MFCC Model Final

May 6, 2023

[1]:

```
import os
import json
import csv
import sys
import numpy as np
import matplotlib.pyplot as plt
import librosa
import tensorflow as tf
from sklearn.model_selection import train_test_split, StratifiedShuffleSplit
from tensorflow.keras.utils import plot_model
import datetime
import time
from tensorflow.keras.callbacks import TensorBoard
```

```
2023-05-04 12:10:32.231539: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild
TensorFlow with the appropriate compiler flags.
```

[2]:

```
#Paths and declaration
audio_path = "./FMA Balanced"
csv_path = "csv_data.csv"

sr=22050

csv.field_size_limit(sys.maxsize)
```

[2]:

```
131072
```

[3]:

```
#All songs under 30 seconds
TOTAL_SAMPLES = 29 * sr

#Split the song in 3
NUM_SLICES = 3
SAMPLES_PER_SLICE = int(TOTAL_SAMPLES / NUM_SLICES)
```

[4]:

```
#Write MFCC to CSV
def csv_write_data(audio_path, csv_path):
    #Create a list of rows for writing to CSV
    rows = []

    #Generate MFCC for every song & writing to CSV
    for i, (dirpath, dirnames, filenames) in enumerate(os.walk(audio_path)):
        for file in filenames:
            #Generate MFCC for every item in audio_path * slice
            song, sr = librosa.load(os.path.join(dirpath, file),duration=29)

            for s in range(NUM_SLICES):
                start_sample = SAMPLES_PER_SLICE * s
                end_sample = start_sample + SAMPLES_PER_SLICE


                mfcc = librosa.feature.mfcc(y=song[start_sample:end_sample],␣
 ↪sr=sr, n_mfcc=40)
                mfcc = mfcc.T

                rows.append([i-1,json.dumps(mfcc.tolist())])

        #Writing CSV
        with open(csv_path, 'w', newline='') as csvfile:
            writer = csv.writer(csvfile)

            # Write the header row
            writer.writerow(["genre", "mfcc"])

            # Write the values rows
            for row in rows:
                writer.writerow(row)
```

[5]:

```
#Read MFCC data from CSV
def csv_read_data(csv_path):
    # Load data from CSV file
    with open(csv_path, 'r') as csvfile:
        reader = csv.reader(csvfile)

        next(reader)

        # Initialize lists to hold genre and MFCC data
        genres = []
        mfcc = []

        # Iterate over each row of the CSV file
        for row in reader:
            # Extract genre and MFCC data from the row
            genre = int(row[0])
            mfcc_data = json.loads(row[1])

            # Append genre and MFCC data to lists
            genres.append(genre)
            mfcc.append(mfcc_data)

    # Convert lists to numpy arrays
    X = np.array(mfcc)
    y = np.array(genres)

    return X, y
```

[6]:

```
#Use stratified split to seperate data into training, validation and test

def stratified_split_dataset(inputs, targets, split_size):
    sss = StratifiedShuffleSplit(n_splits=1, test_size=split_size,␣
 ↪random_state=42)

    train_val_indices, test_indices = next(sss.split(inputs, targets))
    inputs_train_val, targets_train_val = inputs[train_val_indices],␣
 ↪targets[train_val_indices]

    sss_train = StratifiedShuffleSplit(n_splits=1, test_size=split_size,␣
 ↪random_state=43)
    train_indices, val_indices = next(sss_train.split(inputs_train_val,␣
 ↪targets_train_val))

    inputs_train, targets_train = inputs_train_val[train_indices],␣
 ↪targets_train_val[train_indices]
    inputs_val, targets_val = inputs_train_val[val_indices],␣
 ↪targets_train_val[val_indices]
    inputs_test, targets_test = inputs[test_indices], targets[test_indices]

    #Needed for compatibility reasons
    inputs_train = inputs_train[...,np.newaxis]
    inputs_val = inputs_val[...,np.newaxis]
    inputs_test=  inputs_test[..., np.newaxis]


    return inputs_train, inputs_val, inputs_test, targets_train, targets_val,␣
 ↪targets_test
```

[15]:

```
#Design the model
def design_model(input_shape):
    model = tf.keras.models.Sequential([

        tf.keras.layers.Conv2D(64, (3,3), activation='relu',␣
 ↪input_shape=input_shape),
        tf.keras.layers.MaxPooling2D((3,3), strides=(2,2), padding='same'),
        tf.keras.layers.BatchNormalization(),

        tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
        tf.keras.layers.MaxPooling2D((3,3), strides=(2,2), padding='same'),
        tf.keras.layers.BatchNormalization(),

        tf.keras.layers.Conv2D(64, (2,2), activation='relu'),
        tf.keras.layers.MaxPooling2D((3,3), strides=(2,2), padding='same'),
        tf.keras.layers.BatchNormalization(),
        tf.keras.layers.Dropout(0.3),

        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(len(np.unique(targets)), activation='softmax')
    ])

    return model
```

[8]:

```
#Used to plot performance history of model
def plot_performance(hist):

    acc = hist.history['acc']
    val_acc = hist.history['val_acc']
    loss = hist.history['loss']
    val_loss = hist.history['val_loss']

    epochs = range(len(acc))

    plt.plot(epochs, acc, 'r', label='Training accuracy')
    plt.plot(epochs, val_acc, 'b', label='Validation accuracy')
    plt.title('Training and validation accuracy')
    plt.legend()
    plt.figure()

    plt.plot(epochs, loss, 'r', label='Training Loss')
    plt.plot(epochs, val_loss, 'b', label='Validation Loss')
    plt.title('Training and validation loss')
    plt.legend()

    plt.show()
```

[9]:

```
#=============== MAIN ===============

#CSV WRITING DATA
csv_write_data(audio_path, csv_path)
```

[10]:

```
#Reading MFCC data from CSV
inputs, targets = csv_read_data(csv_path)
```

[11]:

```
#Splitting data
Xtrain, Xval, Xtest, ytrain, yval, ytest =stratified_split_dataset(inputs,␣
 ↪targets, 0.2)
```

[16]:

```
#Model Creation
input_shape = (Xtrain.shape[1], Xtrain.shape[2], 1)
model = design_model(input_shape)

model.compile(optimizer = tf.keras.optimizers.Adam(learning_rate=0.001),
             loss = 'sparse_categorical_crossentropy',
             metrics = ['acc'])
```

```
2023-05-04 12:10:59.823788: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1635] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 22250 MB memory:  -> device:
0, name: NVIDIA GeForce RTX 3090, pci bus id: 0000:81:00.0, compute capability:
8.6
```

[22]:

```
#Model Summary
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 415, 38, 64)       640

 max_pooling2d (MaxPooling2D  (None, 208, 19, 64)      0
 )

 batch_normalization (BatchN  (None, 208, 19, 64)      256
 ormalization)

 conv2d_1 (Conv2D)           (None, 206, 17, 64)       36928

 max_pooling2d_1 (MaxPooling  (None, 103, 9, 64)       0
 2D)

 batch_normalization_1 (Batc  (None, 103, 9, 64)       256
 hNormalization)

 conv2d_2 (Conv2D)           (None, 102, 8, 64)        16448

 max_pooling2d_2 (MaxPooling  (None, 51, 4, 64)        0
 2D)

 batch_normalization_2 (Batc  (None, 51, 4, 64)        256
 hNormalization)

 dropout (Dropout)           (None, 51, 4, 64)         0

 flatten (Flatten)           (None, 13056)             0

 dense (Dense)               (None, 64)                835648

 dense_1 (Dense)             (None, 7)                 455

=================================================================
Total params: 890,887
Trainable params: 890,503
Non-trainable params: 384
_________________________________________________________________
```

[17]:

```
#TENSORBOARD
NAME= "Final Version"
log_dir = "logs/fit/" + NAME
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir,␣
 ↪histogram_freq=1)
```

[18]:

```
#COMPILATION
history = model.fit(Xtrain, ytrain,
                    validation_data = (Xval, yval),
                    epochs = 15,
                    batch_size = 64,
                    callbacks=[tensorboard_callback])
```

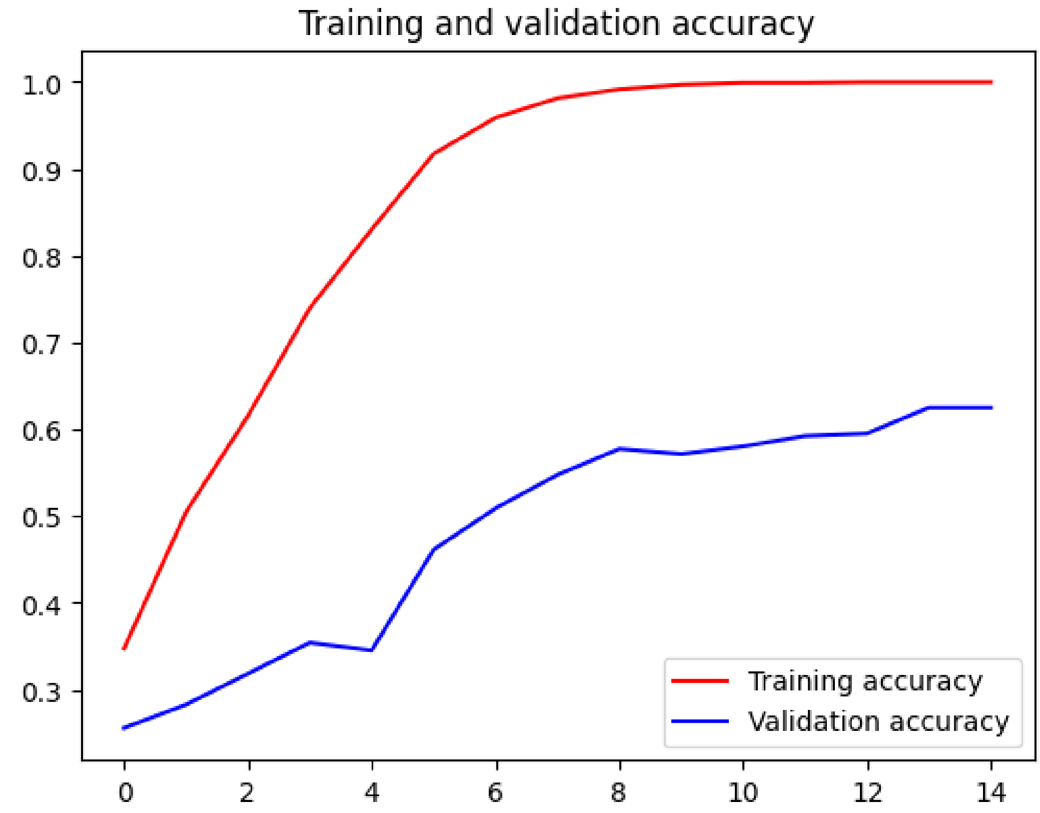
```
Epoch 1/15

2023-05-04 12:11:01.034813: E
tensorflow/core/grappler/optimizers/meta_optimizer.cc:954] layout failed:
INVALID_ARGUMENT: Size of values 0 does not match size of permutation 4 @ fanin
shape insequential/dropout/dropout/SelectV2-2-TransposeNHWCToNCHW-
LayoutOptimizer
2023-05-04 12:11:02.000143: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:424] Loaded cuDNN
version 8600
2023-05-04 12:11:02.704844: I
```

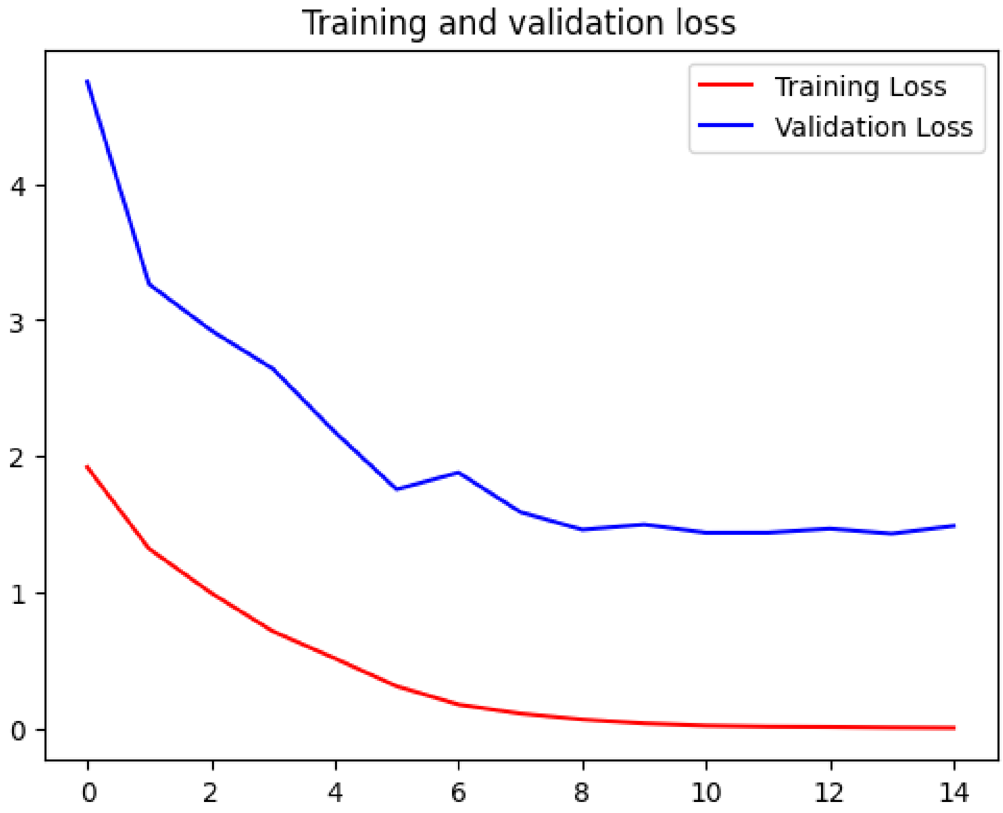
```
tensorflow/compiler/xla/stream_executor/cuda/cuda_blas.cc:637] TensorFloat-32
will be used for the matrix multiplication. This will only be logged once.
2023-05-04 12:11:02.706143: I tensorflow/compiler/xla/service/service.cc:169]
XLA service 0x7fe0c6dc0f70 initialized for platform CUDA (this does not
guarantee that XLA will be used). Devices:
2023-05-04 12:11:02.706160: I tensorflow/compiler/xla/service/service.cc:177]
StreamExecutor device (0): NVIDIA GeForce RTX 3090, Compute Capability 8.6
2023-05-04 12:11:02.710435: I
tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:269] disabling MLIR
crash reproducer, set env var `MLIR_CRASH_REPRODUCER_DIRECTORY` to enable.
2023-05-04 12:11:02.853797: I ./tensorflow/compiler/jit/device_compiler.h:180]
Compiled cluster using XLA!  This line is logged at most once for the lifetime
of the process.
```

```
21/21 [==============================] - 5s 35ms/step - loss: 1.9201 - acc:
0.3475 - val_loss: 4.7497 - val_acc: 0.2560
Epoch 2/15
21/21 [==============================] - 0s 23ms/step - loss: 1.3210 - acc:
0.5045 - val_loss: 3.2636 - val_acc: 0.2827
Epoch 3/15
21/21 [==============================] - 0s 22ms/step - loss: 0.9974 - acc:
0.6153 - val_loss: 2.9248 - val_acc: 0.3185
Epoch 4/15
21/21 [==============================] - 0s 22ms/step - loss: 0.7149 - acc:
0.7396 - val_loss: 2.6424 - val_acc: 0.3542
Epoch 5/15
21/21 [==============================] - 0s 22ms/step - loss: 0.5168 - acc:
0.8304 - val_loss: 2.1787 - val_acc: 0.3452
Epoch 6/15
21/21 [==============================] - 0s 22ms/step - loss: 0.3119 - acc:
0.9174 - val_loss: 1.7571 - val_acc: 0.4613
Epoch 7/15
21/21 [==============================] - 0s 22ms/step - loss: 0.1776 - acc:
0.9591 - val_loss: 1.8806 - val_acc: 0.5089
Epoch 8/15
21/21 [==============================] - 0s 22ms/step - loss: 0.1116 - acc:
0.9814 - val_loss: 1.5899 - val_acc: 0.5476
Epoch 9/15
21/21 [==============================] - 0s 22ms/step - loss: 0.0679 - acc:
0.9918 - val_loss: 1.4615 - val_acc: 0.5774
Epoch 10/15
21/21 [==============================] - 0s 22ms/step - loss: 0.0392 - acc:
0.9970 - val_loss: 1.4996 - val_acc: 0.5714
Epoch 11/15
21/21 [==============================] - 0s 22ms/step - loss: 0.0225 - acc:
0.9993 - val_loss: 1.4392 - val_acc: 0.5804
Epoch 12/15
21/21 [==============================] - 0s 21ms/step - loss: 0.0156 - acc:
```

```
0.9993 - val_loss: 1.4398 - val_acc: 0.5923
Epoch 13/15
21/21 [==============================] - 0s 21ms/step - loss: 0.0134 - acc:
1.0000 - val_loss: 1.4690 - val_acc: 0.5952
Epoch 14/15
21/21 [==============================] - 0s 22ms/step - loss: 0.0093 - acc:
1.0000 - val_loss: 1.4324 - val_acc: 0.6250
Epoch 15/15
21/21 [==============================] - 0s 22ms/step - loss: 0.0067 - acc:
1.0000 - val_loss: 1.4887 - val_acc: 0.6250
```

[19]:
```
#Plot Performance
plot_performance(history)
```





[20]:
```
model.save(NAME)
```

```
2023-05-04 12:11:12.700613: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'inputs' with dtype float and shape [?,51,4,64]
         [[{{node inputs}}]]
2023-05-04 12:11:13.229436: I tensorflow/core/common_runtime/executor.cc:1197]
[/device:CPU:0] (DEBUG INFO) Executor start aborting (this does not indicate an
error and you can ignore this message): INVALID_ARGUMENT: You must feed a value
for placeholder tensor 'inputs' with dtype float and shape [?,51,4,64]
         [[{{node inputs}}]]
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op,
_jit_compiled_convolution_op, _jit_compiled_convolution_op while saving (showing
3 of 3). These functions will not be directly callable after loading.

INFO:tensorflow:Assets written to: Random Sampler Re run4/assets

INFO:tensorflow:Assets written to: Random Sampler Re run4/assets
```

[21]:
```
model.save(NAME+".h5", save_format='h5')
```