In [ ]:
```
1
```

In [ ]:
```
1 from google.colab import drive
2 drive.mount('/content/drive')
```

In [1]:
```
1  from keras.layers import Input, Dense, Flatten, Dropout
2  from keras.models import Model
3  from keras.optimizers import Adam, SGD
4  from keras.utils import np_utils
5  from keras import backend as K
6  import numpy as np
7  import os
8  from keras.regularizers import l2
9  import tensorflow as tf
10 import time
11 import datetime
12 import argparse
13 import datetime
14 import socket
15 import keras
16 from sklearn import preprocessing
17 import scipy.io as sio
18 import numpy as np
19 import matplotlib.pyplot as plt
20 from sklearn import preprocessing
21 import time
22 from keras.preprocessing.image import ImageDataGenerator
23 from PIL import Image, ImageOps
24 from keras.preprocessing import image
25 from keras.preprocessing.image import ImageDataGenerator
26 ##### For one-hot label
27 from keras.utils import np_utils
28
```

```
/root/anaconda3/lib/python3.6/site-packages/h5py/__init__.py:36: FutureWa
rning: Conversion of the second argument of issubdtype from `float` to `n
p.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.
```

In [2]:
```
1 os.environ["CUDA_VISIBLE_DEVICES"]="0";
```

In [3]:
```
1 # pip install -U scikit-learn
2
```

In [ ]:
```
nb_classes = 397
img_depth = 3
data_dir ='/content/drive/My Drive/Colab Notebooks/SUN_Practice/'+'SUN39
train_img_file = '/content/drive/My Drive/Colab Notebooks/SUN_Practice/I
test_img_file = '/content/drive/My Drive/Colab Notebooks/SUN_Practice/Pa
classes_name_list = '/content/drive/My Drive/Colab Notebooks/SUN_Practic
train_label_file ='/content/drive/My Drive/Colab Notebooks/SUN_Practice/
test_label_file = '/content/drive/My Drive/Colab Notebooks/SUN_Practice/

train_img_file_path='/content/drive/My Drive/Colab Notebooks/SUN_Practic
test_img_file_path='/content/drive/My Drive/Colab Notebooks/SUN_Practice


```

In [ ]:
```
print(train_img_file)
```

In [ ]:
```
print('Begin to create a map to tansfer the str label to int label...')
class_name_file =  classes_name_list
class_str = [str(line.strip()) for line in open(class_name_file).readlin
class_count = len(class_str)
print('%d class names are loaded' % class_count)
        # begin to create the map
le = preprocessing.LabelEncoder()
le.fit(class_str)
print(list(le.classes_))
print('Label map created...')

```

In [ ]:
```
x_train=[]

x_test=[]

x_train = np.array(x_train)

x_test = np.array(x_test)

```

In [ ]:
```
x_train.shape
```

load training data

In [ ]:
```
print('\nBegin to load training data...\n')
desired_img_dim=224
print('Loading image file %s' % train_img_file_path)

```

In [ ]:
```
start_time_ = time.time()
train_img_file_path = [str(line.strip()) for line in open(train_img_file_path
nb_sample = len(train_img_file_path)
print('Image count: %d' % nb_sample)

data_resized_holder = np.empty([nb_sample, desired_img_dim, desired_img_dim,

for idx in range(nb_sample):
    img_file1 = train_img_file_path[idx].replace("\\", "/")     # the image f
    # print(str(img_file1))
    # 1. read the image
    img1 = image.load_img(data_dir+img_file1)

    # 2. resize
    img1 = img1.resize((desired_img_dim, desired_img_dim), resample=0)


    # 6. give to the holder
    data_resized_holder[idx] = img1
    if(idx % 1000==0):
        print('%d image loaded.' % idx)

print('\nImage file loaded, the shape is ' + str(data_resized_holder.shape))

```

In [ ]:
```
x_train.shape
```

loading the training labels text

In [ ]:
```
one_hot = True
print('Loading label file %s' % train_label_file)
label_str = [str(line.strip()) for line in open(train_label_file).readli
nb_unique = len(label_str)
labels_unique = le.transform(label_str)
# print(labels_unique)
labels_holder = np.hstack((  [ labels_unique[i] ] * 50 for i in range(nb
# print(labels_holder)
nb_sample = len(labels_holder)
if one_hot == True:
    labels = np.array([[float(i == l) for i in range(nb_classes)] for l
else:
    labels = labels_holder
print('Labels loaded, shape is:' + str(labels.shape))


```

loading training data

In [ ]:
```
x_train, nb_train_sample_1 = data_resized_holder, nb_sample
```

In [ ]:
```
y_train, nb_train_sample_2 = labels, nb_sample
```

In [ ]:
```
del data_resized_holder
del labels
```

In [ ]:
```
x_train.shape
```

In [ ]:
```
y_train.shape
```

Saving train data and test data

Saving x_train y_train as .npy file

In [ ]:
```
np.save('/content/drive/My Drive/Colab Notebooks/SUN_Practice/x_tain.npy
```

In [ ]:
```
np.save('/content/drive/My Drive/Colab Notebooks/SUN_Practice/y_train.np
```

In [ ]:
```
del x_train
#del y_train

```

loading testing data

load testing data

In [ ]:
```
print('Loading image file %s' % test_img_file_path )
start_time_ = time.time()
test_img_file_path = [str(line.strip()) for line in open(test_img_file_p
nb_sample = len(test_img_file_path)
print('Image count: %d' % nb_sample)

data_resized_holder = np.empty([nb_sample, desired_img_dim, desired_img_

for idx in range(nb_sample):
    img_file1 = data_dir + test_img_file_path[idx].replace("\\", "/")
    # print(str(img_file1))
    # 1. read the image
    img1 = image.load_img(img_file1)

    # 2. resize
    img1 = img1.resize((desired_img_dim, desired_img_dim), resample=0)


    # 6. give to the holder
    data_resized_holder[idx] = img1
    if(idx % 1000==0):
        print('%d image loaded.' % idx)

print('\nImage file loaded, the shape is ' + str(data_resized_holder.sha


```

Load test labels

In [ ]:
```
one_hot = True
# loading the training labels
print('Loading label file %s' % test_label_file)
label_str = [str(line.strip()) for line in open(test_label_file).readlir
nb_unique = len(label_str)
labels_unique = le.transform(label_str)
# print(labels_unique)
labels_holder = np.hstack((  [ labels_unique[i] ] * 50 for i in range(nb
# print(labels_holder)
nb_sample = len(labels_holder)
if one_hot == True:
    labels = np.array([[float(i == l) for i in range(nb_classes)] for l
else:
    labels = labels_holder
print('Labels loaded, shape is:' + str(labels.shape))


```

In [ ]:
```
x_test, nb_test_sample_1 = data_resized_holder, nb_sample
```

In [ ]:
```
y_test, nb_test_sample_2 = labels, nb_sample
```

In [ ]:
```
del data_resized_holder
del labels
```

Saving x_test y_test .npy file

In [ ]:
```
np.save('/content/drive/My Drive/Colab Notebooks/SUN_Practice/x_test.npy
```

In [ ]:
```
np.save('/content/drive/My Drive/Colab Notebooks/SUN_Practice/y_test.npy
```

In [ ]:
```
del x_test
del y_test
```

In [ ]:
```
y_test.shape
```

Load train data and test data

Load train data

In [4]:
```
x_train = np.load('/root/Code_GCP/SUN_Practice/x_tain.npy')
```

In [5]:
```
y_train = np.load('/root/Code_GCP/SUN_Practice/y_train.npy')
```

In [6]:
```
x_train.shape
```

Out[6]:
```
(19850, 224, 224, 3)
```

In [7]:
```
print(y_train.shape)
```

```
(19850, 397)
```

Load test data

In [8]:
```
x_test = np.load('/root/Code_GCP/SUN_Practice/x_test.npy')
```

In [9]:
```
y_test = np.load('/root/Code_GCP/SUN_Practice/y_test.npy')
```

In [10]:
```
print(x_train.shape)
print(y_train.shape)
print(x_test.shape)
print(y_test.shape)
```

```
(19850, 224, 224, 3)
(19850, 397)
(19850, 224, 224, 3)
(19850, 397)
```

In [11]:
```
!/opt/bin/nvidia-smi
```

```
/bin/sh: 1: /opt/bin/nvidia-smi: not found
```

Data Auguation

In [ ]:
```
generator = ImageDataGenerator(
        rotation_range=40,
        width_shift_range=0.2,
        height_shift_range=0.2,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=True,
        fill_mode='nearest')

```

Set data to one-hot encoded format (vector of 397 class binary values)

In [ ]:
```
# import keras

# y_train = keras.utils.to_categorical(y_train, 397)
# y_test = keras.utils.to_categorical(y_test, 397)
```

In [11]:
```
from tensorflow.keras.applications.vgg16 import preprocess_input

x_train = preprocess_input(x_train)
x_test = preprocess_input(x_test)
# x_train /= 255
# x_test /= 255
```

In [ ]:
```
y_train.shape
```

Using VGG16 Pre-trained model based imagnet train this dataset

In [ ]:
```
import os
import keras
from keras.models import Model
from keras.layers import Dense,Flatten,Dropout
from keras import datasets
from keras.applications.vgg16 import VGG16
#from vgg16_places_365 import VGG16_Places365
from keras.optimizers import SGD, Adam
from keras import optimizers
from keras.callbacks import EarlyStopping

```

In [20]:
```
dim=224
num_classes=397
```

In [ ]:
```
model_sun_vgg = VGG16(include_top=False, weights='imagenet', input_shape

for layer in model_sun_vgg.layers:
    layer.trainable = False

model = Flatten()(model_sun_vgg.output)
# model.add(layers.BatchNormalization())
#keras.layers.normalization.BatchNormalization(axis=-1, momentum=0.99, e
model = Dense(4096, activation="relu")(model)
model = Dense(1000, activation="relu")(model)
model = Dense(1000, activation="relu")(model)
model = Dropout(0.3)(model)
model = Dense(num_classes, activation="softmax")(model)
model_pretrain_vgg = Model(model_sun_vgg.input, model, name='model_preti
model_pretrain_vgg.summary()


```

In [ ]:
```
from keras import optimizers
from keras.callbacks import EarlyStopping

```

In [ ]:
```
def learning_rate_schedule(epoch):
    if epoch <= 10:
        return 1e-4 # 0.00001
    elif epoch <= 20:
        return 1e-5
    elif epoch <= 30:
        return 1e-6
    else:
        return 1e-7
    return LR
```

In [ ]:
```
#learning_rate = 0.05
# batch_size=64
# Epoch = 10
# decay_rate = learning_rate / Epoch
# momentum = 0.9
# #sgd = SGD(lr=learning_rate, momentum=momentum, decay=decay_rate, nest
# # sgd=SGD(lr=0.05,decay=1e-5)
# #opt= Adam(lr=0.01)

```

In [ ]:
```
model_pretrain_vgg.save_weights('model_sun_initial.h5')
```

In [ ]:
```
batch_size = 128
training_runs = []
for i in range(3):
    #model_updated.compile(loss='categorical_crossentropy', optimizer='sgd

    model_pretrain_vgg.compile(loss='mean_squared_error', optimizer=optimi
    keras.callbacks.LearningRateScheduler(learning_rate_schedule)

#     history = model_pretrain_vgg.fit_generator(generator.flow(x_train, y
#                     steps_per_epoch=len(x_train) / batch_size,
#                     epochs=10,
#                     verbose=1,
#                     shuffle=True ,
#                     validation_data=(x_test, y_test))
    history = model_pretrain_vgg.fit(
    x_train, y_train,
    batch_size=128, shuffle=True, epochs=10,
    validation_data=(x_test, y_test)
    )


    training_runs.append(history)
    model_pretrain_vgg.get_weights()
    if i == 2:
        model_pretrain_vgg.save_weights('model1.h5')
    else:
        model_pretrain_vgg.load_weights('model_sun_initial.h5')
    print()
```

In [ ]:
```
import tensorflow as tf
#sess = tf.Session(config=tf.ConfigProto(log_device_placement=True))
tf.__version__
tf.test.is_gpu_available()
```

In [ ]:
```

```

In [ ]:
```
#hist = pretrain_model.fit(x_train, y_train, validation_data = (x_test,
```

In [ ]:

```
import matplotlib.pyplot as plt
import numpy as np

plt.subplot(2, 3, 1)
plt.plot(training_runs[0].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 2)
plt.plot(training_runs[1].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 3)
plt.plot(training_runs[2].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 4)
plt.plot(training_runs[0].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.subplot(2, 3, 5)
plt.plot(training_runs[1].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.subplot(2, 3, 6)
plt.plot(training_runs[2].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.tight_layout()

plt.show()


```

In [ ]:
```
acc = history.history['acc']
val_acc = history.history['val_acc']

loss = history.history['loss']
val_loss = history.history['val_loss']

plt.figure(figsize=(8, 8))
plt.subplot(2, 1, 1)
plt.plot(acc, label='Training Accuracy')
plt.plot(val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.ylabel('Accuracy')
plt.ylim([min(plt.ylim()),1])
plt.title('Training and Validation Accuracy')

plt.subplot(2, 1, 2)
plt.plot(loss, label='Training Loss')
plt.plot(val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.ylabel('Cross Entropy')
plt.ylim([0,1.0])
plt.title('Training and Validation Loss')
plt.xlabel('epoch')
plt.show()
```

In [ ]:
```
print("Average training accuracy: {}".format(np.mean([training_runs[0].h
                                                       training_runs[1].hi
print("Average testing accuracy: {}".format(np.mean([training_runs[0].hi
                                                       training_runs[1].hi
```

In [ ]:
```
# loss, accuracy = model.evaluate(x_test, y_test, verbose=0)
# print('Test loss:', loss)
# print('Test accuracy:', accuracy)
```

VGG16 Pre-trian model based on Places365

In [12]:
```
import vgg16_places_365
```

In [13]:
```
from keras import backend as K
from keras.layers import Input
from keras.layers.core import Activation, Dense, Flatten
from keras.layers.pooling import MaxPooling2D
from keras.models import Model
from keras.layers import Conv2D
from keras.regularizers import l2
from keras.layers.core import Dropout
from keras.layers import GlobalAveragePooling2D
from keras.layers import GlobalMaxPooling2D
from keras_applications.imagenet_utils import _obtain_input_shape
from keras.engine.topology import get_source_inputs
from keras.utils.data_utils import get_file
from keras.utils import layer_utils
from keras.preprocessing import image
from keras.applications.imagenet_utils import preprocess_input
from urllib.request import urlopen
import numpy as np
from PIL import Image
from cv2 import resize
```

In [14]:
```
WEIGHTS_PATH = 'https://github.com/GKalliatakis/Keras-VGG16-places365/re
WEIGHTS_PATH_NO_TOP = 'https://github.com/GKalliatakis/Keras-VGG16-place

```

In [15]:
```
from vgg16_places_365 import VGG16_Places365
```

In [16]:
```
model_places365 = VGG16_Places365(include_top=False,
                                  weights='places',
                                  input_tensor=None,
                                  input_shape=(224,224,3),
                                  pooling=None,
                                  classes=365
                                 )

```

In [17]:
```
1 model_places365.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 224, 224, 3)       0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 224, 224, 64)      1792
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 224, 224, 64)      36928
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 112, 112, 64)      0
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 112, 112, 128)     73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 112, 112, 128)     147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 56, 56, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 56, 56, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 56, 56, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 56, 56, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 28, 28, 256)       0
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 28, 28, 512)       1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 28, 28, 512)       2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 28, 28, 512)       2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 14, 14, 512)       0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 14, 14, 512)       2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 7, 7, 512)         0
=================================================================
Total params: 14,714,688
Trainable params: 14,714,688
Non-trainable params: 0
_________________________________________________________________
```

In [21]:
```
for layer in model_places365.layers:
    layer.trainable = False

model = Flatten()(model_places365.output)
# model.add(layers.BatchNormalization())
#keras.layers.normalization.BatchNormalization(axis=-1, momentum=0.99, e
model = Dense(4096, activation="relu")(model)
model = Dense(1000, activation="relu")(model)
model = Dense(1000, activation="relu")(model)
model = Dropout(0.3)(model)
model = Dense(num_classes, activation="softmax")(model)
model_pretrain_vgg_places = Model(model_places365.input, model, name='mo
model_pretrain_vgg_places.summary()
```

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, 224, 224, 3)	0
block1_conv1 (Conv2D)	(None, 224, 224, 64)	1792
block1_conv2 (Conv2D)	(None, 224, 224, 64)	36928
block1_pool (MaxPooling2D)	(None, 112, 112, 64)	0
block2_conv1 (Conv2D)	(None, 112, 112, 128)	73856
block2_conv2 (Conv2D)	(None, 112, 112, 128)	147584
block2_pool (MaxPooling2D)	(None, 56, 56, 128)	0
block3_conv1 (Conv2D)	(None, 56, 56, 256)	295168
block3_conv2 (Conv2D)	(None, 56, 56, 256)	590080
block3_conv3 (Conv2D)	(None, 56, 56, 256)	590080
block3_pool (MaxPooling2D)	(None, 28, 28, 256)	0
block4_conv1 (Conv2D)	(None, 28, 28, 512)	1180160
block4_conv2 (Conv2D)	(None, 28, 28, 512)	2359808
block4_conv3 (Conv2D)	(None, 28, 28, 512)	2359808
block4_pool (MaxPooling2D)	(None, 14, 14, 512)	0
block5_conv1 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv2 (Conv2D)	(None, 14, 14, 512)	2359808
block5_conv3 (Conv2D)	(None, 14, 14, 512)	2359808
block5_pool (MaxPooling2D)	(None, 7, 7, 512)	0
flatten_2 (Flatten)	(None, 25088)	0

```
dense_4 (Dense)              (None, 4096)              102764544
_________________________________________________________________
dense_5 (Dense)              (None, 1000)              4097000
_________________________________________________________________
dense_6 (Dense)              (None, 1000)              1001000
_________________________________________________________________
dropout_2 (Dropout)          (None, 1000)              0
_________________________________________________________________
dense_7 (Dense)              (None, 397)               397397
=================================================================
Total params: 122,974,629
Trainable params: 108,259,941
Non-trainable params: 14,714,688
_________________________________________________________________
```

In [22]:
```
from keras import optimizers
from keras.callbacks import EarlyStopping

```

In [23]:
```
def learning_rate_schedule(epoch):
    if epoch <= 10:
        return 1e-4 # 0.00001
    elif epoch <= 20:
        return 1e-5
    elif epoch <= 30:
        return 1e-6
    else:
        return 1e-7
    return LR
```

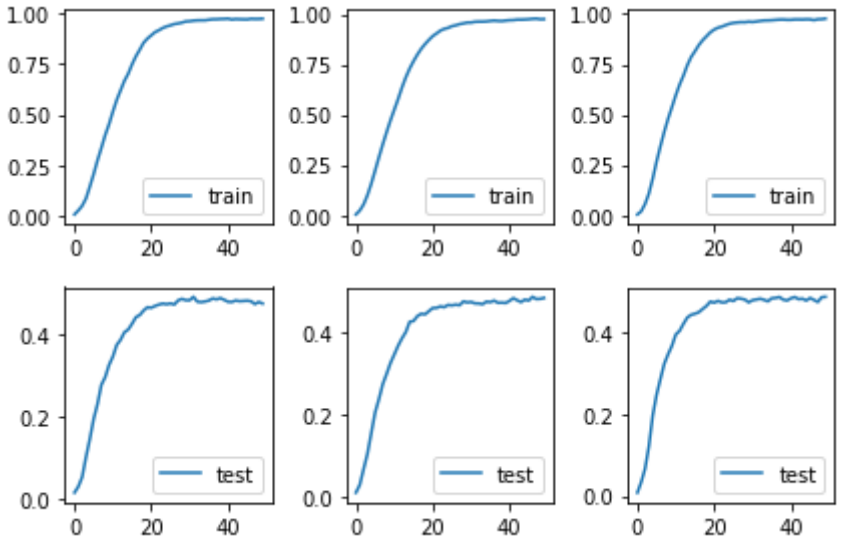
In [24]:
```
model_pretrain_vgg_places.save_weights('model_sun_places_initial.h5')
```

In [25]:
```
#batch_size = 128
training_runs = []
for i in range(3):
    #model_updated.compile(loss='categorical_crossentropy', optimizer='sg


    model_pretrain_vgg_places.compile(loss='mean_squared_error', optimize
    keras.callbacks.LearningRateScheduler(learning_rate_schedule)

#     history = model_pretrain_vgg.fit_generator(generator.flow(x_train,
#                       steps_per_epoch=len(x_train) / batch_size,
#                       epochs=10,
#                       verbose=1,
#                       shuffle=True ,
#                       validation_data=(x_test, y_test))
    history = model_pretrain_vgg_places.fit(
    x_train, y_train,
    batch_size=128, shuffle=True, epochs=50,
    validation_data=(x_test, y_test)
    )


    training_runs.append(history)
    model_pretrain_vgg_places.get_weights()
    if i == 2:
        model_pretrain_vgg_places.save_weights('model1_places.h5')
    else:
        model_pretrain_vgg_places.load_weights('model_sun_places_initial.
    print()
```

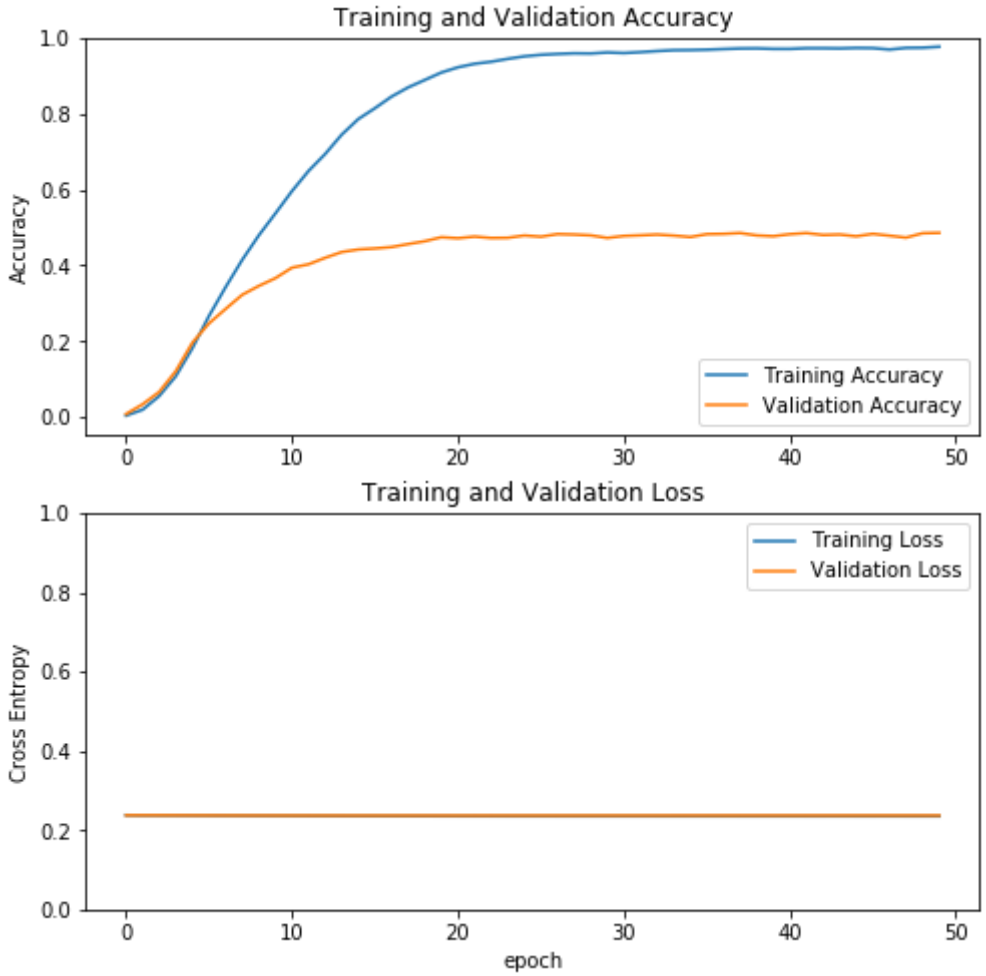
```
353 - acc: 0.9724 - val_loss: 0.2371 - val_acc: 0.4815
Epoch 45/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
353 - acc: 0.9736 - val_loss: 0.2371 - val_acc: 0.4768
Epoch 46/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
353 - acc: 0.9731 - val_loss: 0.2371 - val_acc: 0.4833
Epoch 47/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
353 - acc: 0.9694 - val_loss: 0.2371 - val_acc: 0.4784
Epoch 48/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
353 - acc: 0.9738 - val_loss: 0.2371 - val_acc: 0.4733
Epoch 49/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
353 - acc: 0.9742 - val_loss: 0.2371 - val_acc: 0.4849
Epoch 50/50
19850/19850 [==============================] - 243s 12ms/step - loss: 0.2
352 - acc: 0.9768 - val_loss: 0.2371 - val_acc: 0.4859
```

In [26]:

```
import matplotlib.pyplot as plt
import numpy as np

plt.subplot(2, 3, 1)
plt.plot(training_runs[0].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 2)
plt.plot(training_runs[1].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 3)
plt.plot(training_runs[2].history['acc'])
plt.legend(['train'], loc='lower right')

plt.subplot(2, 3, 4)
plt.plot(training_runs[0].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.subplot(2, 3, 5)
plt.plot(training_runs[1].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.subplot(2, 3, 6)
plt.plot(training_runs[2].history['val_acc'])
plt.legend(['test'], loc='lower right')

plt.tight_layout()

plt.show()

```



In [27]:
```
acc = history.history['acc']
val_acc = history.history['val_acc']

loss = history.history['loss']
val_loss = history.history['val_loss']

plt.figure(figsize=(8, 8))
plt.subplot(2, 1, 1)
plt.plot(acc, label='Training Accuracy')
plt.plot(val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.ylabel('Accuracy')
plt.ylim([min(plt.ylim()),1])
plt.title('Training and Validation Accuracy')

plt.subplot(2, 1, 2)
plt.plot(loss, label='Training Loss')
plt.plot(val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.ylabel('Cross Entropy')
plt.ylim([0,1.0])
plt.title('Training and Validation Loss')
plt.xlabel('epoch')
plt.show()
```



In [28]:
```
print("Average training accuracy: {}".format(np.mean([training_runs[0].h
                                                       training_runs[1].hi
print("Average testing accuracy: {}".format(np.mean([training_runs[0].hi
                                                       training_runs[1].hi
```

```
Average training accuracy: 0.9761209067970039
Average testing accuracy: 0.48223341729939234
```

In [ ]:
```
loss, accuracy = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', loss)
print('Test accuracy:', accuracy)
```

New Section