Real Time Facial Expression Recognition

Description

Computer animated agents and robots bring new dimension in human computer interaction which makes it vital as how computers can affect our social life in day-to-day activities. Face to face communication is a real-time process operating at a a time scale in the order of milliseconds. The level of uncertainty at this time scale is considerable, making it necessary for humans and machines to rely on sensory rich perceptual primitives rather than slow symbolic inference processes.

In this project we are presenting the real time facial expression recognition of seven most basic human expressions: ANGER, DISGUST, FEAR, HAPPY, NEUTRAL SAD, SURPRISE.

This model can be used for prediction of expressions of both still images and real time video. However, in both the cases we have to provide image to the model. In case of real time video the image should be taken at any point in time and feed it to the model for prediction of expression. The system automatically detects face using HAAR cascade then its crops it and resize the image to a specific size and give it to the model for prediction. The model will generate seven probability values corresponding to seven expressions. The highest probability value to the corresponding expression will be the predicted expression for that image.

Business Problem

However, our goal here is to predict the human expressions, but we have trained our model on both human and animated images. Since, we had only approx 1500 human images which are very less to make a good model, so we took approximately 9000 animated images and leverage those animated images for training the model and ultimately do the prediction of expressions on human images.

For better prediction we have decided to keep the size of each image **350∗350**.

For any image our goal is to predict the expression of the face in that image out of seven basic human expression

Problem Statement

CLASSIFY THE EXPRESSION OF FACE IN IMAGE OUT OF SEVEN BASIC HUMAN EXPRESSION

Performance Metric

This is a multi-class classification problem with 7 different classes, so we have considered three performance metrics:

1. Multi-Class Log-loss
2. Accuracy
3. Confusion Metric

Source Data

We have downloaded data from 4 different sources.

1. Human Images Source-1: http://www.consortium.ri.cmu.edu/ckagree/ (http://www.consortium.ri.cmu.edu/ckagree/)
2. Human Images Source-2: http://app.visgraf.impa.br/database/faces/ (http://app.visgraf.impa.br/database/faces/)
3. Human Images Source-3: http://www.kasrl.org/jaffe.html (http://www.kasrl.org/jaffe.html)
4. Animated Images Source: https://grail.cs.washington.edu/projects/deepexpr/ferg-db.html (https://grail.cs.washington.edu/projects/deepexpr/ferg-db.html)

Real-World Business Objective & Constraints

1. Low-latency is required.
2. Interpretability is important for still images but not in real time. For still images, probability of predicted expressions can be given.
3. Errors are not costly.

Y- Encoded Labels

Angry--1
Disgust --2
Fear--3

Happy--4
Neutral--5
Sad--6
Surprise--7

Mapping real-world to ML Problem

In [1]:
```
import os
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from PIL import Image
import glob
import cv2
from sklearn.model_selection import train_test_split
from keras.layers import Dropout, Dense
from keras.layers.normalization import BatchNormalization
from keras.models import Sequential, load_model
from keras.applications import VGG16
from sklearn.metrics import accuracy_score, confusion_matrix
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\h5py\__init__.py:36: FutureWarning: Conversion of the second argument of i
ssubdtype from `float` to `np.floating` is deprecated. In future, it will be treated as `np.float64 == np.dtype(float).
type`.
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

1. Reading the Data of Human Images

Angry

In [40]:
```
human_angry = glob.glob("../Data/Human/Angry/*")
human_angry.remove('../Data/Human/Angry\\Thumbs.db')
print("Number of images in Angry emotion = "+str(len(human_angry)))
```

```
Number of images in Angry emotion = 168
```

In [84]:
```
human_angry_folderName = [str(i.split("\\")[0])+"/" for i in human_angry]
human_angry_imageName = [str(i.split("\\")[1]) for i in human_angry]
human_angry_emotion = [["Angry"]*len(human_angry)][0]
human_angry_label = [1]*len(human_angry)

len(human_angry_folderName), len(human_angry_imageName), len(human_angry_emotion), len(human_angry_label)
```

Out[84]:
```
(168, 168, 168, 168)
```

In [86]:
```
df_angry = pd.DataFrame()
df_angry["folderName"] = human_angry_folderName
df_angry["imageName"] = human_angry_imageName
df_angry["Emotion"] = human_angry_emotion
df_angry["Labels"] = human_angry_label
df_angry.head()
```

Out[86]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Angry/	KA.AN1.39.tiff	Angry	1
1	../Data/Human/Angry/	KA.AN2.40.tiff	Angry	1
2	../Data/Human/Angry/	KA.AN3.41.tiff	Angry	1
3	../Data/Human/Angry/	KL.AN1.167.tiff	Angry	1
4	../Data/Human/Angry/	KL.AN2.168.tiff	Angry	1

Disgust

In [87]:
```
human_disgust = glob.glob("../Data/Human/Disgust/*")
human_disgust.remove('../Data/Human/Disgust\\Thumbs.db')
print("Number of images in Disgust emotion = "+str(len(human_disgust)))
```

```
Number of images in Disgust emotion = 221
```

In [88]:
```
human_disgust_folderName = [str(i.split("\\")[0])+"/" for i in human_disgust]
human_disgust_imageName = [str(i.split("\\")[1]) for i in human_disgust]
human_disgust_emotion = [["Disgust"]*len(human_disgust)][0]
human_disgust_label = [2]*len(human_disgust)

len(human_disgust_folderName), len(human_disgust_imageName), len(human_disgust_emotion), len(human_disgust_label)
```

Out[88]:
```
(221, 221, 221, 221)
```

In [89]:
```
df_disgust = pd.DataFrame()
df_disgust["folderName"] = human_disgust_folderName
df_disgust["imageName"] = human_disgust_imageName
df_disgust["Emotion"] = human_disgust_emotion
df_disgust["Labels"] = human_disgust_label
df_disgust.head()
```

Out[89]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Disgust/	KA.DI1.42.tiff	Disgust	2
1	../Data/Human/Disgust/	KA.DI2.43.tiff	Disgust	2
2	../Data/Human/Disgust/	KA.DI3.44.tiff	Disgust	2
3	../Data/Human/Disgust/	KL.DI1.170.tiff	Disgust	2
4	../Data/Human/Disgust/	KL.DI2.171.tiff	Disgust	2

Fear

In [117]:
```
human_fear = glob.glob("../Data/Human/Fear/*")
human_fear.remove('../Data/Human/Fear\\Thumbs.db')
print("Number of images in Fear emotion = "+str(len(human_fear)))
```

```
Number of images in Fear emotion = 122
```

In [118]:
```
human_fear_folderName = [str(i.split("\\")[0])+"/" for i in human_fear]
human_fear_imageName = [str(i.split("\\")[1]) for i in human_fear]
human_fear_emotion = [["Fear"]*len(human_fear)][0]
human_fear_label = [3]*len(human_fear)

len(human_fear_folderName), len(human_fear_imageName), len(human_fear_emotion), len(human_fear_label)
```

Out[118]:
```
(122, 122, 122, 122)
```

In [119]:
```
df_fear = pd.DataFrame()
df_fear["folderName"] = human_fear_folderName
df_fear["imageName"] = human_fear_imageName
df_fear["Emotion"] = human_fear_emotion
df_fear["Labels"] = human_fear_label
df_fear.head()
```

Out[119]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Fear/	KA.FE3.47.tiff	Fear	3
1	../Data/Human/Fear/	KA.FE4.48.tiff	Fear	3
2	../Data/Human/Fear/	KL.FE1.174.tiff	Fear	3
3	../Data/Human/Fear/	MK.FE1.131.tiff	Fear	3
4	../Data/Human/Fear/	MK.FE2.132.tiff	Fear	3

Happy

In [149]:
```
human_happy = glob.glob("../Data/Human/Happy/*")
human_happy.remove('../Data/Human/Happy\\Thumbs.db')
print("Number of images in Happy emotion = "+str(len(human_happy)))
```

```
Number of images in Happy emotion = 280
```

In [151]:
```
human_happy_folderName = [str(i.split("\\")[0])+"/" for i in human_happy]
human_happy_imageName = [str(i.split("\\")[1]) for i in human_happy]
human_happy_emotion = [["Happy"]*len(human_happy)][0]
human_happy_label = [4]*len(human_happy)

len(human_happy_folderName), len(human_happy_imageName), len(human_happy_emotion), len(human_happy_label)
```

Out[151]:
```
(280, 280, 280, 280)
```

In [153]:
```
df_happy = pd.DataFrame()
df_happy["folderName"] = human_happy_folderName
df_happy["imageName"] = human_happy_imageName
df_happy["Emotion"] = human_happy_emotion
df_happy["Labels"] = human_happy_label
df_happy.head()
```

Out[153]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Happy/	KA.HA1.29.tiff	Happy	4
1	../Data/Human/Happy/	KA.HA2.30.tiff	Happy	4
2	../Data/Human/Happy/	KA.HA3.31.tiff	Happy	4
3	../Data/Human/Happy/	KL.HA1.158.tiff	Happy	4
4	../Data/Human/Happy/	KL.HA2.159.tiff	Happy	4

Neutral

In [154]:
```
human_neutral = glob.glob("../Data/Human/Neutral/*")
human_neutral.remove('../Data/Human/Neutral\\Thumbs.db')
print("Number of images in Neutral emotion = "+str(len(human_neutral)))
```

```
Number of images in Neutral emotion = 270
```

In [155]:
```
human_neutral_folderName = [str(i.split("\\")[0])+"/" for i in human_neutral]
human_neutral_imageName = [str(i.split("\\")[1]) for i in human_neutral]
human_neutral_emotion = [["Neutral"]*len(human_neutral)][0]
human_neutral_label = [5]*len(human_neutral)

len(human_neutral_folderName), len(human_neutral_imageName), len(human_neutral_emotion), len(human_neutral_label)
```

Out[155]:
```
(270, 270, 270, 270)
```

In [156]:
```
df_neutral = pd.DataFrame()
df_neutral["folderName"] = human_neutral_folderName
df_neutral["imageName"] = human_neutral_imageName
df_neutral["Emotion"] = human_neutral_emotion
df_neutral["Labels"] = human_neutral_label
df_neutral.head()
```

Out[156]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Neutral/	KA.NE1.26.tiff	Neutral	5
1	../Data/Human/Neutral/	KA.NE2.27.tiff	Neutral	5
2	../Data/Human/Neutral/	KA.NE3.28.tiff	Neutral	5
3	../Data/Human/Neutral/	KL.NE1.155.tiff	Neutral	5
4	../Data/Human/Neutral/	KL.NE2.156.tiff	Neutral	5

Sad

In [181]:
```
human_sad = glob.glob("../Data/Human/Sad/*")
human_sad.remove('../Data/Human/Sad\\Thumbs.db')
print("Number of images in Sad emotion = "+str(len(human_sad)))
```

```
Number of images in Sad emotion = 157
```

In [182]:
```
human_sad_folderName = [str(i.split("\\")[0])+"/" for i in human_sad]
human_sad_imageName = [str(i.split("\\")[1]) for i in human_sad]
human_sad_emotion = [["Sad"]*len(human_sad)][0]
human_sad_label = [6]*len(human_sad)

len(human_sad_folderName), len(human_sad_imageName), len(human_sad_emotion), len(human_sad_label)
```

Out[182]:
```
(157, 157, 157, 157)
```

In [183]:
```
df_sad = pd.DataFrame()
df_sad["folderName"] = human_sad_folderName
df_sad["imageName"] = human_sad_imageName
df_sad["Emotion"] = human_sad_emotion
df_sad["Labels"] = human_sad_label
df_sad.head()
```

Out[183]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Sad/	KA.SA1.33.tiff	Sad	6
1	../Data/Human/Sad/	KA.SA2.34.tiff	Sad	6
2	../Data/Human/Sad/	KA.SA3.35.tiff	Sad	6
3	../Data/Human/Sad/	KL.SA1.161.tiff	Sad	6
4	../Data/Human/Sad/	KL.SA2.162.tiff	Sad	6

Surprise

In [231]:
```
human_surprise = glob.glob("../Data/Human/Surprise/*")
human_surprise.remove('../Data/Human/Surprise\\Thumbs.db')
print("Number of images in Surprise emotion = "+str(len(human_surprise)))
```

```
Number of images in Surprise emotion = 278
```

In [232]:
```
human_surprise_folderName = [str(i.split("\\")[0])+"/" for i in human_surprise]
human_surprise_imageName = [str(i.split("\\")[1]) for i in human_surprise]
human_surprise_emotion = [["Surprise"]*len(human_surprise)][0]
human_surprise_label = [7]*len(human_surprise)

len(human_surprise_folderName), len(human_surprise_imageName), len(human_surprise_emotion), len(human_surprise_label)
```

Out[232]:
```
(278, 278, 278, 278)
```

In [233]:
```
df_surprise = pd.DataFrame()
df_surprise["folderName"] = human_surprise_folderName
df_surprise["imageName"] = human_surprise_imageName
df_surprise["Emotion"] = human_surprise_emotion
df_surprise["Labels"] = human_surprise_label
df_surprise.head()
```

Out[233]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Surprise/	KA.SU1.36.tiff	Surprise	7
1	../Data/Human/Surprise/	KA.SU2.37.tiff	Surprise	7
2	../Data/Human/Surprise/	KA.SU3.38.tiff	Surprise	7
3	../Data/Human/Surprise/	KL.SU1.164.tiff	Surprise	7
4	../Data/Human/Surprise/	KL.SU2.165.tiff	Surprise	7

In [255]:
```
length = df_angry.shape[0] + df_disgust.shape[0] + df_fear.shape[0] + df_happy.shape[0] + df_neutral.shape[0] + df_sad.sh
print("Total number of images in all the emotions = "+str(length))
```

```
Total number of images in all the emotions = 1496
```

Concatenating all dataframes

In [256]:
```
frames = [df_angry, df_disgust, df_fear, df_happy, df_neutral, df_sad, df_surprise]
Final_human = pd.concat(frames)
Final_human.shape
```

Out[256]: (1496, 4)

In [261]:
```
Final_human.reset_index(inplace = True, drop = True)
Final_human = Final_human.sample(frac = 1.0)   #shuffling the dataframe
Final_human.reset_index(inplace = True, drop = True)
Final_human.head()
```

Out[261]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Neutral/	S099_001_00000002.png	Neutral	5
1	../Data/Human/Neutral/	S103_006_00000002.png	Neutral	5
2	../Data/Human/Surprise/	S106_001_00000016.png	Surprise	7
3	../Data/Human/Surprise/	s037-03_img.jpg	Surprise	7
4	../Data/Human/Surprise/	S022_001_00000028.png	Surprise	7

2. Train, CV and Test Split for Human Images

In [307]:
```
df_human_train_data, df_human_test = train_test_split(Final_human, stratify=Final_human["Labels"], test_size = 0.197860)
df_human_train, df_human_cv = train_test_split(df_human_train_data, stratify=df_human_train_data["Labels"], test_size = 0
df_human_train.shape, df_human_cv.shape, df_human_test.shape
```

Out[307]: ((1000, 4), (200, 4), (296, 4))

In [308]:
```
df_human_train.reset_index(inplace = True, drop = True)
df_human_train.to_pickle("../Data/Dataframes/Human/df_human_train.pkl")

df_human_cv.reset_index(inplace = True, drop = True)
df_human_cv.to_pickle("../Data/Dataframes/Human/df_human_cv.pkl")

df_human_test.reset_index(inplace = True, drop = True)
df_human_test.to_pickle("../Data/Dataframes/Human/df_human_test.pkl")
```

In [2]:
```
df_human_train = pd.read_pickle("../Data/Dataframes/Human/df_human_train.pkl")
df_human_train.head()
```

Out[2]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Disgust/	S076_005_00000011.png	Disgust	2
1	../Data/Human/Sad/	S130_009_00000019.png	Sad	6
2	../Data/Human/Angry/	S503_001_00000070.png	Angry	1
3	../Data/Human/Neutral/	S045_004_00000002.png	Neutral	5
4	../Data/Human/Sad/	S068_001_00000024.png	Sad	6

In [3]:
```
df_human_train.shape
```

Out[3]:
```
(1000, 4)
```

In [4]:
```
df_human_cv = pd.read_pickle("../Data/Dataframes/Human/df_human_cv.pkl")
df_human_cv.head()
```

Out[4]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Surprise/	s028-03_img.jpg	Surprise	7
1	../Data/Human/Disgust/	S078_007_00000011.png	Disgust	2
2	../Data/Human/Sad/	S064_004_00000014.png	Sad	6
3	../Data/Human/Angry/	S028_001_00000022.png	Angry	1
4	../Data/Human/Neutral/	S160_006_00000001.png	Neutral	5

In [5]:
```
df_human_cv.shape
```

Out[5]:
```
(200, 4)
```

In [6]:
```
df_human_test = pd.read_pickle("../Data/Dataframes/Human/df_human_test.pkl")
df_human_test.head()
```

Out[6]:

	folderName	imageName	Emotion	Labels
0	../Data/Human/Neutral/	S147_002_00000002.png	Neutral	5
1	../Data/Human/Angry/	s011-04_img.jpg	Angry	1
2	../Data/Human/Sad/	S071_002_00000018.png	Sad	6
3	../Data/Human/Happy/	s035-01_img.jpg	Happy	4
4	../Data/Human/Happy/	S052_004_00000031.png	Happy	4

In [7]:
```
df_human_test.shape
```

Out[7]:
```
(296, 4)
```

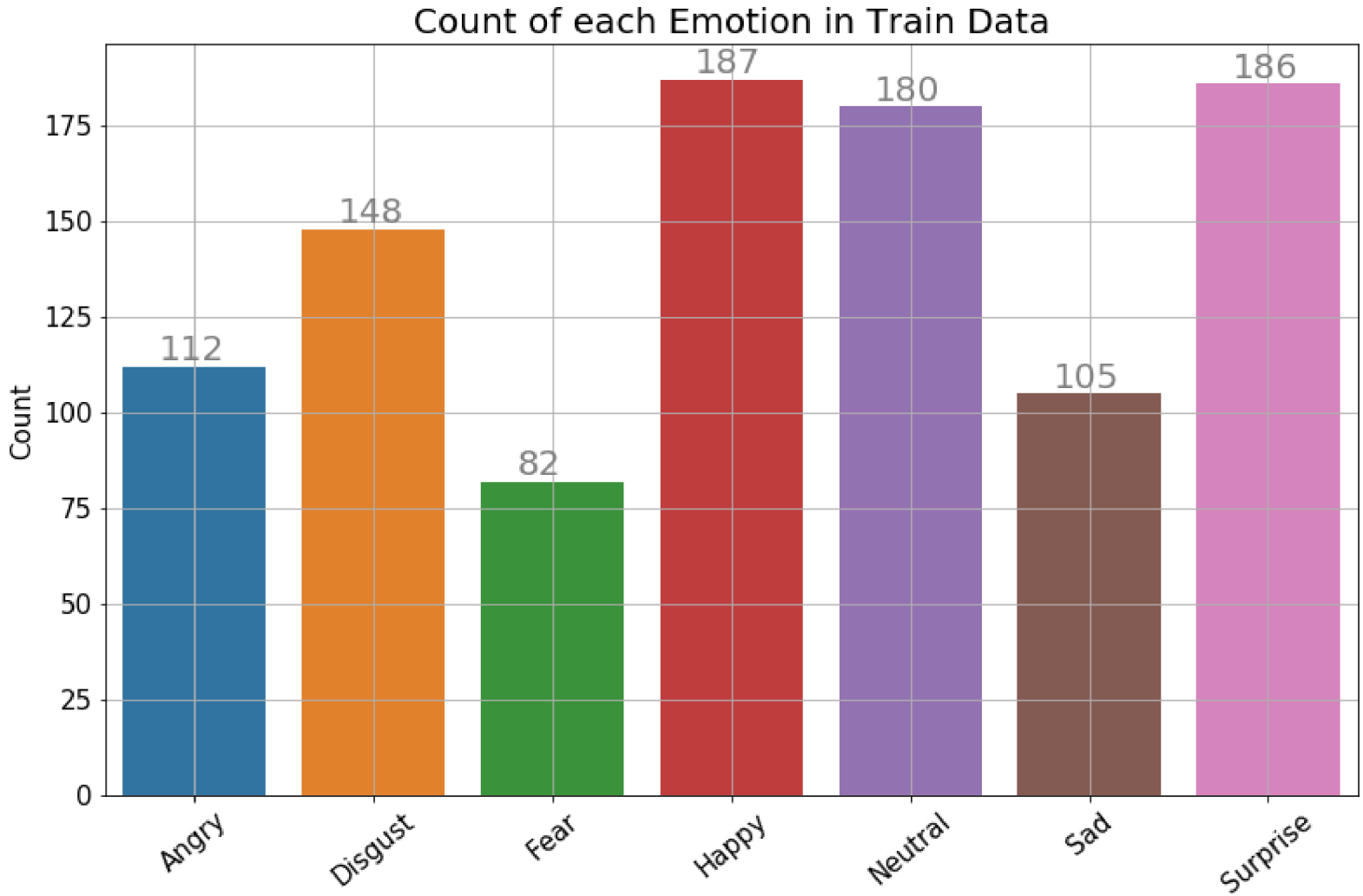
3. Analysing Data of Human Images

Distribution of class labels in Train, CV and Test

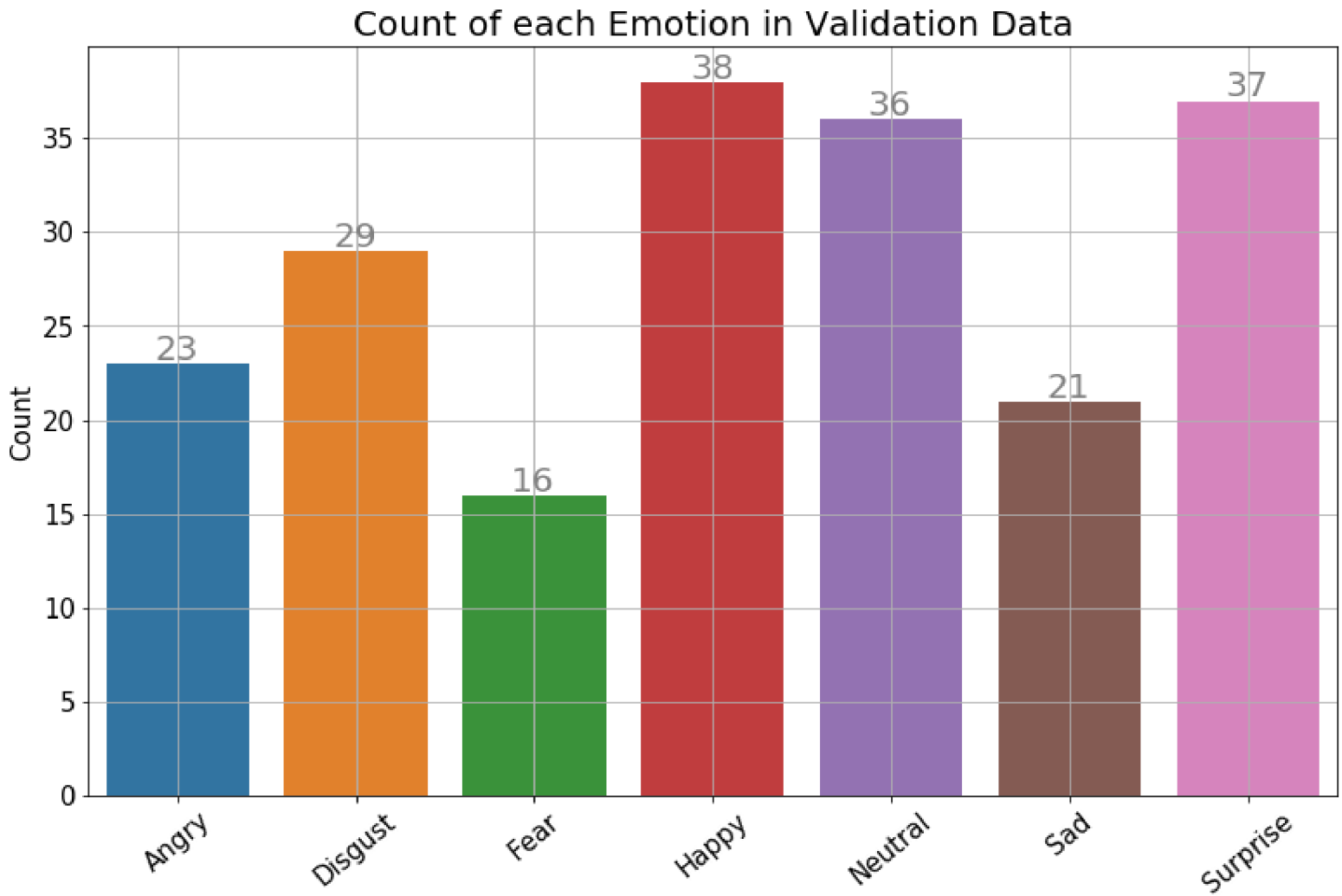
In [354]:
```
df_temp_train = df_human_train.sort_values(by = "Labels", inplace = False)
df_temp_cv = df_human_cv.sort_values(by = "Labels", inplace = False)
df_temp_test = df_human_test.sort_values(by = "Labels", inplace = False)

TrainData_distribution = df_human_train["Emotion"].value_counts().sort_index()
CVData_distribution = df_human_cv["Emotion"].value_counts().sort_index()
TestData_distribution = df_human_test["Emotion"].value_counts().sort_index()

TrainData_distribution_sorted = sorted(TrainData_distribution.items(), key = lambda d: d[1], reverse = True)
CVData_distribution_sorted = sorted(CVData_distribution.items(), key = lambda d: d[1], reverse = True)
TestData_distribution_sorted = sorted(TestData_distribution.items(), key = lambda d: d[1], reverse = True)
```

In [365]:
```
fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Train Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_train)
plt.grid()
for i in ax.patches:
    ax.text(x = i.get_x() + 0.2, y = i.get_height()+1.5, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in TrainData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_train.sha

print("-"*80)

fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Validation Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_cv)
plt.grid()
for i in ax.patches:
    ax.text(x = i.get_x() + 0.27, y = i.get_height()+0.2, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in CVData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_cv.shape[

print("-"*80)

fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Test Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_test)
plt.grid()
```

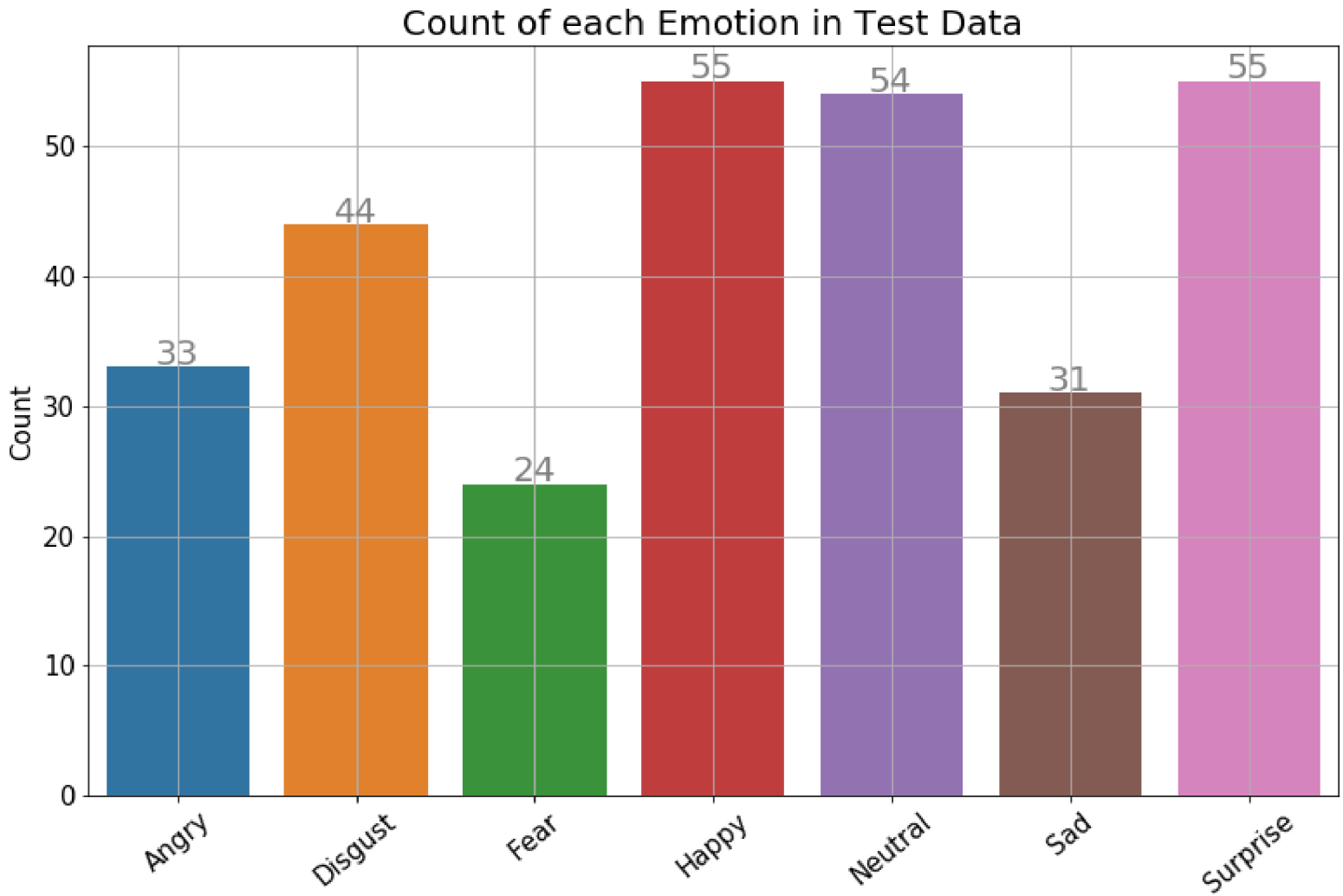
```
for i in ax.patches:
    ax.text(x = i.get_x() + 0.27, y = i.get_height()+0.2, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in TestData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_test.shap
```




```
Number of training data points in class Happy = 187(18.7%)
Number of training data points in class Surprise = 186(18.6%)
Number of training data points in class Neutral = 180(18.0%)
Number of training data points in class Disgust = 148(14.8%)
Number of training data points in class Angry = 112(11.2%)
Number of training data points in class Sad = 105(10.5%)
Number of training data points in class Fear = 82(8.2%)
--------------------------------------------------------------------------------
```




```
Number of training data points in class Happy = 38(19.0%)
Number of training data points in class Surprise = 37(18.5%)
Number of training data points in class Neutral = 36(18.0%)
Number of training data points in class Disgust = 29(14.5%)
Number of training data points in class Angry = 23(11.5%)
Number of training data points in class Sad = 21(10.5%)
Number of training data points in class Fear = 16(8.0%)
--------------------------------------------------------------------------------
```




```
Number of training data points in class Happy = 55(18.5811%)
Number of training data points in class Surprise = 55(18.5811%)
Number of training data points in class Neutral = 54(18.2432%)
Number of training data points in class Disgust = 44(14.8649%)
Number of training data points in class Angry = 33(11.1486%)
Number of training data points in class Sad = 31(10.473%)
Number of training data points in class Fear = 24(8.1081%)
```

4. Pre-Processing Human Images

4.1 Converting all the images to grayscale and save them

In [47]:
```
def convt_to_gray(df):
    count = 0
    for i in range(len(df)):
        path1 = df["folderName"][i]
        path2 = df["imageName"][i]
        img = cv2.imread(os.path.join(path1, path2))
        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
        cv2.imwrite(os.path.join(path1, path2), gray)
        count += 1
    print("Total number of images converted and saved = "+str(count))
```

In [48]:
```
convt_to_gray(df_human_train)
```

```
Total number of images converted and saved = 1000
```

In [49]:
```
convt_to_gray(df_human_cv)
```

```
Total number of images converted and saved = 200
```

In [50]:
```
convt_to_gray(df_human_test)
```

```
Total number of images converted and saved = 296
```

4.2 Detecting face in image using HAAR then crop it then resize then save the image

In [94]:
```
#detect the face in image using HAAR cascade then crop it then resize it and finally save it.
face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')
#download this xml file from link: https://github.com/opencv/opencv/tree/master/data/haarcascades.
def face_det_crop_resize(img_path):
    img = cv2.imread(img_path)
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    faces = face_cascade.detectMultiScale(gray, 1.3, 5)

    for (x,y,w,h) in faces:
        face_clip = img[y:y+h, x:x+w]  #cropping the face in image
        cv2.imwrite(img_path, cv2.resize(face_clip, (350, 350)))  #resizing image then saving it
```

In [96]:
```
for i, d in df_human_train.iterrows():
    img_path = os.path.join(d["folderName"], d["imageName"])
    face_det_crop_resize(img_path)
```

In [97]:
```
for i, d in df_human_cv.iterrows():
    img_path = os.path.join(d["folderName"], d["imageName"])
    face_det_crop_resize(img_path)
```

In [98]:
```
for i, d in df_human_test.iterrows():
    img_path = os.path.join(d["folderName"], d["imageName"])
    face_det_crop_resize(img_path)
```

5. Reading the Data of Animated Images

Angry

In [14]:
```
anime_angry = glob.glob("../Data/Animated/Angry/*.png")
print("Number of images in Angry emotion = "+str(len(anime_angry)))
```

```
Number of images in Angry emotion = 9169
```

In [16]:
```
anime_angry_folderName = [str(i.split("\\")[0])+"/" for i in anime_angry]
anime_angry_imageName = [str(i.split("\\")[1]) for i in anime_angry]
anime_angry_emotion = [["Angry"]*len(anime_angry)][0]
anime_angry_label = [1]*len(anime_angry)

len(anime_angry_folderName), len(anime_angry_imageName), len(anime_angry_emotion), len(anime_angry_label)
```

Out[16]:
```
(9169, 9169, 9169, 9169)
```

In [17]:
```
df_angry = pd.DataFrame()
df_angry["folderName"] = anime_angry_folderName
df_angry["imageName"] = anime_angry_imageName
df_angry["Emotion"] = anime_angry_emotion
df_angry["Labels"] = anime_angry_label
df_angry.head()
```

Out[17]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Angry/	aia_anger_1.png	Angry	1
1	../Data/Animated/Angry/	aia_anger_10.png	Angry	1
2	../Data/Animated/Angry/	aia_anger_100.png	Angry	1
3	../Data/Animated/Angry/	aia_anger_1000.png	Angry	1
4	../Data/Animated/Angry/	aia_anger_1001.png	Angry	1

In [25]:
```
df_angry = df_angry.sample(frac = 1.0) #shuffling dataframe
df_angry_reduced = df_angry.sample(n = 1300)  #taking only 1300 random images
df_angry_reduced.shape
```

Out[25]:
```
(1300, 4)
```

In [39]:
```
#removing all the extra images from storage
df_angry_reducedIndx = df_angry_reduced.index
count = 0
for i, d in df_angry.iterrows():
    if i not in df_angry_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 7896
```

Disgust

In [42]:
```
anime_disgust = glob.glob("../Data/Animated/Disgust/*.png")
print("Number of images in Disgust emotion = "+str(len(anime_disgust)))
```

```
Number of images in Disgust emotion = 8571
```

In [43]:
```
anime_disgust_folderName = [str(i.split("\\")[0])+"/" for i in anime_disgust]
anime_disgust_imageName = [str(i.split("\\")[1]) for i in anime_disgust]
anime_disgust_emotion = [["Disgust"]*len(anime_disgust)][0]
anime_disgust_label = [2]*len(anime_disgust)

len(anime_disgust_folderName), len(anime_disgust_imageName), len(anime_disgust_emotion), len(anime_disgust_label)
```

Out[43]:
```
(8571, 8571, 8571, 8571)
```

In [44]:
```
df_disgust = pd.DataFrame()
df_disgust["folderName"] = anime_disgust_folderName
df_disgust["imageName"] = anime_disgust_imageName
df_disgust["Emotion"] = anime_disgust_emotion
df_disgust["Labels"] = anime_disgust_label
df_disgust.head()
```

Out[44]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Disgust/	aia_disgust_1.png	Disgust	2
1	../Data/Animated/Disgust/	aia_disgust_10.png	Disgust	2
2	../Data/Animated/Disgust/	aia_disgust_100.png	Disgust	2
3	../Data/Animated/Disgust/	aia_disgust_1000.png	Disgust	2
4	../Data/Animated/Disgust/	aia_disgust_1001.png	Disgust	2

In [46]:
```
df_disgust = df_disgust.sample(frac = 1.0) #shuffling dataframe
df_disgust_reduced = df_disgust.sample(n = 1300)  #taking only 1300 random images
df_disgust_reduced.shape
```

Out[46]:
```
(1300, 4)
```

In [47]:
```
#removing all the extra images from storage
df_disgust_reducedIndx = df_disgust_reduced.index
count = 0
for i, d in df_disgust.iterrows():
    if i not in df_disgust_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 7271
```

Fear

In [48]:
```
anime_fear = glob.glob("../Data/Animated/Fear/*.png")
print("Number of images in Fear emotion = "+str(len(anime_fear)))
```

```
Number of images in Fear emotion = 7419
```

In [50]:
```
anime_fear_folderName = [str(i.split("\\")[0])+"/" for i in anime_fear]
anime_fear_imageName = [str(i.split("\\")[1]) for i in anime_fear]
anime_fear_emotion = [["Fear"]*len(anime_fear)][0]
anime_fear_label = [3]*len(anime_fear)

len(anime_fear_folderName), len(anime_fear_imageName), len(anime_fear_emotion), len(anime_fear_label)
```

Out[50]: (7419, 7419, 7419, 7419)

In [51]:
```
df_fear = pd.DataFrame()
df_fear["folderName"] = anime_fear_folderName
df_fear["imageName"] = anime_fear_imageName
df_fear["Emotion"] = anime_fear_emotion
df_fear["Labels"] = anime_fear_label
df_fear.head()
```

Out[51]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Fear/	aia_fear_1.png	Fear	3
1	../Data/Animated/Fear/	aia_fear_10.png	Fear	3
2	../Data/Animated/Fear/	aia_fear_100.png	Fear	3
3	../Data/Animated/Fear/	aia_fear_1000.png	Fear	3
4	../Data/Animated/Fear/	aia_fear_1001.png	Fear	3

In [52]:
```
df_fear = df_fear.sample(frac = 1.0) #shuffling dataframe
df_fear_reduced = df_fear.sample(n = 1300)  #taking only 1300 random images
df_fear_reduced.shape
```

Out[52]: (1300, 4)

In [53]:
```
#removing all the extra images from storage
df_fear_reducedIndx = df_fear_reduced.index
count = 0
for i, d in df_fear.iterrows():
    if i not in df_fear_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 6119
```

Happy

In [90]:
```
anime_happy = glob.glob("../Data/Animated/Happy/*.png")
print("Number of images in Happy emotion = "+str(len(anime_happy)))
```

```
Number of images in Happy emotion = 7330
```

In [91]:
```
anime_happy_folderName = [str(i.split("\\")[0])+"/" for i in anime_happy]
anime_happy_imageName = [str(i.split("\\")[1]) for i in anime_happy]
anime_happy_emotion = [["Happy"]*len(anime_happy)][0]
anime_happy_label = [4]*len(anime_happy)

len(anime_happy_folderName), len(anime_happy_imageName), len(anime_happy_emotion), len(anime_happy_label)
```

Out[91]:
```
(7330, 7330, 7330, 7330)
```

In [92]:
```
df_happy = pd.DataFrame()
df_happy["folderName"] = anime_happy_folderName
df_happy["imageName"] = anime_happy_imageName
df_happy["Emotion"] = anime_happy_emotion
df_happy["Labels"] = anime_happy_label
df_happy.head()
```

Out[92]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Happy/	aia_joy_1.png	Happy	4
1	../Data/Animated/Happy/	aia_joy_10.png	Happy	4
2	../Data/Animated/Happy/	aia_joy_100.png	Happy	4
3	../Data/Animated/Happy/	aia_joy_1000.png	Happy	4
4	../Data/Animated/Happy/	aia_joy_1001.png	Happy	4

In [93]:
```
df_happy = df_happy.sample(frac = 1.0) #shuffling dataframe
df_happy_reduced = df_happy.sample(n = 1300)  #taking only 1300 random images
df_happy_reduced.shape
```

Out[93]: (1300, 4)

In [94]:
```
#removing all the extra images from storage
df_happy_reducedIndx = df_happy_reduced.index
count = 0
for i, d in df_happy.iterrows():
    if i not in df_happy_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 6030
```

Neutral

In [95]:
```
anime_neutral = glob.glob("../Data/Animated/Neutral/*.png")
print("Number of images in Neutral emotion = "+str(len(anime_neutral)))
```

```
Number of images in Neutral emotion = 6939
```

In [96]:
```
anime_neutral_folderName = [str(i.split("\\")[0])+"/" for i in anime_neutral]
anime_neutral_imageName = [str(i.split("\\")[1]) for i in anime_neutral]
anime_neutral_emotion = [["Neutral"]*len(anime_neutral)][0]
anime_neutral_label = [5]*len(anime_neutral)

len(anime_neutral_folderName), len(anime_neutral_imageName), len(anime_neutral_emotion), len(anime_neutral_label)
```

Out[96]:
```
(6939, 6939, 6939, 6939)
```

In [97]:
```
df_neutral = pd.DataFrame()
df_neutral["folderName"] = anime_neutral_folderName
df_neutral["imageName"] = anime_neutral_imageName
df_neutral["Emotion"] = anime_neutral_emotion
df_neutral["Labels"] = anime_neutral_label
df_neutral.head()
```

Out[97]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Neutral/	aia_neutral_1.png	Neutral	5
1	../Data/Animated/Neutral/	aia_neutral_10.png	Neutral	5
2	../Data/Animated/Neutral/	aia_neutral_100.png	Neutral	5
3	../Data/Animated/Neutral/	aia_neutral_1000.png	Neutral	5
4	../Data/Animated/Neutral/	aia_neutral_1001.png	Neutral	5

In [98]:
```
df_neutral = df_neutral.sample(frac = 1.0) #shuffling dataframe
df_neutral_reduced = df_neutral.sample(n = 1300)  #taking only 1300 random images
df_neutral_reduced.shape
```

Out[98]:
```
(1300, 4)
```

In [99]:
```
#removing all the extra images from storage
df_neutral_reducedIndx = df_neutral_reduced.index
count = 0
for i, d in df_neutral.iterrows():
    if i not in df_neutral_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 5639
```

Sad

In [100]:
```
anime_sad = glob.glob("../Data/Animated/Sad/*.png")
print("Number of images in Sad emotion = "+str(len(anime_sad)))
```

```
Number of images in Sad emotion = 7627
```

In [101]:
```
anime_sad_folderName = [str(i.split("\\")[0])+"/" for i in anime_sad]
anime_sad_imageName = [str(i.split("\\")[1]) for i in anime_sad]
anime_sad_emotion = [["Sad"]*len(anime_sad)][0]
anime_sad_label = [6]*len(anime_sad)

len(anime_sad_folderName), len(anime_sad_imageName), len(anime_sad_emotion), len(anime_sad_label)
```

Out[101]:
```
(7627, 7627, 7627, 7627)
```

In [102]:
```
df_sad = pd.DataFrame()
df_sad["folderName"] = anime_sad_folderName
df_sad["imageName"] = anime_sad_imageName
df_sad["Emotion"] = anime_sad_emotion
df_sad["Labels"] = anime_sad_label
df_sad.head()
```

Out[102]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Sad/	aia_sadness_1.png	Sad	6
1	../Data/Animated/Sad/	aia_sadness_10.png	Sad	6
2	../Data/Animated/Sad/	aia_sadness_100.png	Sad	6
3	../Data/Animated/Sad/	aia_sadness_1000.png	Sad	6
4	../Data/Animated/Sad/	aia_sadness_1001.png	Sad	6

In [103]:
```
df_sad = df_sad.sample(frac = 1.0) #shuffling dataframe
df_sad_reduced = df_sad.sample(n = 1300)  #taking only 1300 random images
df_sad_reduced.shape
```

Out[103]: (1300, 4)

In [104]:
```
#removing all the extra images from storage
df_sad_reducedIndx = df_sad_reduced.index
count = 0
for i, d in df_sad.iterrows():
    if i not in df_sad_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 6327
```

Surprise

In [105]:
```
anime_surprise = glob.glob("../Data/Animated/Surprise/*.png")
print("Number of images in Surprise emotion = "+str(len(anime_surprise)))
```

```
Number of images in Surprise emotion = 8712
```

In [106]:
```
anime_surprise_folderName = [str(i.split("\\")[0])+"/" for i in anime_surprise]
anime_surprise_imageName = [str(i.split("\\")[1]) for i in anime_surprise]
anime_surprise_emotion = [["Surprise"]*len(anime_surprise)][0]
anime_surprise_label = [7]*len(anime_surprise)

len(anime_surprise_folderName), len(anime_surprise_imageName), len(anime_surprise_emotion), len(anime_surprise_label)
```

Out[106]:
```
(8712, 8712, 8712, 8712)
```

In [107]:
```
df_surprise = pd.DataFrame()
df_surprise["folderName"] = anime_surprise_folderName
df_surprise["imageName"] = anime_surprise_imageName
df_surprise["Emotion"] = anime_surprise_emotion
df_surprise["Labels"] = anime_surprise_label
df_surprise.head()
```

Out[107]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Surprise/	aia_surprise_1.png	Surprise	7
1	../Data/Animated/Surprise/	aia_surprise_10.png	Surprise	7
2	../Data/Animated/Surprise/	aia_surprise_100.png	Surprise	7
3	../Data/Animated/Surprise/	aia_surprise_1000.png	Surprise	7
4	../Data/Animated/Surprise/	aia_surprise_1001.png	Surprise	7

In [108]:
```
df_surprise = df_surprise.sample(frac = 1.0) #shuffling dataframe
df_surprise_reduced = df_surprise.sample(n = 1300)  #taking only 1300 random images
df_surprise_reduced.shape
```

Out[108]:
```
(1300, 4)
```

In [109]:
```
#removing all the extra images from storage
df_surprise_reducedIndx = df_surprise_reduced.index
count = 0
for i, d in df_surprise.iterrows():
    if i not in df_surprise_reducedIndx:
        os.remove(os.path.join(d["folderName"], d["imageName"]))
        count += 1
print("Total number of images removed = "+str(count))
```

```
Total number of images removed = 7412
```

Concatenating all Datafames

In [110]:
```
frames = [df_angry_reduced, df_disgust_reduced, df_fear_reduced, df_happy_reduced, df_neutral_reduced, df_sad_reduced, df
Final_Animated = pd.concat(frames)
Final_Animated.shape
```

Out[110]:
```
(9100, 4)
```

In [111]:
```
Final_Animated.reset_index(inplace = True, drop = True)
Final_Animated = Final_Animated.sample(frac = 1.0)   #shuffling the dataframe
Final_Animated.reset_index(inplace = True, drop = True)
Final_Animated.head()
```

Out[111]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Neutral/	ray_neutral_512.png	Neutral	5
1	../Data/Animated/Surprise/	jules_surprise_552.png	Surprise	7
2	../Data/Animated/Neutral/	malcolm_neutral_533.png	Neutral	5
3	../Data/Animated/Neutral/	mery_neutral_488.png	Neutral	5
4	../Data/Animated/Happy/	bonnie_joy_985.png	Happy	4

6. Train, CV and Test Split for Animated Images

In [152]:
```
df_anime_train_data, df_anime_test = train_test_split(Final_Animated, stratify=Final_Animated["Labels"], test_size = 0.13
df_anime_train, df_anime_cv = train_test_split(df_anime_train_data, stratify=df_anime_train_data["Labels"], test_size = 0
df_anime_train.shape, df_anime_cv.shape, df_anime_test.shape
```

Out[152]:
```
((7200, 4), (700, 4), (1200, 4))
```

In [153]:
```
df_anime_train.reset_index(inplace = True, drop = True)
df_anime_train.to_pickle("../Data/Dataframes/Animated/df_anime_train.pkl")

df_anime_cv.reset_index(inplace = True, drop = True)
df_anime_cv.to_pickle("../Data/Dataframes/Animated/df_anime_cv.pkl")

df_anime_test.reset_index(inplace = True, drop = True)
df_anime_test.to_pickle("../Data/Dataframes/Animated/df_anime_test.pkl")
```

In [8]:
```
df_anime_train = pd.read_pickle("../Data/Dataframes/Animated/df_anime_train.pkl")
df_anime_train.head()
```

Out[8]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Fear/	mery_fear_7.png	Fear	3
1	../Data/Animated/Surprise/	aia_surprise_143.png	Surprise	7
2	../Data/Animated/Neutral/	bonnie_neutral_741.png	Neutral	5
3	../Data/Animated/Disgust/	bonnie_disgust_1562.png	Disgust	2
4	../Data/Animated/Disgust/	aia_disgust_861.png	Disgust	2

In [9]:
```
df_anime_train.shape
```

Out[9]:
```
(7200, 4)
```

In [10]:
```
df_anime_cv = pd.read_pickle("../Data/Dataframes/Animated/df_anime_cv.pkl")
df_anime_cv.head()
```

Out[10]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Happy/	ray_joy_771.png	Happy	4
1	../Data/Animated/Angry/	jules_anger_1269.png	Angry	1
2	../Data/Animated/Disgust/	bonnie_disgust_2023.png	Disgust	2
3	../Data/Animated/Surprise/	jules_surprise_860.png	Surprise	7
4	../Data/Animated/Angry/	ray_anger_648.png	Angry	1

In [11]:
```
df_anime_cv.shape
```

Out[11]:
```
(700, 4)
```

In [12]:
```
df_anime_test = pd.read_pickle("../Data/Dataframes/Animated/df_anime_test.pkl")
df_anime_test.head()
```

Out[12]:

	folderName	imageName	Emotion	Labels
0	../Data/Animated/Sad/	jules_sadness_347.png	Sad	6
1	../Data/Animated/Fear/	malcolm_fear_434.png	Fear	3
2	../Data/Animated/Angry/	mery_anger_897.png	Angry	1
3	../Data/Animated/Surprise/	aia_surprise_550.png	Surprise	7
4	../Data/Animated/Fear/	mery_fear_636.png	Fear	3

In [13]:
```
df_anime_test.shape
```

Out[13]:
```
(1200, 4)
```

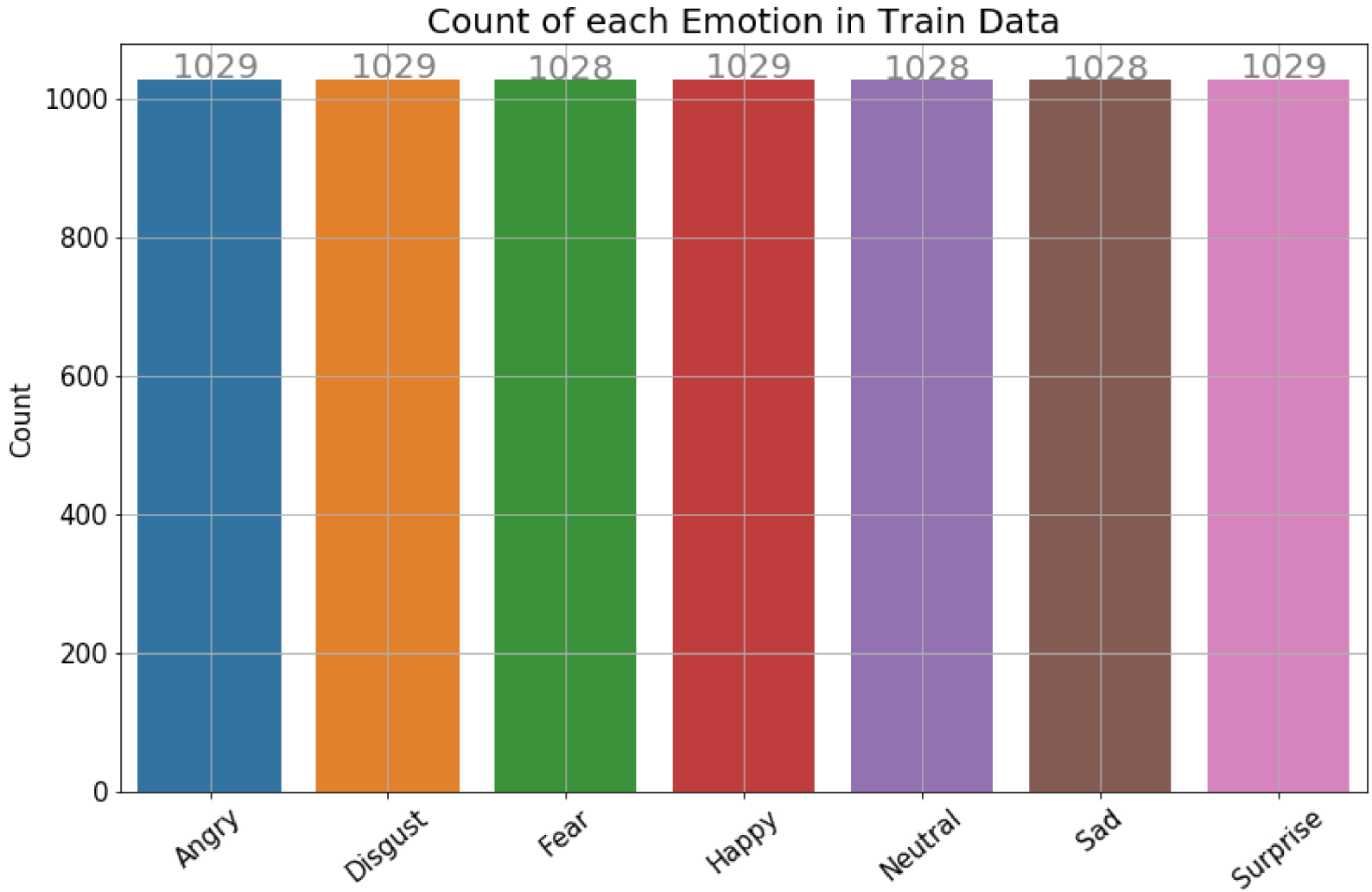
7. Analysing Data of Animated Images

Distribution of class labels in Train, CV and Test

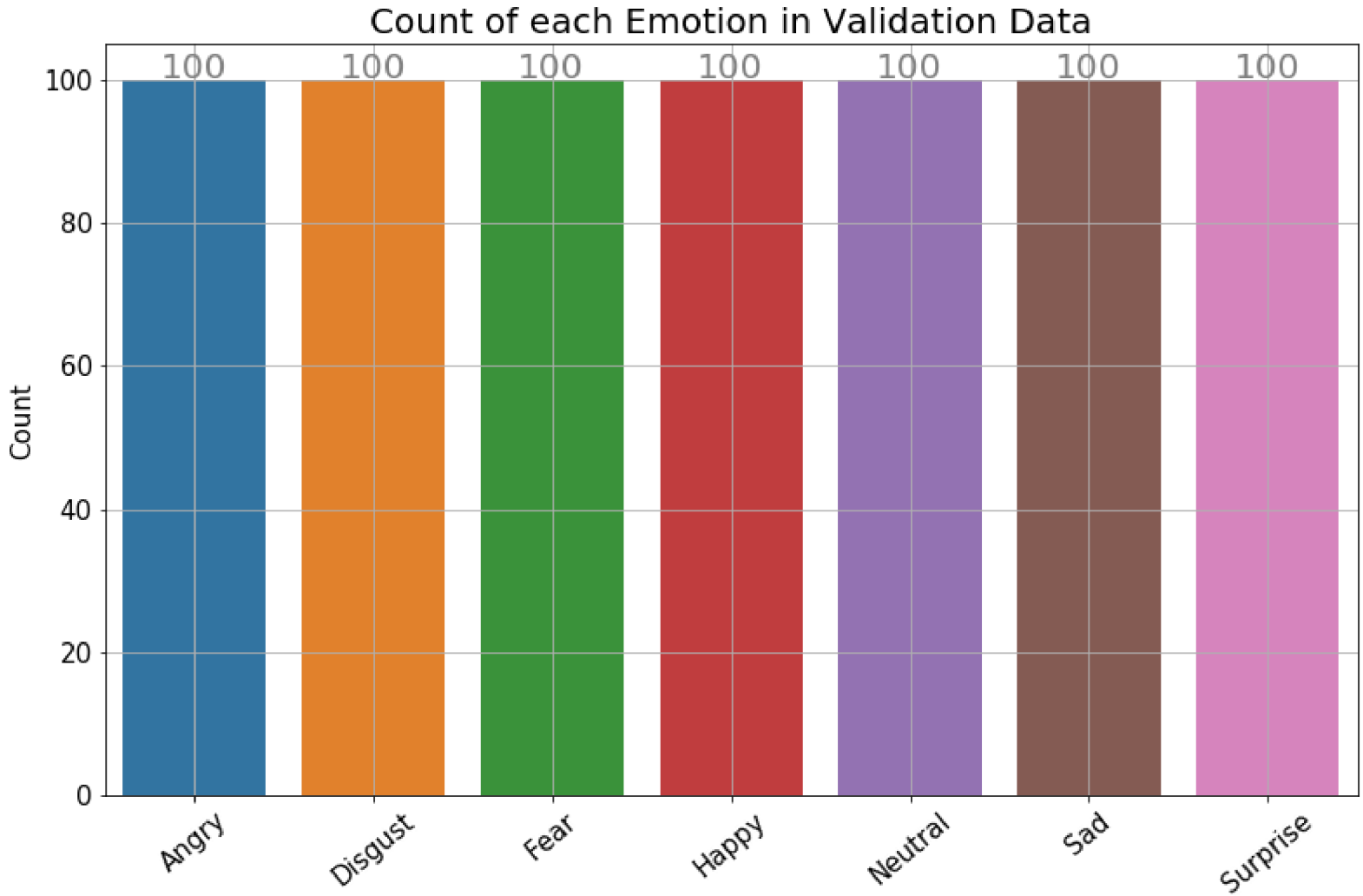
In [160]:
```
df_temp_train = df_anime_train.sort_values(by = "Labels", inplace = False)
df_temp_cv = df_anime_cv.sort_values(by = "Labels", inplace = False)
df_temp_test = df_anime_test.sort_values(by = "Labels", inplace = False)

TrainData_distribution = df_anime_train["Emotion"].value_counts().sort_index()
CVData_distribution = df_anime_cv["Emotion"].value_counts().sort_index()
TestData_distribution = df_anime_test["Emotion"].value_counts().sort_index()

TrainData_distribution_sorted = sorted(TrainData_distribution.items(), key = lambda d: d[1], reverse = True)
CVData_distribution_sorted = sorted(CVData_distribution.items(), key = lambda d: d[1], reverse = True)
TestData_distribution_sorted = sorted(TestData_distribution.items(), key = lambda d: d[1], reverse = True)
```

In [166]:
```
fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Train Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_train)
plt.grid()
for i in ax.patches:
    ax.text(x = i.get_x() + 0.185, y = i.get_height()+1.6, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in TrainData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_train.sha

print("-"*80)

fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Validation Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_cv)
plt.grid()
for i in ax.patches:
    ax.text(x = i.get_x() + 0.21, y = i.get_height()+0.3, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in CVData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_cv.shape[

print("-"*80)

fig = plt.figure(figsize = (10, 6))
ax = fig.add_axes([0,0,1,1])
ax.set_title("Count of each Emotion in Test Data", fontsize = 20)
sns.countplot(x = "Emotion", data = df_temp_test)
plt.grid()
```

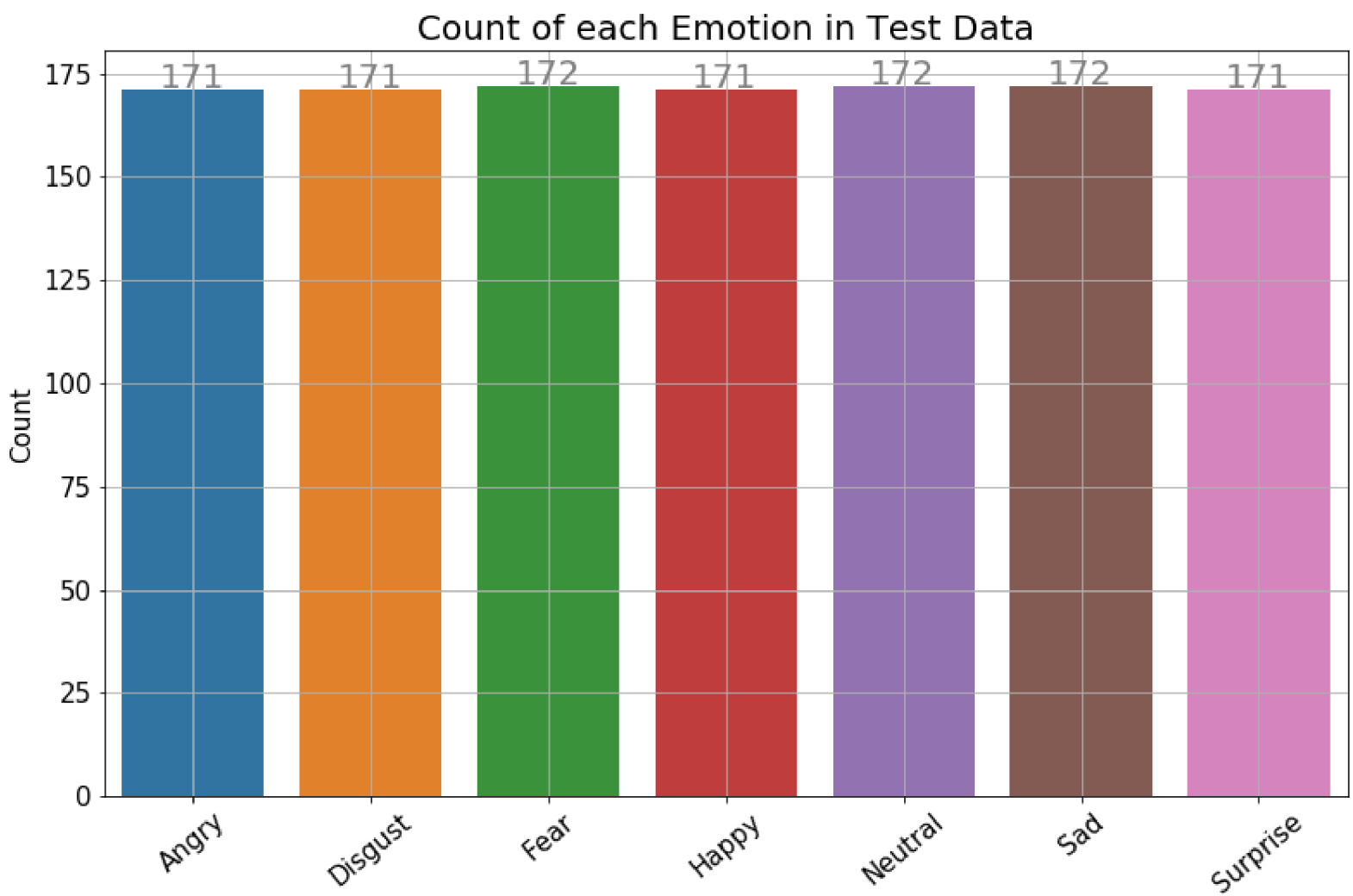
```
for i in ax.patches:
    ax.text(x = i.get_x() + 0.21, y = i.get_height()+0.3, s = str(i.get_height()), fontsize = 20, color = "grey")
plt.xlabel("")
plt.ylabel("Count", fontsize = 15)
plt.tick_params(labelsize = 15)
plt.xticks(rotation = 40)
plt.show()

for i in TestData_distribution_sorted:
    print("Number of training data points in class "+str(i[0])+" = "+str(i[1])+ "("+str(np.round(((i[1]/df_temp_test.shap
```




```
Number of training data points in class Angry = 1029(14.2917%)
Number of training data points in class Disgust = 1029(14.2917%)
Number of training data points in class Happy = 1029(14.2917%)
Number of training data points in class Surprise = 1029(14.2917%)
Number of training data points in class Fear = 1028(14.2778%)
Number of training data points in class Neutral = 1028(14.2778%)
Number of training data points in class Sad = 1028(14.2778%)
------------------------------------------------------------------------
```




```
Number of training data points in class Angry = 100(14.2857%)
Number of training data points in class Disgust = 100(14.2857%)
Number of training data points in class Fear = 100(14.2857%)
Number of training data points in class Happy = 100(14.2857%)
Number of training data points in class Neutral = 100(14.2857%)
Number of training data points in class Sad = 100(14.2857%)
Number of training data points in class Surprise = 100(14.2857%)
--------------------------------------------------------------------------------
```




```
Number of training data points in class Fear = 172(14.3333%)
Number of training data points in class Neutral = 172(14.3333%)
Number of training data points in class Sad = 172(14.3333%)
Number of training data points in class Angry = 171(14.25%)
Number of training data points in class Disgust = 171(14.25%)
Number of training data points in class Happy = 171(14.25%)
Number of training data points in class Surprise = 171(14.25%)
```

8. Pre-Processing Animated Images

8.1 Converting all the images to grayscale and save them

In [169]:
```
def convt_to_gray(df):
    count = 0
    for i in range(len(df)):
        path1 = df["folderName"][i]
        path2 = df["imageName"][i]
        img = cv2.imread(os.path.join(path1, path2))
        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
        cv2.imwrite(os.path.join(path1, path2), gray)
        count += 1
    print("Total number of images converted and saved = "+str(count))
```

In [170]:
```
convt_to_gray(df_anime_train)
```

```
Total number of images converted and saved = 7200
```

In [171]:
```
convt_to_gray(df_anime_cv)
```

```
Total number of images converted and saved = 700
```

In [172]:
```
convt_to_gray(df_anime_test)
```

```
Total number of images converted and saved = 1200
```

8.2 Crop the image then resize them then save them.

In [330]:
```
def change_image(df):
    count = 0
    for i, d in df.iterrows():
        img = cv2.imread(os.path.join(d["folderName"], d["imageName"]))
        face_clip = img[40:240, 35:225]         #cropping the face in image
        face_resized = cv2.resize(face_clip, (350, 350))
        cv2.imwrite(os.path.join(d["folderName"], d["imageName"]), face_resized) #resizing and saving the image
        count += 1
    print("Total number of images cropped and resized = {}".format(count))
```

In [331]:
```
change_image(df_anime_train)
```

```
Total number of images cropped and resized = 7200
```

In [332]:
```
change_image(df_anime_cv)
```

```
Total number of images cropped and resized = 700
```

In [333]:
```
change_image(df_anime_test)
```

```
Total number of images cropped and resized = 1200
```

9. Combining train data of both Animated and Human images

Remember, that here we have combined only the train images of both human and animated so that we can train our model on both human and animated images. However, we have kept CV and test images of both human and animated separate so that we can cross validation our results on both human and animated images separately. At the same time we will also be able to test the efficiency of our model separately on human and animated images. By this we will get to know that how well our model is performing on human and animated images separately.

In [14]:
```
frames = [df_human_train, df_anime_train]
combined_train = pd.concat(frames)
combined_train.shape
```

Out[14]:
```
(8200, 4)
```

In [16]:
```
combined_train = combined_train.sample(frac = 1.0)  #shuffling the dataframe
combined_train.reset_index(inplace = True, drop = True)
combined_train.to_pickle("../Data/Dataframes/combined_train.pkl")
```

10. Creating bottleneck features from VGG-16 model. Here, we are using Transfer learning.

In [7]:
```
# Now since I don't have a computation power so what I have done here, is that I have created bottleneck features from VG
# network. Now since VGG-16 neural network contains lots of convolution layers and it is well trained on Image net datase
# contains million images. Here, we just have to load the VGG-16 network with image-net weights. Here, we have to exclude
# means we do not need the top MLP part of VGG network. We have stopped VGG before MLL so that we can take bottleneck fea
# of our images. Then we have to use predict() function of VGG-16 to generate bottleneck features by passing each of our
# through VGG-16 network. Simultaneously, we have stored those bottleneck features in a numpy file and saved them in our
# disk for later using them for training our own MLP model.
# After, this now for every image we have bottleneck features of VGG-16 which we have created by passing each of our imag
# through VGG-16 network. Now, we just have to create our own MLP and pass those bottleneck features of each image throug
# for training that MLP. This is nothing but transfer learning. Here, we have transfer the learning of VGG-16 for our tas
```

In [2]:
```
Train_Combined = pd.read_pickle("../Data/Dataframes/combined_train.pkl")
CV_Humans = pd.read_pickle("../Data/Dataframes/Human/df_human_cv.pkl")
CV_Animated = pd.read_pickle("../Data/Dataframes/Animated/df_anime_cv.pkl")
Test_Humans = pd.read_pickle("../Data/Dataframes/Human/df_human_test.pkl")
Test_Animated = pd.read_pickle("../Data/Dataframes/Animated/df_anime_test.pkl")

Train_Combined.shape, CV_Humans.shape, CV_Animated.shape, Test_Humans.shape, Test_Animated.shape
```

Out[2]:
```
((8200, 4), (200, 4), (700, 4), (296, 4), (1200, 4))
```

In [5]:
```
TrainCombined_batch_pointer = 0
CVHumans_batch_pointer = 0
CVAnimated_batch_pointer = 0
TestHumans_batch_pointer = 0
TestAnimated_batch_pointer = 0
```

10.1 Bottleneck features for CombinedTrain Data

In [4]:
```
TrainCombined_Labels = pd.get_dummies(Train_Combined["Labels"]).as_matrix()
TrainCombined_Labels.shape
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: FutureWarning: Method .as_matrix will be removed
in a future version. Use .values instead.
  """Entry point for launching an IPython kernel.
```

Out[4]:
```
(8200, 7)
```

In [5]:
```
def loadCombinedTrainBatch(batch_size):
    global TrainCombined_batch_pointer
    batch_images = []
    batch_labels = []
    for i in range(batch_size):
        path1 = Train_Combined.iloc[TrainCombined_batch_pointer + i]["folderName"]
        path2 = Train_Combined.iloc[TrainCombined_batch_pointer + i]["imageName"]
        read_image = cv2.imread(os.path.join(path1, path2))
        read_image_final = read_image/255.0  #here, we are normalizing the images
        batch_images.append(read_image_final)

        batch_labels.append(TrainCombined_Labels[TrainCombined_batch_pointer + i]) #appending corresponding labels

    TrainCombined_batch_pointer += batch_size

    return np.array(batch_images), np.array(batch_labels)
```

In [1]:
```
#creating bottleneck features for train data using VGG-16- Image-net model
model = VGG16(weights='imagenet', include_top=False)
SAVEDIR = "../Data/Bottleneck_Features/Bottleneck_CombinedTrain/"
SAVEDIR_LABELS = "../Data/Bottleneck_Features/CombinedTrain_Labels/"
batch_size = 10
for i in range(int(len(Train_Combined)/batch_size)):
    x, y = loadCombinedTrainBatch(batch_size)
    print("Batch {} loaded".format(i+1))

    np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(i+1)), y)

    print("Creating bottleneck features for batch {}". format(i+1))
    bottleneck_features = model.predict(x)
    np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(i+1)), bottleneck_features)
    print("Bottleneck features for batch {} created and saved\n".format(i+1))
```

10.2 Bottleneck features for CV Human

In [57]:
```
CVHumans_Labels = pd.get_dummies(CV_Humans["Labels"]).as_matrix()
CVHumans_Labels.shape
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: FutureWarning: Method .as_matrix will be removed
in a future version. Use .values instead.
  """Entry point for launching an IPython kernel.
```

Out[57]:
```
(200, 7)
```

In [58]:
```
def loadCVHumanBatch(batch_size):
    global CVHumans_batch_pointer
    batch_images = []
    batch_labels = []
    for i in range(batch_size):
        path1 = CV_Humans.iloc[CVHumans_batch_pointer + i]["folderName"]
        path2 = CV_Humans.iloc[CVHumans_batch_pointer + i]["imageName"]
        read_image = cv2.imread(os.path.join(path1, path2))
        read_image_final = read_image/255.0  #here, we are normalizing the images
        batch_images.append(read_image_final)

        batch_labels.append(CVHumans_Labels[CVHumans_batch_pointer + i]) #appending corresponding labels

    CVHumans_batch_pointer += batch_size

    return np.array(batch_images), np.array(batch_labels)
```

In [2]:
```
#creating bottleneck features for CV Human data using VGG-16- Image-net model
model = VGG16(weights='imagenet', include_top=False)
SAVEDIR = "../Data/Bottleneck_Features/Bottleneck_CVHumans/"
SAVEDIR_LABELS = "../Data/Bottleneck_Features/CVHumans_Labels/"
batch_size = 10
for i in range(int(len(CV_Humans)/batch_size)):
    x, y = loadCVHumanBatch(batch_size)
    print("Batch {} loaded".format(i+1))

    np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(i+1)), y)

    print("Creating bottleneck features for batch {}". format(i+1))
    bottleneck_features = model.predict(x)
    np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(i+1)), bottleneck_features)
    print("Bottleneck features for batch {} created and saved\n".format(i+1))
```

10.3 Bottleneck features for CV Animated

In [63]:
```
CVAnimated_Labels = pd.get_dummies(CV_Animated["Labels"]).as_matrix()
CVAnimated_Labels.shape
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: FutureWarning: Method .as_matrix will be removed
in a future version. Use .values instead.
  """Entry point for launching an IPython kernel.
```

Out[63]:
```
(700, 7)
```

In [64]:
```
def loadCVAnimatedBatch(batch_size):
    global CVAnimated_batch_pointer
    batch_images = []
    batch_labels = []
    for i in range(batch_size):
        path1 = CV_Animated.iloc[CVAnimated_batch_pointer + i]["folderName"]
        path2 = CV_Animated.iloc[CVAnimated_batch_pointer + i]["imageName"]
        read_image = cv2.imread(os.path.join(path1, path2))
        read_image_final = read_image/255.0  #here, we are normalizing the images
        batch_images.append(read_image_final)

        batch_labels.append(CVAnimated_Labels[CVAnimated_batch_pointer + i]) #appending corresponding labels

    CVAnimated_batch_pointer += batch_size

    return np.array(batch_images), np.array(batch_labels)
```

In [3]:
```
#creating bottleneck features for CV Animated data using VGG-16- Image-net model
model = VGG16(weights='imagenet', include_top=False)
SAVEDIR = "../Data/Bottleneck_Features/Bottleneck_CVAnimated/"
SAVEDIR_LABELS = "../Data/Bottleneck_Features/CVAnimated_Labels/"
batch_size = 10
for i in range(int(len(CV_Animated)/batch_size)):
    x, y = loadCVAnimatedBatch(batch_size)
    print("Batch {} loaded".format(i+1))

    np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(i+1)), y)

    print("Creating bottleneck features for batch {}". format(i+1))
    bottleneck_features = model.predict(x)
    np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(i+1)), bottleneck_features)
    print("Bottleneck features for batch {} created and saved\n".format(i+1))
```

10.4 Bottleneck Features for Test Human Data

In [66]:
```
TestHuman_Labels = pd.get_dummies(Test_Humans["Labels"]).as_matrix()
TestHuman_Labels.shape
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: FutureWarning: Method .as_matrix will be removed
in a future version. Use .values instead.
  """Entry point for launching an IPython kernel.
```

Out[66]:
```
(296, 7)
```

In [67]:
```
def loadTestHumansBatch(batch_size):
    global TestHumans_batch_pointer
    batch_images = []
    batch_labels = []
    for i in range(batch_size):
        path1 = Test_Humans.iloc[TestHumans_batch_pointer + i]["folderName"]
        path2 = Test_Humans.iloc[TestHumans_batch_pointer + i]["imageName"]
        read_image = cv2.imread(os.path.join(path1, path2))
        read_image_final = read_image/255.0  #here, we are normalizing the images
        batch_images.append(read_image_final)

        batch_labels.append(TestHuman_Labels[TestHumans_batch_pointer + i]) #appending corresponding labels

    TestHumans_batch_pointer += batch_size

    return np.array(batch_images), np.array(batch_labels)
```

In [4]:
```
#creating bottleneck features for Test Humans data using VGG-16- Image-net model
model = VGG16(weights='imagenet', include_top=False)
SAVEDIR = "../Data/Bottleneck_Features/Bottleneck_TestHumans/"
SAVEDIR_LABELS = "../Data/Bottleneck_Features/TestHumans_Labels/"
batch_size = 10
for i in range(int(len(Test_Humans)/batch_size)):
    x, y = loadTestHumansBatch(batch_size)
    print("Batch {} loaded".format(i+1))

    np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(i+1)), y)

    print("Creating bottleneck features for batch {}". format(i+1))
    bottleneck_features = model.predict(x)
    np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(i+1)), bottleneck_features)
    print("Bottleneck features for batch {} created and saved\n".format(i+1))

leftover_points = len(Test_Humans) - TestHumans_batch_pointer
x, y = loadTestHumansBatch(leftover_points)
np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(int(len(Test_Humans)/batch_size) + 1)), y)
bottleneck_features = model.predict(x)
np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(int(len(Test_Humans)/batch_size) + 1)), bottleneck_features)
```

10.5 Bottleneck Features for Test Animated Data

In [6]:
```
TestAnimated_Labels = pd.get_dummies(Test_Animated["Labels"]).as_matrix()
TestAnimated_Labels.shape
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: FutureWarning: Method .as_matrix will be removed
in a future version. Use .values instead.
  """Entry point for launching an IPython kernel.
```

Out[6]:
```
(1200, 7)
```

In [7]:
```
def loadTestAnimatedBatch(batch_size):
    global TestAnimated_batch_pointer
    batch_images = []
    batch_labels = []
    for i in range(batch_size):
        path1 = Test_Animated.iloc[TestAnimated_batch_pointer + i]["folderName"]
        path2 = Test_Animated.iloc[TestAnimated_batch_pointer + i]["imageName"]
        read_image = cv2.imread(os.path.join(path1, path2))
        read_image_final = read_image/255.0  #here, we are normalizing the images
        batch_images.append(read_image_final)

        batch_labels.append(TestAnimated_Labels[TestAnimated_batch_pointer + i]) #appending corresponding labels

    TestAnimated_batch_pointer += batch_size

    return np.array(batch_images), np.array(batch_labels)
```

In [5]:
```
#creating bottleneck features for Test Animated data using VGG-16- Image-net model
model = VGG16(weights='imagenet', include_top=False)
SAVEDIR = "../Data/Bottleneck_Features/Bottleneck_TestAnimated/"
SAVEDIR_LABELS = "../Data/Bottleneck_Features/TestAnimated_Labels/"
batch_size = 10
for i in range(int(len(Test_Animated)/batch_size)):
    x, y = loadTestAnimatedBatch(batch_size)
    print("Batch {} loaded".format(i+1))

    np.save(os.path.join(SAVEDIR_LABELS, "bottleneck_labels_{}".format(i+1)), y)

    print("Creating bottleneck features for batch {}". format(i+1))
    bottleneck_features = model.predict(x)
    np.save(os.path.join(SAVEDIR, "bottleneck_{}".format(i+1)), bottleneck_features)
    print("Bottleneck features for batch {} created and saved\n".format(i+1))
```

11. Modelling & Training

In [3]:
```
no_of_classes = 7
```

In [30]:
```
#model architecture
def model(input_shape):
    model = Sequential()

    model.add(Dense(512, activation='relu', input_dim = input_shape))
    model.add(Dropout(0.1))

    model.add(Dense(256, activation='relu'))

    model.add(Dense(128, activation='relu'))
    model.add(BatchNormalization())

    model.add(Dense(64, activation='relu'))
    model.add(Dense(output_dim = no_of_classes, activation='softmax'))

    return model
```

In [6]:
```
#training the model
SAVEDIR_COMB_TRAIN = "../Data/Bottleneck_Features/Bottleneck_CombinedTrain/"
SAVEDIR_COMB_TRAIN_LABELS = "../Data/Bottleneck_Features/CombinedTrain_Labels/"

SAVEDIR_CV_HUMANS = "../Data/Bottleneck_Features/Bottleneck_CVHumans/"
SAVEDIR_CV_HUMANS_LABELS = "../Data/Bottleneck_Features/CVHumans_Labels/"

SAVEDIR_CV_ANIME = "../Data/Bottleneck_Features/Bottleneck_CVAnimated/"
SAVEDIR_CV_ANIME_LABELS =  "../Data/Bottleneck_Features/CVAnimated_Labels/"

SAVER = "../Data/Model_Save/"

input_shape = 10*10*512   #this is the shape of bottleneck feature of each image which comes after passing the image thro

model = model(input_shape)
# model.load_weights(os.path.join(SAVER, "model.h5"))
model.summary()
model.compile(loss = 'categorical_crossentropy', optimizer = "adam", metrics = ["accuracy"])

epochs = 20
batch_size = 10
step = 0
combTrain_bottleneck_files = int(len(Train_Combined) / batch_size)
CVHuman_bottleneck_files = int(len(CV_Humans) / batch_size)
CVAnime_bottleneck_files = int(len(CV_Animated) / batch_size)
epoch_number, CombTrain_loss, CombTrain_acc, CVHuman_loss, CVHuman_acc, CVAnime_loss, CVAnime_acc = [], [], [], [], [], [

for epoch in range(epochs):
    avg_epoch_CombTr_loss, avg_epoch_CombTr_acc, avg_epoch_CVHum_loss, avg_epoch_CVHum_acc, avg_epoch_CVAnime_loss, avg_e
    epoch_number.append(epoch + 1)

    for i in range(combTrain_bottleneck_files):

        step += 1

        #loading batch of train bottleneck features for training MLP.
        X_CombTrain_load = np.load(os.path.join(SAVEDIR_COMB_TRAIN, "bottleneck_{}.npy".format(i+1)))
        X_CombTrain = X_CombTrain_load.reshape(X_CombTrain_load.shape[0], X_CombTrain_load.shape[1]*X_CombTrain_load.shap
        Y_CombTrain = np.load(os.path.join(SAVEDIR_COMB_TRAIN_LABELS, "bottleneck_labels_{}.npy".format(i+1)))

        #loading batch of Human CV bottleneck features for cross-validation.
```

```
            X_CVHuman_load = np.load(os.path.join(SAVEDIR_CV_HUMANS, "bottleneck_{}.npy".format((i % CVHuman_bottleneck_files
            X_CVHuman = X_CVHuman_load.reshape(X_CVHuman_load.shape[0], X_CVHuman_load.shape[1]*X_CVHuman_load.shape[2]*X_CVH
            Y_CVHuman = np.load(os.path.join(SAVEDIR_CV_HUMANS_LABELS, "bottleneck_labels_{}.npy".format((i % CVHuman_bottlen

            #loading batch of animated CV bottleneck features for cross-validation.
            X_CVAnime_load = np.load(os.path.join(SAVEDIR_CV_ANIME, "bottleneck_{}.npy".format((i % CVAnime_bottleneck_files)
            X_CVAnime = X_CVAnime_load.reshape(X_CVAnime_load.shape[0], X_CVAnime_load.shape[1]*X_CVAnime_load.shape[2]*X_CVA
            Y_CVAnime = np.load(os.path.join(SAVEDIR_CV_ANIME_LABELS, "bottleneck_labels_{}.npy".format((i % CVAnime_bottlene

            CombTrain_Loss, CombTrain_Accuracy = model.train_on_batch(X_CombTrain, Y_CombTrain) #train the model on batch
            CVHuman_Loss, CVHuman_Accuracy = model.test_on_batch(X_CVHuman, Y_CVHuman) #cross validate the model on CV Human
            CVAnime_Loss, CVAnime_Accuracy = model.test_on_batch(X_CVAnime, Y_CVAnime) #cross validate the model on CV Animat

            print("Epoch: {}, Step: {}, CombTr_Loss: {}, CombTr_Acc: {}, CVHum_Loss: {}, CVHum_Acc: {}, CVAni_Loss: {}, CVAni

            avg_epoch_CombTr_loss += CombTrain_Loss / combTrain_bottleneck_files
            avg_epoch_CombTr_acc += CombTrain_Accuracy / combTrain_bottleneck_files
            avg_epoch_CVHum_loss += CVHuman_Loss / combTrain_bottleneck_files
            avg_epoch_CVHum_acc += CVHuman_Accuracy / combTrain_bottleneck_files
            avg_epoch_CVAnime_loss += CVAnime_Loss / combTrain_bottleneck_files
            avg_epoch_CVAnime_acc += CVAnime_Accuracy / combTrain_bottleneck_files

        print("Avg_CombTrain_Loss: {}, Avg_CombTrain_Acc: {}, Avg_CVHum_Loss: {}, Avg_CVHum_Acc: {}, Avg_CVAnime_Loss: {}, Av

        CombTrain_loss.append(avg_epoch_CombTr_loss)
        CombTrain_acc.append(avg_epoch_CombTr_acc)
        CVHuman_loss.append(avg_epoch_CVHum_loss)
        CVHuman_acc.append(avg_epoch_CVHum_acc)
        CVAnime_loss.append(avg_epoch_CVAnime_loss)
        CVAnime_acc.append(avg_epoch_CVAnime_acc)

        model.save(os.path.join(SAVER, "model.h5"))  #saving the model on each epoc
        model.save_weights(os.path.join(SAVER, "model_weights.h5")) #saving the weights of model on each epoch
        print("Model and weights saved at epoch {}".format(epoch + 1))

log_frame = pd.DataFrame(columns = ["Epoch", "Comb_Train_Loss", "Comb_Train_Accuracy", "CVHuman_Loss", "CVHuman_Accuracy"
log_frame["Epoch"] = epoch_number
log_frame["Comb_Train_Loss"] = CombTrain_loss
log_frame["Comb_Train_Accuracy"] = CombTrain_acc
log_frame["CVHuman_Loss"] = CVHuman_loss
log_frame["CVHuman_Accuracy"] = CVHuman_acc
log_frame["CVAnime_Loss"] = CVAnime_loss
```

```
log_frame["CVAnime_Accuracy"] = CVAnime_acc
log_frame.to_csv("../Data/Logs/Log.csv", index = False)
```

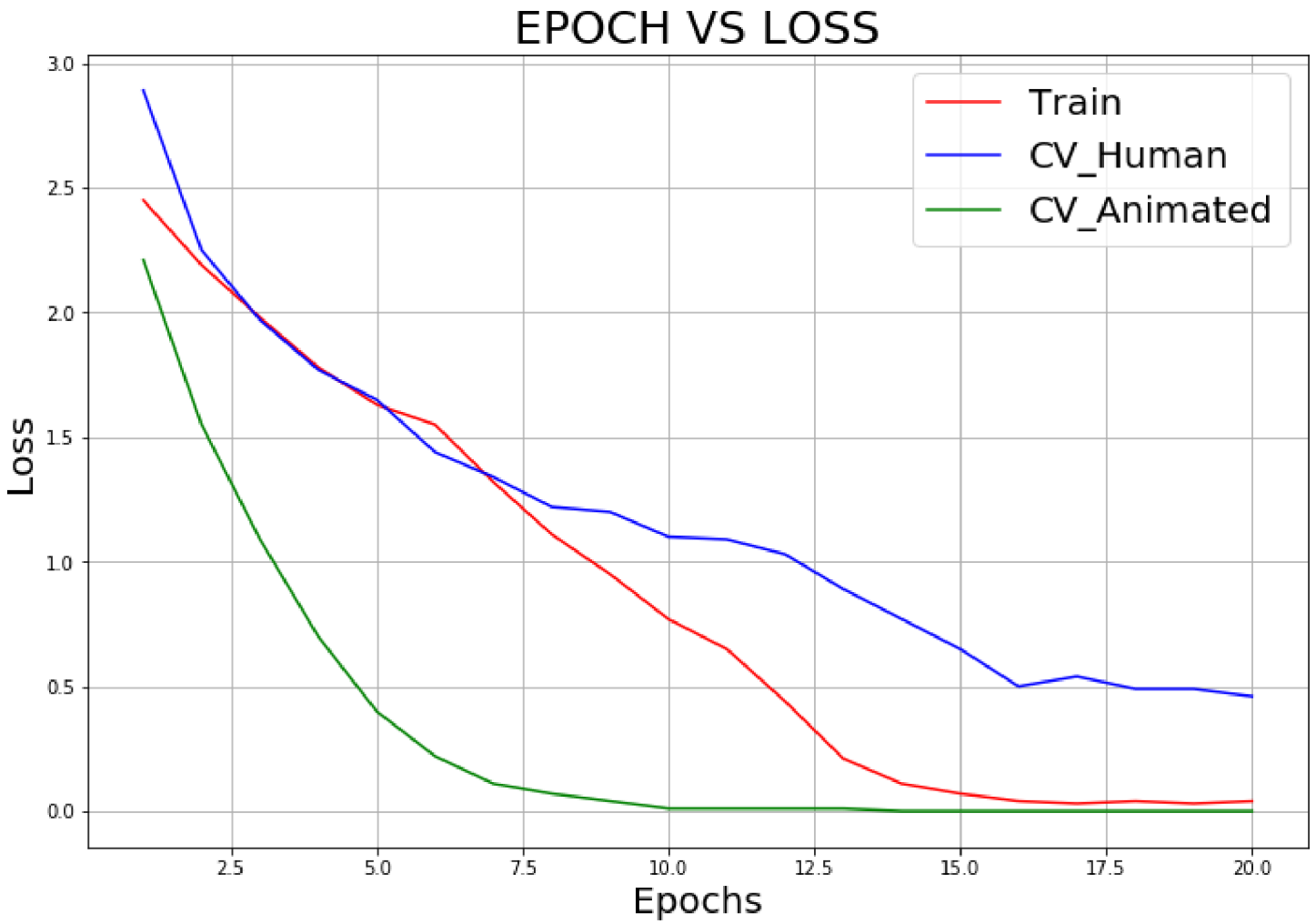
In [40]:
```
log = pd.read_csv("../Data/Logs/Log.csv")
log
```

Out[40]:

	Epoch	Comb_Train_Loss	Comb_Train_Accuracy	CVHuman_Loss	CVHuman_Accuracy	CVAnime_Loss	CVAnime_Accuracy
0	1	2.45	0.17	2.89	0.15	2.21	0.19
1	2	2.19	0.21	2.25	0.21	1.55	0.34
2	3	1.98	0.25	1.97	0.25	1.09	0.51
3	4	1.78	0.31	1.77	0.29	0.70	0.71
4	5	1.63	0.35	1.65	0.35	0.40	0.85
5	6	1.55	0.41	1.44	0.48	0.22	0.91
6	7	1.32	0.51	1.34	0.50	0.11	0.93
7	8	1.11	0.57	1.22	0.54	0.07	0.97
8	9	0.95	0.61	1.20	0.55	0.04	0.98
9	10	0.77	0.69	1.10	0.57	0.01	0.99
10	11	0.65	0.75	1.09	0.60	0.01	0.99
11	12	0.44	0.81	1.03	0.61	0.01	0.99
12	13	0.21	0.89	0.89	0.69	0.01	1.00
13	14	0.11	0.93	0.77	0.75	0.00	1.00
14	15	0.07	0.97	0.65	0.83	0.00	1.00
15	16	0.04	0.99	0.50	0.85	0.00	1.00
16	17	0.03	0.99	0.54	0.84	0.00	1.00
17	18	0.04	0.99	0.49	0.86	0.00	1.00
18	19	0.03	0.99	0.49	0.87	0.00	1.00
19	20	0.04	0.99	0.46	0.87	0.00	1.00

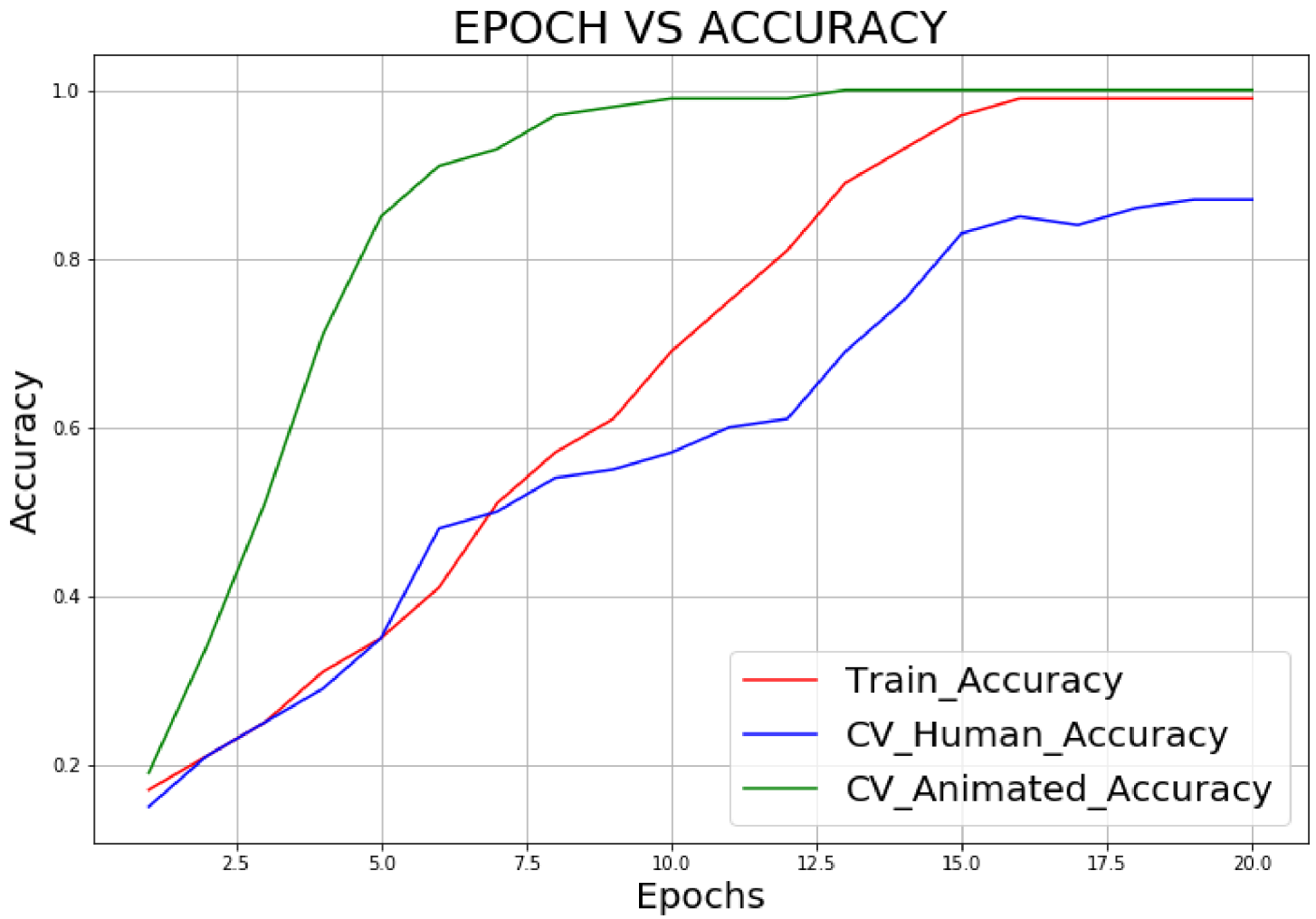
In [41]:
```
def plotting(epoch, train_loss, CVHuman_loss, CVAnimated_loss, title):
    fig, axes = plt.subplots(1,1, figsize = (12, 8))
    axes.plot(epoch, train_loss, color = 'red', label = "Train")
    axes.plot(epoch, CVHuman_loss, color = 'blue', label = "CV_Human")
    axes.plot(epoch, CVAnimated_loss, color = 'green', label = "CV_Animated")
    axes.set_title(title, fontsize = 25)
    axes.set_xlabel("Epochs", fontsize = 20)
    axes.set_ylabel("Loss", fontsize = 20)
    axes.grid()
    axes.legend(fontsize = 20)
```

In [44]:
```
plotting(list(log["Epoch"]), list(log["Comb_Train_Loss"]), list(log["CVHuman_Loss"]), list(log["CVAnime_Loss"]), "EPOCH V
```



In [47]:
```
def plotting(epoch, train_acc, CVHuman_acc, CVAnimated_acc, title):
    fig, axes = plt.subplots(1,1, figsize = (12, 8))
    axes.plot(epoch, train_acc, color = 'red', label = "Train_Accuracy")
    axes.plot(epoch, CVHuman_acc, color = 'blue', label = "CV_Human_Accuracy")
    axes.plot(epoch, CVAnimated_acc, color = 'green', label = "CV_Animated_Accuracy")
    axes.set_title(title, fontsize = 25)
    axes.set_xlabel("Epochs", fontsize = 20)
    axes.set_ylabel("Accuracy", fontsize = 20)
    axes.grid()
    axes.legend(fontsize = 20)
```

In [49]:
```
plotting(list(log["Epoch"]), list(log["Comb_Train_Accuracy"]), list(log["CVHuman_Accuracy"]), list(log["CVAnime_Accuracy"]
```



12. Checking Test Accuracy

In [3]:
```
def print_confusionMatrix(Y_TestLabels, PredictedLabels):
    confusionMatx = confusion_matrix(Y_TestLabels, PredictedLabels)

    precision = confusionMatx/confusionMatx.sum(axis = 0)

    recall = (confusionMatx.T/confusionMatx.sum(axis = 1)).T

    sns.set(font_scale=1.5)

    # confusionMatx = [[1, 2],
    #                  [3, 4]]
    # confusionMatx.T = [[1, 3],
    #                    [2, 4]]
    # confusionMatx.sum(axis = 1)  axis=0 corresponds to columns and axis=1 corresponds to rows in two diamensional array
    # confusionMatx.sum(axix =1) = [[3, 7]]
    # (confusionMatx.T)/(confusionMatx.sum(axis=1)) = [[1/3, 3/7]
    #                                                  [2/3, 4/7]]

    # (confusionMatx.T)/(confusionMatx.sum(axis=1)).T = [[1/3, 2/3]
    #                                                    [3/7, 4/7]]
    # sum of row elements = 1

    labels = ["ANGRY", "DISGUST", "FEAR", "HAPPY", "NEUTRAL", "SAD", "SURPRISE"]

    plt.figure(figsize=(16,7))
    sns.heatmap(confusionMatx, cmap = "Blues", annot = True, fmt = ".1f", xticklabels=labels, yticklabels=labels)
    plt.title("Confusion Matrix", fontsize = 30)
    plt.xlabel('Predicted Class', fontsize = 20)
    plt.ylabel('Original Class', fontsize = 20)
    plt.tick_params(labelsize = 15)
    plt.xticks(rotation = 90)
    plt.show()

    print("-"*125)

    plt.figure(figsize=(16,7))
    sns.heatmap(precision, cmap = "Blues", annot = True, fmt = ".2f", xticklabels=labels, yticklabels=labels)
    plt.title("Precision Matrix", fontsize = 30)
    plt.xlabel('Predicted Class', fontsize = 20)
    plt.ylabel('Original Class', fontsize = 20)
    plt.tick_params(labelsize = 15)
```

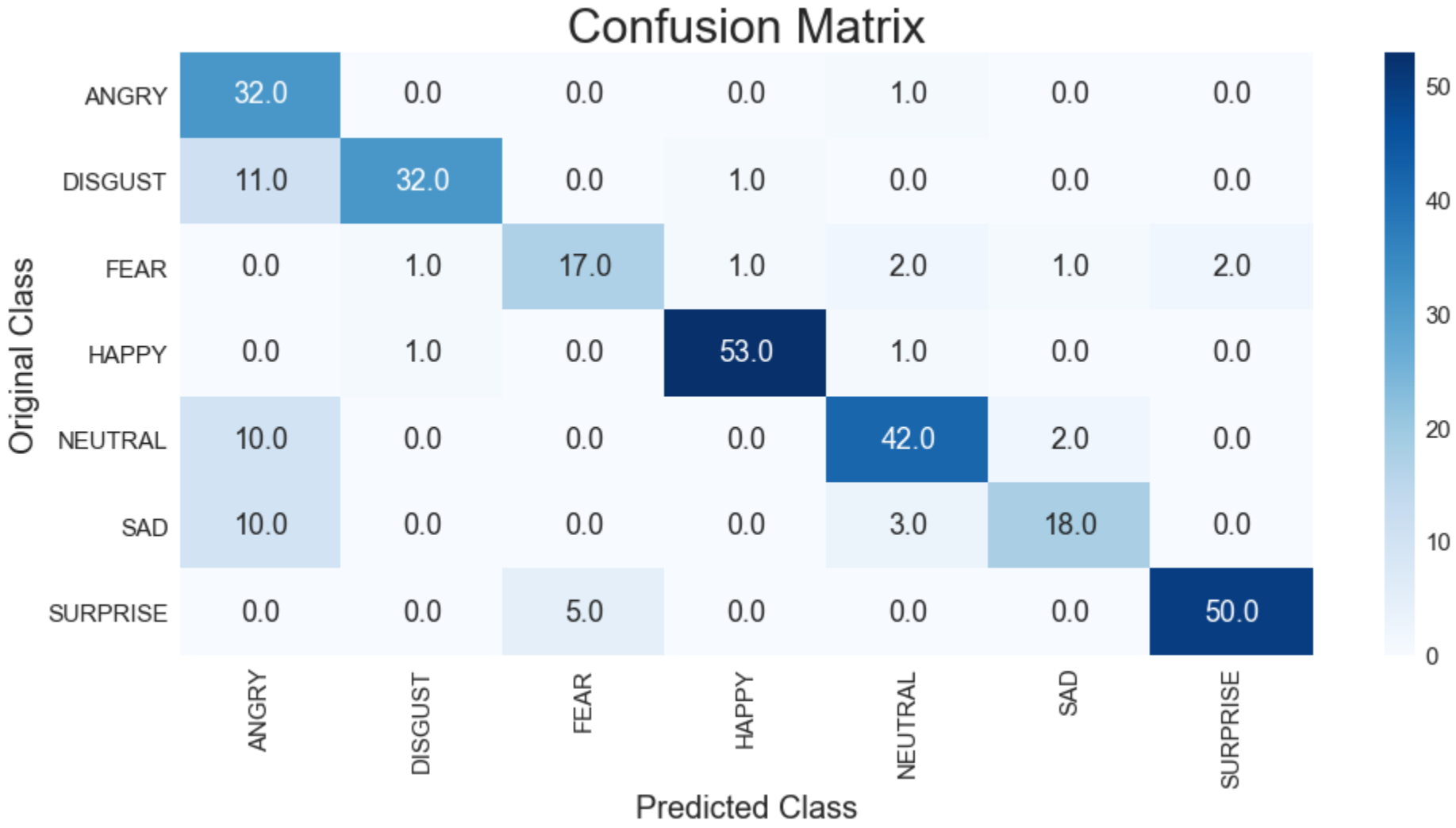
```
    plt.xticks(rotation = 90)
    plt.show()

    print("-"*125)

    plt.figure(figsize=(16,7))
    sns.heatmap(recall, cmap = "Blues", annot = True, fmt = ".2f", xticklabels=labels, yticklabels=labels)
    plt.title("Recall Matrix", fontsize = 30)
    plt.xlabel('Predicted Class', fontsize = 20)
    plt.ylabel('Original Class', fontsize = 20)
    plt.tick_params(labelsize = 15)
    plt.xticks(rotation = 90)
    plt.show()
```

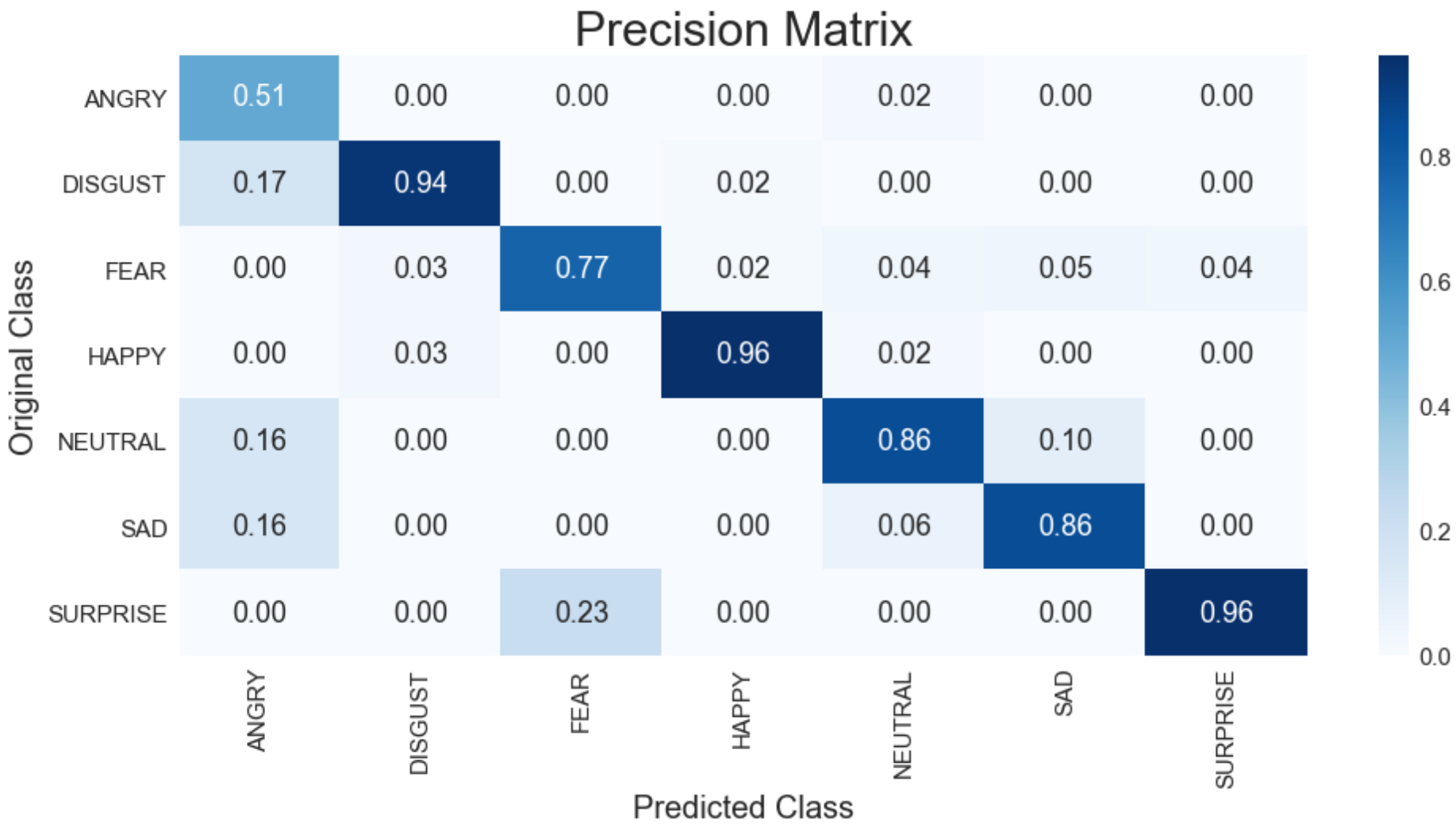
Test Data of Human Images

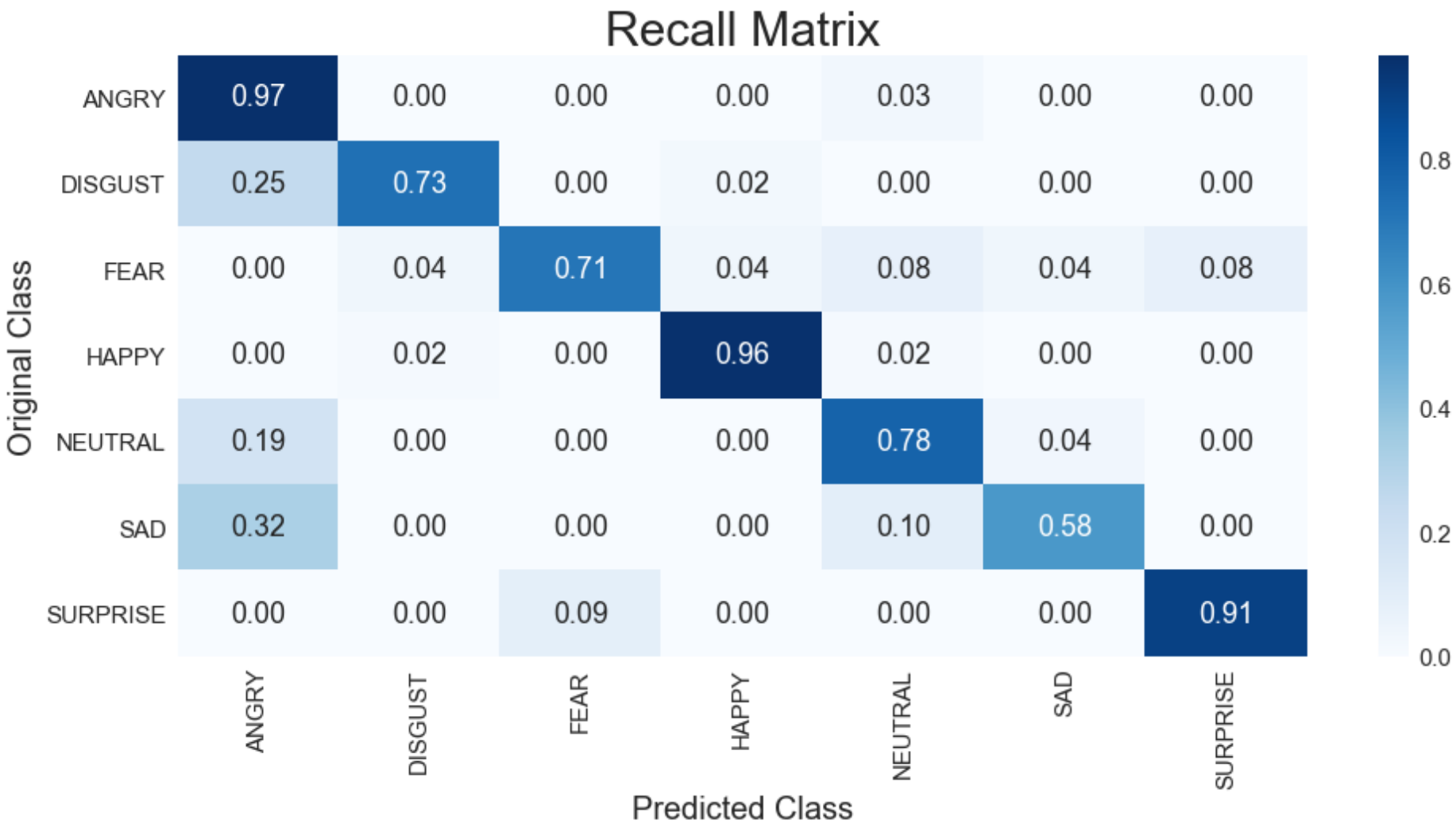
In [4]:
```
model = load_model("../Data/Model_Save/model.h5")
predicted_labels = []
true_labels = []
batch_size = 10
total_files = int(len(Test_Humans) / batch_size) + 2 #here, I have added 2 because there are 30 files in Test_Humans
for i in range(1, total_files, 1):
    img_load = np.load("../Data/Bottleneck_Features/Bottleneck_TestHumans/bottleneck_{}.npy".format(i))
    img_label = np.load("../Data/Bottleneck_Features/TestHumans_Labels/bottleneck_labels_{}.npy".format(i))
    img_bundle = img_load.reshape(img_load.shape[0], img_load.shape[1]*img_load.shape[2]*img_load.shape[3])
    for j in range(img_bundle.shape[0]):
        img = img_bundle[j]
        img = img.reshape(1, img_bundle.shape[1])
        pred = model.predict(img)
        predicted_labels.append(pred[0].argmax())
        true_labels.append(img_label[j].argmax())
acc = accuracy_score(true_labels, predicted_labels)
print("Accuracy on Human Test Data = {}%".format(np.round(float(acc*100), 2)))
```

```
Accuracy on Human Test Data = 82.43%
```

In [5]:
```
print_confusionMatrix(true_labels, predicted_labels)
```




Precision Matrix
ANGRY
DISGUST
FEAR
HAPPY
NEUTRAL
SAD
SURPRISE
Original Class
0.51 0.00 0.00 0.00 0.02 0.00 0.00
0.17 0.94 0.00 0.02 0.00 0.00 0.00
0.00 0.03 0.77 0.02 0.04 0.05 0.04
0.00 0.03 0.00 0.96 0.02 0.00 0.00
0.16 0.00 0.00 0.00 0.86 0.10 0.00
0.16 0.00 0.00 0.00 0.06 0.86 0.00
0.00 0.00 0.23 0.00 0.00 0.00 0.96
0.8
0.6
0.4
0.2
0.0
Predicted Class

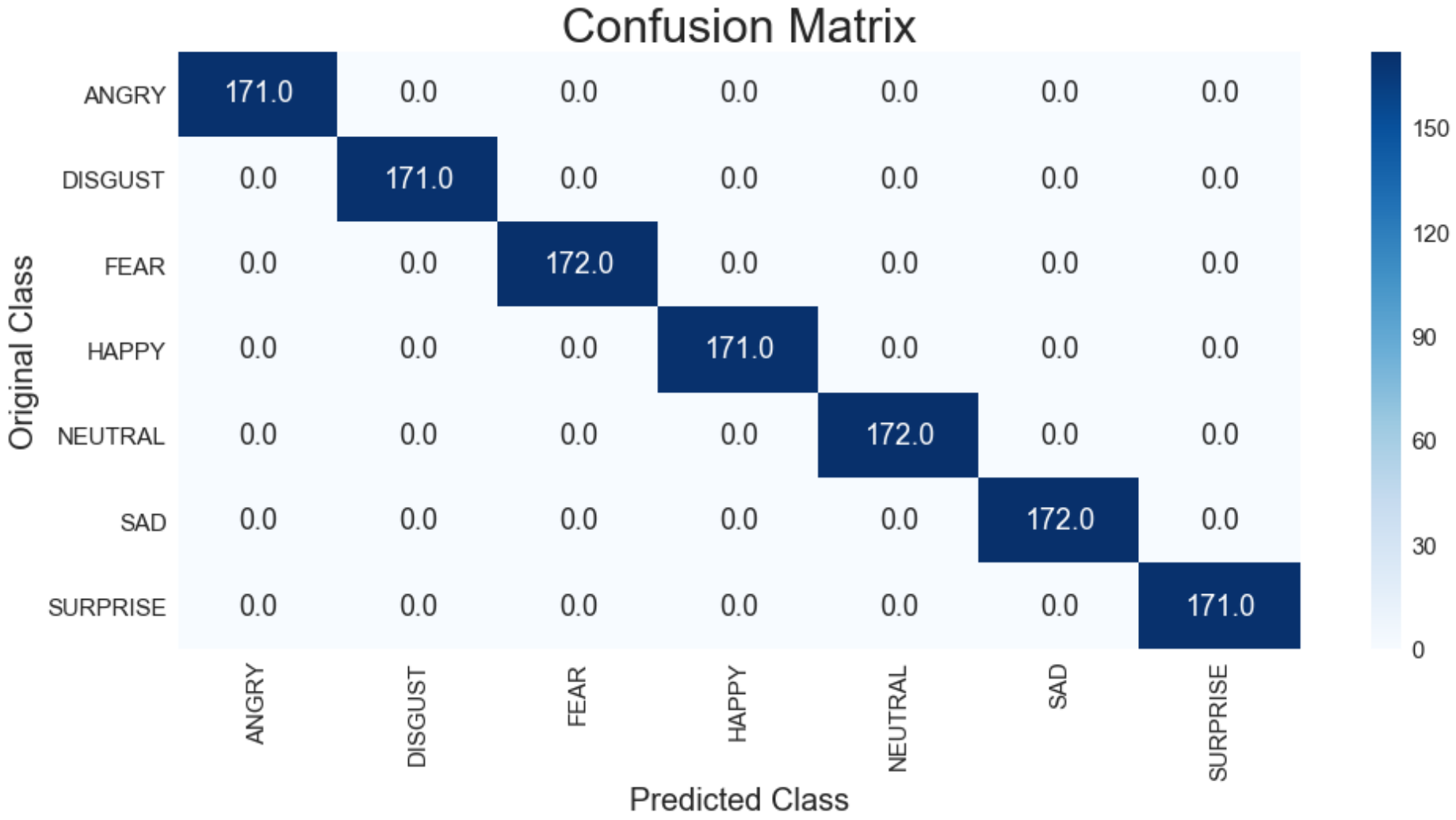


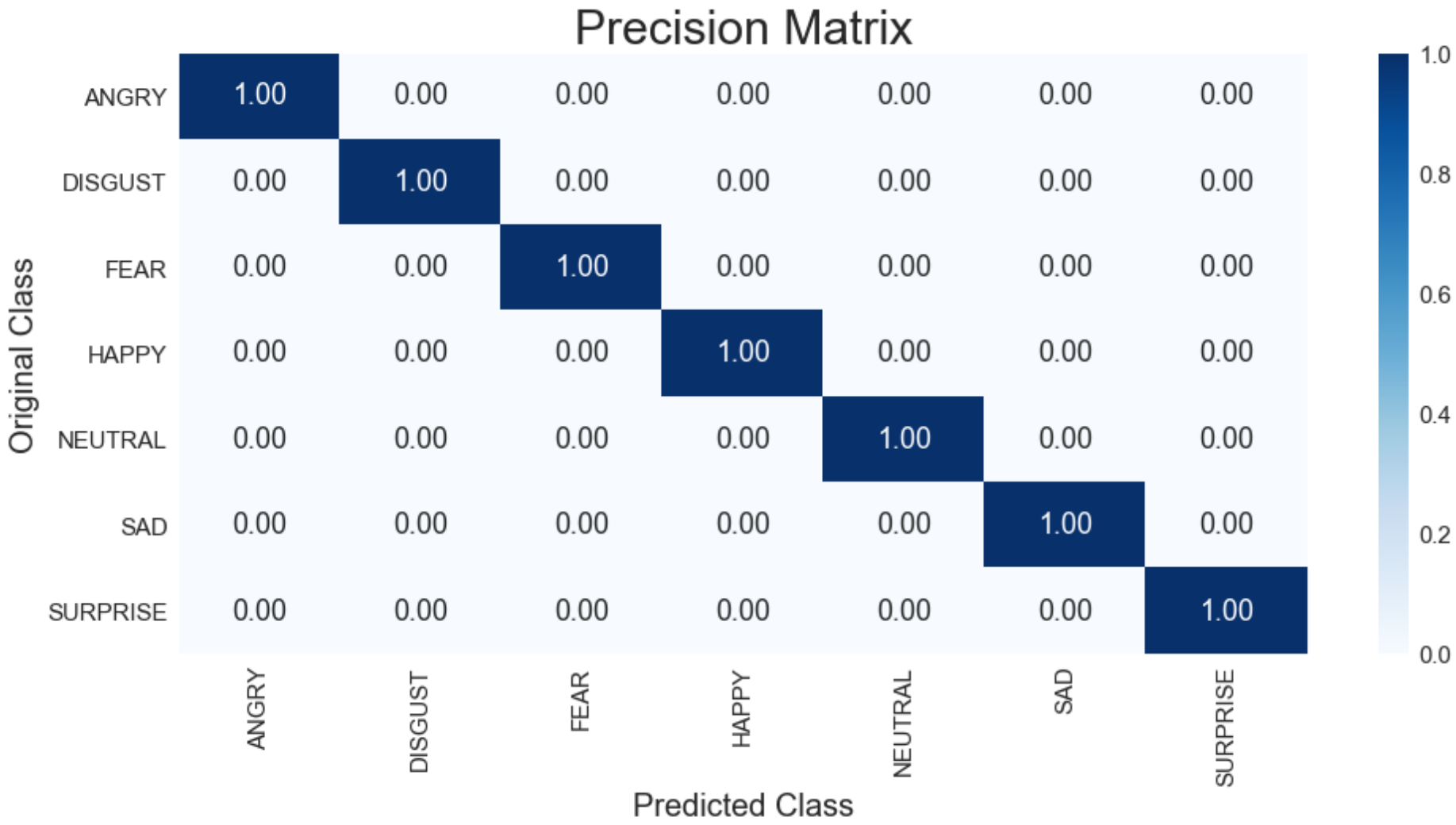
Test Data of Animated Images

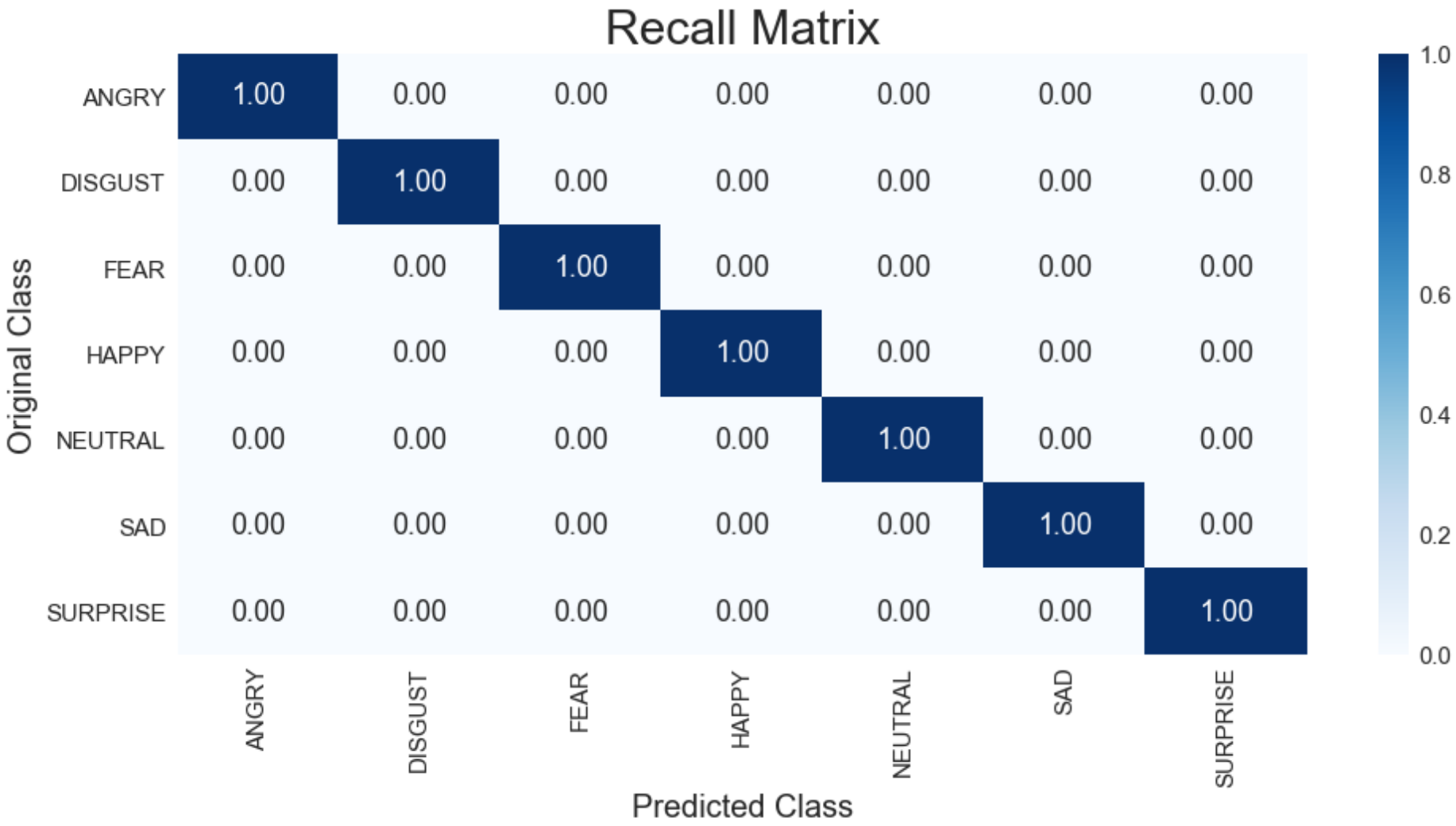
In [6]:
```
model = load_model("../Data/Model_Save/model.h5")
predicted_labels = []
true_labels = []
batch_size = 10
total_files = int(len(Test_Animated) / batch_size) + 1
for i in range(1, total_files, 1):
    img_load = np.load("../Data/Bottleneck_Features/Bottleneck_TestAnimated/bottleneck_{}.npy".format(i))
    img_label = np.load("../Data/Bottleneck_Features/TestAnimated_Labels/bottleneck_labels_{}.npy".format(i))
    img_bundle = img_load.reshape(img_load.shape[0], img_load.shape[1]*img_load.shape[2]*img_load.shape[3])
    for j in range(img_bundle.shape[0]):
        img = img_bundle[j]
        img = img.reshape(1, img_bundle.shape[1])
        pred = model.predict(img)
        predicted_labels.append(pred[0].argmax())
        true_labels.append(img_label[j].argmax())
acc = accuracy_score(true_labels, predicted_labels)
print("Accuracy on Animated Test Data = {}%".format(np.round(float(acc*100), 2)))
```

```
Accuracy on Animated Test Data = 100.0%
```

In [7]:
```
print_confusionMatrix(true_labels, predicted_labels)
```




Precision Matrix
ANGRY
DISGUST
FEAR
HAPPY
NEUTRAL
SAD
SURPRISE
1.00
0.00
Original Class
Predicted Class
1.0
0.8
0.6
0.4
0.2
0.0



13. Testing on Real World with Still Images

In [8]:
```
# Now for testing the model on real world images we have to follow all of the same steps which we have done on our traini
# and test images. Like here we have to first pre-preocess our images then create its VGG-16 bottleneck features then pas
# bottleneck features through our own MLP model for prediction.
# Steps are as follows:
# 1. Read the image, convert it to grayscale and save it.
# 2. Read that grayscale saved image, the detect face in it using HAAR cascade.
# 3. Crop the image to the detected face and resize it to 350*350 and save the image.
# 4. Read that processed cropped-resized image, then reshape it and normalize it.
# 5. Then feed that image to VGG-16 and create bottleneck features of that image and then reshape it.
# 6. Then use our own model for final prediction of expression.
```

In [2]:
```
EMOTION_DICT = {1:"ANGRY", 2:"DISGUST", 3:"FEAR", 4:"HAPPY", 5:"NEUTRAL", 6:"SAD", 7:"SURPRISE"}
model_VGG = VGG16(weights='imagenet', include_top=False)
model_top = load_model("../Data/Model_Save/model.h5")
```

In [3]:
```
def make_prediction(path):
    #converting image to gray scale and save it
    img = cv2.imread(path)
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    cv2.imwrite(path, gray)

    #detect face in image, crop it then resize it then save it
    face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')
    img = cv2.imread(path)
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    faces = face_cascade.detectMultiScale(gray, 1.3, 5)
    for (x,y,w,h) in faces:
        face_clip = img[y:y+h, x:x+w]
        cv2.imwrite(path, cv2.resize(face_clip, (350, 350)))

    #read the processed image then make prediction and display the result
    read_image = cv2.imread(path)
    read_image = read_image.reshape(1, read_image.shape[0], read_image.shape[1], read_image.shape[2])
    read_image_final = read_image/255.0  #normalizing the image
    VGG_Pred = model_VGG.predict(read_image_final)  #creating bottleneck features of image using VGG-16.
    VGG_Pred = VGG_Pred.reshape(1, VGG_Pred.shape[1]*VGG_Pred.shape[2]*VGG_Pred.shape[3])
    top_pred = model_top.predict(VGG_Pred)  #making prediction from our own model.
    emotion_label = top_pred[0].argmax() + 1
    print("Predicted Expression Probabilities")
    print("ANGRY: {}\nDISGUST: {}\nFEAR: {}\nHAPPY: {}\nNEUTRAL: {}\nSAD: {}\nSURPRISE: {}\n\n".format(top_pred[0][0], to
    print("Dominant Probability = "+str(EMOTION_DICT[emotion_label])+": "+str(max(top_pred[0])))
```

ANGRY

Correct Result

In [17]:
```
Image.open("../Data/Test_Images/Angry_1.JPG")
```

Out[17]:

In [20]:
```
make_prediction("../Data/Test_Images/Angry_1.JPG")
```

```
Predicted Expression Probabilities
ANGRY: 0.7257885932922363
DISGUST: 0.009196578525006771
FEAR: 0.00836753286421299
HAPPY: 0.0022135425824671984
NEUTRAL: 0.13011476397514343
SAD: 0.12406197190284729
SURPRISE: 0.00025709287729114294


Dominant Probability = ANGRY: 0.7257886
```

Correct Result

In [21]:
```
Image.open("../Data/Test_Images/Angry_2.png")
```

Out[21]:

In [22]:
```
make_prediction("../Data/Test_Images/Angry_2.png")
```

```
Predicted Expression Probabilities
ANGRY: 0.9992955923080444
DISGUST: 0.0002044820721494034
FEAR: 9.613921065465547e-06
HAPPY: 4.289282514946535e-06
NEUTRAL: 2.7359423256712034e-05
SAD: 0.00045741876238025725
SURPRISE: 1.1059050848416518e-06


Dominant Probability = ANGRY: 0.9992956
```

DISGUST

Incorrect Result

In [21]:
```
Image.open("../Data/Test_Images/Disgust_1.jpg")
```

Out[21]:

In [20]:
```
make_prediction("../Data/Test_Images/Disgust_1.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 0.6820868849754333
DISGUST: 0.3178218901157379
FEAR: 1.021714297166909e-06
HAPPY: 2.2017935407347977e-05
NEUTRAL: 5.1129391067661345e-06
SAD: 6.297716026892886e-05
SURPRISE: 8.2167117554377e-10


Dominant Probability = ANGRY: 0.6820869
```

Correct Result

In [31]:
```
Image.open("../Data/Test_Images/Disgust_2.png")
```

Out[31]:

In [32]:
```
make_prediction("../Data/Test_Images/Disgust_2.png")
```

```
Predicted Expression Probabilities
ANGRY: 5.865476282451709e-07
DISGUST: 0.9999994039535522
FEAR: 1.0832363651902543e-12
HAPPY: 4.008695597690348e-10
NEUTRAL: 2.2506696506496837e-10
SAD: 2.0564636660225233e-09
SURPRISE: 1.620196828804911e-14


Dominant Probability = DISGUST: 0.9999994
```

FEAR

Correct Result

In [17]:
```
Image.open("../Data/Test_Images/Fear_1.jpg")
```

Out[17]:

In [16]:
```
make_prediction("../Data/Test_Images/Fear_1.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 0.0014409959549084306
DISGUST: 0.0011888426961377263
FEAR: 0.8639399409294128
HAPPY: 0.0012069966178387403
NEUTRAL: 0.040269557386636734
SAD: 0.07585041970014572
SURPRISE: 0.01610312983393669


Dominant Probability = FEAR: 0.86393994
```

Correct Result

In [6]:
```
Image.open("../Data/Test_Images/Fear_2.png")
```

Out[6]:

In [4]:
```
make_prediction("../Data/Test_Images/Fear_2.png")
```

```
Predicted Expression Probabilities
ANGRY: 6.208167633303674e-07
DISGUST: 2.3438562948285835e-06
FEAR: 0.9993552565574646
HAPPY: 6.2351973610930145e-06
NEUTRAL: 0.00013250419578980654
SAD: 0.00022573411115445197
SURPRISE: 0.0002773168671410531


Dominant Probability = FEAR: 0.99935526
```

HAPPY

Correct Result

In [14]:
```
Image.open("../Data/Test_Images/Happy_1.jpg")
```

Out[14]:

In [23]:
```
make_prediction("../Data/Test_Images/Happy_1.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 6.918347025930416e-06
DISGUST: 0.05933113768696785
FEAR: 3.4089982364093885e-05
HAPPY: 0.9405853152275085
NEUTRAL: 3.5700180887943134e-05
SAD: 6.779935574741103e-06
SURPRISE: 2.4646456608934386e-07


Dominant Probability = HAPPY: 0.9405853
```

Correct Result

In [22]:
```
Image.open("../Data/Test_Images/Happy_2.png")
```

Out[22]:

In [24]:
```
make_prediction("../Data/Test_Images/Happy_2.png")
```

```
Predicted Expression Probabilities
ANGRY: 1.0575328590264887e-12
DISGUST: 1.3165504242351744e-06
FEAR: 4.739036896239668e-08
HAPPY: 0.9999984502792358
NEUTRAL: 1.801792421929349e-07
SAD: 9.010955176469437e-11
SURPRISE: 3.67006064427855e-10


Dominant Probability = HAPPY: 0.99999845
```

Neutral

Correct Result

In [4]:
```
Image.open("../Data/Test_Images/Neutral_1.jpg")
```

Out[4]:

In [3]:
```
make_prediction("../Data/Test_Images/Neutral_6.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 0.056531112641096115
DISGUST: 0.00017849539290182292
FEAR: 0.00038363729254342616
HAPPY: 0.00012379800318740308
NEUTRAL: 0.9326807260513306
SAD: 0.009718898683786392
SURPRISE: 0.00038327727816067636


Dominant Probability = NEUTRAL: 0.9326807
```

Sad

Correct Prediction

In [9]:
```
Image.open("../Data/Test_Images/Sad_1.jpg")
```

Out[9]:

In [7]:
```
make_prediction("../Data/Test_Images/Sad_1.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 0.3095955550670624
DISGUST: 0.01769070141017437
FEAR: 0.07686590403318405
HAPPY: 0.006198391318321228
NEUTRAL: 0.1944163292646408
SAD: 0.39325907826423645
SURPRISE: 0.001974012004211545


Dominant Probability = SAD: 0.39325908
```

Correct Prediction

In [11]:
```
Image.open("../Data/Test_Images/Sad_2.png")
```

Out[11]:

In [10]:
```
make_prediction("../Data/Test_Images/Sad_2.png")
```

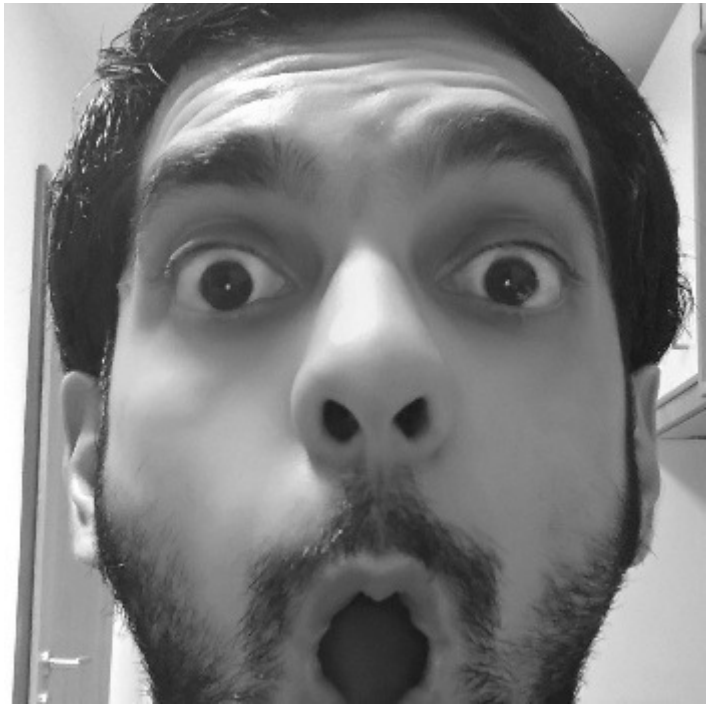
```
Predicted Expression Probabilities
ANGRY: 1.8063846596305666e-07
DISGUST: 2.109569777530851e-06
FEAR: 3.813128923724207e-09
HAPPY: 2.0874833979445118e-12
NEUTRAL: 1.9764388525800314e-06
SAD: 0.9999957084655762
SURPRISE: 7.052668671292395e-09


Dominant Probability = SAD: 0.9999957
```

Surprise

Correct Prediction

In [13]:
```
Image.open("../Data/Test_Images/Surprise_1.jpg")
```

Out[13]:



In [12]:
```
make_prediction("../Data/Test_Images/Surprise_1.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 3.6574178921000566e-06
DISGUST: 2.397854359514895e-08
FEAR: 0.015543382614850998
HAPPY: 1.7507695702079218e-06
NEUTRAL: 9.84826692729257e-05
SAD: 8.507548045599833e-06
SURPRISE: 0.9843442440032959


Dominant Probability = SURPRISE: 0.98434424
```

Correct Prediction

In [16]:
```
Image.open("../Data/Test_Images/Surprise_2.png")
```

Out[16]:

In [15]:
```
make_prediction("../Data/Test_Images/Surprise_2.png")
```

```
Predicted Expression Probabilities
ANGRY: 8.131757420204444e-12
DISGUST: 2.8135717226093065e-14
FEAR: 1.1461297333426046e-07
HAPPY: 3.016933647348452e-10
NEUTRAL: 4.252813934346733e-10
SAD: 2.2675119160792123e-12
SURPRISE: 0.9999998807907104


Dominant Probability = SURPRISE: 0.9999999
```

In [7]:
```
Image.open("../Data/Test_Images/Surprise_3.jpg")
```

Out[7]:

In [8]:
```
make_prediction("../Data/Test_Images/Surprise_3.jpg")
```

```
Predicted Expression Probabilities
ANGRY: 7.466517854481936e-05
DISGUST: 8.049021005263057e-09
FEAR: 0.0035154588986188173
HAPPY: 1.8760174498311244e-06
NEUTRAL: 0.00012389293988235295
SAD: 1.6487249013152905e-05
SURPRISE: 0.9962676167488098


Dominant Probability = SURPRISE: 0.9962676
```

In [337]:
```
# cnt_correct = 0
# cnt_incorrect = 0
# for i, d in df_anime_test.iterrows():
#     img_path = os.path.join(d["folderName"], d["imageName"])
#     im_size = cv2.imread(img_path).shape
#     if im_size == (350, 350, 3):
#         cnt_correct += 1
#     else:
#         cnt_incorrect += 1
# print("Correct = "+str(cnt_correct))
# print("incorrect = "+str(cnt_incorrect))
```

In [123]:
```
# a = Train_Combined
# randInt = np.random.randint(0, a.shape[0], size = (1))[0]
# emotion = a["Emotion"][randInt]
# label = a["Labels"][randInt]
# path1 = a["folderName"][randInt]
# path2 = a["imageName"][randInt]
# img = Image.open(os.path.join(path1, path2))
# img
```

In [124]:
```
# print(emotion)
# print(label)
```

In [41]:
```
# count_present = 0
# count_absent = 0
# for i, d in df_angry_reduced.iterrows():
#     path1 = d["folderName"]
#     path2 = d["imageName"]
#     if os.path.isfile(os.path.join(path1, path2)):
#         count_present += 1
#     else:
#         count_absent += 1
# print("Count present = "+str(count_present))
# print("Count absent = "+str(count_absent))
```

In [ ]:
```

```