples')
plot2.imshow(spectrogram_cut.T, aspect='auto', origin='lower',
             extent=[times.min(), times.max(), freqs.min(), freqs.max()])
plot2.set_yticks(freqs[::16])
```

```

plot2.set_xticks(times[::16])
plot2.text(0.06, 1000, 'Y', fontsize=16)
plot2.text(0.17, 1000, 'E', fontsize=16)
plot2.text(0.36, 1000, 'S', fontsize=16)

xcoords = [0.025, 0.11, 0.23, 0.49]
for xc in xcoords:
    plot1.axvline(x=xc*16000, c='r')
    plot2.axvline(x=xc, c='r')

```



1.4 Features extraction steps

A generalized feature extraction algorithm for an audio data sample is like:

1. Resampling
2. VAD
3. Maybe padding with 0 to make signals be equal length
4. Log spectrogram (or MFCC, or PLP)
5. Features normalization with mean and std
6. Stacking of a given number of frames to get temporal information

Though it can't be done in notebook. It has not much sense to write things from zero, and everything is ready to take, but in packages, that cannot be imported in Kernels.

2. Voice Activity Detection (VAD)

Using the webrtcvad library to identify segments as speech or not

```
In [25]: !pip install webrtcvad
```

Collecting webrtcvad

Downloading <https://files.pythonhosted.org/packages/89/34/e2de2d97f3288512b9ea56f92e7452f8207eb5a0096500badf9dfd48f5e6/webRTCvad-2.0.10.tar.gz> (66kB)

|██| 71kB 929kB/s eta 0:00:01

Building wheels for collected packages: webrtcvad

Building wheel for webrtcvad (setup.py) ... done

Created wheel for webrtcvad: filename=webrtcvad-2.0.10-cp36-cp36m-linux_x86_64.whl size=80370 sha256=9805536e673d1fd7b4c5b8d11cafc2c025c012f48057164b7547a30e078cb583

Stored in directory: /root/.cache/pip/wheels/44/2a/18/bd1aec41cac7c3051fe95d92a6ed446122ea31dc713c432fa1

Successfully built webrtcvad

Installing collected packages: webrtcvad

Successfully installed webrtcvad-2.0.10

```
In [26]: import webrtcvad
```

Reading the samples and sample_rate feature again to make them compatible with the webrtcvad library.

It reads at sample_rate = 16000, 32000, 48000; but we had sample_rate = 22050 with librosa.

```
In [27]: sample_rate, samples = wavfile.read(str(train_audio_path) + filename)
```

```
In [28]: vad = webrtcvad.Vad()

# set aggressiveness from 0 to 3
vad.set_mode(3)
```

Convert samples to raw 16 bit/sample stream needed by webrtcvad(there are other options available too , like 32)

```
In [29]: import struct
raw_samples = struct.pack("%dh" % len(samples), *samples)
```

2.1 run the detector on windows of 30 ms

[example here](#)

```
In [30]: window_duration = 0.03 # duration in seconds

samples_per_window = int(window_duration * sample_rate + 0.5)

bytes_per_sample = 2
```

2.2 Detect Speech instances in an audio

```
In [31]: segments = []

for start in np.arange(0, len(samples), samples_per_window):
    stop = min(start + samples_per_window, len(samples))

    is_speech = vad.is_speech(raw_samples[start * bytes_per_sample: stop * bytes_per_sa
```

```
segments.append(dict(
    start = start,
    stop = stop,
    is_speech = is_speech))
```

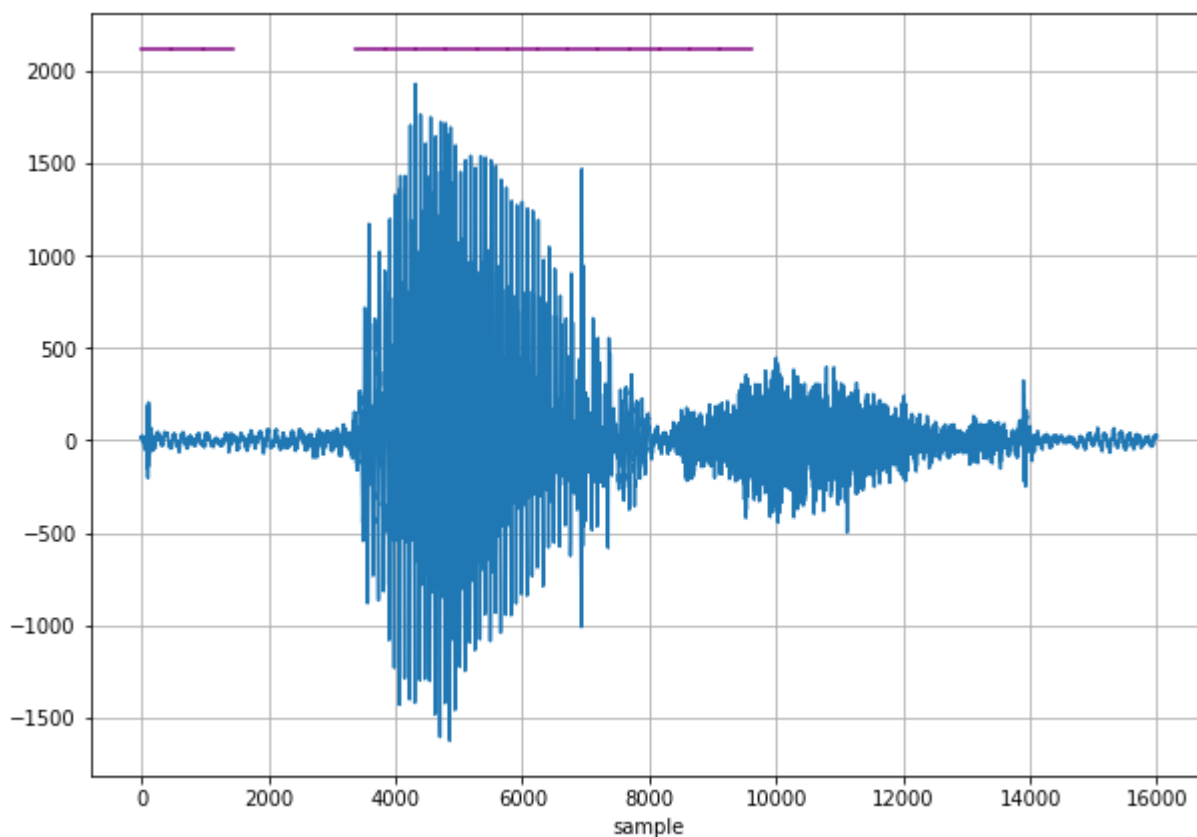
2.3 Plotting the range of samples identified as speech in purple

```
In [34]: plt.figure(figsize = (10,7))
plt.plot(samples)

ymax = max(samples)

# plot segment identified as speech
for segment in segments:
    if segment['is_speech']:
        plt.plot([ segment['start'], segment['stop'] - 1], [ymax * 1.1, ymax * 1.1], co

plt.xlabel('sample')
plt.grid()
```



3. Listen to the speech only segments

```
In [35]: speech_samples = np.concatenate([ samples[segment['start']:segment['stop']] for segment
```

```
import IPython.display as ipd
ipd.Audio(speech_samples, rate=sample_rate)
```

Out[35]:

0:00 / 0:00

Till now we have processed for a single audio of any one word : **YES** here.

Now, its time to have an overall view on other words also. So, lets visualize frequency components for other words as well.

4. Frequency components across the words

Plotting for first 8 words only to avoid clumsy tight plots.

In [38]:

```
def violinplot_frequency(dirs, freq_ind):
    """ Plot violinplots for given words (waves in dirs) and frequency freq_ind
    from all frequencies freqs."""

    spec_all = [] # Contain spectrograms
    ind = 0
    # taking first 8 words only to keep the plots clean and unclumsy.
    for direct in dirs[:8]:
        spec_all.append([])

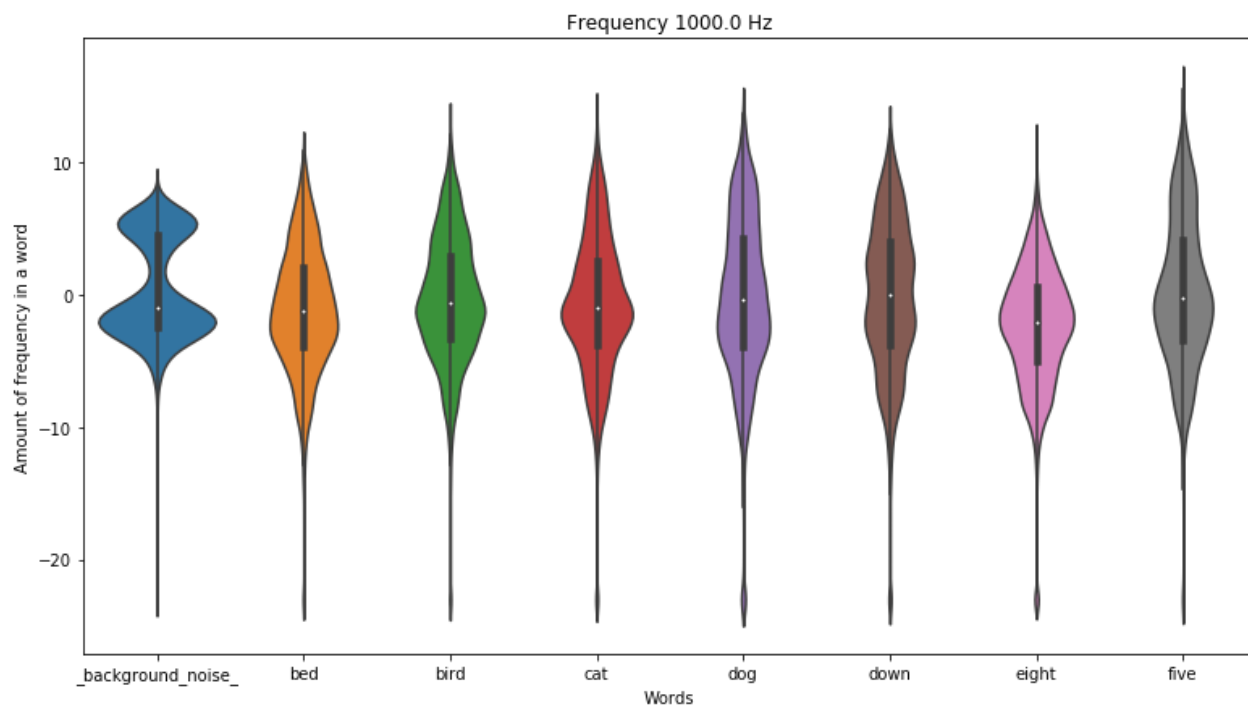
        waves = [f for f in os.listdir(join(train_audio_path, direct)) if
                  f.endswith('.wav')]
        for wav in waves[:100]:
            sample_rate, samples = wavfile.read(
                train_audio_path + '/' + direct + '/' + wav)
            freqs, times, spec = log_specgram(samples, sample_rate)
            spec_all[ind].extend(spec[:, freq_ind])
            ind += 1

    # Different Lengths = different num of frames. Make number equal
    minimum = min([len(spec) for spec in spec_all])
    spec_all = np.array([spec[:minimum] for spec in spec_all])

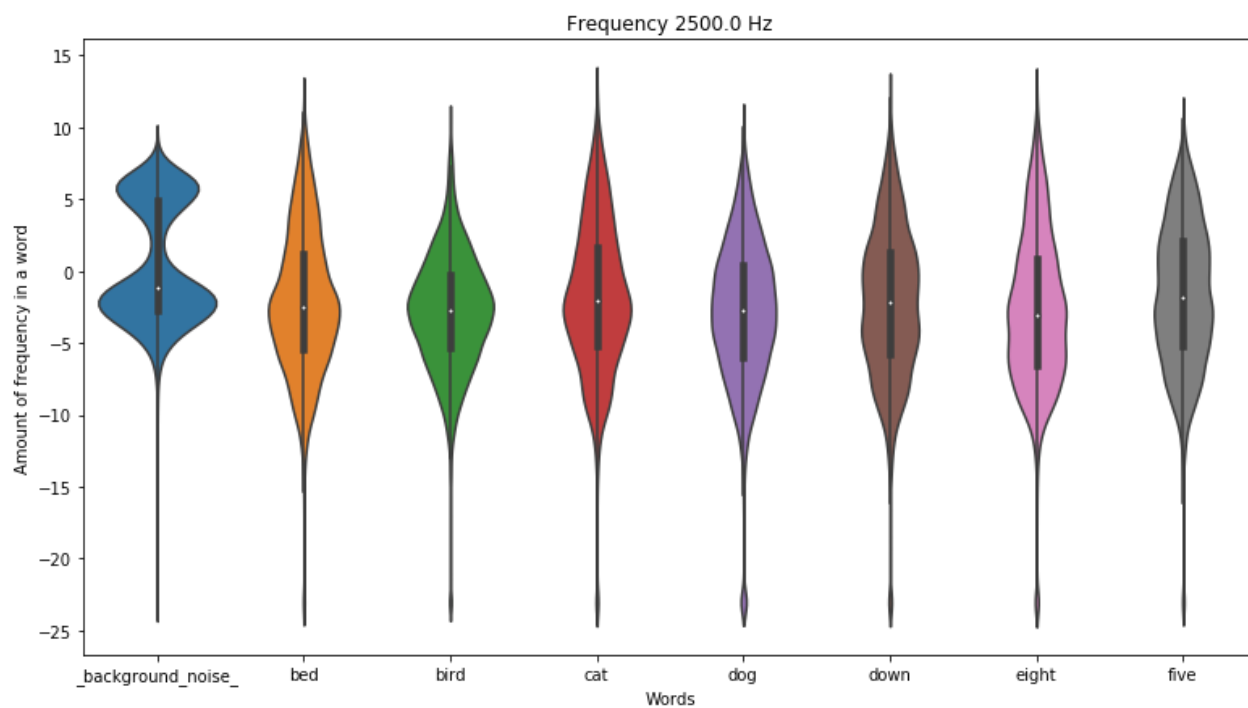
    plt.figure(figsize=(13,7))
    plt.title('Frequency ' + str(freqs[freq_ind]) + ' Hz')
    plt.ylabel('Amount of frequency in a word')
    plt.xlabel('Words')
    sns.violinplot(data=pd.DataFrame(spec_all.T, columns=dirs[:8]))
    plt.show()
```

In [39]:

```
violinplot_frequency(dirs, 20)
```



```
In [40]: violinplot_frequency(dirs, 50)
```



```
In [41]: violinplot_frequency(dirs, 120)
```

