Facial Expression Classfication App - Rui Li

Preview

- Goal and Explanation
- The Final Application
- Preview of data
- Training
- Visualizing the model accuracy and model loss
- Reference

FER2013 Dataset

Dataset from https://www.kaggle.com/c/challenges-in-representation-learning-facial-expression-recognition-challenge/data (https://www.kaggle.com/c/challenges-in-representation-learning-facial-expression-recognition-challenge/data)

Image Properties: 48 x 48 pixels (2304 bytes) labels: 0=Angry, 1=Disgust, 2=Fear, 3=Happy, 4=Sad, 5=Surprise, 6=Neutral The training set consists of 28,709 examples. The public test set consists of 3,589 examples. The private test set consists of another 3,589 examples.

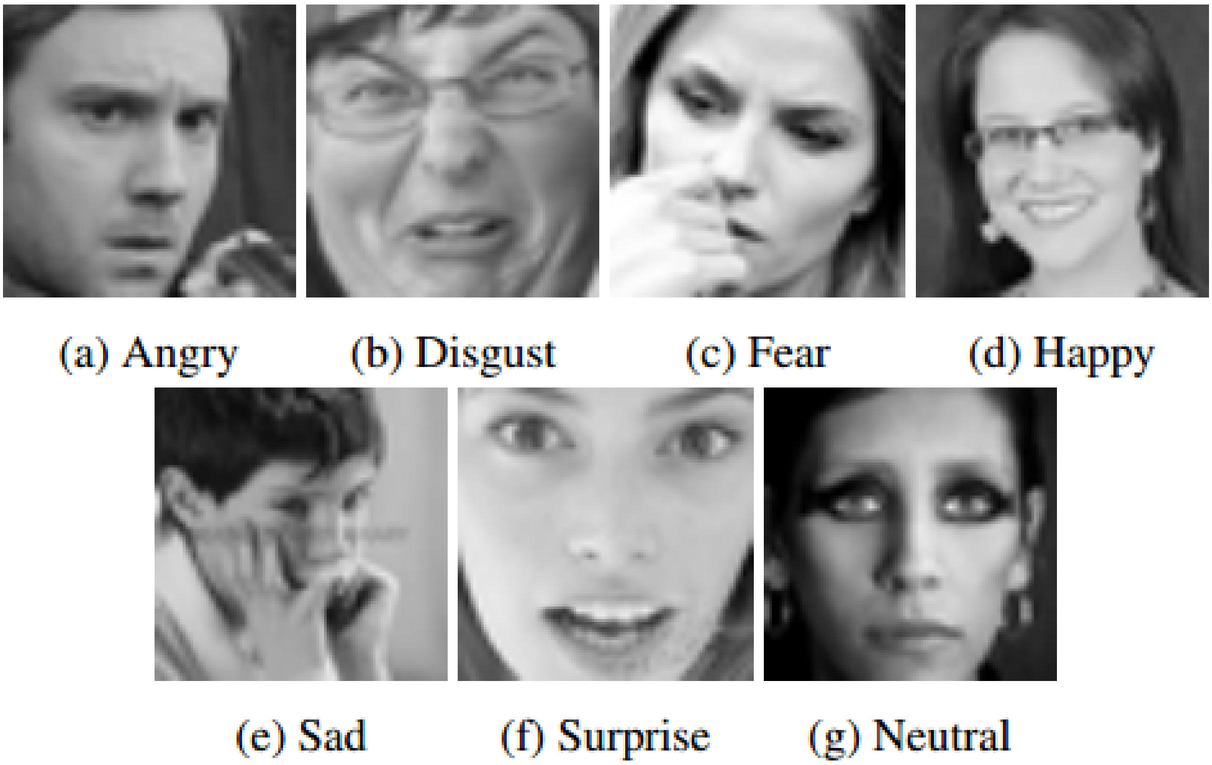
Some indication:

Before the start our course, I had experience programming in languages including: (Python, Java, R, C, JavaScript, etc.) and had defined/written my own functions or methods and also defined my own classes or objects.

data source and some other references are listed in the reference at the bottom

1.Goal and Explanation

- The dataset example



(a) Angry (b) Disgust (c) Fear (d) Happy

(e) Sad (f) Surprise (g) Neutral

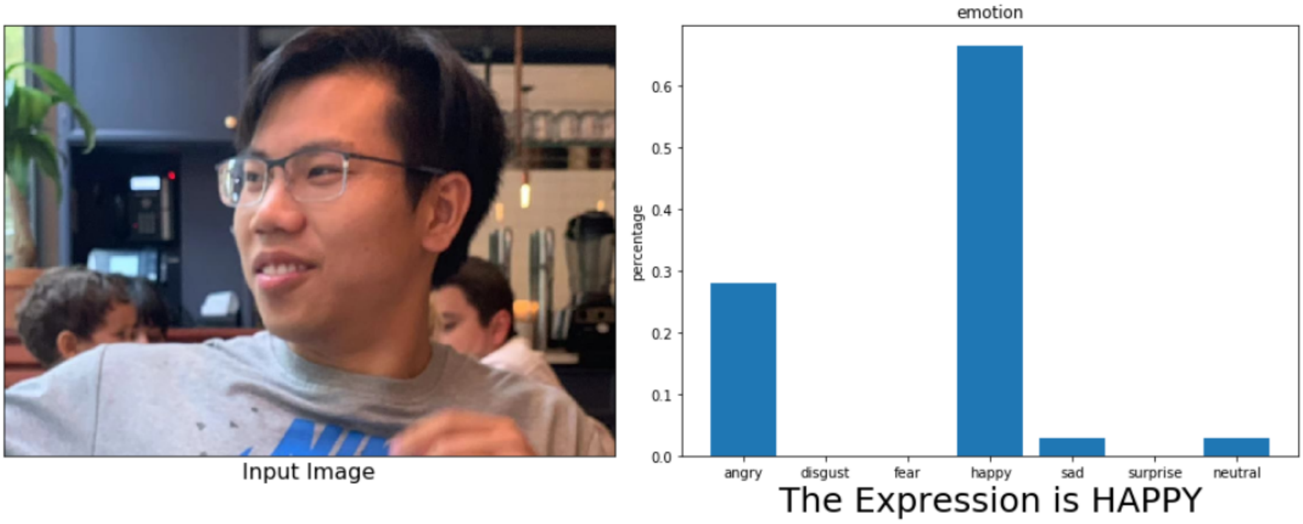
- An image of final application example

```
: expression_classifier()
```

```
Put in your expression picture in the directory input
these are all the pictures in the directory: test_images
['larry.png', 'ng1.jpg', 'unhappybaby.jpg']
enter the name of the pic you want to test; remember to also type in the .jpg or pnglarry.png
```

```
D:\Envs\py3deep\lib\site-packages\keras_preprocessing\image\utils.py:104: UserWarning: grayscale is deprecated. Please use color_mode = "g
rayscale"
  warnings.warn('grayscale is deprecated. Please use '
```

```
The Expression is happy
```



Objective

To develop a program that can detect facial expression and link it to emotion. I think this is very useful for emotion recognition.

This jupyter file contains how to use the pretrained model and the process of training the model.

2.Application: Emotion classifier

(1) input: a picture of expression

(2) output: the prediction of the emotion

(3) model: a pretrained model (training process in the next part)

ps. If you are running on the TensorFlow or CNTK backends, your code will automatically run on GPU if any available GPU is detected. The codes below is based on the TensorFlow backends by default.

In [1]:

```python
"""
visualize results for test image
"""
# import all the necessary python packages for reading image, reading the model and ploting
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image
# using the keras by default
# in my environment, it is CUDA 10.0, tensorflow 1.14.0, python 3.7
from keras.models import model_from_json, load_model
from skimage import io
from keras.preprocessing import image
import os

# this is the pretrained model
trained_model = load_model('the_pretrained_model_epoch20.h5')
# trained_model = load_model('model_expression.h5')


def expression_classifier():

    # this is for the input image
    print("Put in your expression picture in the directory test_images")
    print("these are all the pictures in the directory: test_images")
    print(os.listdir("./test_images"))
    image_name = input("enter the name of the pic you want to test; remember to also type in the .jp
    image_path = './test_images/'+image_name

    #  Output: The first plot: Raw Image
    raw_img = io.imread(image_path)
    plt.rcParams['figure.figsize'] = (13.5,5.5)
    axes=plt.subplot(1, 2, 1)
    plt.imshow(raw_img)
    plt.xlabel('Input Image', fontsize=16)
    axes.set_xticks([])
    axes.set_yticks([])
    plt.tight_layout()

    # Prediction
    plt.subplots_adjust(left=0.05, bottom=0.2, right=0.95, top=0.9, hspace=0.02, wspace=0.3)
    plt.subplot(1, 2, 2)
    img = image.load_img(image_path, grayscale=True, target_size=(48, 48))

    # Output: Bar plot (the second plot)
    x = image.img_to_array(img)
    x = np.expand_dims(x, axis = 0)
    x /= 255
    custom = trained_model.predict(x)
    emotions = custom[0]
    objects = ('angry', 'disgust', 'fear', 'happy', 'sad', 'surprise', 'neutral')
    y_pos = np.arange(len(objects))
    plt.bar(y_pos, emotions)
    plt.xticks(y_pos, objects)
    plt.ylabel('percentage')
    plt.xlabel("The Expression is %s" %str(objects[list(emotions).index(max(list(emotions)))]).upper
    plt.title('emotion')
    plt.tight_layout()
    print("The Expression is %s" %str(objects[list(emotions).index(max(list(emotions)))]))
Using TensorFlow backend.
WARNING: Logging before flag parsing goes to stderr.
W0814 18:50:05.892238 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:517: The name tf.placeholder is depre
cated. Please use tf.compat.v1.placeholder instead.

W0814 18:50:05.905189 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:4138: The name tf.random_uniform is d
eprecated. Please use tf.random.uniform instead.

W0814 18:50:05.934113 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:245: The name tf.get_default_graph is
deprecated. Please use tf.compat.v1.get_default_graph instead.

W0814 18:50:05.935109 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:174: The name tf.get_default_session
is deprecated. Please use tf.compat.v1.get_default_session instead.

W0814 18:50:05.935109 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:181: The name tf.ConfigProto is depre
cated. Please use tf.compat.v1.ConfigProto instead.

W0814 18:50:06.953384 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:1834: The name tf.nn.fused_batch_norm
is deprecated. Please use tf.compat.v1.nn.fused_batch_norm instead.

W0814 18:50:07.001277 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\backend\tensorflow_backend.py:3976: The name tf.nn.max_pool is depr
ecated. Please use tf.nn.max_pool2d instead.

W0814 18:50:07.219692 13848 deprecation.py:506] From D:\Envs\py3deep\lib\site-packag
es\keras\backend\tensorflow_backend.py:3445: calling dropout (from tensorflow.pytho
n.ops.nn_ops) with keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_pro
b`.
W0814 18:50:07.447089 13848 deprecation_wrapper.py:119] From D:\Envs\py3deep\lib\sit
e-packages\keras\optimizers.py:790: The name tf.train.Optimizer is deprecated. Pleas
e use tf.compat.v1.train.Optimizer instead.

W0814 18:50:07.575746 13848 deprecation.py:323] From D:\Envs\py3deep\lib\site-packag
es\tensorflow\python\ops\math_grad.py:1250: add_dispatch_support.<locals>.wrapper (f
rom tensorflow.python.ops.array_ops) is deprecated and will be removed in a future v
ersion.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
```

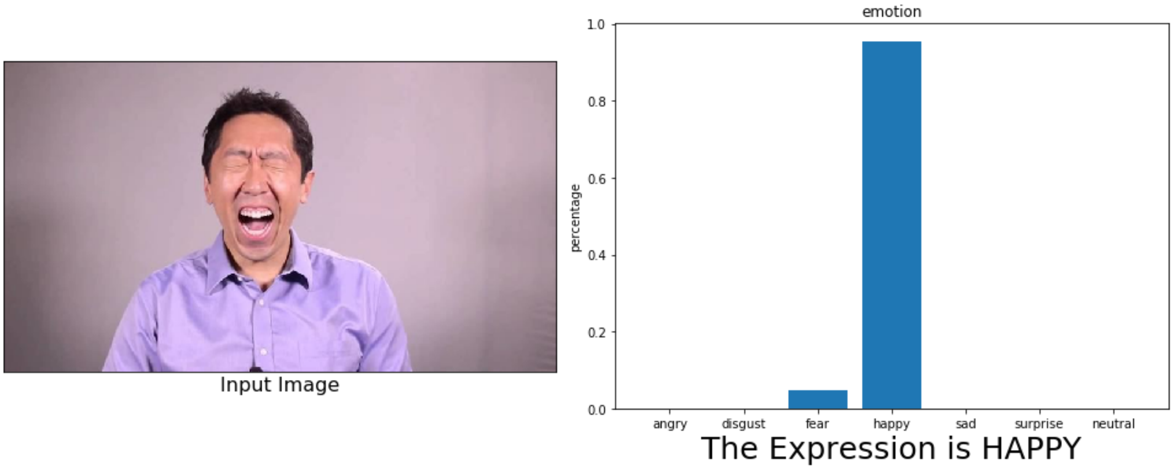
In [2]:

```
expression_classifier()
```

```
Put in your expression picture in the directory input
these are all the pictures in the directory: test_images
['larry.png', 'ng1.jpg', 'unhappybaby.jpg']
enter the name of the pic you want to test; remember to also type in the .jpg or png
ng1.jpg
```

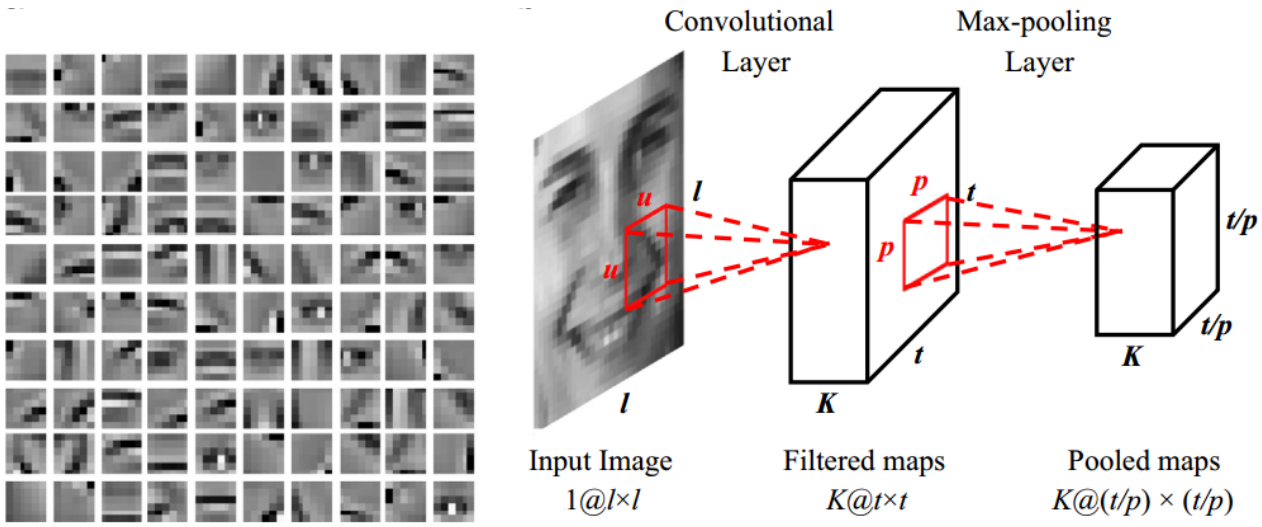
```
D:\Envs\py3deep\lib\site-packages\keras_preprocessing\image\utils.py:104: UserWarnin
g: grayscale is deprecated. Please use color_mode = "grayscale"
  warnings.warn('grayscale is deprecated. Please use '
```

```
The Expression is happy
```



3.1 Preview of the data

Process:



In [7]:

```
# import packages for loading the dataset fer2013(a facial expression dataset)
import numpy as np
import pandas as pd
import tensorflow as tf
import keras
from keras.models import Sequential
from keras.layers import Conv2D, MaxPooling2D, AveragePooling2D
from keras.layers import Dense, Activation, Dropout, Flatten
from keras.preprocessing import image
from keras.preprocessing.image import ImageDataGenerator

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

# data processing, CSV file I/O (e.g. pd.read_csv)
# Input data file (fer2013 dataset)

filname = 'fer2013.csv'
label_map = ['Anger', 'Disgust', 'Fear', 'Happy', 'Sad', 'Surprise', 'Neutral']
names=['emotion','pixels','usage']
df=pd.read_csv(filname,names=names, na_filter=False)
im=df['pixels']
print(df.head(10))
```

```
   emotion                                             pixels     usage
0  emotion                                             pixels     Usage
1        0  70 80 82 72 58 58 60 63 54 58 60 48 89 115 121...  Training
2        0  151 150 147 155 148 133 111 140 170 174 182 15...  Training
3        2  231 212 156 164 174 138 161 173 182 200 106 38...  Training
4        4  24 32 36 30 32 23 19 20 30 41 21 22 32 34 21 1...  Training
5        6  4 0 0 0 0 0 0 0 0 0 0 0 3 15 23 28 48 50 58 84...  Training
6        2  55 55 55 55 55 54 60 68 54 85 151 163 170 179 ...  Training
7        4  20 17 19 21 25 38 42 42 46 54 56 62 63 66 82 1...  Training
8        3  77 78 79 79 78 75 60 55 47 48 58 73 77 79 57 5...  Training
9        3  85 84 90 121 101 102 133 153 153 169 177 189 1...  Training
```

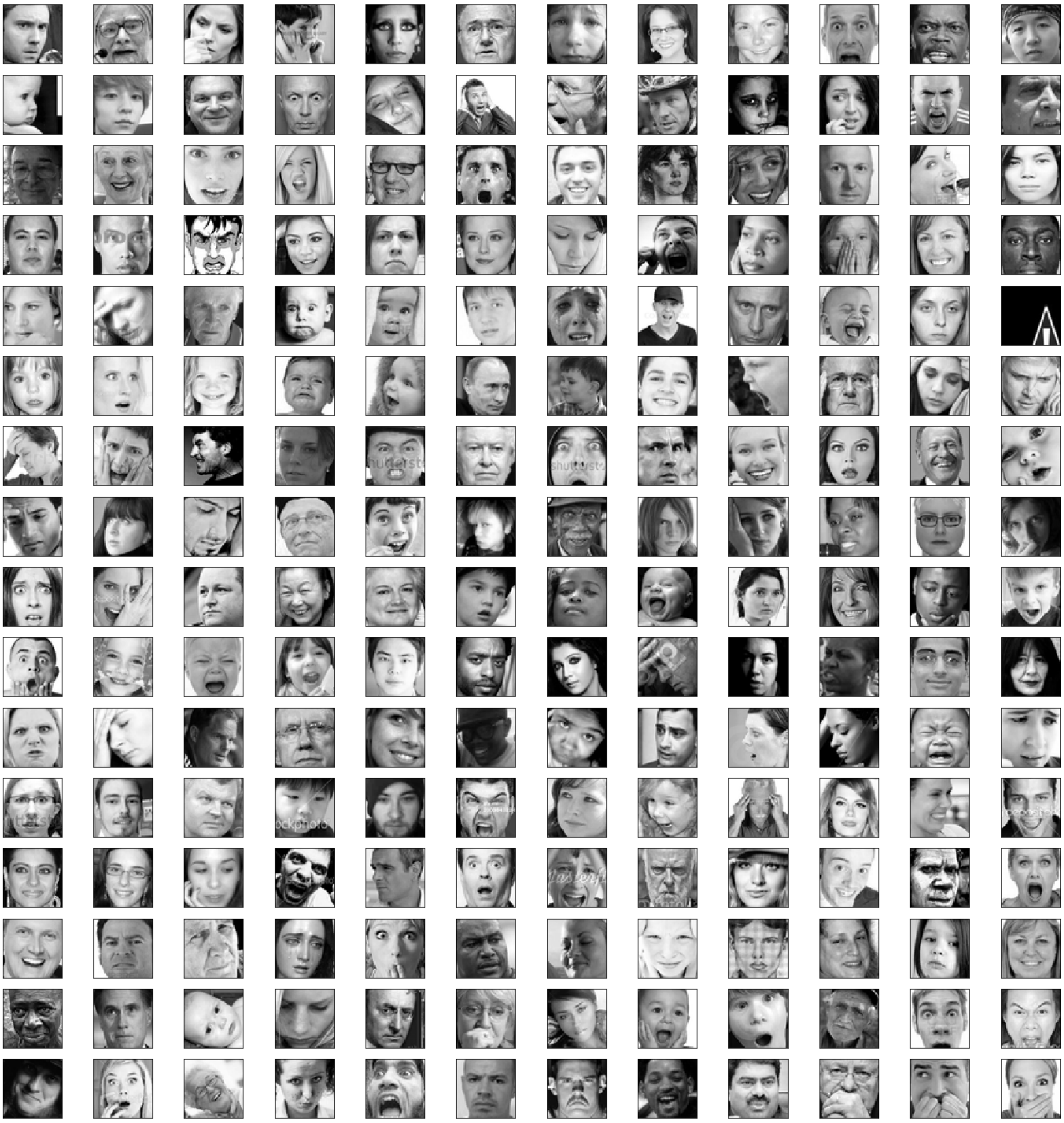
In [4]:

```
# this is the function for processing the data into X and Y
def getData(filname):
    # images are 48x48
    # N = 35887
    Y = []
    X = []
    first = True
    for line in open(filname):
        if first:
            first = False
        else:
            row = line.split(',')
            Y.append(int(row[0]))
            X.append([int(p) for p in row[1].split()])
    X, Y = np.array(X) / 255.0, np.array(Y)
    return X, Y
X, Y = getData(filname)
num_class = len(set(Y))
print(num_class)
# X.shape (35887, 2304)
# reshape X into the desired dimensions
N, D = X.shape
X = X.reshape(N, 48, 48, 1)
# X.shape
```

```
7
```

In [5]:

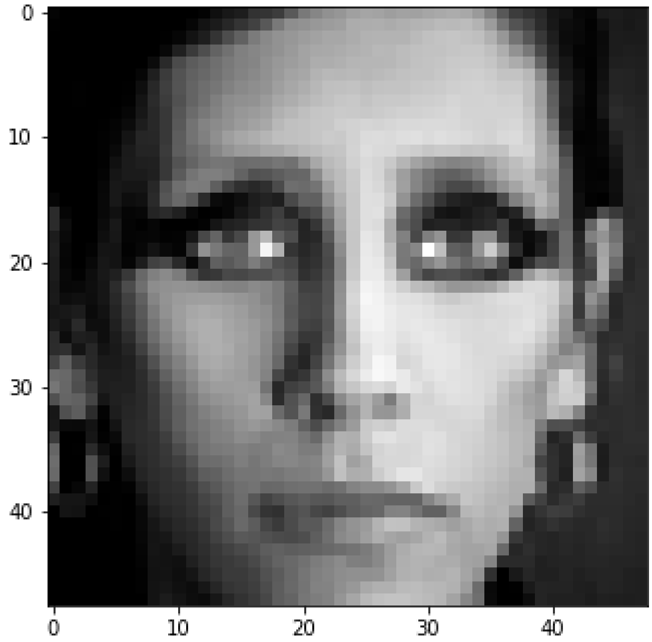
```
def overview(start, end, X):
    """
    The function is used to plot first several pictures for overviewing inputs format
    """
    fig = plt.figure(figsize=(20,20))
    for i in range(start, end+1):
        input_img = X[i:(i+1),:,:,:]
        ax = fig.add_subplot(16,12,i+1)
        ax.imshow(input_img[0,:,:,0], cmap=plt.cm.gray)
        plt.xticks(np.array([]))
        plt.yticks(np.array([]))
        plt.tight_layout()
    plt.show()
overview(0,191, X)
```



In [6]:

```
input_img = X[4:5,:,:,:]
print (input_img.shape)
plt.imshow(input_img[0,:,:,0], cmap='gray')
plt.show()
```

```
(1, 48, 48, 1)
```



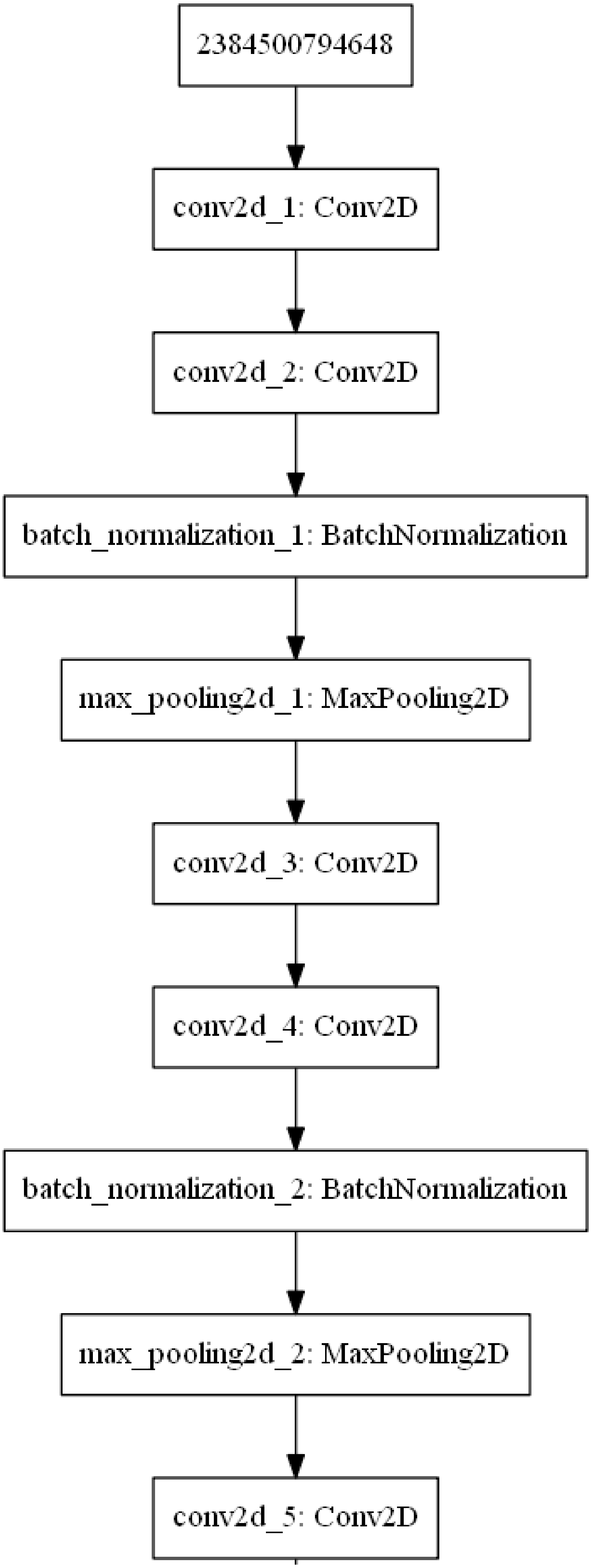
3.2 Training

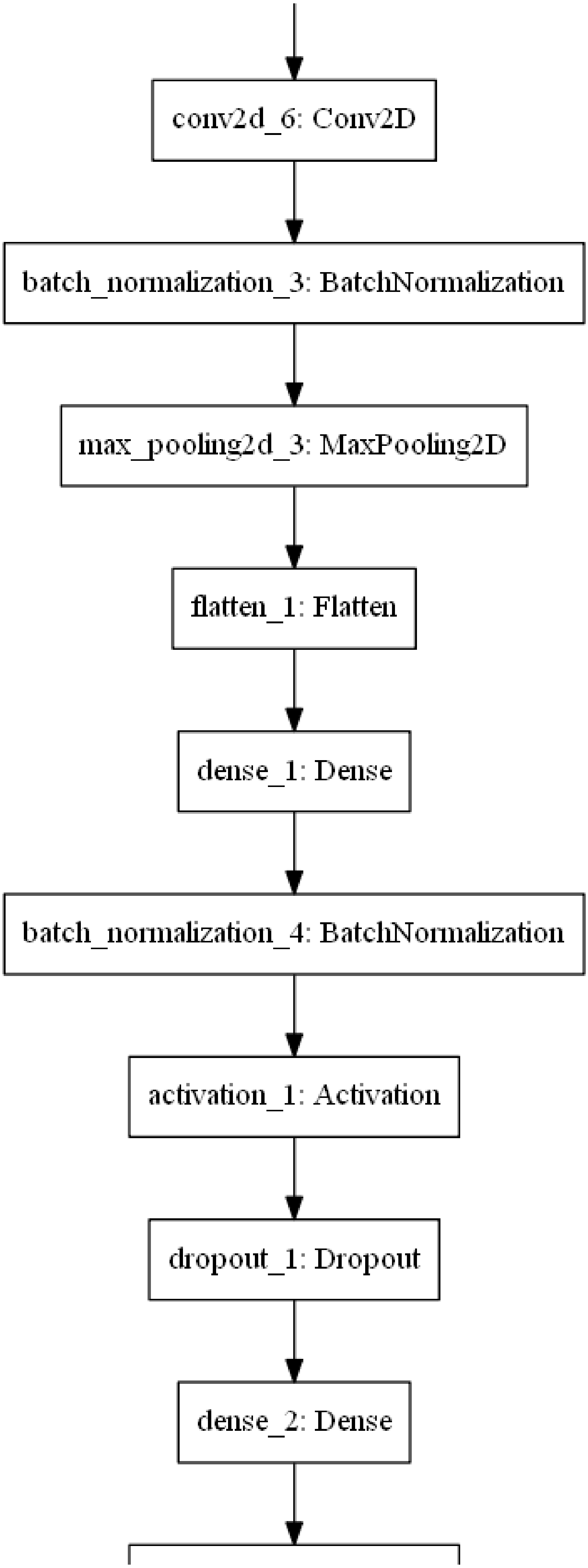
CNN Layer Set

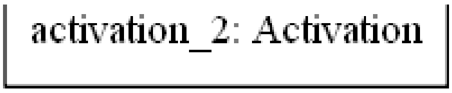
In [4]:

```
from keras.utils import plot_model
# trained_model = load_model('model_expression.h5')
trained_model = load_model('the_pretrained_model_epoch20.h5')
#  Should install GraphViz in this step and ensure that its executables are in the $PATH.
# plot_model(trained_model, to_file='model_expression.png')
plot_model(trained_model, to_file='model_model.png')
```

- The picture of the model: (code above)


2384500794648
conv2d_1: Conv2D
conv2d_2: Conv2D
batch_normalization_1: BatchNormalization
max_pooling2d_1: MaxPooling2D
conv2d_3: Conv2D
conv2d_4: Conv2D
batch_normalization_2: BatchNormalization
max_pooling2d_2: MaxPooling2D
conv2d_5: Conv2D


conv2d_6: Conv2D
batch_normalization_3: BatchNormalization
max_pooling2d_3: MaxPooling2D
flatten_1: Flatten
dense_1: Dense
batch_normalization_4: BatchNormalization
activation_1: Activation
dropout_1: Dropout
dense_2: Dense


activation_2: Activation

In [7]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.1, random_state=0)
y_train = (np.arange(num_class) == y_train[:, None]).astype(np.float32)
y_test = (np.arange(num_class) == y_test[:, None]).astype(np.float32)

from keras.models import Sequential
from keras.layers import Dense , Activation , Dropout ,Flatten
from keras.layers.convolutional import Conv2D
from keras.layers.convolutional import MaxPooling2D
from keras.metrics import categorical_accuracy
from keras.models import model_from_json
from keras.callbacks import ModelCheckpoint
from keras.optimizers import *
from keras.layers.normalization import BatchNormalization

def my_model():
    model = Sequential()
    input_shape = (48,48,1)
    model.add(Conv2D(64, (5, 5), input_shape=input_shape,activation='relu', padding='same'))
    model.add(Conv2D(64, (5, 5), activation='relu', padding='same'))
    model.add(BatchNormalization())
    model.add(MaxPooling2D(pool_size=(2, 2)))

    model.add(Conv2D(128, (5, 5),activation='relu',padding='same'))
    model.add(Conv2D(128, (5, 5),activation='relu',padding='same'))
    model.add(BatchNormalization())
    model.add(MaxPooling2D(pool_size=(2, 2)))

    model.add(Conv2D(256, (3, 3),activation='relu',padding='same'))
    model.add(Conv2D(256, (3, 3),activation='relu',padding='same'))
    model.add(BatchNormalization())
    model.add(MaxPooling2D(pool_size=(2, 2)))

    model.add(Flatten())
    model.add(Dense(128))
    model.add(BatchNormalization())
    model.add(Activation('relu'))
    model.add(Dropout(0.2))
    model.add(Dense(7))
    model.add(Activation('softmax'))

    model.compile(loss='categorical_crossentropy', metrics=['accuracy'],optimizer='adam')

    return model
model=my_model()
# The Architecture
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 48, 48, 64)        1664
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 48, 48, 64)        102464
_________________________________________________________________
batch_normalization_1 (Batch (None, 48, 48, 64)        256
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 24, 24, 64)        0
_________________________________________________________________
```

```
conv2d_3 (Conv2D)            (None, 24, 24, 128)       204928    
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 24, 24, 128)       409728    
_________________________________________________________________
batch_normalization_2 (Batch (None, 24, 24, 128)       512       
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 12, 12, 128)       0         
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 12, 12, 256)       295168    
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 12, 12, 256)       590080    
_________________________________________________________________
batch_normalization_3 (Batch (None, 12, 12, 256)       1024      
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 6, 6, 256)         0         
_________________________________________________________________
flatten_1 (Flatten)          (None, 9216)              0         
_________________________________________________________________
dense_1 (Dense)              (None, 128)               1179776   
_________________________________________________________________
batch_normalization_4 (Batch (None, 128)               512       
_________________________________________________________________
activation_1 (Activation)    (None, 128)               0         
_________________________________________________________________
dropout_1 (Dropout)          (None, 128)               0         
_________________________________________________________________
dense_2 (Dense)              (None, 7)                 903       
_________________________________________________________________
activation_2 (Activation)    (None, 7)                 0         
=================================================================
Total params: 2,787,015
Trainable params: 2,785,863
Non-trainable params: 1,152
_________________________________________________________________
```

Finally! The training begins!

Warning! Good people! It might take a bit long time to run this step if not using GPU

In [8]:

```
path_model='model_expression.h5' # save model at this location after each epoch
K.tensorflow_backend.clear_session() # destroys the current graph and builds a new one
model=my_model() # create the model
K.set_value(model.optimizer.lr,1e-3) # set the learning rate
# fit the model
history=model.fit(x=X_train,
            y=y_train,
            batch_size=64,
            epochs=20,
            verbose=1,
            validation_data=(X_test,y_test),
            shuffle=True,
            callbacks=[
                ModelCheckpoint(filepath=path_model),
            ]
            )
```

```
Train on 32298 samples, validate on 3589 samples
Epoch 1/20
32298/32298 [==============================] - 83s 3ms/step - loss: 1.6524 - acc: 0.
3619 - val_loss: 1.4280 - val_acc: 0.4522
Epoch 2/20
32298/32298 [==============================] - 78s 2ms/step - loss: 1.3010 - acc: 0.
5033 - val_loss: 1.3849 - val_acc: 0.4765
Epoch 3/20
32298/32298 [==============================] - 77s 2ms/step - loss: 1.1195 - acc: 0.
5796 - val_loss: 1.1641 - val_acc: 0.5531
Epoch 4/20
32298/32298 [==============================] - 76s 2ms/step - loss: 0.9920 - acc: 0.
6316 - val_loss: 1.1017 - val_acc: 0.5829
Epoch 5/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.8712 - acc: 0.
6768 - val_loss: 1.1308 - val_acc: 0.5821
Epoch 6/20
32298/32298 [==============================] - 76s 2ms/step - loss: 0.7260 - acc: 0.
7334 - val_loss: 1.1511 - val_acc: 0.5918
Epoch 7/20
32298/32298 [==============================] - 78s 2ms/step - loss: 0.5622 - acc: 0.
7961 - val_loss: 1.2866 - val_acc: 0.5893
Epoch 8/20
32298/32298 [==============================] - 76s 2ms/step - loss: 0.4119 - acc: 0.
8553 - val_loss: 1.3382 - val_acc: 0.5932
Epoch 9/20
32298/32298 [==============================] - 78s 2ms/step - loss: 0.2847 - acc: 0.
9018 - val_loss: 1.4341 - val_acc: 0.6147
Epoch 10/20
32298/32298 [==============================] - 78s 2ms/step - loss: 0.2033 - acc: 0.
9315 - val_loss: 1.6609 - val_acc: 0.6052
Epoch 11/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.1454 - acc: 0.
9512 - val_loss: 1.7891 - val_acc: 0.6032
Epoch 12/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.1402 - acc: 0.
9543 - val_loss: 1.8974 - val_acc: 0.6105
Epoch 13/20
32298/32298 [==============================] - 79s 2ms/step - loss: 0.1204 - acc: 0.
9593 - val_loss: 1.8249 - val_acc: 0.6172
Epoch 14/20
32298/32298 [==============================] - 78s 2ms/step - loss: 0.1129 - acc: 0.
```

```
9638 - val_loss: 1.9312 - val_acc: 0.6138
Epoch 15/20
32298/32298 [==============================] - 76s 2ms/step - loss: 0.0992 - acc: 0.
9677 - val_loss: 1.9016 - val_acc: 0.6116
Epoch 16/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.1008 - acc: 0.
9658 - val_loss: 1.9596 - val_acc: 0.6021
Epoch 17/20
32298/32298 [==============================] - 78s 2ms/step - loss: 0.0866 - acc: 0.
9714 - val_loss: 2.1509 - val_acc: 0.6013
Epoch 18/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.0804 - acc: 0.
9738 - val_loss: 2.2540 - val_acc: 0.6091
Epoch 19/20
32298/32298 [==============================] - 79s 2ms/step - loss: 0.0831 - acc: 0.
9709 - val_loss: 2.0893 - val_acc: 0.6094
Epoch 20/20
32298/32298 [==============================] - 77s 2ms/step - loss: 0.0764 - acc: 0.
9739 - val_loss: 2.0982 - val_acc: 0.6130
```

In [27]:

```
# save the history for later use

# method 1
# import pickle
# with open('/trainHistoryDict.txt', 'wb') as file_pi:
#     pickle.dump(history.history, file_pi)

# method 2
import json
# Get the dictionary containing each metric and the loss for each epoch
history_dict = history.history
# Save it under the form of a json file
json.dump(history_dict, open("trainHistoryDict.json", 'w'))
print(history_dict['loss'])
```

```
[1.6523512922224153, 1.3010347802555298, 1.1195297345663935, 0.9920307688576067, 0.8
712031991166281, 0.7260414739756165, 0.5621824558194307, 0.41191538352849383, 0.2847
4593554143085, 0.2033206407861729, 0.1453572019867295, 0.1402310108841739, 0.1203633
7609255718, 0.11293436192989689, 0.09919682996890458, 0.10082613619992413, 0.0865873
1534234643, 0.08042366264510342, 0.08311961923149601, 0.07635098764406091]
```

3.2 Visualizing the model accuracy and model loss

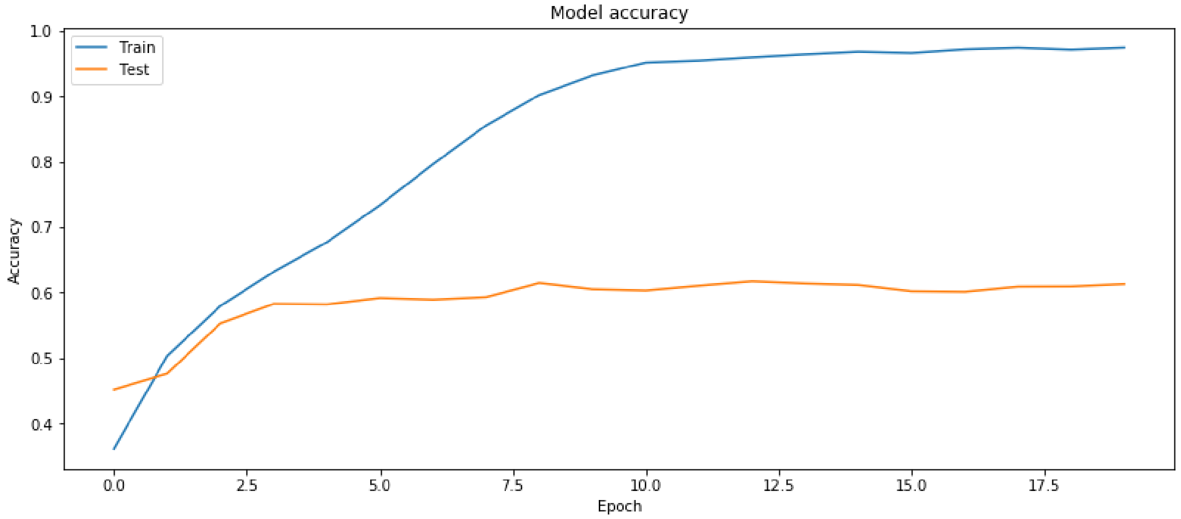
In [15]:

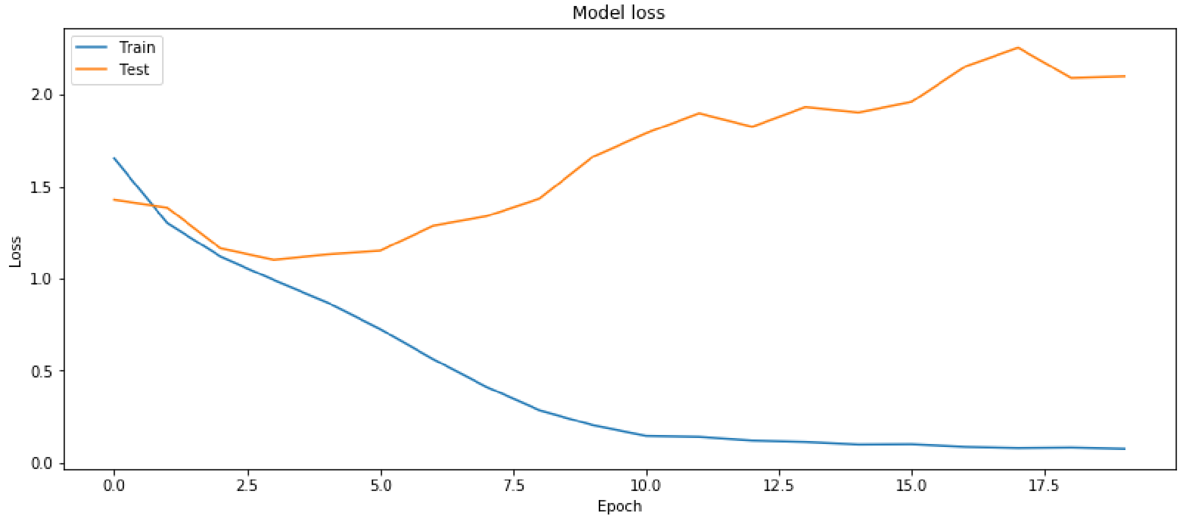
```
# model = trained_model


import matplotlib.pyplot as plt


# Plot training & validation accuracy values
plt.plot(history.history['acc'])
plt.plot(history.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```





In [ ]:

```

```

Use the saved history

In [3]:

```
# # model = trained_model
# import matplotlib.pyplot as plt


# # load the saved history dict and use it for evaluation
# # history_dict = json.load(open("trainHistoryDict.json", 'r'))

# # Plot training & validation accuracy values
# plt.plot(history_dict['acc'])
# plt.plot(history_dict['val_acc'])
# plt.title('Model accuracy')
# plt.ylabel('Accuracy')
# plt.xlabel('Epoch')
# plt.legend(['Train', 'Test'], loc='upper left')
# plt.show()

# # Plot training & validation loss values
# plt.plot(history_dict['loss'])
# plt.plot(history_dict['val_loss'])
# plt.title('Model loss')
# plt.ylabel('Loss')
# plt.xlabel('Epoch')
# plt.legend(['Train', 'Test'], loc='upper left')
# plt.show()



# # this plot_model function works if you install graph
# # from keras.utils import plot_model
# # # trained_model = load_model('model_expression.h5')
# # trained_model = load_model('the_pretrained_model_epoch20.h5')
# # plot_model(trained_model, to_file='model.png')
```

4.Reference

- data;

FER2013 Dataset from

https://www.kaggle.com/c/challenges-in-representation-learning-facial-expression-recognition-challenge/data (https://www.kaggle.com/c/challenges-in-representation-learning-facial-expression-recognition-challenge/data)

code reference (keras documents):

- To use the model in keras:

https://keras.io/models/sequential/ (https://keras.io/models/sequential/)

https://keras.io/getting-started/sequential-model-guide/ (https://keras.io/getting-started/sequential-model-guide/)

- To run Keras on GPU:

https://keras.io/getting-started/faq/ (https://keras.io/getting-started/faq/)

https://www.tensorflow.org/install/gpu (https://www.tensorflow.org/install/gpu)

- inspiration from:

"AU-inspired Deep Networks for Facial Expression Feature Learning" by Mengyi Liu, Shaoxin Li, Shiguang Shan, Xilin Chen

"Visual Saliency Maps Can Apply to Facial Expression Recognition" by Zhenyue Qin, Jie Wuy, Yang Liu, and Tom Gedeon