Problem Defination

Speech Recognition is an important feature in several applications used such as home automation, artificial intelligence, etc. In many cases we need to convert the speech coming from live stream into text.

Data

Data has been taken from the :
http://download.tensorflow.org/data/speech_commands_v0.01.tar.gz

Features

Data Contains a few informational files and a folder of audio files. The audio folder contains subfolders with 1 second clips of voice commands, with the folder name being the label of the audio clip. There are more labels that should be predicted. The labels you will need to predict in Test are yes, no, up, down, left, right, on, off, stop, go. Everything else should be considered either unknown or silence. The folder *background_noise* contains longer clips of "silence" that you can break up and use as training input.

The files contained in the training audio are not uniquely named across labels, but they are unique if you include the label folder. For example, 00f0204f_nohash_0.wav is found in 14 folders, but that file is a different speech command in each folder.

The files are named so the first element is the subject id of the person who gave the voice command, and the last element indicated repeated commands. Repeated commands are when the subject repeats the same word multiple times. Subject id is not provided for the test data, and you can assume that the majority of commands in the test data were from subjects not seen in train.

You can expect some inconsistencies in the properties of the training data (e.g., length of the audio).

```
!wget "http://download.tensorflow.org/data/speech_commands_v0.01.tar.gz"
```

```
--2020-11-27 17:28:16--  http://download.tensorflow.org/data/speech_commands_v0.01.tar.g
Resolving download.tensorflow.org (download.tensorflow.org)... 142.250.31.128, 2607:f8b0
Connecting to download.tensorflow.org (download.tensorflow.org)|142.250.31.128|:80... co
HTTP request sent, awaiting response... 200 OK
Length: 1489096277 (1.4G) [application/gzip]
Saving to: ‘speech_commands_v0.01.tar.gz’

speech_commands_v0. 100%[===================>]   1.39G   154MB/s    in 9.1s

2020-11-27 17:28:26 (156 MB/s) - ‘speech_commands_v0.01.tar.gz’ saved [1489096277/148909
```

```
!tar -xvf 'speech_commands_v0.01.tar.gz' -C data/
```

Streaming output truncated to the last 5000 lines.

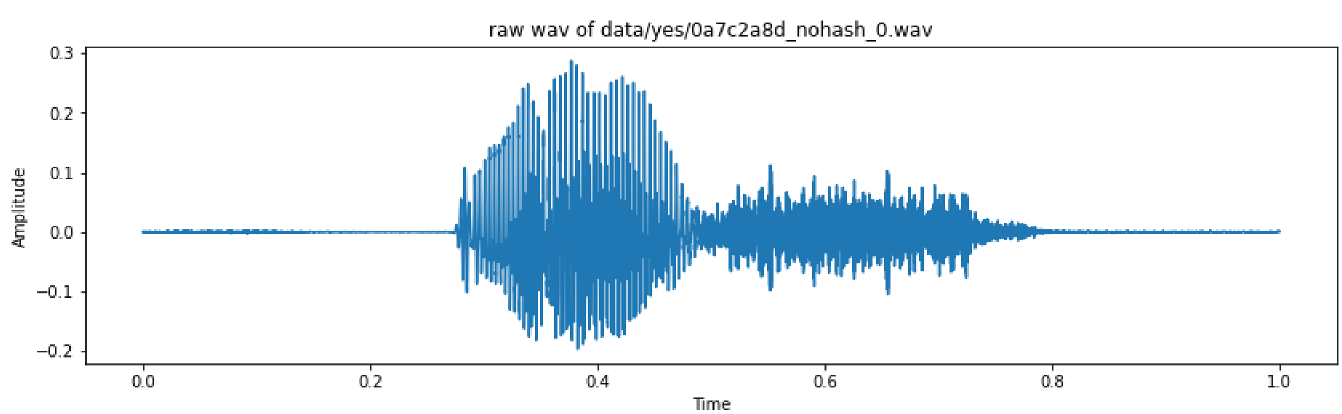
```
./up/6f9088d7_nohash_0.wav
./up/6f342826_nohash_0.wav
./up/e0a7c5a0_nohash_0.wav
./up/4d4e17f5_nohash_1.wav
./up/b0f24c9b_nohash_0.wav
./up/735845ab_nohash_2.wav
./up/53d5b86f_nohash_0.wav
./up/1a5b9ca4_nohash_1.wav
./up/23abe1c9_nohash_2.wav
./up/bdee441c_nohash_1.wav
./up/a1cff772_nohash_1.wav
./up/1ecfb537_nohash_3.wav
./up/37fc5d97_nohash_3.wav
./up/bd8412df_nohash_1.wav
./up/e53139ad_nohash_1.wav
./up/10ace7eb_nohash_3.wav
./up/30065f33_nohash_0.wav
./up/eefd26f3_nohash_0.wav
./up/c9b653a0_nohash_2.wav
./up/02746d24_nohash_0.wav
./up/e1469561_nohash_0.wav
./up/4bba14ce_nohash_0.wav
./up/b5d1e505_nohash_1.wav
./up/531a5b8a_nohash_1.wav
./up/0135f3f2_nohash_0.wav
./up/dbb40d24_nohash_4.wav
./up/e9287461_nohash_1.wav
./up/71e6ab20_nohash_0.wav
./up/ead2934a_nohash_1.wav
./up/f9af0887_nohash_0.wav
./up/ff63ab0b_nohash_0.wav
./up/f3d06008_nohash_0.wav
./up/918a2473_nohash_4.wav
./up/e54a0f16_nohash_0.wav
./up/cb8f8307_nohash_1.wav
./up/d197e3ae_nohash_3.wav
./up/53578f4e_nohash_0.wav
./up/234ab0fb_nohash_0.wav
./up/b00dff7e_nohash_1.wav
./up/8056e897_nohash_0.wav
./up/ad5aeec2_nohash_1.wav
./up/1365dd89_nohash_0.wav
./up/e4a2cf79_nohash_0.wav
./up/152491bc_nohash_0.wav
./up/18c54a68_nohash_0.wav
./up/9e46cfa1_nohash_1.wav
./up/7e6bd776_nohash_0.wav
./up/333784b7_nohash_0.wav
./up/f1b35ace_nohash_0.wav
./up/edc53350_nohash_0.wav
./up/229978fd_nohash_3.wav
./up/9e42ae25_nohash_0.wav
```

```
./up/28ce0c58_nohash_4.wav
./up/86fa2dcd_nohash_1.wav
./up/33f60c62_nohash_0.wav
./up/d103dd6e_nohash_1.wav
./up/712e4d58_nohash_3.wav
./up/982babaf_nohash_2.wav
```

```
import os
import librosa
import IPython.display as ipd
import matplotlib.pyplot as plt
import numpy as np
from scipy.io import wavfile
import warnings
warnings.filterwarnings("ignore")
```

Data exploration and visualization

```
train_audio_path='data/'
samples,sample_rate = librosa.load(train_audio_path+'yes/0a7c2a8d_nohash_0.wav',sr=16000)
fig = plt.figure(figsize=(14,8))
ax1 = fig.add_subplot(211)
ax1.set_title("raw wav of " +"data/yes/0a7c2a8d_nohash_0.wav")
ax1.set_xlabel("Time")
ax1.set_ylabel("Amplitude")
ax1.plot(np.linspace(0,sample_rate/len(samples),sample_rate),samples);
```



Sampling rate

The reason why I'm doing sample rate conversion is to transform data so that they all have the same shape and easy to be processed with machine learning models. But in real life, there are many more use cases of sample rate conversion.

```
ipd.Audio(samples,rate=sample_rate)
print(sample_rate)
```

```
16000
```

Resampling

```
samples = librosa.resample(samples,sample_rate,8000)
ipd.Audio(samples,rate=8000)
```

0:00 / 0:01

Number of recording of each voice

```
labels = os.listdir(train_audio_path)
labels
```

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

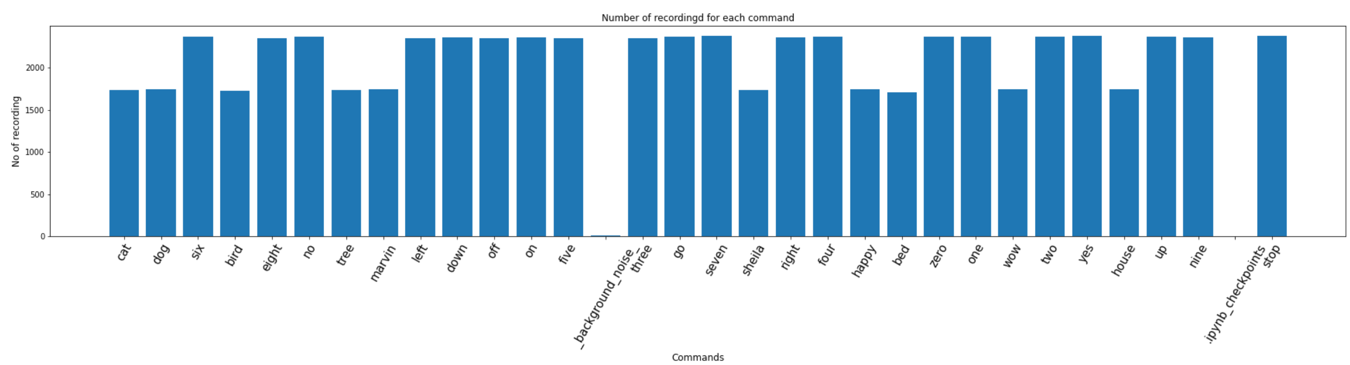
```
      '.ipynb_checkpoints',
      'stop']
```

```
labels = os.listdir(train_audio_path)
# Find the count of every wav file in different folder
no_of_recording=[]

for label in labels:
  waves = [f for f in os.listdir(train_audio_path+label) if f.endswith('.wav')]
  no_of_recording.append(len(waves))

# plot
fig = plt.figure(figsize=(30,5))
index = np.arange(len(labels))
plt.bar(index,no_of_recording)
plt.xlabel('Commands',fontsize=12)
plt.ylabel('No of recording',fontsize=12)
plt.xticks(index,labels,fontsize=15,rotation=60)
plt.title('Number of recordingd for each command')
plt.show()

labels=["yes","no","up","down","left","right","on","off","stop","go"]
```



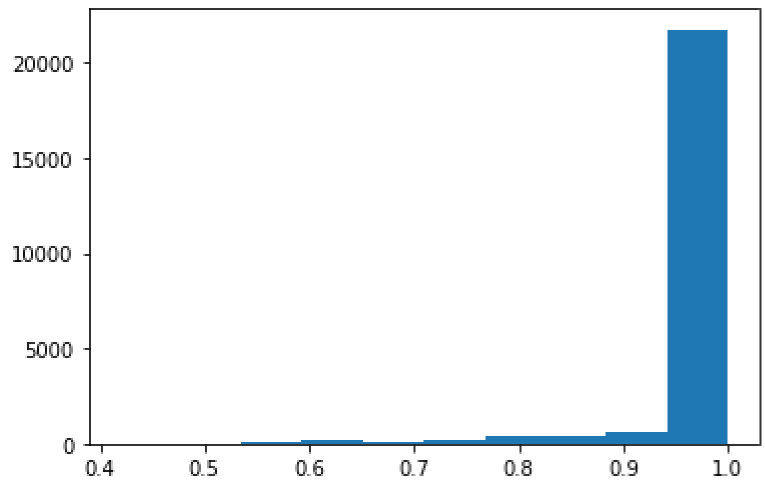
Duration of recordings

```
duration_of_recording=[]
```

```
for label in labels:
  waves = [f for f in os.listdir(train_audio_path+ '/' +label) if f.endswith('.wav')]
  for wav in waves:
    sample_rate,samples = wavfile.read(train_audio_path+ '/' +label+ '/' +wav)
    duration_of_recording.append(float(len(samples)/sample_rate))

plt.hist(np.array(duration_of_recording))
```

```
(array([1.5000e+01, 3.0000e+01, 4.4000e+01, 1.3800e+02, 1.3600e+02,
        1.7900e+02, 3.6600e+02, 4.3400e+02, 5.9300e+02, 2.1747e+04]),
 array([0.418 , 0.4762, 0.5344, 0.5926, 0.6508, 0.709 , 0.7672, 0.8254,
        0.8836, 0.9418, 1.    ]),
 <a list of 10 Patch objects>)
```




```
train_audio_path = 'data'

all_wave = []
all_label = []
for label in labels:
    print(label)
    waves = [f for f in os.listdir(train_audio_path + '/'+ label) if f.endswith('.wav')]
    for wav in waves:
        samples, sample_rate = librosa.load(train_audio_path + '/' + label + '/' + wav, sr =
        samples = librosa.resample(samples, sample_rate, 8000)
        if(len(samples)== 8000) :
            all_wave.append(samples)
            all_label.append(label)
```

```
yes
no
up
down
left
right
on
off
stop
go
```

Preprocess

```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
y=le.fit_transform(all_label)
classes= list(le.classes_)
```

```
from keras.utils import np_utils
y=np_utils.to_categorical(y, num_classes=len(labels))
all_wave = np.array(all_wave).reshape(-1,8000,1)
```

Splitiing the data

```
from sklearn.model_selection import train_test_split
x_tr, x_val, y_tr, y_val = train_test_split(np.array(all_wave),np.array(y),stratify=y,test_si
```

Building a model

```
from keras.layers import Dense, Dropout, Flatten, Conv1D, Input, MaxPooling1D
from keras.models import Model
from keras.callbacks import EarlyStopping, ModelCheckpoint
from keras import backend as K
K.clear_session()

inputs = Input(shape=(8000,1))

#First Conv1D layer
conv = Conv1D(8,13, padding='valid', activation='relu', strides=1)(inputs)
conv = MaxPooling1D(3)(conv)
conv = Dropout(0.2)(conv)

#Second Conv1D layer
conv = Conv1D(16, 11, padding='valid', activation='relu', strides=1)(conv)
conv = MaxPooling1D(3)(conv)
conv = Dropout(0.2)(conv)

#Third Conv1D layer
conv = Conv1D(32, 9, padding='valid', activation='relu', strides=1)(conv)
conv = MaxPooling1D(3)(conv)
conv = Dropout(0.2)(conv)

#Fourth Conv1D layer
conv = Conv1D(64, 7, padding='valid', activation='relu', strides=1)(conv)
```

```
conv = MaxPooling1D(3)(conv)
conv = Dropout(0.2)(conv)

#Flatten layer
conv = Flatten()(conv)

#Dense Layer 1
conv = Dense(256, activation='relu')(conv)
conv = Dropout(0.2)(conv)

#Dense Layer 2
conv = Dense(128, activation='relu')(conv)
conv = Dropout(0.2)(conv)

outputs = Dense(len(labels), activation='softmax')(conv)

model = Model(inputs, outputs)
model.summary()
```

```
Model: "functional_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_1 (InputLayer)         [(None, 8000, 1)]         0         
_________________________________________________________________
conv1d (Conv1D)              (None, 7988, 8)           112       
_________________________________________________________________
max_pooling1d (MaxPooling1D) (None, 2662, 8)           0         
_________________________________________________________________
dropout (Dropout)            (None, 2662, 8)           0         
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 2652, 16)          1424      
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 884, 16)           0         
_________________________________________________________________
dropout_1 (Dropout)          (None, 884, 16)           0         
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 876, 32)           4640      
_________________________________________________________________
max_pooling1d_2 (MaxPooling1 (None, 292, 32)           0         
_________________________________________________________________
dropout_2 (Dropout)          (None, 292, 32)           0         
_________________________________________________________________
conv1d_3 (Conv1D)            (None, 286, 64)           14400     
_________________________________________________________________
max_pooling1d_3 (MaxPooling1 (None, 95, 64)            0         
_________________________________________________________________
dropout_3 (Dropout)          (None, 95, 64)            0         
_________________________________________________________________
flatten (Flatten)            (None, 6080)              0         
_________________________________________________________________
dense (Dense)                (None, 256)               1556736   
_________________________________________________________________
dropout_4 (Dropout)          (None, 256)               0         
_________________________________________________________________
```

```
dense_1 (Dense)              (None, 128)               32896
_________________________________________________________________
dropout_5 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_2 (Dense)              (None, 10)                1290
=================================================================
Total params: 1,611,498
Trainable params: 1,611,498
Non-trainable params: 0
_________________________________________________________________
```

```
model.compile(loss='categorical_crossentropy',optimizer='sgd',metrics=['accuracy'])
```

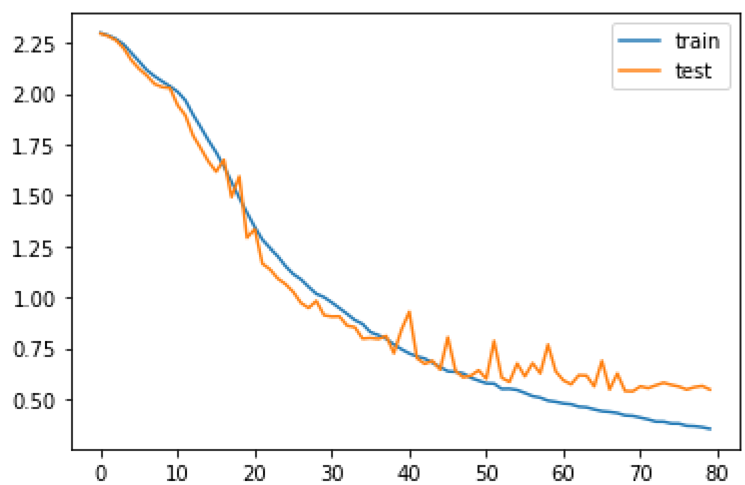
```
es = EarlyStopping(monitor='val_loss', mode='min', verbose=1, patience=10, min_delta=0.00001)
mc = ModelCheckpoint('best_model.hdf5', monitor='val_acc', verbose=1, save_best_only=True, mo
```

```
history=model.fit(x_tr, y_tr ,epochs=100, callbacks=[es,mc], batch_size=32, validation_data=(
```

```
Epoch 1/100
531/533 [============================>.] - ETA: 0s - loss: 2.2980 - accuracy: 0.1105W
533/533 [==============================] - 5s 9ms/step - loss: 2.2980 - accuracy: 0.1
Epoch 2/100
527/533 [============================>.] - ETA: 0s - loss: 2.2858 - accuracy: 0.1395W
533/533 [==============================] - 4s 8ms/step - loss: 2.2858 - accuracy: 0.1
Epoch 3/100
530/533 [============================>.] - ETA: 0s - loss: 2.2687 - accuracy: 0.1553W
533/533 [==============================] - 4s 8ms/step - loss: 2.2685 - accuracy: 0.1
Epoch 4/100
532/533 [============================>.] - ETA: 0s - loss: 2.2415 - accuracy: 0.1699W
533/533 [==============================] - 4s 8ms/step - loss: 2.2414 - accuracy: 0.1
Epoch 5/100
529/533 [============================>.] - ETA: 0s - loss: 2.2000 - accuracy: 0.1882W
533/533 [==============================] - 4s 8ms/step - loss: 2.1996 - accuracy: 0.1
Epoch 6/100
529/533 [============================>.] - ETA: 0s - loss: 2.1585 - accuracy: 0.2000W
533/533 [==============================] - 4s 8ms/step - loss: 2.1581 - accuracy: 0.2
Epoch 7/100
531/533 [============================>.] - ETA: 0s - loss: 2.1149 - accuracy: 0.2113W
533/533 [==============================] - 4s 8ms/step - loss: 2.1155 - accuracy: 0.2
Epoch 8/100
533/533 [==============================] - ETA: 0s - loss: 2.0853 - accuracy: 0.2245W
533/533 [==============================] - 4s 8ms/step - loss: 2.0853 - accuracy: 0.2
Epoch 9/100
532/533 [============================>.] - ETA: 0s - loss: 2.0600 - accuracy: 0.2305W
533/533 [==============================] - 4s 8ms/step - loss: 2.0598 - accuracy: 0.2
Epoch 10/100
526/533 [============================>.] - ETA: 0s - loss: 2.0366 - accuracy: 0.2372W
533/533 [==============================] - 4s 8ms/step - loss: 2.0359 - accuracy: 0.2
Epoch 11/100
528/533 [============================>.] - ETA: 0s - loss: 2.0091 - accuracy: 0.2450W
533/533 [==============================] - 4s 8ms/step - loss: 2.0087 - accuracy: 0.2
Epoch 12/100
529/533 [============================>.] - ETA: 0s - loss: 1.9665 - accuracy: 0.2644W
```

```
533/533 [==============================] - 4s 8ms/step - loss: 1.9670 - accuracy: 0.2
Epoch 13/100
531/533 [============================>.] - ETA: 0s - loss: 1.8969 - accuracy: 0.2942W
533/533 [==============================] - 4s 8ms/step - loss: 1.8962 - accuracy: 0.2
Epoch 14/100
526/533 [============================>.] - ETA: 0s - loss: 1.8358 - accuracy: 0.3166W
533/533 [==============================] - 4s 8ms/step - loss: 1.8340 - accuracy: 0.3
Epoch 15/100
533/533 [==============================] - ETA: 0s - loss: 1.7693 - accuracy: 0.3417W
533/533 [==============================] - 4s 8ms/step - loss: 1.7693 - accuracy: 0.3
Epoch 16/100
531/533 [============================>.] - ETA: 0s - loss: 1.7105 - accuracy: 0.3633W
533/533 [==============================] - 4s 8ms/step - loss: 1.7105 - accuracy: 0.3
Epoch 17/100
530/533 [============================>.] - ETA: 0s - loss: 1.6412 - accuracy: 0.3963W
533/533 [==============================] - 4s 8ms/step - loss: 1.6410 - accuracy: 0.3
Epoch 18/100
532/533 [============================>.] - ETA: 0s - loss: 1.5651 - accuracy: 0.4267W
533/533 [==============================] - 4s 8ms/step - loss: 1.5651 - accuracy: 0.4
Epoch 19/100
533/533 [==============================] - ETA: 0s - loss: 1.4865 - accuracy: 0.4584W
533/533 [==============================] - 4s 8ms/step - loss: 1.4865 - accuracy: 0.4
Epoch 20/100
```

```
from matplotlib import pyplot
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()
```




```
def predict(audio):
    prob=model.predict(audio.reshape(1,8000,1))
    index=np.argmax(prob[0])
    return classes[index]
```

```
import random
index=random.randint(0,len(x_val)-1)
samples=x_val[index].ravel()
```

```
samples=x_val[index].ravel()
print("Audio:",classes[np.argmax(y_val[index])])
ipd.Audio(samples, rate=8000)
print("Text:",predict(samples))
```

```
Audio: go
Text: go
```