In [1]:

```
%load_ext nb_black
```

```
<IPython.core.display.Javascript object>
```

In [2]:

```
import csv
import os
import pandas as pd
import librosa
import math
import json
import wave
import contextlib
```

```
<IPython.core.display.Javascript object>
```

In [3]:

```
SAMPLE_RATE = 22050
DURATION = 3
Total_Sample = SAMPLE_RATE * DURATION
```

```
<IPython.core.display.Javascript object>
```

In [4]:

```
def save_mfcc(
    dataset_path, json_path, n_mfcc=13, n_fft=1024, hop_length=256, num_segments=5
):

    data = {"id": [], "mfcc": [], "labels": []}
    c = 0
    count = 0
    number_of_sample_per_segment = int(Total_Sample / num_segments)

    expected_mfcc_per_segment = math.ceil(number_of_sample_per_segment / hop_length

    for root, dir, files in os.walk(dataset_path):
        for d in dir:
            print(d)
            if d not in d_less_2:
                c += 1
                for file in os.listdir(os.path.join(root, d)):
                    if file.endswith(".wav"):
                        print(file)

                        signal, sr = librosa.load(
                            os.path.join(root, d, file), sr=SAMPLE_RATE
                        )
                        label_string = disease_dict[d]
                        label_index = label_encoder[label_string]

                        for s in range(num_segments):
                            start_sample = number_of_sample_per_segment * s
                            finish_sample = number_of_sample_per_segment + start_sample

                            mfcc = librosa.feature.mfcc(
                                signal[start_sample:finish_sample],
                                sr=sr,
                                n_fft=n_fft,
                                n_mfcc=n_mfcc,
                                hop_length=hop_length,
                            )

                            mfcc = mfcc.T

                            if len(mfcc) == expected_mfcc_per_segment:
                                data["id"].append(d)
                                data["mfcc"].append(mfcc.tolist())
                                data["labels"].append(label_index)
                print("count", c)

    with open(json_path, "w") as fw:
```

```
    json.dump(data, fw, indent=4)
```

```
<IPython.core.display.Javascript object>
```

In [5]:

```
DATASET_PATH = "COVID-19"
JSON_PATH = "covid_19_data.json"
```

```
<IPython.core.display.Javascript object>
```

In [6]:

```
files = []
# r=root, d=directories, f = files
for r, d, f in os.walk(DATASET_PATH):
  for file in f:
    if ".wav" in file:
      files.append(os.path.join(r, file))
```

```
<IPython.core.display.Javascript object>
```

In [7]:

```
files
```

```
...
```

In [8]:

```
disease_dict = {}
d_less_2 = set()

for fname in files:
  with contextlib.closing(wave.open(fname, "r")) as f:
    d = fname.split("/")[1]

    frames = f.getnframes()
    rate = f.getframerate()
    duration = math.ceil(frames / float(rate))

    if duration == 0 or duration == 2 or duration == 1 or duration == 3:
      d_less_2.add(d)
```

```
<IPython.core.display.Javascript object>
```

In [9]:

```
len(d_less_2)
```

Out[9]:

116

<IPython.core.display.Javascript object>

In [10]:

```
disease = pd.read_csv(
   "https://raw.githubusercontent.com/iiscleap/Coswara-Data/master/combined_data.csv
)
ids = disease["id"].tolist()
labels = disease["covid_status"].tolist()
```

<IPython.core.display.Javascript object>

In [11]:

```
disease.head()
```

Out[11]:

| | id | a | covid_status | record_date | ep | g | l_c | |
|---|---|---|---|---|---|---|---|---|
| 0 | iV3Db6t1T8b7c5HQY2TwxIhjbzD3 | 28 | healthy | 2020-04-23 | y | male | India | An |
| 1 | AxuYWBN0jFVLINCBqIW5aZmGCdu1 | 25 | healthy | 2020-04-20 | y | male | India | BENG |
| 2 | C5eIsssb9GSkaAgIfsHMHeR6fSh1 | 28 | healthy | 2020-04-24 | y | female | United States | Pit |
| 3 | YjbEAECMBIaZKyfqOvWy5DDImUb2 | 26 | healthy | 2020-04-23 | y | male | India | Ba |
| 4 | aGOvk4ji0cVqIzCs1jHnzlw2UEy2 | 32 | healthy | 2020-04-22 | y | male | India | N |

5 rows × 36 columns

<IPython.core.display.Javascript object>

In [12]:

```
for id, label in zip(ids, labels):
   disease_dict[id] = label
```

<IPython.core.display.Javascript object>

In [13]:

```
label_encoder = {
   "healthy": 0,
   "no_resp_illness_exposed": 1,
   "positive_asymp": 2,
   "positive_mild": 3,
   "positive_moderate": 4,
   "recovered_full": 5,
   "resp_illness_not_identified": 6,
}
```

```
<IPython.core.display.Javascript object>
```

In [14]:

```
save_mfcc(DATASET_PATH, JSON_PATH)
```

...

## Model Preparation

In [16]:

```
import json
```

```
<IPython.core.display.Javascript object>
```

In [19]:

```
import numpy as np
import os
import json
from sklearn.model_selection import train_test_split
import tensorflow.keras as keras
from tensorflow.keras.models import load_model
import matplotlib.pyplot as plt
from sklearn.metrics import accuracy_score, f1_score, recall_score, precision_score
```

```
<IPython.core.display.Javascript object>
```

In [20]:

```
def load_dataset(dataset_path):

    with open(dataset_path, "r") as fr:
        data = json.load(fr)

    X = np.array(data["mfcc"])
    y = np.array(data["labels"])

    return X, y
```

```
<IPython.core.display.Javascript object>
```

In [21]:

```
def prepare_dataset(test_size, val_size):

    # load dataset
    X, y = load_dataset("covid_19_data.json")

    # split into train_test
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=test_size)

    # split into train and validation set
    X_train, X_validation, y_train, y_validation = train_test_split(
        X_train, y_train, test_size=val_size
    )

    # CNN take 4d array convert it into 4d array -> (number_Samples, 52, 13, 1)
    X_train = X_train[..., np.newaxis]
    X_test = X_test[..., np.newaxis]
    X_validation = X_validation[..., np.newaxis]

    return X_train, X_validation, X_test, y_train, y_validation, y_test
```

```
<IPython.core.display.Javascript object>
```

In [22]:

```
def build_model(input_shape):

  model = keras.Sequential()

  model.add(
    keras.layers.Conv2D(64, (3, 3), activation="relu", input_shape=input_shape)
  )
  model.add(keras.layers.MaxPool2D((3, 3), strides=(2, 2), padding="same"))
  model.add(keras.layers.BatchNormalization())

  #    model.add(keras.layers.Conv2D(64, (3,3), activation="relu"))
  #    model.add(keras.layers.MaxPool2D((3,3), strides=(2,2), padding= "same"))
  #    model.add(keras.layers.BatchNormalization())

  model.add(keras.layers.Conv2D(128, (2, 2), activation="relu"))
  model.add(keras.layers.MaxPool2D((2, 2), strides=(2, 2), padding="same"))
  model.add(keras.layers.BatchNormalization())

  model.add(keras.layers.Flatten())
  model.add(keras.layers.Dense(128, activation="relu"))
  model.add(keras.layers.Dropout(0.5))

  model.add(keras.layers.Dense(7, activation="softmax"))
  return model
```

```
<IPython.core.display.Javascript object>
```

In [23]:

```
def predict(model, X, y):

  # X is 3 dimentional array convert it into 4 dimention array
  X = X[np.newaxis, ...]

  # predict return array with probability
  prediction = model.predict(X)

  # extract the index with max value
  predicted_index = np.argmax(prediction, axis=1)
  print("The Expected index : {}, Predicted index : {}".format(y, predicted_index))
```

```
<IPython.core.display.Javascript object>
```

In [24]:

```
def plot_graph(epochs, history):
  N = epochs
  plt.style.use("ggplot")
  plt.figure()
  plt.plot(np.arange(0, N), history.history["loss"], label="train_loss")

  plt.plot(np.arange(0, N), history.history["val_loss"], label="val_loss")

  plt.plot(np.arange(0, N), history.history["accuracy"], label="train_acc")

  plt.plot(np.arange(0, N), history.history["val_accuracy"], label="val_acc")

  plt.title("Training Loss and Accuracy on Dataset")
  plt.xlabel("Epoch")
  plt.ylabel("Loss/Accuracy")
  plt.legend(loc="upper right")
  plt.savefig("plots\covid_plot.png")
```

```
<IPython.core.display.Javascript object>
```

In [25]:

```
# create train, validation and test set
X_train, X_validation, X_test, y_train, y_validation, y_test = prepare_dataset(
  0.25, 0.2
)

print(len(X_train))  # 8261
print(len(X_test))  # 3443
print(len(X_validation))  # 2066
```

```
8261
3443
2066

<IPython.core.display.Javascript object>
```

In [26]:

```
X_train.shape
```

Out[26]:

```
(8261, 52, 13, 1)

<IPython.core.display.Javascript object>
```

In [31]:

```
# build model
input_shape = (X_train.shape[1], X_train.shape[2], X_train.shape[3])
```

```
<IPython.core.display.Javascript object>
```

In [32]:

```
model = build_model(input_shape)
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_4 (Conv2D)            (None, 50, 11, 64)        640       
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 25, 6, 64)         0         
_________________________________________________________________
batch_normalization_4 (Batch (None, 25, 6, 64)         256       
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 24, 5, 128)        32896     
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 12, 3, 128)        0         
_________________________________________________________________
batch_normalization_5 (Batch (None, 12, 3, 128)        512       
_________________________________________________________________
flatten_2 (Flatten)          (None, 4608)              0         
_________________________________________________________________
dense_4 (Dense)              (None, 128)               589952    
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0         
_________________________________________________________________
dense_5 (Dense)              (None, 7)                 903       
=================================================================
Total params: 625,159
Trainable params: 624,775
Non-trainable params: 384
_________________________________________________________________
```

```
<IPython.core.display.Javascript object>
```

In [33]:

```
# compile the model
optimizer = keras.optimizers.Adam(learning_rate=0.001)
model.compile(
    optimizer=optimizer, loss="sparse_categorical_crossentropy", metrics=["accuracy"]
)
```

```
<IPython.core.display.Javascript object>
```

In [34]:

```
history = model.fit(
    X_train,
    y_train,
    validation_data=(X_validation, y_validation),
    batch_size=32,
    epochs=6,
)
```

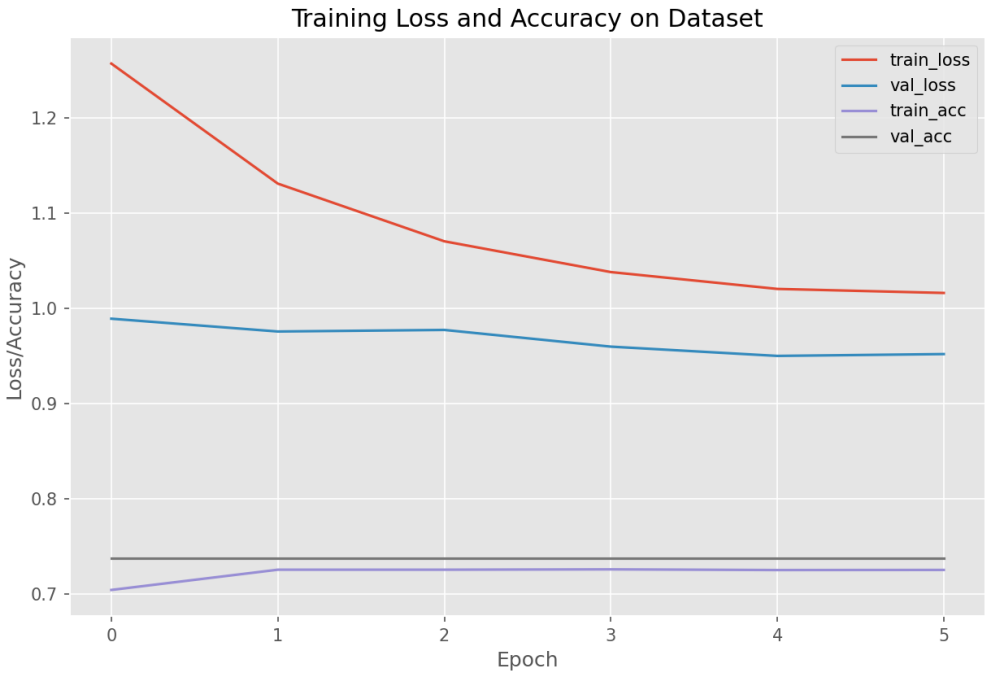
```
Epoch 1/6
259/259 [==============================] - 3s 11ms/step - loss:
1.2575 - accuracy: 0.7039 - val_loss: 0.9892 - val_accuracy: 0.73
77
Epoch 2/6
259/259 [==============================] - 3s 11ms/step - loss:
1.1313 - accuracy: 0.7252 - val_loss: 0.9757 - val_accuracy: 0.73
77
Epoch 3/6
259/259 [==============================] - 3s 11ms/step - loss:
1.0706 - accuracy: 0.7252 - val_loss: 0.9774 - val_accuracy: 0.73
77
Epoch 4/6
259/259 [==============================] - 3s 11ms/step - loss:
1.0382 - accuracy: 0.7256 - val_loss: 0.9598 - val_accuracy: 0.73
77
Epoch 5/6
259/259 [==============================] - 3s 11ms/step - loss:
1.0205 - accuracy: 0.7249 - val_loss: 0.9501 - val_accuracy: 0.73
77
Epoch 6/6
259/259 [==============================] - 3s 11ms/step - loss:
1.0163 - accuracy: 0.7250 - val_loss: 0.9520 - val_accuracy: 0.73
77


<IPython.core.display.Javascript object>
```

In [36]:

```
# # plot accuracy graph
%matplotlib notebook
plot_graph(6, history)
```

```
<IPython.core.display.Javascript object>
```




```
<IPython.core.display.Javascript object>
```

In [27]:

```
model.save("model_4_6_Extract_MFCCs_Features.h5")
```

```
<IPython.core.display.Javascript object>
```

In [38]:

```
yhat_classes = model.predict_classes(X_test, verbose=0)
print(yhat_classes)
print(y_test)
```

```
[0 0 0 ... 0 0 0]
[1 0 0 ... 0 3 0]

<IPython.core.display.Javascript object>
```

In [39]:

```
accuracy = accuracy_score(y_test, yhat_classes)
print("Accuracy: %f" % accuracy)
```

```
Accuracy: 0.718269

<IPython.core.display.Javascript object>
```

In [40]:

```
test_error, test_accuracy = model.evaluate(X_test, y_test, verbose=1)
print("Accuracy on test set is: {}".format(test_accuracy))
```

```
108/108 [==============================] - 0s 3ms/step - loss: 1.
0016 - accuracy: 0.7183
Accuracy on test set is: 0.7182689309120178

<IPython.core.display.Javascript object>
```

In [41]:

```
# make prediction on single sample
X = X_test[457]
y = y_test[457]

predict(model, X, y)
```

```
The Expected index : 0, Predicted index : [0]

<IPython.core.display.Javascript object>
```

In [ ]:

```

```