this is basically https://www.kaggle.com/bmarcos/image-recognition-gender-detection-inceptionv3 i only changed a couple things around so it would be able to run on my computer. the link has a lot more to look at to help understand the data, but i took it out to simplify what we actually need. i think it would be relatively simple to add in variables we want to test for, i just havent tried that. so far, this one is just training on the "male" variable.

i did have some trouble with the validation testing, so that still needs some work because when I ran it, the loss kept going up and im not sure why.

In [24…

```python
import pandas as pd
import numpy as np
import cv2
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import f1_score
from keras import applications
from keras.applications.inception_v3 import InceptionV3, preprocess_input
from keras import optimizers
from keras.models import Sequential, Model
from keras.layers import Dropout, Flatten, Dense, GlobalAveragePooling2D
from keras.callbacks import ModelCheckpoint
from keras.preprocessing.image import ImageDataGenerator, array_to_img, img_to_array, load_img
from keras.utils import np_utils
from keras.optimizers import SGD, Adam

from IPython.core.display import display, HTML
from PIL import Image
from io import BytesIO
import base64

plt.style.use('ggplot')

%matplotlib inline
```

In [25…

```python
import tensorflow as tf
print(tf.__version__)
```

```
2.1.0
```

Hyperparameters

In [26…
```
# set variables
main_folder = 'Data/'
images_folder = main_folder + 'img_align_celeba/img_align_celeba/'

#EXAMPLE_PIC = images_folder + '000506.jpg'

TRAINING_SAMPLES = 10000
VALIDATION_SAMPLES = 2000
TEST_SAMPLES = 2000
IMG_WIDTH = 178
IMG_HEIGHT = 218
BATCH_SIZE = 16
NUM_EPOCHS = 15
```

In [27…
```
# import the data set that include the attribute for each picture
df_attr = pd.read_csv('Data/list_attr_celeba.csv')
df_attr.set_index('image_id', inplace=True)
df_attr.replace(to_replace=-1, value=0, inplace=True) #replace -1 by 0
df_attr.shape
#returns (202559, 40)
```

Out[27…
```
(202599, 40)
```

In [28…
```
#List of available attributes

# for i, j in enumerate(df_attr.columns):
#     print(i, j)
```

Partitioning of data

In [29…
```
df_partition = pd.read_csv('Data/list_eval_partition.csv')
# display counter by partition
# 0 -> TRAINING
# 1 -> VALIDATION
# 2 -> TEST
df_partition['partition'].value_counts().sort_index()
```

Out[29…
```
0    162770
1     19867
```

```
2     19962
Name: partition, dtype: int64
```

In [30…

```python
# join the partition with the attributes for GENDER

df_partition.set_index('image_id', inplace=True)
df_par_attr = df_partition.join(df_attr['Male'], how='inner')
```

In [31…

```python
def load_reshape_img(fname):
    img = load_img(fname)
    x = img_to_array(img)/255.
    x = x.reshape((1,) + x.shape)

    return x


def generate_df(partition, attr, num_samples):
    '''
    partition
        0 -> train
        1 -> validation
        2 -> test

    '''

    df_ = df_par_attr[(df_par_attr['partition'] == partition)
                           & (df_par_attr[attr] == 0)].sample(int(num_samples/2))
    df_ = pd.concat([df_,
                      df_par_attr[(df_par_attr['partition'] == partition)
                                  & (df_par_attr[attr] == 1)].sample(int(num_samples/2))])

    # for Train and Validation
    if partition != 2:
        x_ = np.array([load_reshape_img(images_folder + fname) for fname in df_.index])
        x_ = x_.reshape(x_.shape[0], 218, 178, 3)
        y_ = np_utils.to_categorical(df_[attr],2)
    # for Test
    else:
        x_ = []
        y_ = []
        for index, target in df_.iterrows():
            im = cv2.imread(images_folder + index)
            im = cv2.resize(cv2.cvtColor(im, cv2.COLOR_BGR2RGB), (IMG_WIDTH, IMG_HEIGHT)).astype(np.float
            im = np.expand_dims(im, axis =0)
            x_.append(im)
            y_.append(target[attr])

    return x_, y_
```

Pre-processing/data augmentation

In [32…

```
# Generate image generator for data augmentation
datagen =  ImageDataGenerator(
  #preprocessing_function=preprocess_input,
  rotation_range=30,
  width_shift_range=0.2,
  height_shift_range=0.2,
  shear_range=0.2,
  zoom_range=0.2,
  horizontal_flip=True
)

# # load one image and reshape
# img = load_img(EXAMPLE_PIC)
# x = img_to_array(img)/255.
# x = x.reshape((1,) + x.shape)

# # plot 10 augmented images of the loaded iamge
# plt.figure(figsize=(20,10))
# plt.suptitle('Data Augmentation', fontsize=28)

# i = 0
# for batch in datagen.flow(x, batch_size=1):
#     plt.subplot(3, 5, i+1)
#     plt.grid(False)
#     plt.imshow( batch.reshape(218, 178, 3))

#     if i == 9:
#         break
#     i += 1
# plt.show()
```

build data generators

In [33…

```
# Train data
x_train, y_train = generate_df(0, 'Male', TRAINING_SAMPLES)

# Train - Data Preparation - Data Augmentation with generators
train_datagen =  ImageDataGenerator(
  preprocessing_function=preprocess_input,
  rotation_range=30,
  width_shift_range=0.2,
  height_shift_range=0.2,
  shear_range=0.2,
  zoom_range=0.2,
  horizontal_flip=True,
)

train_datagen.fit(x_train)

train_generator = train_datagen.flow(
x_train, y_train,
batch_size=BATCH_SIZE,
)
```

In [34…

```
# Validation Data
x_valid, y_valid = generate_df(1, 'Male', VALIDATION_SAMPLES)


# Validation - Data Preparation - Data Augmentation with generators
valid_datagen = ImageDataGenerator(
  preprocessing_function=preprocess_input,
)

valid_datagen.fit(x_valid)

validation_generator = valid_datagen.flow(
x_valid, y_valid,
)
```

build model - for gender recognition

In [35…
```
# Import InceptionV3 Model
inc_model = InceptionV3(weights='imagenet',
                        include_top=False,
                        input_shape=(IMG_HEIGHT, IMG_WIDTH, 3))

print("number of layers:", len(inc_model.layers))
#inc_model.summary()
```

```
number of layers: 311
```

In [36…
```
#Adding custom Layers
x = inc_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(1024, activation = "relu")(x)
x = Dropout(0.5)(x)
x = Dense(512, activation = "relu")(x)
predictions = Dense(2, activation = "softmax")(x)
```

In [37…
```
# creating the final model
model_ = Model(inputs=inc_model.input, outputs=predictions)

# Lock initial layers to do not be trained
for layer in model_.layers[:52]:
    layer.trainable = False

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

train model

In [38…
```
#https://keras.io/models/sequential/ fit generator
checkpointer = ModelCheckpoint(filepath='weights.best.inc.male2.hdf5',
                               verbose=1, save_best_only=True)
```

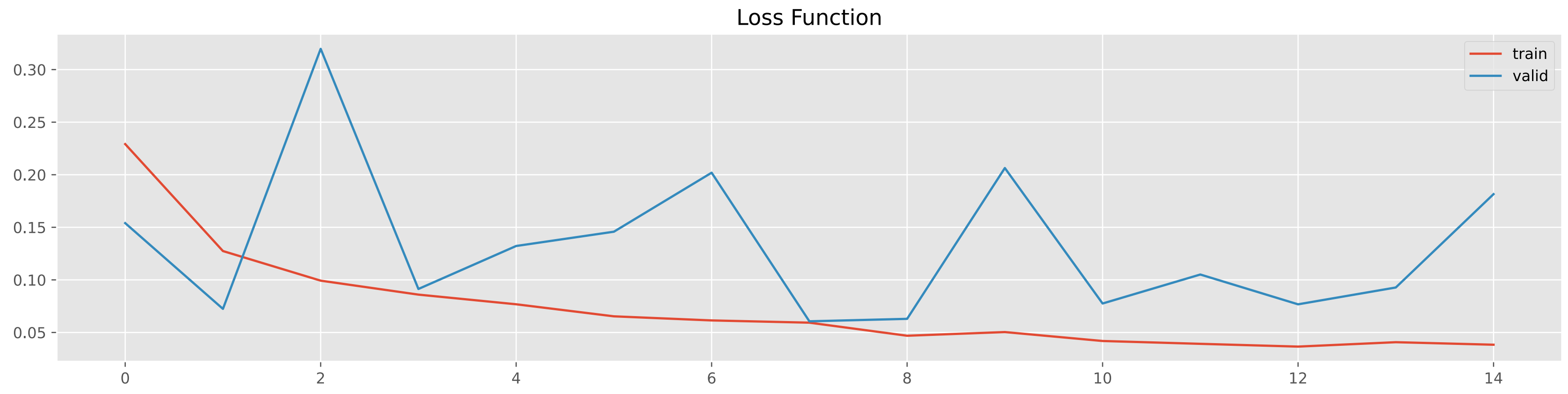
In [39…
```
hist = model_.fit_generator(train_generator
                     , validation_data = (x_valid, y_valid)
```

```
                    , steps_per_epoch= TRAINING_SAMPLES/BATCH_SIZE
                    , epochs= NUM_EPOCHS
                    , callbacks=[checkpointer]
                    , verbose=1
                  )
```

```
Epoch 1/15
625/625 [==============================] - 845s 1s/step - loss: 0.2292 - accuracy: 0.9058 - val_loss: 0.1
540 - val_accuracy: 0.9545

Epoch 00001: val_loss improved from inf to 0.15399, saving model to weights.best.inc.male2.hdf5
Epoch 2/15
625/625 [==============================] - 828s 1s/step - loss: 0.1274 - accuracy: 0.9538 - val_loss: 0.0
724 - val_accuracy: 0.9725

Epoch 00002: val_loss improved from 0.15399 to 0.07242, saving model to weights.best.inc.male2.hdf5
Epoch 3/15
625/625 [==============================] - 827s 1s/step - loss: 0.0993 - accuracy: 0.9646 - val_loss: 0.3
197 - val_accuracy: 0.8860

Epoch 00003: val_loss did not improve from 0.07242
Epoch 4/15
625/625 [==============================] - 854s 1s/step - loss: 0.0860 - accuracy: 0.9696 - val_loss: 0.0
914 - val_accuracy: 0.9665

Epoch 00004: val_loss did not improve from 0.07242
Epoch 5/15
625/625 [==============================] - 860s 1s/step - loss: 0.0768 - accuracy: 0.9735 - val_loss: 0.1
322 - val_accuracy: 0.9585

Epoch 00005: val_loss did not improve from 0.07242
Epoch 6/15
625/625 [==============================] - 858s 1s/step - loss: 0.0653 - accuracy: 0.9761 - val_loss: 0.1
458 - val_accuracy: 0.9525

Epoch 00006: val_loss did not improve from 0.07242
Epoch 7/15
625/625 [==============================] - 860s 1s/step - loss: 0.0614 - accuracy: 0.9786 - val_loss: 0.2
019 - val_accuracy: 0.9405

Epoch 00007: val_loss did not improve from 0.07242
Epoch 8/15
625/625 [==============================] - 859s 1s/step - loss: 0.0593 - accuracy: 0.9787 - val_loss: 0.0
606 - val_accuracy: 0.9805

Epoch 00008: val_loss improved from 0.07242 to 0.06060, saving model to weights.best.inc.male2.hdf5
Epoch 9/15
625/625 [==============================] - 835s 1s/step - loss: 0.0469 - accuracy: 0.9834 - val_loss: 0.0
629 - val_accuracy: 0.9790

Epoch 00009: val_loss did not improve from 0.06060
Epoch 10/15
625/625 [==============================] - 854s 1s/step - loss: 0.0504 - accuracy: 0.9818 - val_loss: 0.2
064 - val_accuracy: 0.9335

Epoch 00010: val_loss did not improve from 0.06060
Epoch 11/15
625/625 [==============================] - 855s 1s/step - loss: 0.0419 - accuracy: 0.9858 - val_loss: 0.0
775 - val_accuracy: 0.9785

Epoch 00011: val_loss did not improve from 0.06060
Epoch 12/15
625/625 [==============================] - 856s 1s/step - loss: 0.0392 - accuracy: 0.9871 - val_loss: 0.1
051 - val_accuracy: 0.9665

Epoch 00012: val_loss did not improve from 0.06060
Epoch 13/15
625/625 [==============================] - 857s 1s/step - loss: 0.0365 - accuracy: 0.9880 - val_loss: 0.0
768 - val_accuracy: 0.9785

Epoch 00013: val_loss did not improve from 0.06060
Epoch 14/15
625/625 [==============================] - 860s 1s/step - loss: 0.0407 - accuracy: 0.9864 - val_loss: 0.0
928 - val_accuracy: 0.9725

Epoch 00014: val_loss did not improve from 0.06060
Epoch 15/15
625/625 [==============================] - 858s 1s/step - loss: 0.0383 - accuracy: 0.9865 - val_loss: 0.1
815 - val_accuracy: 0.9465

Epoch 00015: val_loss did not improve from 0.06060
```

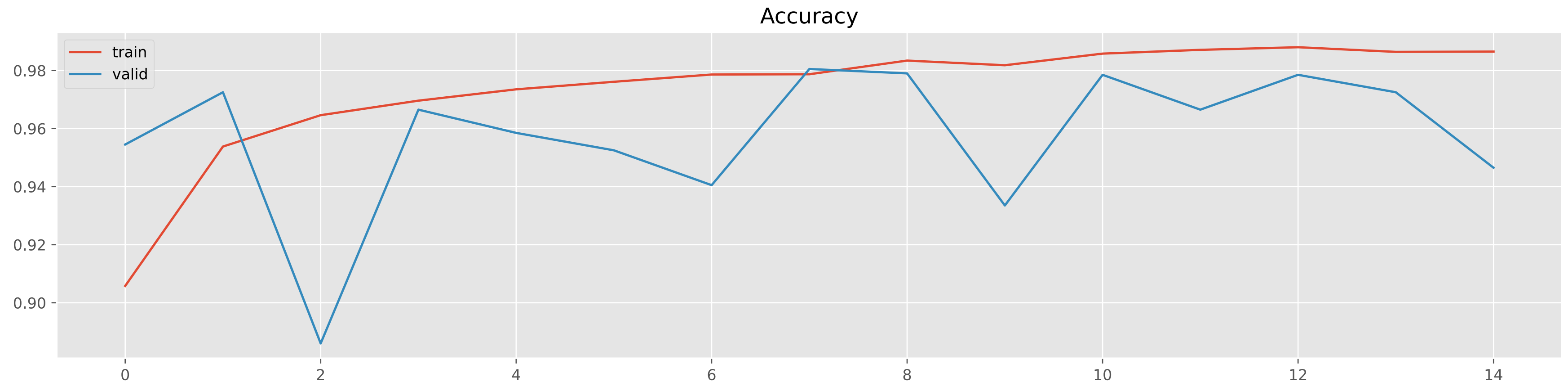
In [40…

```
# Plot loss function value through epochs
plt.figure(figsize=(18, 4))
plt.plot(hist.history['loss'], label = 'train')
plt.plot(hist.history['val_loss'], label = 'valid')
plt.legend()
plt.title('Loss Function')
plt.show()
```



In [41…

```
# Plot accuracy through epochs
plt.figure(figsize=(18, 4))
plt.plot(hist.history['accuracy'], label = 'train')
plt.plot(hist.history['val_accuracy'], label = 'valid')
plt.legend()
plt.title('Accuracy')
plt.show()
```



model evaluation

In [42…
```
#load the best model
model_.load_weights('weights.best.inc.male2.hdf5')
```

In [43…
```
# Test Data
x_test, y_test = generate_df(2, 'Male', TEST_SAMPLES)

# generate prediction
model_predictions = [np.argmax(model_.predict(feature)) for feature in x_test ]

# report test accuracy
test_accuracy = 100 * np.sum(np.array(model_predictions)==y_test) / len(model_predictions)
print('Model Evaluation')
print('Test accuracy: %.4f%%' % test_accuracy)
print('f1_score:', f1_score(y_test, model_predictions))
```

```
Model Evaluation
Test accuracy: 97.4500%
f1_score: 0.9742813918305597
```

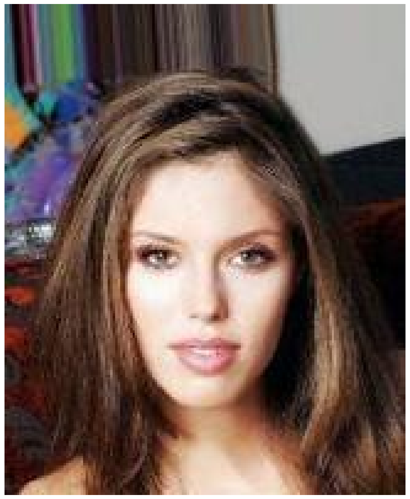
In [44…
```
#dictionary to name the prediction
gender_target = {0: 'Female'
                , 1: 'Male'}

def img_to_display(filename):
    i = Image.open(filename)
    i.thumbnail((200, 200), Image.LANCZOS)

    with BytesIO() as buffer:
        i.save(buffer, 'jpeg')
        return base64.b64encode(buffer.getvalue()).decode()

##this part is extra#####
def display_result(filename, prediction, target):
    '''
    Display the results in HTML

    '''

    gender = 'Male'
    gender_icon = "https://i.imgur.com/nxWan2u.png"

    if prediction[1] <= 0.5:
        gender_icon = "https://i.imgur.com/oAAb8rd.png"
        gender = 'Female'

    display_html = '''
    <div style="overflow: auto;  border: 2px solid #D8D8D8;
        padding: 5px; width: 420px;" >
        <img src="data:image/jpeg;base64,{}" style="float: left;" width="200" height="200">
        <div style="padding: 10px 0px 0px 20px; overflow: auto;">
            <img src="{}" style="float: left;" width="40" height="40">
            <h3 style="margin-left: 50px; margin-top: 2px;">{}</h3>
            <p style="margin-left: 50px; margin-top: -6px; font-size: 12px">{} prob.</p>

        </div>
    </div>
    '''.format(img_to_display(filename)
               , gender_icon
               , gender
               , "{0:.2f}%".format(round(max(prediction)*100,2))
               , gender_target[target]
               , filename.split('/')[-1]
               )

    display(HTML(display_html))
```

In [45...
```
def gender_prediction(filename):
    '''
    predict the gender

    input:
        filename: str of the file name

    return:
        array of the prob of the targets.

    '''


    im = cv2.imread(filename)
    im = cv2.resize(cv2.cvtColor(im, cv2.COLOR_BGR2RGB), (178, 218)).astype(np.float32) / 255.0
    im = np.expand_dims(im, axis =0)

    # prediction
    result = model_.predict(im)
    prediction = np.argmax(result)

    return result
```

In [46...
```
#select random images of the test partition
df_to_test = df_par_attr[(df_par_attr['partition'] == 2)].sample(2)

for index, target in df_to_test.iterrows():
    result = gender_prediction(images_folder + index)

    #display result
    display_result(images_folder + index, result[0], target['Male'])
```

Female

100.00% prob.



Male

99.42% prob.