In [1]:

```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
%matplotlib inline

import cv2

import os
```

Global Constants

In [2]:

```
# Fixed for our Cats & Dogs classes
NUM_CLASSES = 2

# Fixed for Cats & Dogs color images
CHANNELS = 3

IMAGE_RESIZE = 224
RESNET50_POOLING_AVERAGE = 'avg'
DENSE_LAYER_ACTIVATION = 'softmax'
OBJECTIVE_FUNCTION = 'categorical_crossentropy'

# Common accuracy metric for all outputs, but can use different metrics for different out
put
LOSS_METRICS = ['accuracy']

# EARLY_STOP_PATIENCE must be < NUM_EPOCHS
NUM_EPOCHS = 10
EARLY_STOP_PATIENCE = 3

# These steps value should be proper FACTOR of no.-of-images in train & valid folders res
pectively
# Training images processed in each step would be no.-of-train-images / STEPS_PER_EPOCH_T
RAINING
STEPS_PER_EPOCH_TRAINING = 10
STEPS_PER_EPOCH_VALIDATION = 10

# These steps value should be proper FACTOR of no.-of-images in train & valid folders res
pectively
# NOTE that these BATCH* are for Keras ImageDataGenerator batching to fill epoch step inp
ut
BATCH_SIZE_TRAINING = 100
BATCH_SIZE_VALIDATION = 100

# Using 1 to easily manage mapping between test_generator & prediction for submission pre
paration
BATCH_SIZE_TESTING = 1
```

In [3]:

```
from tensorflow.python.keras.applications import ResNet50
from tensorflow.python.keras.models import Sequential
from tensorflow.python.keras.layers import Dense

###
### Below systax is available with TensorFlow 1.11 onwards but this upgrade is not availa
ble for Kaggle kernel yet
###
#import tensorflow as tf
#print(tf.__version__)
#import tensorflow as tf
#from tf.keras.applications import ResNet50
```

```
#from tf.keras.models import Sequential
```

In [4]:

```
resnet_weights_path = '../input/resnet50/resnet50_weights_tf_dim_ordering_tf_kernels_noto
p.h5'
```

Define Our Transfer Learning Network Model Consisting of 2 Layers

Here, we are preparing specification or blueprint of the TensorFlow DAG (directed acyclcic graph) for just the MODEL part.

In [5]:

```
#Still not talking about our train/test data or any pre-processing.

model = Sequential()

# 1st layer as the lumpsum weights from resnet50_weights_tf_dim_ordering_tf_kernels_notop
.h5
# NOTE that this layer will be set below as NOT TRAINABLE, i.e., use it as is
model.add(ResNet50(include_top = False, pooling = RESNET50_POOLING_AVERAGE, weights = re
snet_weights_path))

# 2nd layer as Dense for 2-class classification, i.e., dog or cat using SoftMax activatio
n
model.add(Dense(NUM_CLASSES, activation = DENSE_LAYER_ACTIVATION))

# Say not to train first layer (ResNet) model as it is already trained
model.layers[0].trainable = False
```

In [6]:

```
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
resnet50 (Model)             (None, 2048)              23587712
_________________________________________________________________
dense (Dense)                (None, 2)                 4098
=================================================================
Total params: 23,591,810
Trainable params: 4,098
Non-trainable params: 23,587,712
_________________________________________________________________
```

Compile Our Transfer Learning Model

In [7]:

```
from tensorflow.python.keras import optimizers

sgd = optimizers.SGD(lr = 0.01, decay = 1e-6, momentum = 0.9, nesterov = True)
model.compile(optimizer = sgd, loss = OBJECTIVE_FUNCTION, metrics = LOSS_METRICS)
```

In [8]:

```
from keras.applications.resnet50 import preprocess_input
from keras.preprocessing.image import ImageDataGenerator

image_size = IMAGE_RESIZE

# preprocessing_function is applied on each image but only after re-sizing & augmentation
(resize => augment => pre-process)
# Each of the keras.application.resnet* preprocess_input MOSTLY mean BATCH NORMALIZATION
(applied on each batch) stabilize the inputs to nonlinear activation functions
# Batch Normalization helps in faster convergence
```

```
data_generator = ImageDataGenerator(preprocessing_function=preprocess_input)

# flow_From_directory generates batches of augmented data (where augmentation can be colo
r conversion, etc)
# Both train & valid folders must have NUM_CLASSES sub-folders
train_generator = data_generator.flow_from_directory(
        '../input/catsdogs-trainvalid-80pc-prepd/trainvalidfull4keras/trainvalidfull4kera
s/train',
        target_size=(image_size, image_size),
        batch_size=BATCH_SIZE_TRAINING,
        class_mode='categorical')

validation_generator = data_generator.flow_from_directory(
        '../input/catsdogs-trainvalid-80pc-prepd/trainvalidfull4keras/trainvalidfull4kera
s/valid',
        target_size=(image_size, image_size),
        batch_size=BATCH_SIZE_VALIDATION,
        class_mode='categorical')
```

```
Using TensorFlow backend.
```

```
Found 20000 images belonging to 2 classes.
Found 5000 images belonging to 2 classes.
```

In [9]:

```
# Max number of steps that these generator will have opportunity to process their source
content
# len(train_generator) should be 'no. of available train images / BATCH_SIZE_TRAINING'
# len(valid_generator) should be 'no. of available train images / BATCH_SIZE_VALIDATION'
(BATCH_SIZE_TRAINING, len(train_generator), BATCH_SIZE_VALIDATION, len(validation_generat
or))
```

Out[9]:

```
(100, 200, 100, 50)
```

Train Our Model With Cats & Dogs Train (splitted) Data Set

In [10]:

```
# Early stopping & checkpointing the best model in ../working dir & restoring that as our
model for prediction
from tensorflow.python.keras.callbacks import EarlyStopping, ModelCheckpoint

cb_early_stopper = EarlyStopping(monitor = 'val_loss', patience = EARLY_STOP_PATIENCE)
cb_checkpointer = ModelCheckpoint(filepath = '../working/best.hdf5', monitor = 'val_loss
', save_best_only = True, mode = 'auto')
```

In [11]:

```
# Grid Search is an ideal candidate for distributed machine learning
# Pseudo code for hyperparameters Grid Search

'''
from sklearn.grid_search import ParameterGrid
param_grid = {'epochs': [5, 10, 15], 'steps_per_epoch' : [10, 20, 50]}

grid = ParameterGrid(param_grid)

# Accumulate history of all permutations (may be for viewing trend) and keep watching for
lowest val_loss as final model
for params in grid:
    print(params)
'''
```

Out[11]:

```
"\nfrom sklearn.grid_search import ParameterGrid\nparam_grid = {'epochs': [5, 10, 15], 's
teps_per_epoch' : [10, 20, 50]}\n\ngrid = ParameterGrid(param_grid)\n\n# Accumulate histo
ry of all permutations (may be for viewing trend) and keep watching for lowest val_loss a
s final model\nfor params in grid:\n    print(params)\n"
```

s final model\nfor params in grid:\n   print(params)\n

In [12]:

```
fit_history = model.fit_generator(
        train_generator,
        steps_per_epoch=STEPS_PER_EPOCH_TRAINING,
        epochs = NUM_EPOCHS,
        validation_data=validation_generator,
        validation_steps=STEPS_PER_EPOCH_VALIDATION,
        callbacks=[cb_checkpointer, cb_early_stopper]
)
model.load_weights("../working/best.hdf5")
```

```
Epoch 1/10
10/10 [==============================] - 23s 2s/step - loss: 0.3993 - acc: 0.8090 - val_l
oss: 0.0592 - val_acc: 0.9770
Epoch 2/10
10/10 [==============================] - 14s 1s/step - loss: 0.0885 - acc: 0.9670 - val_l
oss: 0.0729 - val_acc: 0.9750
Epoch 3/10
10/10 [==============================] - 14s 1s/step - loss: 0.0904 - acc: 0.9640 - val_l
oss: 0.0699 - val_acc: 0.9790
Epoch 4/10
10/10 [==============================] - 14s 1s/step - loss: 0.0621 - acc: 0.9760 - val_l
oss: 0.0577 - val_acc: 0.9830
Epoch 5/10
10/10 [==============================] - 12s 1s/step - loss: 0.0580 - acc: 0.9770 - val_l
oss: 0.0276 - val_acc: 0.9920
Epoch 6/10
10/10 [==============================] - 8s 825ms/step - loss: 0.0599 - acc: 0.9770 - val
_loss: 0.0533 - val_acc: 0.9770
Epoch 7/10
10/10 [==============================] - 11s 1s/step - loss: 0.0834 - acc: 0.9770 - val_l
oss: 0.0262 - val_acc: 0.9920
Epoch 8/10
10/10 [==============================] - 12s 1s/step - loss: 0.0712 - acc: 0.9770 - val_l
oss: 0.0500 - val_acc: 0.9840
Epoch 9/10
10/10 [==============================] - 11s 1s/step - loss: 0.0503 - acc: 0.9810 - val_l
oss: 0.0390 - val_acc: 0.9890
Epoch 10/10
10/10 [==============================] - 11s 1s/step - loss: 0.0559 - acc: 0.9780 - val_l
oss: 0.0423 - val_acc: 0.9880
```

Training Metrics

One of the default callbacks that is registered when training all deep learning models is the History callback. It records training metrics (training accuracy, training loss, validation loss & validation accuracy) for each epoch. Note that training accuracy & loss during epoch steps are somewhat incomplete information and they are not recorded in history.

Observe that training uses early stopping, hence metrics is available for epochs run, not for NUM_EPOCHS.

In [13]:

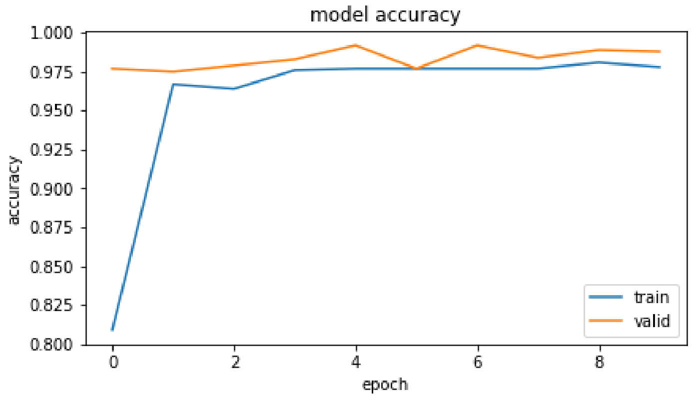
```
print(fit_history.history.keys())
```

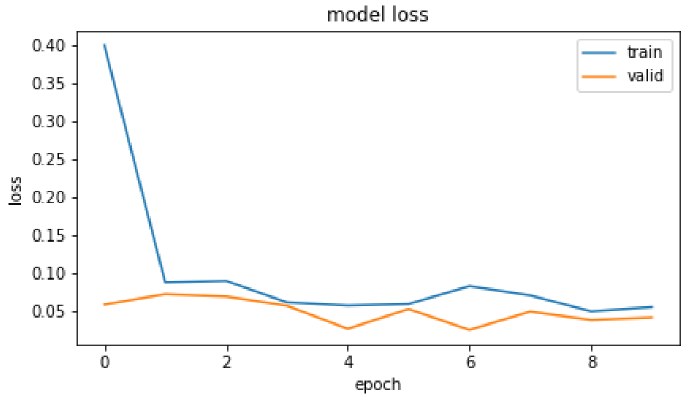
```
dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
```

In [14]:

```
plt.figure(1, figsize = (15,8))

plt.subplot(221)
plt.plot(fit_history.history['acc'])
plt.plot(fit_history.history['val_acc'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
```

```
plt.legend(['train', 'valid'])

plt.subplot(222)
plt.plot(fit_history.history['loss'])
plt.plot(fit_history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'valid'])

plt.show()
```





In [15]:

```
# NOTE that flow_from_directory treats each sub-folder as a class which works fine for tr
aining data
# Actually class_mode=None is a kind of workaround for test data which too must be kept i
n a subfolder

# batch_size can be 1 or any factor of test dataset size to ensure that test dataset is s
amples just once, i.e., no data is left out
test_generator = data_generator.flow_from_directory(
    directory = '../input/test-files-prepd/test4keras/test4keras',
    target_size = (image_size, image_size),
    batch_size = BATCH_SIZE_TESTING,
    class_mode = None,
    shuffle = False,
    seed = 123
)

# Try batch size of 1+ in test_generator & check batch_index & filenames in resulting bat
ches
'''
for i in test_generator:
    #print(test_generator.batch_index, test_generator.batch_size)
    idx = (test_generator.batch_index - 1) * test_generator.batch_size
    print(test_generator.filenames[idx : idx + test_generator.batch_size])
'''
```

```
Found 12500 images belonging to 1 classes.
```

Out[15]:

```
'\nfor i in test_generator:\n    #print(test_generator.batch_index, test_generator.batch_
size)\n    idx = (test_generator.batch_index - 1) * test_generator.batch_size\n    print(
test_generator.filenames[idx : idx + test_generator.batch_size])\n'
```

In [16]:

```
# Reset before each call to predict
test_generator.reset()

pred = model.predict_generator(test_generator, steps = len(test_generator), verbose = 1)

predicted_class_indices = np.argmax(pred, axis = 1)
```

```
12500/12500 [==============================] - 155s 12ms/step
```

In [17]:

```
TEST_DIR = '../input/test-files-prepd/test4keras/test4keras/'
f, ax = plt.subplots(5, 5, figsize = (15, 15))

for i in range(0,25):
    imgBGR = cv2.imread(TEST_DIR + test_generator.filenames[i])
    imgRGB = cv2.cvtColor(imgBGR, cv2.COLOR_BGR2RGB)

    # a if condition else b
    predicted_class = "Dog" if predicted_class_indices[i] else "Cat"

    ax[i//5, i%5].imshow(imgRGB)
    ax[i//5, i%5].axis('off')
    ax[i//5, i%5].set_title("Predicted:{}".format(predicted_class))

plt.show()
```

In [18]:

```
results_df = pd.DataFrame(
    {
        'id': pd.Series(test_generator.filenames),
        'label': pd.Series(predicted_class_indices)
    })
```

```
results_df['id'] = results_df.id.str.extract('(\d+)')
results_df['id'] = pd.to_numeric(results_df['id'], errors = 'coerce')
results_df.sort_values(by='id', inplace = True)

results_df.to_csv('submission.csv', index=False)
results_df.head()
```

Out[18]:

	id	label
0	1	1
3612	2	1
4723	3	1
5834	4	1
6945	5	0