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ModelTraining.ipynb

Code Python 3

[1]:
```
import numpy as np
import pandas as pd
import os
import tensorflow as tf
from keras.preprocessing.image import ImageDataGenerator, load_img
from keras.layers import Conv2D, Dense, BatchNormalization, Activation, Dropout, MaxPool2D, Flatten
from keras.optimizers import Adam, RMSprop, SGD
from keras import regularizers
from keras.callbacks import ModelCheckpoint
from keras.callbacks import ModelCheckpoint, CSVLogger, TensorBoard, EarlyStopping, ReduceLROnPlateau
import datetime
import matplotlib.pyplot as plt
from keras.utils import plot_model
```

[2]:
```
train_dir = './Dataset/train/'
test_dir = './Dataset/test/'

row, col = 48, 48
classes = 7
input_size = row, col
```

[3]:
```
plt.figure(figsize=(14,22))
i = 1
for expression in os.listdir(train_dir):
    img = load_img((train_dir + expression +'/'+ os.listdir(train_dir + expression)[1]))
    plt.subplot(1,7,i)
    plt.imshow(img)
    plt.title(expression)
    plt.axis('off')
    i += 1
plt.show()
```

[4]:
```
train_datagen = ImageDataGenerator(rescale=1./255,
                                   zoom_range=0.3,
                                   horizontal_flip=True)

training_set = train_datagen.flow_from_directory(train_dir,
                                                 batch_size=64,
                                                 target_size=(48,48),
                                                 shuffle=True,
                                                 color_mode='grayscale',
                                                 class_mode='categorical')

test_datagen = ImageDataGenerator(rescale=1./255)
test_set = test_datagen.flow_from_directory(test_dir,
                                                 batch_size=64,
                                                 target_size=(48,48),
                                                 shuffle=True,
                                                 color_mode='grayscale',
                                                 class_mode='categorical')
```

```
Found 28709 images belonging to 7 classes.
Found 7178 images belonging to 7 classes.
```

[5]:
```
training_set.class_indices
```

[5]:
```
{'angry': 0,
 'disgust': 1,
 'fear': 2,
 'happy': 3,
 'neutral': 4,
 'sad': 5,
 'surprise': 6}
```

[6]:
```
model= tf.keras.models.Sequential()
model.add(Conv2D(32, kernel_size=(3, 3), padding='same', activation='relu', input_shape=(48, 48,1)))
model.add(Conv2D(64,(3,3), padding='same', activation='relu' ))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(128,(5,5), padding='same', activation='relu'))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(512,(3,3), padding='same', activation='relu', kernel_regularizer=regularizers.l2(0.01)))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(512,(3,3), padding='same', activation='relu', kernel_regularizer=regularizers.l2(0.01)))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(256,activation = 'relu'))
model.add(BatchNormalization())
model.add(Dropout(0.25))

model.add(Dense(512,activation = 'relu'))
```

```
model.add(BatchNormalization())
model.add(Dropout(0.25))

model.add(Dense(7, activation='softmax'))

model.compile(
    optimizer = Adam(lr=0.0001),
    loss='categorical_crossentropy',
    metrics=['accuracy']
  )
```

[11]:
```
checkpoint = ModelCheckpoint("test1.h5",
                             monitor="val_loss",
                             mode="min",
                             save_best_only = True,
                             verbose=1)
callbacks = [checkpoint]
```

[12]:
```
epochs = 60
batch_size = 64
```

[13]:
```
%%time
history = model.fit(x = training_set,
                    epochs = epochs,
                    callbacks = callbacks,
                    validation_data = test_set)
```

```
Epoch 1/60
  1/449 [..............................] - ETA: 0s - loss: 9.8547 - accuracy: 0.2344WARNING:tensorflow:Callbacks method `on_train_batch_end` is slow compared to the batc
h time (batch time: 0.0180s vs `on_train_batch_end` time: 0.0269s). Check your callbacks.
449/449 [==============================] - ETA: 0s - loss: 9.1612 - accuracy: 0.2022
Epoch 00001: val_loss improved from inf to 8.98401, saving model to test1.h5
449/449 [==============================] - 31s 69ms/step - loss: 9.1612 - accuracy: 0.2022 - val_loss: 8.9840 - val_accuracy: 0.1725
Epoch 2/60
449/449 [==============================] - ETA: 0s - loss: 7.8877 - accuracy: 0.2486
Epoch 00002: val_loss improved from 8.98401 to 7.17838, saving model to test1.h5
449/449 [==============================] - 29s 65ms/step - loss: 7.8877 - accuracy: 0.2486 - val_loss: 7.1784 - val_accuracy: 0.2816
Epoch 3/60
449/449 [==============================] - ETA: 0s - loss: 6.6892 - accuracy: 0.2783
Epoch 00003: val_loss improved from 7.17838 to 5.93084, saving model to test1.h5
449/449 [==============================] - 32s 72ms/step - loss: 6.6892 - accuracy: 0.2783 - val_loss: 5.9308 - val_accuracy: 0.3396
Epoch 4/60
449/449 [==============================] - ETA: 0s - loss: 5.5872 - accuracy: 0.3124 ETA: 0s - loss: 5.5883 - accuracy: 0.31
Epoch 00004: val_loss improved from 5.93084 to 4.93715, saving model to test1.h5
449/449 [==============================] - 27s 60ms/step - loss: 5.5872 - accuracy: 0.3124 - val_loss: 4.9372 - val_accuracy: 0.3631
Epoch 5/60
448/449 [============================>.] - ETA: 0s - loss: 4.6606 - accuracy: 0.3359
Epoch 00005: val_loss improved from 4.93715 to 4.11600, saving model to test1.h5
449/449 [==============================] - 29s 64ms/step - loss: 4.6598 - accuracy: 0.3359 - val_loss: 4.1160 - val_accuracy: 0.3897
Epoch 6/60
449/449 [==============================] - ETA: 0s - loss: 3.9175 - accuracy: 0.3605 ETA: 0s - loss: 3.9199 - accuracy:
Epoch 00006: val_loss improved from 4.11600 to 3.46907, saving model to test1.h5
449/449 [==============================] - 28s 61ms/step - loss: 3.9175 - accuracy: 0.3605 - val_loss: 3.4691 - val_accuracy: 0.4081
Epoch 7/60
448/449 [============================>.] - ETA: 0s - loss: 3.3462 - accuracy: 0.3783
Epoch 00007: val_loss improved from 3.46907 to 3.11482, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 3.3458 - accuracy: 0.3784 - val_loss: 3.1148 - val_accuracy: 0.3586
Epoch 8/60
448/449 [============================>.] - ETA: 0s - loss: 2.8926 - accuracy: 0.4079
Epoch 00008: val_loss improved from 3.11482 to 2.53663, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 2.8924 - accuracy: 0.4077 - val_loss: 2.5366 - val_accuracy: 0.4755
Epoch 9/60
448/449 [============================>.] - ETA: 0s - loss: 2.5545 - accuracy: 0.4312
Epoch 00009: val_loss improved from 2.53663 to 2.27468, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 2.5539 - accuracy: 0.4313 - val_loss: 2.2747 - val_accuracy: 0.4873
Epoch 10/60
448/449 [============================>.] - ETA: 0s - loss: 2.3033 - accuracy: 0.4567
Epoch 00010: val_loss improved from 2.27468 to 2.06409, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 2.3030 - accuracy: 0.4567 - val_loss: 2.0641 - val_accuracy: 0.5170
Epoch 11/60
448/449 [============================>.] - ETA: 0s - loss: 2.1067 - accuracy: 0.4766 ETA: 0s - loss: 2.1097
Epoch 00011: val_loss improved from 2.06409 to 1.92530, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 2.1067 - accuracy: 0.4765 - val_loss: 1.9253 - val_accuracy: 0.5231
Epoch 12/60
449/449 [==============================] - ETA: 0s - loss: 1.9653 - accuracy: 0.4932
Epoch 00012: val_loss improved from 1.92530 to 1.76336, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.9653 - accuracy: 0.4932 - val_loss: 1.7634 - val_accuracy: 0.5508
Epoch 13/60
449/449 [==============================] - ETA: 0s - loss: 1.8665 - accuracy: 0.5051
Epoch 00013: val_loss improved from 1.76336 to 1.73444, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.8665 - accuracy: 0.5051 - val_loss: 1.7344 - val_accuracy: 0.5390
Epoch 14/60
448/449 [============================>.] - ETA: 0s - loss: 1.7925 - accuracy: 0.5137
Epoch 00014: val_loss improved from 1.73444 to 1.66458, saving model to test1.h5
449/449 [==============================] - 24s 53ms/step - loss: 1.7919 - accuracy: 0.5140 - val_loss: 1.6646 - val_accuracy: 0.5517
Epoch 15/60
448/449 [============================>.] - ETA: 0s - loss: 1.7083 - accuracy: 0.5328
Epoch 00015: val_loss improved from 1.66458 to 1.66457, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.7080 - accuracy: 0.5328 - val_loss: 1.6646 - val_accuracy: 0.5446
Epoch 16/60
448/449 [============================>.] - ETA: 0s - loss: 1.6628 - accuracy: 0.5371
Epoch 00016: val_loss did not improve from 1.66457
449/449 [==============================] - 23s 51ms/step - loss: 1.6630 - accuracy: 0.5371 - val_loss: 1.6901 - val_accuracy: 0.5124
Epoch 17/60
449/449 [==============================] - ETA: 0s - loss: 1.6245 - accuracy: 0.5445
Epoch 00017: val_loss improved from 1.66457 to 1.56306, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.6245 - accuracy: 0.5445 - val_loss: 1.5631 - val_accuracy: 0.5653
Epoch 18/60
448/449 [============================>.] - ETA: 0s - loss: 1.6004 - accuracy: 0.5502
Epoch 00018: val_loss improved from 1.56306 to 1.51144, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.6005 - accuracy: 0.5502 - val_loss: 1.5114 - val_accuracy: 0.5834
Epoch 19/60
448/449 [============================>.] - ETA: 0s - loss: 1.5695 - accuracy: 0.5584
Epoch 00019: val_loss improved from 1.51144 to 1.45906, saving model to test1.h5
449/449 [==============================] - 23s 51ms/step - loss: 1.5695 - accuracy: 0.5584 - val_loss: 1.4591 - val_accuracy: 0.6025
Epoch 20/60
448/449 [============================>.] - ETA: 0s - loss: 1.5395 - accuracy: 0.5661
Epoch 00020: val_loss improved from 1.45906 to 1.45896, saving model to test1.h5
449/449 [==============================] - 23s 51ms/step - loss: 1.5397 - accuracy: 0.5660 - val_loss: 1.4590 - val_accuracy: 0.6045
Epoch 21/60
448/449 [============================>.] - ETA: 0s - loss: 1.5213 - accuracy: 0.5721
Epoch 00021: val_loss improved from 1.45896 to 1.43982, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.5212 - accuracy: 0.5722 - val_loss: 1.4398 - val_accuracy: 0.6025
Epoch 22/60
```

```
448/449 [============================>.] - ETA: 0s - loss: 1.5029 - accuracy: 0.5767
Epoch 00022: val_loss did not improve from 1.43982
449/449 [==============================] - 23s 51ms/step - loss: 1.5030 - accuracy: 0.5766 - val_loss: 1.4997 - val_accuracy: 0.5800
Epoch 23/60
449/449 [==============================] - ETA: 0s - loss: 1.4952 - accuracy: 0.5770
Epoch 00023: val_loss did not improve from 1.43982
449/449 [==============================] - 23s 51ms/step - loss: 1.4952 - accuracy: 0.5770 - val_loss: 1.4672 - val_accuracy: 0.5935
Epoch 24/60
449/449 [==============================] - ETA: 0s - loss: 1.4800 - accuracy: 0.5831
Epoch 00024: val_loss improved from 1.43982 to 1.42667, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.4800 - accuracy: 0.5831 - val_loss: 1.4267 - val_accuracy: 0.6063
Epoch 25/60
449/449 [==============================] - ETA: 0s - loss: 1.4728 - accuracy: 0.5898
Epoch 00025: val_loss did not improve from 1.42667
449/449 [==============================] - 24s 53ms/step - loss: 1.4728 - accuracy: 0.5898 - val_loss: 1.4294 - val_accuracy: 0.6102
Epoch 26/60
449/449 [==============================] - ETA: 0s - loss: 1.4679 - accuracy: 0.5938
Epoch 00026: val_loss improved from 1.42667 to 1.41754, saving model to test1.h5
449/449 [==============================] - 23s 52ms/step - loss: 1.4679 - accuracy: 0.5938 - val_loss: 1.4175 - val_accuracy: 0.6154
Epoch 27/60
449/449 [==============================] - ETA: 0s - loss: 1.4558 - accuracy: 0.5965
Epoch 00027: val_loss did not improve from 1.41754
449/449 [==============================] - 23s 52ms/step - loss: 1.4558 - accuracy: 0.5965 - val_loss: 1.4276 - val_accuracy: 0.6085
Epoch 28/60
448/449 [============================>.] - ETA: 0s - loss: 1.4528 - accuracy: 0.6003
Epoch 00028: val_loss did not improve from 1.41754
449/449 [==============================] - 23s 52ms/step - loss: 1.4529 - accuracy: 0.6002 - val_loss: 1.5139 - val_accuracy: 0.5814
Epoch 29/60
449/449 [==============================] - ETA: 0s - loss: 1.4414 - accuracy: 0.6017
Epoch 00029: val_loss improved from 1.41754 to 1.41690, saving model to test1.h5
449/449 [==============================] - 25s 55ms/step - loss: 1.4414 - accuracy: 0.6017 - val_loss: 1.4169 - val_accuracy: 0.6162
Epoch 30/60
449/449 [==============================] - ETA: 0s - loss: 1.4353 - accuracy: 0.6051
Epoch 00030: val_loss did not improve from 1.41690
449/449 [==============================] - 25s 56ms/step - loss: 1.4353 - accuracy: 0.6051 - val_loss: 1.4171 - val_accuracy: 0.6112
Epoch 31/60
449/449 [==============================] - ETA: 0s - loss: 1.4210 - accuracy: 0.6113
Epoch 00031: val_loss improved from 1.41690 to 1.39373, saving model to test1.h5
449/449 [==============================] - 24s 53ms/step - loss: 1.4210 - accuracy: 0.6113 - val_loss: 1.3937 - val_accuracy: 0.6180
Epoch 32/60
449/449 [==============================] - ETA: 0s - loss: 1.4182 - accuracy: 0.6126
Epoch 00032: val_loss did not improve from 1.39373
449/449 [==============================] - 23s 52ms/step - loss: 1.4182 - accuracy: 0.6126 - val_loss: 1.3978 - val_accuracy: 0.6199
Epoch 33/60
448/449 [============================>.] - ETA: 0s - loss: 1.4184 - accuracy: 0.6102
Epoch 00033: val_loss did not improve from 1.39373
449/449 [==============================] - 25s 55ms/step - loss: 1.4182 - accuracy: 0.6103 - val_loss: 1.4345 - val_accuracy: 0.6084
Epoch 34/60
448/449 [============================>.] - ETA: 0s - loss: 1.4086 - accuracy: 0.6146
Epoch 00034: val_loss did not improve from 1.39373
449/449 [==============================] - 25s 56ms/step - loss: 1.4086 - accuracy: 0.6145 - val_loss: 1.4241 - val_accuracy: 0.6172
Epoch 35/60
449/449 [==============================] - ETA: 0s - loss: 1.4098 - accuracy: 0.6188
Epoch 00035: val_loss improved from 1.39373 to 1.36851, saving model to test1.h5
449/449 [==============================] - 26s 58ms/step - loss: 1.4098 - accuracy: 0.6188 - val_loss: 1.3685 - val_accuracy: 0.6344
Epoch 36/60
449/449 [==============================] - ETA: 0s - loss: 1.4085 - accuracy: 0.6176
Epoch 00036: val_loss did not improve from 1.36851
449/449 [==============================] - 28s 63ms/step - loss: 1.4085 - accuracy: 0.6176 - val_loss: 1.3832 - val_accuracy: 0.6372
Epoch 37/60
449/449 [==============================] - ETA: 0s - loss: 1.4036 - accuracy: 0.6213
Epoch 00037: val_loss did not improve from 1.36851
449/449 [==============================] - 28s 63ms/step - loss: 1.4036 - accuracy: 0.6213 - val_loss: 1.4062 - val_accuracy: 0.6237
Epoch 38/60
448/449 [============================>.] - ETA: 0s - loss: 1.3947 - accuracy: 0.6261
Epoch 00038: val_loss did not improve from 1.36851
449/449 [==============================] - 28s 63ms/step - loss: 1.3947 - accuracy: 0.6262 - val_loss: 1.3934 - val_accuracy: 0.6329
Epoch 39/60
449/449 [==============================] - ETA: 0s - loss: 1.4081 - accuracy: 0.6227
Epoch 00039: val_loss did not improve from 1.36851
449/449 [==============================] - 34s 75ms/step - loss: 1.4081 - accuracy: 0.6227 - val_loss: 1.4057 - val_accuracy: 0.6204
Epoch 40/60
449/449 [==============================] - ETA: 0s - loss: 1.3847 - accuracy: 0.6268
Epoch 00040: val_loss improved from 1.36851 to 1.35783, saving model to test1.h5
449/449 [==============================] - 51s 114ms/step - loss: 1.3847 - accuracy: 0.6268 - val_loss: 1.3578 - val_accuracy: 0.6385
Epoch 41/60
449/449 [==============================] - ETA: 0s - loss: 1.3855 - accuracy: 0.6269
Epoch 00041: val_loss did not improve from 1.35783
449/449 [==============================] - 35s 79ms/step - loss: 1.3855 - accuracy: 0.6269 - val_loss: 1.3892 - val_accuracy: 0.6305
Epoch 42/60
449/449 [==============================] - ETA: 0s - loss: 1.3842 - accuracy: 0.6295 ETA: 1s - loss:
Epoch 00042: val_loss did not improve from 1.35783
449/449 [==============================] - 30s 66ms/step - loss: 1.3842 - accuracy: 0.6295 - val_loss: 1.4144 - val_accuracy: 0.6283
Epoch 43/60
449/449 [==============================] - ETA: 0s - loss: 1.3842 - accuracy: 0.6316
Epoch 00043: val_loss did not improve from 1.35783
449/449 [==============================] - 28s 63ms/step - loss: 1.3842 - accuracy: 0.6316 - val_loss: 1.3649 - val_accuracy: 0.6478
Epoch 44/60
449/449 [==============================] - ETA: 0s - loss: 1.3792 - accuracy: 0.6334
Epoch 00044: val_loss did not improve from 1.35783
449/449 [==============================] - 28s 63ms/step - loss: 1.3792 - accuracy: 0.6334 - val_loss: 1.3590 - val_accuracy: 0.6463
Epoch 45/60
449/449 [==============================] - ETA: 0s - loss: 1.3836 - accuracy: 0.6319
Epoch 00045: val_loss did not improve from 1.35783
449/449 [==============================] - 25s 55ms/step - loss: 1.3836 - accuracy: 0.6319 - val_loss: 1.3885 - val_accuracy: 0.6397
Epoch 46/60
448/449 [============================>.] - ETA: 0s - loss: 1.3767 - accuracy: 0.6371 ETA: 0s - loss: 1.375
Epoch 00046: val_loss did not improve from 1.35783
449/449 [==============================] - 25s 55ms/step - loss: 1.3774 - accuracy: 0.6369 - val_loss: 1.3713 - val_accuracy: 0.6408
Epoch 47/60
448/449 [============================>.] - ETA: 0s - loss: 1.3760 - accuracy: 0.6359
Epoch 00047: val_loss did not improve from 1.35783
449/449 [==============================] - 23s 52ms/step - loss: 1.3756 - accuracy: 0.6359 - val_loss: 1.3670 - val_accuracy: 0.6452
Epoch 48/60
449/449 [==============================] - ETA: 0s - loss: 1.3777 - accuracy: 0.6367
Epoch 00048: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3777 - accuracy: 0.6367 - val_loss: 1.3721 - val_accuracy: 0.6436
Epoch 49/60
449/449 [==============================] - ETA: 0s - loss: 1.3739 - accuracy: 0.6400
Epoch 00049: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3739 - accuracy: 0.6400 - val_loss: 1.3716 - val_accuracy: 0.6474
Epoch 50/60
448/449 [============================>.] - ETA: 0s - loss: 1.3678 - accuracy: 0.6386
Epoch 00050: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 52ms/step - loss: 1.3677 - accuracy: 0.6386 - val_loss: 1.3941 - val_accuracy: 0.6289
Epoch 51/60
449/449 [==============================] - ETA: 0s - loss: 1.3570 - accuracy: 0.6432
Epoch 00051: val_loss did not improve from 1.35783
449/449 [==============================] - 26s 59ms/step - loss: 1.3570 - accuracy: 0.6432 - val_loss: 1.3826 - val_accuracy: 0.6485
Epoch 52/60
```

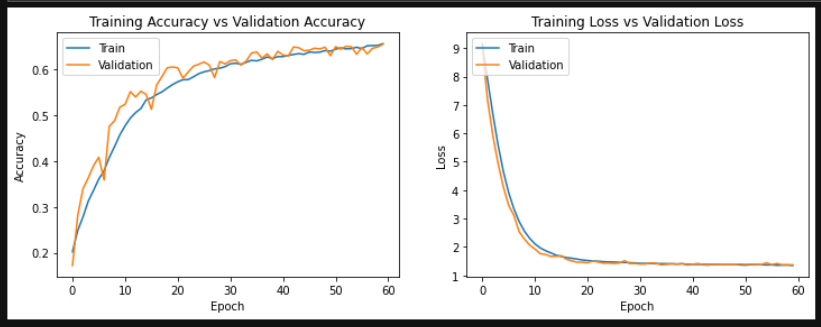
```
448/449 [============================>.] - ETA: 0s - loss: 1.3745 - accuracy: 0.6458
Epoch 00052: val_loss did not improve from 1.35783
449/449 [==============================] - 25s 56ms/step - loss: 1.3743 - accuracy: 0.6458 - val_loss: 1.3867 - val_accuracy: 0.6432
Epoch 53/60
449/449 [==============================] - ETA: 0s - loss: 1.3738 - accuracy: 0.6438
Epoch 00053: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3738 - accuracy: 0.6438 - val_loss: 1.3767 - val_accuracy: 0.6495
Epoch 54/60
449/449 [==============================] - ETA: 0s - loss: 1.3709 - accuracy: 0.6444
Epoch 00054: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3709 - accuracy: 0.6444 - val_loss: 1.3730 - val_accuracy: 0.6485
Epoch 55/60
449/449 [==============================] - ETA: 0s - loss: 1.3648 - accuracy: 0.6473
Epoch 00055: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3648 - accuracy: 0.6473 - val_loss: 1.4404 - val_accuracy: 0.6319
Epoch 56/60
448/449 [============================>.] - ETA: 0s - loss: 1.3659 - accuracy: 0.6441
Epoch 00056: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 55ms/step - loss: 1.3657 - accuracy: 0.6441 - val_loss: 1.3745 - val_accuracy: 0.6471
Epoch 57/60
449/449 [==============================] - ETA: 0s - loss: 1.3531 - accuracy: 0.6506
Epoch 00057: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3531 - accuracy: 0.6506 - val_loss: 1.4153 - val_accuracy: 0.6326
Epoch 58/60
449/449 [==============================] - ETA: 0s - loss: 1.3573 - accuracy: 0.6509 ETA: 1s - los
Epoch 00058: val_loss did not improve from 1.35783
449/449 [==============================] - 27s 60ms/step - loss: 1.3573 - accuracy: 0.6509 - val_loss: 1.3693 - val_accuracy: 0.6449
Epoch 59/60
448/449 [============================>.] - ETA: 0s - loss: 1.3590 - accuracy: 0.6511
Epoch 00059: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3587 - accuracy: 0.6513 - val_loss: 1.3711 - val_accuracy: 0.6478
Epoch 60/60
448/449 [============================>.] - ETA: 0s - loss: 1.3452 - accuracy: 0.6553 ETA:
Epoch 00060: val_loss did not improve from 1.35783
449/449 [==============================] - 24s 53ms/step - loss: 1.3459 - accuracy: 0.6551 - val_loss: 1.3685 - val_accuracy: 0.6538
Wall time: 25min 49s
```

[14]:
```
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
fig.set_size_inches(12,4)

ax[0].plot(history.history['accuracy'])
ax[0].plot(history.history['val_accuracy'])
ax[0].set_title('Training Accuracy vs Validation Accuracy')
ax[0].set_ylabel('Accuracy')
ax[0].set_xlabel('Epoch')
ax[0].legend(['Train', 'Validation'], loc='upper left')

ax[1].plot(history.history['loss'])
ax[1].plot(history.history['val_loss'])
ax[1].set_title('Training Loss vs Validation Loss')
ax[1].set_ylabel('Loss')
ax[1].set_xlabel('Epoch')
ax[1].legend(['Train', 'Validation'], loc='upper left')

plt.show()
```



[16]:
```
y_pred = model.predict(training_set)
y_pred = np.argmax(y_pred, axis=1)
class_labels = test_set.class_indices
class_labels = {v:k for k,v in class_labels.items()}
class_labels
```

[16]:
```
{0: 'angry',
 1: 'disgust',
 2: 'fear',
 3: 'happy',
 4: 'neutral',
 5: 'sad',
 6: 'surprise'}
```

[17]:
```
from sklearn.metrics import classification_report, confusion_matrix
cm_train = confusion_matrix(training_set.classes, y_pred)
print('Confusion Matrix')
print(cm_train)
print('Classification Report')
target_names = list(class_labels.values())
print(classification_report(training_set.classes, y_pred, target_names=target_names))
```

```
Confusion Matrix
[[ 550   65  275 1119  681  861  444]
 [  72    8   33  113   72   95   43]
 [ 563   54  310 1086  704  898  482]
 [1044   99  519 1934 1253 1551  815]
 [ 706   69  345 1365  850 1055  575]
 [ 671   58  375 1330  829 1004  563]
 [ 467   48  254  838  530  674  360]]
Classification Report
              precision    recall  f1-score   support

       angry       0.14      0.14      0.14      3995
     disgust       0.02      0.02      0.02       436
        fear       0.15      0.08      0.10      4097
       happy       0.25      0.27      0.26      7215
```

```
              neutral       0.17      0.17      0.17      4965
                  sad       0.16      0.21      0.18      4830
             surprise       0.11      0.11      0.11      3171

             accuracy                           0.17     28709
            macro avg       0.14      0.14      0.14     28709
         weighted avg       0.17      0.17      0.17     28709
```

[ ]: