In [1]:

```
import numpy as np
import pandas as pd
import cv2
import tensorflow as tf
import keras
import matplotlib.pyplot as plt
from keras.preprocessing.image import ImageDataGenerator
from keras.preprocessing import image
from keras.models import Sequential
from keras.layers import Dense, Conv2D, MaxPooling2D, Flatten, AveragePooling2D, Dropout, Input
from keras import models
from keras.models import Model
from keras.utils.vis_utils import plot_model
```

In [2]:

```
test_data = 'test'
train_data = 'train'
```

In [3]:

```
train_datagen = ImageDataGenerator()
test_datagen = ImageDataGenerator()
```

In [4]:

```
train_set = train_datagen.flow_from_directory(train_data,
                    target_size = (48,48),
                    batch_size = 32,
                    color_mode = 'grayscale',
                    shuffle = True,
                    class_mode = 'categorical')
```

```
Found 14407 images belonging to 10 classes.
```

In [5]:

```
test_set = test_datagen.flow_from_directory(test_data,
                    target_size = (48,48),
                    batch_size = 32,
                    color_mode = 'grayscale',
                    shuffle = True,
                    class_mode = 'categorical')
```

```
Found 3602 images belonging to 10 classes.
```

In [6]:

```
input_img = Input(shape=(48,48,1))

### 1st layer
layer_1 = Conv2D(10, (1,1), padding='same', activation='relu')(input_img)
layer_1 = Conv2D(10, (3,3), padding='same', activation='relu')(layer_1)

layer_2 = Conv2D(10, (1,1), padding='same', activation='relu')(input_img)
layer_2 = Conv2D(10, (5,5), padding='same', activation='relu')(layer_2)

layer_3 = MaxPooling2D((3,3), strides=(1,1), padding='same')(input_img)
layer_3 = Conv2D(10, (1,1), padding='same', activation='relu')(layer_3)

mid_1 = tf.keras.layers.concatenate([layer_1, layer_2, layer_3], axis = 3)
```

In [7]:

```
flat_1 = Flatten()(mid_1)

dense_1 = Dense(1200, activation='relu')(flat_1)
dense_2 = Dense(600, activation='relu')(dense_1)
dense_3 = Dense(150, activation='relu')(dense_2)
output = Dense(10, activation='softmax')(dense_3)
```

In [8]:

```
model = Model([input_img], output)
```

In [9]:

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

In [10]:

```
hist = model.fit(train_set, steps_per_epoch=100, epochs=20, validation_data=test_set, validation_steps=100)
```

```
Epoch 1/20
100/100 [==============================] - 7s 74ms/step - loss: 51.8297
- accuracy: 0.7362 - val_loss: 6.0578 - val_accuracy: 0.8037
Epoch 2/20
100/100 [==============================] - 7s 70ms/step - loss: 2.9132
- accuracy: 0.8981 - val_loss: 1.4612 - val_accuracy: 0.9244
Epoch 3/20
100/100 [==============================] - 7s 68ms/step - loss: 1.2937
- accuracy: 0.9331 - val_loss: 1.0294 - val_accuracy: 0.9344
Epoch 4/20
100/100 [==============================] - 7s 68ms/step - loss: 0.6879
- accuracy: 0.9450 - val_loss: 0.9024 - val_accuracy: 0.9406
Epoch 5/20
100/100 [==============================] - 7s 68ms/step - loss: 0.6397
- accuracy: 0.9519 - val_loss: 0.8354 - val_accuracy: 0.9397
Epoch 6/20
100/100 [==============================] - 7s 67ms/step - loss: 0.6687
- accuracy: 0.9469 - val_loss: 1.0135 - val_accuracy: 0.9156
Epoch 7/20
100/100 [==============================] - 7s 70ms/step - loss: 0.4156
- accuracy: 0.9591 - val_loss: 0.3887 - val_accuracy: 0.9628
Epoch 8/20
100/100 [==============================] - 7s 68ms/step - loss: 0.3188
- accuracy: 0.9684 - val_loss: 0.6621 - val_accuracy: 0.9366
Epoch 9/20
100/100 [==============================] - 7s 68ms/step - loss: 0.3529
- accuracy: 0.9616 - val_loss: 0.3976 - val_accuracy: 0.9616
Epoch 10/20
100/100 [==============================] - 7s 68ms/step - loss: 0.3090
- accuracy: 0.9666 - val_loss: 0.5448 - val_accuracy: 0.9494
Epoch 11/20
100/100 [==============================] - 7s 68ms/step - loss: 0.1570
- accuracy: 0.9791 - val_loss: 0.2527 - val_accuracy: 0.9678
Epoch 12/20
100/100 [==============================] - 7s 68ms/step - loss: 0.1421
- accuracy: 0.9766 - val_loss: 0.4865 - val_accuracy: 0.9559
Epoch 13/20
100/100 [==============================] - 7s 68ms/step - loss: 0.1330
- accuracy: 0.9795 - val_loss: 0.3162 - val_accuracy: 0.9641
```

```
Epoch 14/20
100/100 [==============================] - 7s 70ms/step - loss: 0.1844
- accuracy: 0.9734 - val_loss: 0.4884 - val_accuracy: 0.9559
Epoch 15/20
100/100 [==============================] - 7s 71ms/step - loss: 0.1484
- accuracy: 0.9828 - val_loss: 0.4343 - val_accuracy: 0.9534
Epoch 16/20
100/100 [==============================] - 7s 72ms/step - loss: 0.1423
- accuracy: 0.9803 - val_loss: 0.3268 - val_accuracy: 0.9712
Epoch 17/20
100/100 [==============================] - 7s 74ms/step - loss: 0.1771
- accuracy: 0.9767 - val_loss: 0.4419 - val_accuracy: 0.9653
Epoch 18/20
100/100 [==============================] - 8s 75ms/step - loss: 0.1922
- accuracy: 0.9750 - val_loss: 0.4937 - val_accuracy: 0.9581
Epoch 19/20
100/100 [==============================] - 8s 76ms/step - loss: 0.1863
- accuracy: 0.9791 - val_loss: 0.4381 - val_accuracy: 0.9609
Epoch 20/20
100/100 [==============================] - 7s 71ms/step - loss: 0.1181
- accuracy: 0.9872 - val_loss: 0.4315 - val_accuracy: 0.9644
```

In [11]:

```
model.summary()
```

```
Model: "functional_1"
_______________________________________________________________________
___________________________
Layer (type)                    Output Shape          Param #     Connec
ted to
=======================================================================
===========================
input_1 (InputLayer)            [(None, 48, 48, 1)]   0

_______________________________________________________________________
___________________________
conv2d (Conv2D)                 (None, 48, 48, 10)    20          input_
1[0][0]
_______________________________________________________________________
___________________________
```

```
conv2d_2 (Conv2D)              (None, 48, 48, 10)   20          input_
1[0][0]                                                                 
________________________________________________________________________
___________________________
max_pooling2d (MaxPooling2D)   (None, 48, 48, 1)    0           input_
1[0][0]                                                                 
________________________________________________________________________
___________________________
conv2d_1 (Conv2D)              (None, 48, 48, 10)   910         conv2d
[0][0]                                                                  
________________________________________________________________________
___________________________
conv2d_3 (Conv2D)              (None, 48, 48, 10)   2510        conv2d
_2[0][0]                                                                
________________________________________________________________________
___________________________
conv2d_4 (Conv2D)              (None, 48, 48, 10)   20          max_po
oling2d[0][0]                                                           
________________________________________________________________________
___________________________
concatenate (Concatenate)      (None, 48, 48, 30)   0           conv2d
_1[0][0]                                                                
                                                                conv2d
_3[0][0]                                                                
                                                                conv2d
_4[0][0]                                                                
________________________________________________________________________
___________________________
flatten (Flatten)              (None, 69120)        0           concat
enate[0][0]                                                             
________________________________________________________________________
___________________________
dense (Dense)                  (None, 1200)         82945200    flatte
n[0][0]                                                                 
________________________________________________________________________
___________________________
dense_1 (Dense)                (None, 600)          720600      dense
[0][0]                                                                  
________________________________________________________________________
```

```
___________________________
dense_2 (Dense)                 (None, 150)          90150       dense_
1[0][0]

_______________________________________________________________________
___________________________
dense_3 (Dense)                 (None, 10)           1510        dense_
2[0][0]
=======================================================================
===========================
Total params: 83,760,940
Trainable params: 83,760,940
Non-trainable params: 0

_______________________________________________________________________
___________________________
```

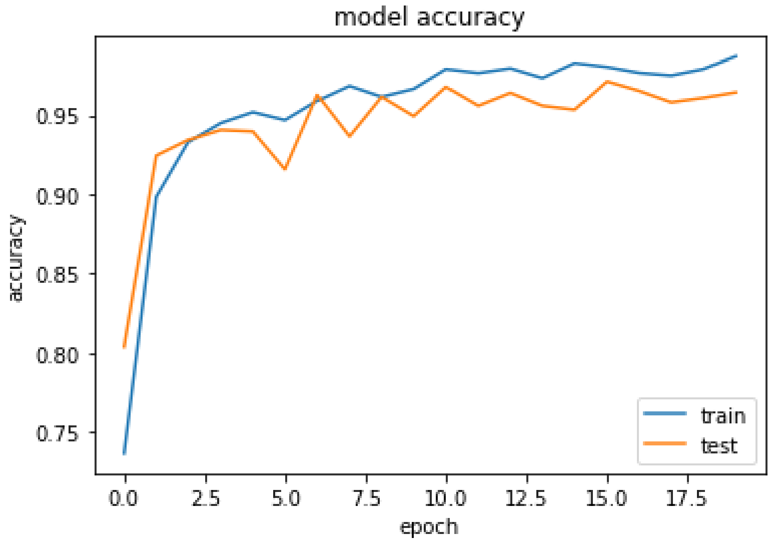
In [12]:

```
print(hist.history.keys())
```

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

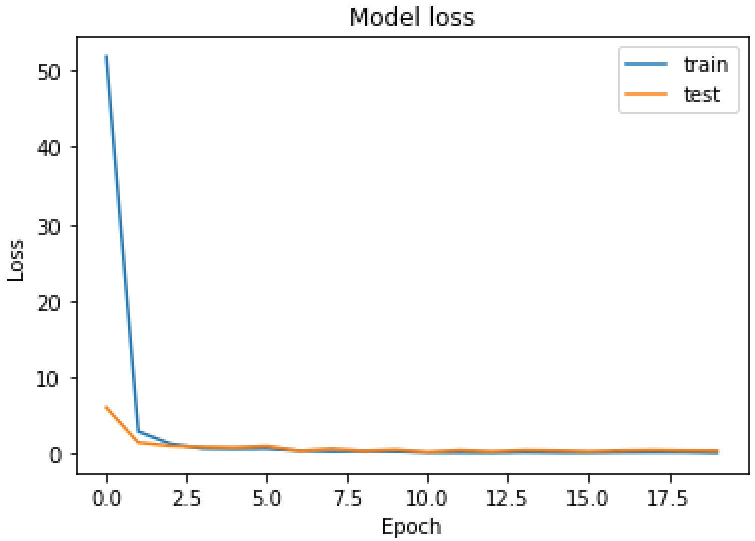
In [18]:

```
plt.plot(hist.history['accuracy'])
plt.plot(hist.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='lower right')
plt.show()
```



In [19]:

```
plt.plot(hist.history['loss'])
plt.plot(hist.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['train', 'test'], loc = 'upper right')
plt.show()
```



In [15]:

```
img = keras.preprocessing.image.load_img("30213.jpg",color_mode = 'gray
scale', target_size=(48,48,1))  ##image for 3

img_array = keras.preprocessing.image.img_to_array(img)
img_array = tf.expand_dims(img_array, 0)                   # Create bat
ch axis

predictions = model.predict(img_array)
score1 = predictions[0]
print(score1)
```

```
[7.8136983e-21 8.9801586e-17 1.7120331e-22 9.9999988e-01 6.8822091e-30
 4.5539274e-32 7.9432655e-19 1.5187982e-07 8.6690686e-26 1.6634684e-27]
```

In [16]:

```
img = keras.preprocessing.image.load_img("70405.jpg", color_mode = 'gra
yscale', target_size=(48,48,1))  ##image for 7

img_array = keras.preprocessing.image.img_to_array(img)
img_array = tf.expand_dims(img_array, 0)                   # Create bat
ch axis
```

```
predictions = model.predict(img_array)
score = predictions[0]
print(score)
```

```
[1.1550408e-20 6.4151683e-23 2.8512109e-32 9.1893314e-17 0.0000000e+00
 7.9732077e-32 2.8619413e-19 1.0000000e+00 0.0000000e+00 0.0000000e+00]
```

In [ ]: