In [1]:
```
#importing the libararies required
from keras.layers import Input, Lambda, Dense, Flatten
from keras.models import Model
from keras.applications.vgg16 import VGG16
from keras.applications.vgg16 import preprocess_input
from keras.preprocessing import image
from keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, CS
VLogger, ReduceLROnPlateau
from keras.models import Sequential
import numpy as np
from glob import glob
import matplotlib.pyplot as plt
```

```
/opt/conda/lib/python3.10/site-packages/scipy/__init__.py:146: UserWar
ning: A NumPy version >=1.16.5 and <1.23.0 is required for this versio
n of SciPy (detected version 1.23.5
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversio
n}"
```

In [2]:
```
IMAGE_SIZE = [224, 224]
```

In [3]:
```
#path of the dataset
train_dir='/kaggle/input/stanford-dogs-dataset/images/Images'
```

In [4]:
```
# adding preprocessing layer to  VGG16
vgg = VGG16(input_shape=IMAGE_SIZE + [3], weights='imagenet', include_top
=False)

# not train existing weights
for layer in vgg.layers:
  layer.trainable = False
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 [==============================] - 2s 0us/step
```

In [5]:
```
folders = glob('/kaggle/input/stanford-dogs-dataset/images/Images/*')
len(folders)
```

Out[5]:
```
120
```

In [6]:
```
x = Flatten()(vgg.output)
#activating dense layers tot he model
prediction = Dense(len(folders), activation='softmax')(x)
```

In [7]:

```
# create a model object
model = Model(inputs=vgg.input, outputs=prediction)

# structure of the model
model.summary()
```

```
Model: "model"
_________________________________________________________________
 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 (Flatten)           (None, 25088)             0

 dense (Dense)               (None, 120)               3010680

=================================================================
Total params: 17,725,368
Trainable params: 3,010,680
Non-trainable params: 14,714,688
_________________________________________________________________
```

In [8]:

```
#compiling the model
model.compile(
  loss='binary_crossentropy',
  optimizer='adam',
  metrics=['accuracy']
)
```

In [9]:

```
from keras.preprocessing.image import ImageDataGenerator
#to rescale the training images
train_datagen = ImageDataGenerator(rescale = 1./255,
                                   shear_range = 0.2,
                                   zoom_range = 0.2,
                                   horizontal_flip = True)
#to rescale the validation images
valid_datagen = ImageDataGenerator(rescale = 1./255,validation_split=0.2)

#to create the training data
training_model = train_datagen.flow_from_directory(
    train_dir,
    target_size= (224, 224),
    color_mode= 'rgb',
    batch_size= 32,
    class_mode= 'categorical',
    subset='training',
    shuffle= True,
    seed= 1337
)
#to create the validating data
validating_model = valid_datagen.flow_from_directory(
    train_dir,
    target_size= (224, 224),
    color_mode= 'rgb',
    batch_size= 32,
    class_mode= 'categorical',
    subset='validation',
    shuffle= True,
    seed= 1337
)
```

```
Found 20580 images belonging to 120 classes.
Found 4072 images belonging to 120 classes.
```

In [10]:
```
print(len(training_model))
print(len(validating_model))
```

```
644
128
```

In [11]:
```
from keras.callbacks import EarlyStopping, ModelCheckpoint

# Checkpoint and monitoring val accuracy
mc = ModelCheckpoint(
    'dog_class_model.h5',
    monitor='val_accuracy',
    mode='max',
    verbose=1,
    save_best_only=True,
)
```

In [12]:

```
#training the model
r = model.fit(
    training_model,
    epochs=100,
    steps_per_epoch=len(training_model),
    validation_data=validating_model,
    validation_steps=len(validating_model),
    verbose = 2,
    callbacks=[mc],
    shuffle = True
)
!mkdir -p saved_model
model.save('saved_model/dog_class_model.h5')
```

```
Epoch 1/100

Epoch 1: val_accuracy improved from -inf to 0.31852, saving model to d
og_class_model.h5
644/644 - 480s - loss: 0.0584 - accuracy: 0.1017 - val_loss: 0.0390 -
val_accuracy: 0.3185 - 480s/epoch - 745ms/step
Epoch 2/100

Epoch 2: val_accuracy improved from 0.31852 to 0.49361, saving model t
o dog_class_model.h5
644/644 - 337s - loss: 0.0427 - accuracy: 0.2758 - val_loss: 0.0303 -
val_accuracy: 0.4936 - 337s/epoch - 523ms/step
Epoch 3/100

Epoch 3: val_accuracy improved from 0.49361 to 0.54715, saving model t
o dog_class_model.h5
644/644 - 328s - loss: 0.0363 - accuracy: 0.3853 - val_loss: 0.0320 -
val_accuracy: 0.5472 - 328s/epoch - 510ms/step
Epoch 4/100

Epoch 4: val_accuracy improved from 0.54715 to 0.62083, saving model t
o dog_class_model.h5
644/644 - 325s - loss: 0.0325 - accuracy: 0.4601 - val_loss: 0.0245 -
val_accuracy: 0.6208 - 325s/epoch - 505ms/step
Epoch 5/100

Epoch 5: val_accuracy improved from 0.62083 to 0.69106, saving model t
o dog_class_model.h5
644/644 - 326s - loss: 0.0276 - accuracy: 0.5371 - val_loss: 0.0205 -
val_accuracy: 0.6911 - 326s/epoch - 507ms/step
Epoch 6/100

Epoch 6: val_accuracy improved from 0.69106 to 0.73551, saving model t
o dog_class_model.h5
644/644 - 326s - loss: 0.0260 - accuracy: 0.5729 - val_loss: 0.0199 -
val_accuracy: 0.7355 - 326s/epoch - 506ms/step
Epoch 7/100

Epoch 7: val_accuracy improved from 0.73551 to 0.78340, saving model t
o dog_class_model.h5
```

```
644/644 - 324s - loss: 0.0242 - accuracy: 0.6237 - val_loss: 0.0168 -
val_accuracy: 0.7834 - 324s/epoch - 503ms/step
Epoch 8/100

Epoch 8: val_accuracy did not improve from 0.78340
644/644 - 329s - loss: 0.0211 - accuracy: 0.6694 - val_loss: 0.0171 -
val_accuracy: 0.7827 - 329s/epoch - 511ms/step
Epoch 9/100

Epoch 9: val_accuracy improved from 0.78340 to 0.81508, saving model t
o dog_class_model.h5
644/644 - 327s - loss: 0.0197 - accuracy: 0.6944 - val_loss: 0.0156 -
val_accuracy: 0.8151 - 327s/epoch - 507ms/step
Epoch 10/100

Epoch 10: val_accuracy improved from 0.81508 to 0.84774, saving model
to dog_class_model.h5
644/644 - 325s - loss: 0.0190 - accuracy: 0.7159 - val_loss: 0.0154 -
val_accuracy: 0.8477 - 325s/epoch - 505ms/step
Epoch 11/100

Epoch 11: val_accuracy improved from 0.84774 to 0.86076, saving model
to dog_class_model.h5
644/644 - 324s - loss: 0.0172 - accuracy: 0.7442 - val_loss: 0.0128 -
val_accuracy: 0.8608 - 324s/epoch - 504ms/step
Epoch 12/100

Epoch 12: val_accuracy improved from 0.86076 to 0.87181, saving model
to dog_class_model.h5
644/644 - 323s - loss: 0.0168 - accuracy: 0.7564 - val_loss: 0.0119 -
val_accuracy: 0.8718 - 323s/epoch - 501ms/step
Epoch 13/100

Epoch 13: val_accuracy improved from 0.87181 to 0.89514, saving model
to dog_class_model.h5
644/644 - 324s - loss: 0.0150 - accuracy: 0.7852 - val_loss: 0.0108 -
val_accuracy: 0.8951 - 324s/epoch - 503ms/step
Epoch 14/100

Epoch 14: val_accuracy did not improve from 0.89514
644/644 - 328s - loss: 0.0144 - accuracy: 0.7948 - val_loss: 0.0117 -
```

```
val_accuracy: 0.8829 - 328s/epoch - 509ms/step
Epoch 15/100

Epoch 15: val_accuracy did not improve from 0.89514
644/644 - 334s - loss: 0.0145 - accuracy: 0.8010 - val_loss: 0.0138 -
val_accuracy: 0.8922 - 334s/epoch - 518ms/step
Epoch 16/100

Epoch 16: val_accuracy did not improve from 0.89514
644/644 - 329s - loss: 0.0148 - accuracy: 0.8075 - val_loss: 0.0115 -
val_accuracy: 0.8892 - 329s/epoch - 511ms/step
Epoch 17/100

Epoch 17: val_accuracy improved from 0.89514 to 0.90570, saving model
to dog_class_model.h5
644/644 - 335s - loss: 0.0130 - accuracy: 0.8290 - val_loss: 0.0117 -
val_accuracy: 0.9057 - 335s/epoch - 520ms/step
Epoch 18/100

Epoch 18: val_accuracy improved from 0.90570 to 0.93811, saving model
to dog_class_model.h5
644/644 - 330s - loss: 0.0124 - accuracy: 0.8322 - val_loss: 0.0078 -
val_accuracy: 0.9381 - 330s/epoch - 513ms/step
Epoch 19/100

Epoch 19: val_accuracy improved from 0.93811 to 0.94769, saving model
to dog_class_model.h5
644/644 - 334s - loss: 0.0117 - accuracy: 0.8513 - val_loss: 0.0081 -
val_accuracy: 0.9477 - 334s/epoch - 519ms/step
Epoch 20/100

Epoch 20: val_accuracy did not improve from 0.94769
644/644 - 336s - loss: 0.0119 - accuracy: 0.8525 - val_loss: 0.0083 -
val_accuracy: 0.9420 - 336s/epoch - 521ms/step
Epoch 21/100

Epoch 21: val_accuracy did not improve from 0.94769
644/644 - 334s - loss: 0.0115 - accuracy: 0.8561 - val_loss: 0.0104 -
val_accuracy: 0.9271 - 334s/epoch - 519ms/step
Epoch 22/100
```

```
Epoch 22: val_accuracy did not improve from 0.94769
644/644 - 335s - loss: 0.0112 - accuracy: 0.8673 - val_loss: 0.0081 -
val_accuracy: 0.9416 - 335s/epoch - 519ms/step
Epoch 23/100

Epoch 23: val_accuracy did not improve from 0.94769
644/644 - 333s - loss: 0.0107 - accuracy: 0.8755 - val_loss: 0.0176 -
val_accuracy: 0.8956 - 333s/epoch - 516ms/step
Epoch 24/100

Epoch 24: val_accuracy improved from 0.94769 to 0.95334, saving model
to dog_class_model.h5
644/644 - 333s - loss: 0.0106 - accuracy: 0.8775 - val_loss: 0.0069 -
val_accuracy: 0.9533 - 333s/epoch - 517ms/step
Epoch 25/100

Epoch 25: val_accuracy did not improve from 0.95334
644/644 - 327s - loss: 0.0096 - accuracy: 0.8892 - val_loss: 0.0096 -
val_accuracy: 0.9344 - 327s/epoch - 507ms/step
Epoch 26/100

Epoch 26: val_accuracy did not improve from 0.95334
644/644 - 331s - loss: 0.0105 - accuracy: 0.8908 - val_loss: 0.0081 -
val_accuracy: 0.9511 - 331s/epoch - 515ms/step
Epoch 27/100

Epoch 27: val_accuracy improved from 0.95334 to 0.96439, saving model
to dog_class_model.h5
644/644 - 331s - loss: 0.0099 - accuracy: 0.8897 - val_loss: 0.0062 -
val_accuracy: 0.9644 - 331s/epoch - 514ms/step
Epoch 28/100

Epoch 28: val_accuracy did not improve from 0.96439
644/644 - 330s - loss: 0.0092 - accuracy: 0.8978 - val_loss: 0.0066 -
val_accuracy: 0.9612 - 330s/epoch - 512ms/step
Epoch 29/100

Epoch 29: val_accuracy did not improve from 0.96439
644/644 - 330s - loss: 0.0091 - accuracy: 0.9037 - val_loss: 0.0076 -
val_accuracy: 0.9617 - 330s/epoch - 512ms/step
Epoch 30/100
```

```
Epoch 30: val_accuracy did not improve from 0.96439
644/644 - 323s - loss: 0.0092 - accuracy: 0.9057 - val_loss: 0.0069 -
val_accuracy: 0.9543 - 323s/epoch - 502ms/step
Epoch 31/100

Epoch 31: val_accuracy improved from 0.96439 to 0.97250, saving model
to dog_class_model.h5
644/644 - 331s - loss: 0.0086 - accuracy: 0.9088 - val_loss: 0.0065 -
val_accuracy: 0.9725 - 331s/epoch - 515ms/step
Epoch 32/100

Epoch 32: val_accuracy improved from 0.97250 to 0.97765, saving model
to dog_class_model.h5
644/644 - 325s - loss: 0.0086 - accuracy: 0.9109 - val_loss: 0.0055 -
val_accuracy: 0.9777 - 325s/epoch - 504ms/step
Epoch 33/100

Epoch 33: val_accuracy did not improve from 0.97765
644/644 - 322s - loss: 0.0088 - accuracy: 0.9094 - val_loss: 0.0076 -
val_accuracy: 0.9612 - 322s/epoch - 501ms/step
Epoch 34/100

Epoch 34: val_accuracy did not improve from 0.97765
644/644 - 324s - loss: 0.0087 - accuracy: 0.9128 - val_loss: 0.0071 -
val_accuracy: 0.9732 - 324s/epoch - 504ms/step
Epoch 35/100

Epoch 35: val_accuracy did not improve from 0.97765
644/644 - 326s - loss: 0.0086 - accuracy: 0.9178 - val_loss: 0.0076 -
val_accuracy: 0.9585 - 326s/epoch - 507ms/step
Epoch 36/100

Epoch 36: val_accuracy did not improve from 0.97765
644/644 - 323s - loss: 0.0080 - accuracy: 0.9236 - val_loss: 0.0072 -
val_accuracy: 0.9629 - 323s/epoch - 501ms/step
Epoch 37/100

Epoch 37: val_accuracy did not improve from 0.97765
644/644 - 328s - loss: 0.0075 - accuracy: 0.9269 - val_loss: 0.0070 -
val_accuracy: 0.9641 - 328s/epoch - 509ms/step
```

```
Epoch 38/100

Epoch 38: val_accuracy did not improve from 0.97765
644/644 - 336s - loss: 0.0076 - accuracy: 0.9296 - val_loss: 0.0054 -
val_accuracy: 0.9764 - 336s/epoch - 522ms/step
Epoch 39/100

Epoch 39: val_accuracy improved from 0.97765 to 0.97814, saving model
to dog_class_model.h5
644/644 - 330s - loss: 0.0079 - accuracy: 0.9269 - val_loss: 0.0057 -
val_accuracy: 0.9781 - 330s/epoch - 512ms/step
Epoch 40/100

Epoch 40: val_accuracy improved from 0.97814 to 0.97888, saving model
to dog_class_model.h5
644/644 - 336s - loss: 0.0078 - accuracy: 0.9289 - val_loss: 0.0066 -
val_accuracy: 0.9789 - 336s/epoch - 523ms/step
Epoch 41/100

Epoch 41: val_accuracy improved from 0.97888 to 0.98011, saving model
to dog_class_model.h5
644/644 - 336s - loss: 0.0071 - accuracy: 0.9354 - val_loss: 0.0054 -
val_accuracy: 0.9801 - 336s/epoch - 522ms/step
Epoch 42/100

Epoch 42: val_accuracy did not improve from 0.98011
644/644 - 328s - loss: 0.0074 - accuracy: 0.9357 - val_loss: 0.0050 -
val_accuracy: 0.9801 - 328s/epoch - 510ms/step
Epoch 43/100

Epoch 43: val_accuracy improved from 0.98011 to 0.98207, saving model
to dog_class_model.h5
644/644 - 336s - loss: 0.0071 - accuracy: 0.9346 - val_loss: 0.0066 -
val_accuracy: 0.9821 - 336s/epoch - 522ms/step
Epoch 44/100

Epoch 44: val_accuracy did not improve from 0.98207
644/644 - 332s - loss: 0.0068 - accuracy: 0.9419 - val_loss: 0.0052 -
val_accuracy: 0.9774 - 332s/epoch - 516ms/step
Epoch 45/100
```

```
Epoch 45: val_accuracy improved from 0.98207 to 0.98281, saving model
to dog_class_model.h5
644/644 - 330s - loss: 0.0070 - accuracy: 0.9402 - val_loss: 0.0051 -
val_accuracy: 0.9828 - 330s/epoch - 512ms/step
Epoch 46/100

Epoch 46: val_accuracy improved from 0.98281 to 0.98502, saving model
to dog_class_model.h5
644/644 - 329s - loss: 0.0067 - accuracy: 0.9430 - val_loss: 0.0050 -
val_accuracy: 0.9850 - 329s/epoch - 510ms/step
Epoch 47/100

Epoch 47: val_accuracy did not improve from 0.98502
644/644 - 332s - loss: 0.0069 - accuracy: 0.9404 - val_loss: 0.0048 -
val_accuracy: 0.9831 - 332s/epoch - 516ms/step
Epoch 48/100

Epoch 48: val_accuracy did not improve from 0.98502
644/644 - 329s - loss: 0.0062 - accuracy: 0.9469 - val_loss: 0.0059 -
val_accuracy: 0.9715 - 329s/epoch - 511ms/step
Epoch 49/100

Epoch 49: val_accuracy did not improve from 0.98502
644/644 - 342s - loss: 0.0070 - accuracy: 0.9417 - val_loss: 0.0063 -
val_accuracy: 0.9774 - 342s/epoch - 531ms/step
Epoch 50/100

Epoch 50: val_accuracy did not improve from 0.98502
644/644 - 332s - loss: 0.0065 - accuracy: 0.9466 - val_loss: 0.0051 -
val_accuracy: 0.9835 - 332s/epoch - 515ms/step
Epoch 51/100

Epoch 51: val_accuracy did not improve from 0.98502
644/644 - 335s - loss: 0.0065 - accuracy: 0.9452 - val_loss: 0.0049 -
val_accuracy: 0.9845 - 335s/epoch - 520ms/step
Epoch 52/100

Epoch 52: val_accuracy improved from 0.98502 to 0.98674, saving model
to dog_class_model.h5
644/644 - 333s - loss: 0.0065 - accuracy: 0.9504 - val_loss: 0.0055 -
val_accuracy: 0.9867 - 333s/epoch - 517ms/step
```

```
Epoch 53/100

Epoch 53: val_accuracy did not improve from 0.98674
644/644 - 331s - loss: 0.0064 - accuracy: 0.9490 - val_loss: 0.0063 -
val_accuracy: 0.9796 - 331s/epoch - 515ms/step
Epoch 54/100

Epoch 54: val_accuracy did not improve from 0.98674
644/644 - 329s - loss: 0.0063 - accuracy: 0.9501 - val_loss: 0.0058 -
val_accuracy: 0.9867 - 329s/epoch - 510ms/step
Epoch 55/100

Epoch 55: val_accuracy improved from 0.98674 to 0.98969, saving model
to dog_class_model.h5
644/644 - 330s - loss: 0.0060 - accuracy: 0.9527 - val_loss: 0.0043 -
val_accuracy: 0.9897 - 330s/epoch - 512ms/step
Epoch 56/100

Epoch 56: val_accuracy did not improve from 0.98969
644/644 - 329s - loss: 0.0062 - accuracy: 0.9516 - val_loss: 0.0054 -
val_accuracy: 0.9811 - 329s/epoch - 511ms/step
Epoch 57/100

Epoch 57: val_accuracy did not improve from 0.98969
644/644 - 327s - loss: 0.0061 - accuracy: 0.9529 - val_loss: 0.0060 -
val_accuracy: 0.9850 - 327s/epoch - 508ms/step
Epoch 58/100

Epoch 58: val_accuracy did not improve from 0.98969
644/644 - 327s - loss: 0.0066 - accuracy: 0.9529 - val_loss: 0.0058 -
val_accuracy: 0.9804 - 327s/epoch - 508ms/step
Epoch 59/100

Epoch 59: val_accuracy did not improve from 0.98969
644/644 - 325s - loss: 0.0059 - accuracy: 0.9571 - val_loss: 0.0069 -
val_accuracy: 0.9745 - 325s/epoch - 505ms/step
Epoch 60/100

Epoch 60: val_accuracy did not improve from 0.98969
644/644 - 325s - loss: 0.0057 - accuracy: 0.9580 - val_loss: 0.0048 -
val_accuracy: 0.9838 - 325s/epoch - 505ms/step
```

```
Epoch 61/100

Epoch 61: val_accuracy did not improve from 0.98969
644/644 - 325s - loss: 0.0056 - accuracy: 0.9573 - val_loss: 0.0045 -
val_accuracy: 0.9885 - 325s/epoch - 505ms/step
Epoch 62/100

Epoch 62: val_accuracy did not improve from 0.98969
644/644 - 320s - loss: 0.0059 - accuracy: 0.9585 - val_loss: 0.0058 -
val_accuracy: 0.9823 - 320s/epoch - 498ms/step
Epoch 63/100

Epoch 63: val_accuracy did not improve from 0.98969
644/644 - 323s - loss: 0.0056 - accuracy: 0.9598 - val_loss: 0.0048 -
val_accuracy: 0.9889 - 323s/epoch - 501ms/step
Epoch 64/100

Epoch 64: val_accuracy did not improve from 0.98969
644/644 - 321s - loss: 0.0057 - accuracy: 0.9584 - val_loss: 0.0054 -
val_accuracy: 0.9880 - 321s/epoch - 498ms/step
Epoch 65/100

Epoch 65: val_accuracy did not improve from 0.98969
644/644 - 322s - loss: 0.0056 - accuracy: 0.9583 - val_loss: 0.0042 -
val_accuracy: 0.9885 - 322s/epoch - 500ms/step
Epoch 66/100

Epoch 66: val_accuracy did not improve from 0.98969
644/644 - 314s - loss: 0.0057 - accuracy: 0.9623 - val_loss: 0.0064 -
val_accuracy: 0.9892 - 314s/epoch - 488ms/step
Epoch 67/100

Epoch 67: val_accuracy did not improve from 0.98969
644/644 - 318s - loss: 0.0052 - accuracy: 0.9648 - val_loss: 0.0050 -
val_accuracy: 0.9882 - 318s/epoch - 494ms/step
Epoch 68/100

Epoch 68: val_accuracy did not improve from 0.98969
644/644 - 319s - loss: 0.0060 - accuracy: 0.9569 - val_loss: 0.0049 -
val_accuracy: 0.9875 - 319s/epoch - 495ms/step
Epoch 69/100
```

```
Epoch 69: val_accuracy did not improve from 0.98969
644/644 - 319s - loss: 0.0052 - accuracy: 0.9642 - val_loss: 0.0054 -
val_accuracy: 0.9882 - 319s/epoch - 495ms/step
Epoch 70/100

Epoch 70: val_accuracy did not improve from 0.98969
644/644 - 319s - loss: 0.0055 - accuracy: 0.9638 - val_loss: 0.0045 -
val_accuracy: 0.9894 - 319s/epoch - 495ms/step
Epoch 71/100

Epoch 71: val_accuracy did not improve from 0.98969
644/644 - 322s - loss: 0.0050 - accuracy: 0.9683 - val_loss: 0.0050 -
val_accuracy: 0.9862 - 322s/epoch - 501ms/step
Epoch 72/100

Epoch 72: val_accuracy improved from 0.98969 to 0.99312, saving model
to dog_class_model.h5
644/644 - 321s - loss: 0.0052 - accuracy: 0.9630 - val_loss: 0.0058 -
val_accuracy: 0.9931 - 321s/epoch - 498ms/step
Epoch 73/100

Epoch 73: val_accuracy did not improve from 0.99312
644/644 - 321s - loss: 0.0054 - accuracy: 0.9626 - val_loss: 0.0049 -
val_accuracy: 0.9904 - 321s/epoch - 498ms/step
Epoch 74/100

Epoch 74: val_accuracy did not improve from 0.99312
644/644 - 321s - loss: 0.0050 - accuracy: 0.9660 - val_loss: 0.0042 -
val_accuracy: 0.9919 - 321s/epoch - 498ms/step
Epoch 75/100

Epoch 75: val_accuracy did not improve from 0.99312
644/644 - 325s - loss: 0.0048 - accuracy: 0.9679 - val_loss: 0.0045 -
val_accuracy: 0.9921 - 325s/epoch - 504ms/step
Epoch 76/100

Epoch 76: val_accuracy did not improve from 0.99312
644/644 - 322s - loss: 0.0052 - accuracy: 0.9668 - val_loss: 0.0043 -
val_accuracy: 0.9889 - 322s/epoch - 500ms/step
Epoch 77/100
```

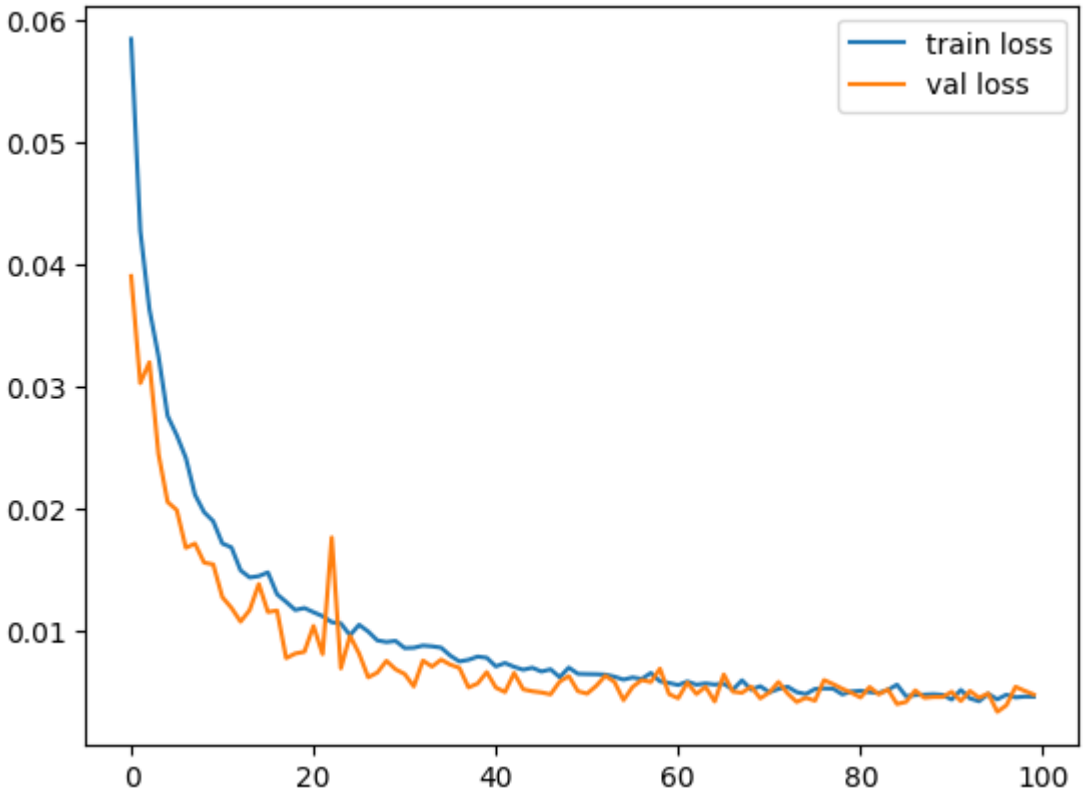
```
Epoch 77: val_accuracy did not improve from 0.99312
644/644 - 322s - loss: 0.0053 - accuracy: 0.9661 - val_loss: 0.0060 -
val_accuracy: 0.9818 - 322s/epoch - 500ms/step
Epoch 78/100

Epoch 78: val_accuracy did not improve from 0.99312
644/644 - 319s - loss: 0.0053 - accuracy: 0.9669 - val_loss: 0.0056 -
val_accuracy: 0.9872 - 319s/epoch - 495ms/step
Epoch 79/100

Epoch 79: val_accuracy did not improve from 0.99312
644/644 - 321s - loss: 0.0048 - accuracy: 0.9683 - val_loss: 0.0053 -
val_accuracy: 0.9907 - 321s/epoch - 498ms/step
Epoch 80/100

Epoch 80: val_accuracy did not improve from 0.99312
644/644 - 322s - loss: 0.0050 - accuracy: 0.9683 - val_loss: 0.0049 -
val_accuracy: 0.9887 - 322s/epoch - 501ms/step
Epoch 81/100

Epoch 81: val_accuracy did not improve from 0.99312
644/644 - 321s - loss: 0.0051 - accuracy: 0.9675 - val_loss: 0.0046 -
val_accuracy: 0.9921 - 321s/epoch - 498ms/step
Epoch 82/100

Epoch 82: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0050 - accuracy: 0.9690 - val_loss: 0.0054 -
val_accuracy: 0.9862 - 318s/epoch - 494ms/step
Epoch 83/100

Epoch 83: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0049 - accuracy: 0.9696 - val_loss: 0.0048 -
val_accuracy: 0.9907 - 318s/epoch - 494ms/step
Epoch 84/100

Epoch 84: val_accuracy did not improve from 0.99312
644/644 - 319s - loss: 0.0052 - accuracy: 0.9669 - val_loss: 0.0052 -
val_accuracy: 0.9924 - 319s/epoch - 496ms/step
Epoch 85/100
```

```
Epoch 85: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0056 - accuracy: 0.9663 - val_loss: 0.0040 -
val_accuracy: 0.9921 - 318s/epoch - 493ms/step
Epoch 86/100

Epoch 86: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0046 - accuracy: 0.9706 - val_loss: 0.0042 -
val_accuracy: 0.9914 - 318s/epoch - 495ms/step
Epoch 87/100

Epoch 87: val_accuracy did not improve from 0.99312
644/644 - 320s - loss: 0.0048 - accuracy: 0.9698 - val_loss: 0.0051 -
val_accuracy: 0.9904 - 320s/epoch - 496ms/step
Epoch 88/100

Epoch 88: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0048 - accuracy: 0.9718 - val_loss: 0.0045 -
val_accuracy: 0.9899 - 318s/epoch - 494ms/step
Epoch 89/100

Epoch 89: val_accuracy did not improve from 0.99312
644/644 - 318s - loss: 0.0048 - accuracy: 0.9717 - val_loss: 0.0046 -
val_accuracy: 0.9912 - 318s/epoch - 493ms/step
Epoch 90/100

Epoch 90: val_accuracy did not improve from 0.99312
644/644 - 315s - loss: 0.0048 - accuracy: 0.9712 - val_loss: 0.0046 -
val_accuracy: 0.9926 - 315s/epoch - 490ms/step
Epoch 91/100

Epoch 91: val_accuracy improved from 0.99312 to 0.99386, saving model
to dog_class_model.h5
644/644 - 327s - loss: 0.0044 - accuracy: 0.9761 - val_loss: 0.0050 -
val_accuracy: 0.9939 - 327s/epoch - 507ms/step
Epoch 92/100

Epoch 92: val_accuracy did not improve from 0.99386
644/644 - 320s - loss: 0.0052 - accuracy: 0.9693 - val_loss: 0.0043 -
val_accuracy: 0.9917 - 320s/epoch - 497ms/step
Epoch 93/100
```

```
Epoch 93: val_accuracy did not improve from 0.99386
644/644 - 321s - loss: 0.0045 - accuracy: 0.9729 - val_loss: 0.0051 -
val_accuracy: 0.9914 - 321s/epoch - 498ms/step
Epoch 94/100

Epoch 94: val_accuracy did not improve from 0.99386
644/644 - 318s - loss: 0.0042 - accuracy: 0.9768 - val_loss: 0.0045 -
val_accuracy: 0.9934 - 318s/epoch - 495ms/step
Epoch 95/100

Epoch 95: val_accuracy did not improve from 0.99386
644/644 - 317s - loss: 0.0048 - accuracy: 0.9727 - val_loss: 0.0049 -
val_accuracy: 0.9934 - 317s/epoch - 493ms/step
Epoch 96/100

Epoch 96: val_accuracy did not improve from 0.99386
644/644 - 317s - loss: 0.0044 - accuracy: 0.9737 - val_loss: 0.0034 -
val_accuracy: 0.9926 - 317s/epoch - 492ms/step
Epoch 97/100

Epoch 97: val_accuracy did not improve from 0.99386
644/644 - 316s - loss: 0.0048 - accuracy: 0.9709 - val_loss: 0.0039 -
val_accuracy: 0.9934 - 316s/epoch - 491ms/step
Epoch 98/100

Epoch 98: val_accuracy did not improve from 0.99386
644/644 - 316s - loss: 0.0046 - accuracy: 0.9745 - val_loss: 0.0054 -
val_accuracy: 0.9919 - 316s/epoch - 491ms/step
Epoch 99/100

Epoch 99: val_accuracy did not improve from 0.99386
644/644 - 314s - loss: 0.0046 - accuracy: 0.9739 - val_loss: 0.0051 -
val_accuracy: 0.9880 - 314s/epoch - 488ms/step
Epoch 100/100

Epoch 100: val_accuracy did not improve from 0.99386
644/644 - 324s - loss: 0.0046 - accuracy: 0.9753 - val_loss: 0.0048 -
val_accuracy: 0.9912 - 324s/epoch - 503ms/step
```

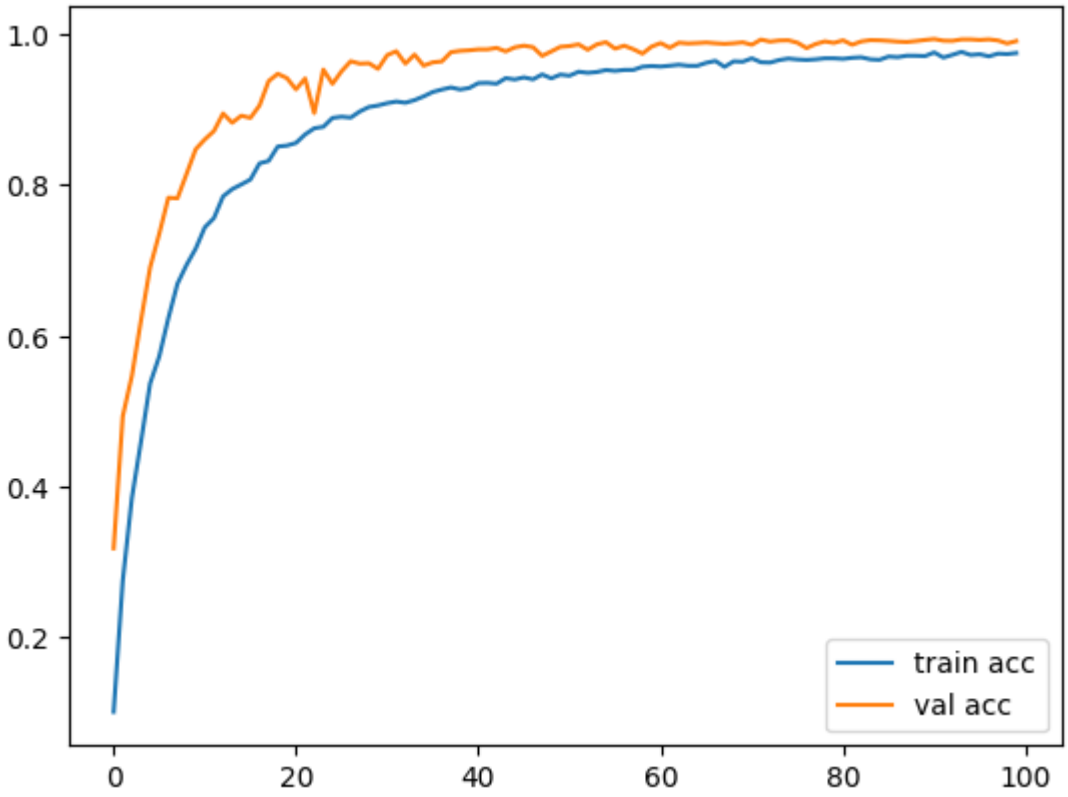
In [13]:

```
# plotting loss occured
plt.plot(r.history['loss'], label='train loss')
plt.plot(r.history['val_loss'], label='val loss')
plt.legend()
plt.show()
```



In [14]:

```
# plotting the accuracy
plt.plot(r.history['accuracy'], label='train acc')
plt.plot(r.history['val_accuracy'], label='val acc')
plt.legend()
plt.show()
```



In [15]:

```
from keras.models import load_model
#loading the model and to check the structure
model1 = load_model('./dog_class_model.h5',compile=False)
model1.summary()
```

```
Model: "model"
_________________________________________________________________
 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 (Flatten)           (None, 25088)             0

 dense (Dense)               (None, 120)               3010680

=================================================================
Total params: 17,725,368
Trainable params: 3,010,680
Non-trainable params: 14,714,688
_________________________________________________________________
```