TASK目标：本次任务的目的是实践迁移学习算法，这是一个非常有用的DL技巧。

具体到本次学习，任务如下：

（1）请首先学习样本代码文档；

（2）查阅Keras文档，其中还有很多经典 DL 模型，请随意挑选一个，并迁移至猫狗大战问题上，看看精度如何？

（3）请详细注释程序代码，以确认你是否真的理解。加油！

迁移学习：站在牛人的肩膀上

学习DL的困难

> 经典网络太多了：
> LeNet，AlexNet，VGG16，Inception.V1+V2+V3，ResNet+ResNext，DenseNet，MobileNet
>
> 计算太昂贵：（1）硬件，CPU+GPU+TPU；（2）数据：ImageNet
>
> 有没有讨巧的方案：站在牛人的肩膀上？

数据生成器：Validation

In [1]:

```
from keras.applications.inception_v3 import preprocess_input
from keras.preprocessing.image import ImageDataGenerator   # 图片预处理

IMSIZE=299   # 图片像素

validation_generator = ImageDataGenerator(
    preprocessing_function=preprocess_input).flow_from_directory(
    './data/CatDog/validation', # 数据路径
    target_size=(IMSIZE, IMSIZE), # 数据像素（目标大小）
    batch_size=100,           # 批处理大小
    class_mode='categorical')   # 生成验证数据集
```

```
Using TensorFlow backend.
Found 10000 images belonging to 2 classes.
```

数据生成器：Train

In [2]:

```
train_generator = ImageDataGenerator(
    preprocessing_function=preprocess_input,  # 数据预处理
    shear_range=0.5,  # 一定角度下的斜方向拉伸强度不超过0.5
    rotation_range=30,  # 图片右旋转不超过30°
    zoom_range=0.2,    # 定义放大或缩小比例不超多0.2
    width_shift_range=0.2,  # 水平方向上平移不超过0.2的宽度
    height_shift_range=0.2,  # 垂直方向的平移不超过0.2的高度
    horizontal_flip=True).flow_from_directory( # 允许水平和竖直方向的翻转
    './data/CatDog/train',  # 数据路径
    target_size=(IMSIZE, IMSIZE), # 数据像素（目标大小）
    batch_size=150,              # 批处理大小
    class_mode='categorical')     # 生成训练数据集
```

Found 15000 images belonging to 2 classes.

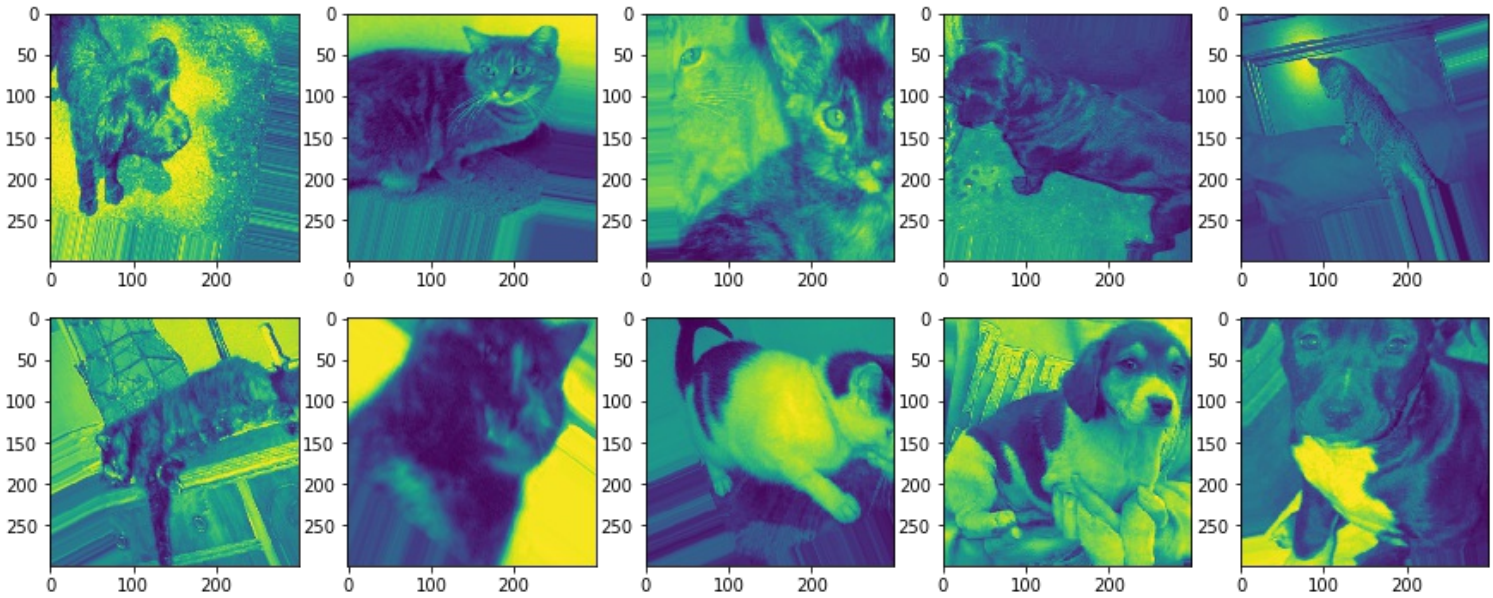
数据展示

In [3]:

```
from matplotlib import pyplot as plt  # 导入画板

plt.figure()  # 创建画板
fig,ax = plt.subplots(2,5)  # 将面板切分成2行5列
fig.set_figheight(6)  # 高为6
fig.set_figwidth(15)  # 宽为15
ax=ax.flatten()      # 拉直
X,Y=next(train_generator)  # 分批吐出数据
for i in range(10): ax[i].imshow(X[i,:,:,0])  # 展示
```

<Figure size 432x288 with 0 Axes>



迁移学习模型

首先执行下面的代码，将模型文件复制到本地的~/.keras/models 目录中，这样可以避免直接从github中下载模型，速度过慢

In [4]:

```
!mkdir -p ~/.keras/models
!cp /clubear/models/inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5 ~/.keras/models
```

In [5]:

```
from keras.applications.inception_v3 import InceptionV3  # 迁移学习
from keras.layers import GlobalAveragePooling2D, Dense, Activation  # 导入各种层函数
from keras import Model  # 模型

base_model = InceptionV3(weights='imagenet', include_top=False) # 基础模型，放弃所有顶层输出的神经元
x = base_model.output       # 嫁接，输出赋值
x = GlobalAveragePooling2D()(x)  # 将每个通道矩阵变为单一数值，全连接输出层向量
predictions = Dense(2,activation='softmax')(x)  # 2个节点的全连接层
model=Model(inputs=base_model.input, outputs=predictions) # 指定模型输入和输出
for layer in base_model.layers:
    layer.trainable = False        # 权重继承
model.summary()    # 模型结构
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            (None, None, None, 3 0
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, None, None, 3 864         input_1[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, None, None, 3 96          conv2d_1[0][0]
__________________________________________________________________________________________________
activation_1 (Activation)       (None, None, None, 3 0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, None, None, 3 9216        activation_1[0][0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, None, None, 3 96          conv2d_2[0][0]
__________________________________________________________________________________________________
activation_2 (Activation)       (None, None, None, 3 0           batch_normalization_2[0][0]
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, None, None, 6 18432       activation_2[0][0]
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, None, None, 6 192         conv2d_3[0][0]
__________________________________________________________________________________________________
activation_3 (Activation)       (None, None, None, 6 0           batch_normalization_3[0][0]
__________________________________________________________________________________________________
max_pooling2d_1 (MaxPooling2D)  (None, None, None, 6 0           activation_3[0][0]
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, None, None, 8 5120        max_pooling2d_1[0][0]
__________________________________________________________________________________________________
batch_normalization_4 (BatchNor (None, None, None, 8 240         conv2d_4[0][0]
__________________________________________________________________________________________________
activation_4 (Activation)       (None, None, None, 8 0           batch_normalization_4[0][0]
```

conv2d_5 (Conv2D) (None, None, None, 1 138240 activation_4[0][0]

batch_normalization_5 (BatchNor (None, None, None, 1 576 conv2d_5[0][0]

activation_5 (Activation) (None, None, None, 1 0 batch_normalization_5[0][0]

max_pooling2d_2 (MaxPooling2D) (None, None, None, 1 0 activation_5[0][0]

conv2d_9 (Conv2D) (None, None, None, 6 12288 max_pooling2d_2[0][0]

batch_normalization_9 (BatchNor (None, None, None, 6 192 conv2d_9[0][0]

activation_9 (Activation) (None, None, None, 6 0 batch_normalization_9[0][0]

conv2d_7 (Conv2D) (None, None, None, 4 9216 max_pooling2d_2[0][0]

conv2d_10 (Conv2D) (None, None, None, 9 55296 activation_9[0][0]

batch_normalization_7 (BatchNor (None, None, None, 4 144 conv2d_7[0][0]

batch_normalization_10 (BatchNo (None, None, None, 9 288 conv2d_10[0][0]

activation_7 (Activation) (None, None, None, 4 0 batch_normalization_7[0][0]

activation_10 (Activation) (None, None, None, 9 0 batch_normalization_10[0][0]

average_pooling2d_1 (AveragePoo (None, None, None, 1 0 max_pooling2d_2[0][0]

conv2d_6 (Conv2D) (None, None, None, 6 12288 max_pooling2d_2[0][0]

conv2d_8 (Conv2D) (None, None, None, 6 76800 activation_7[0][0]

conv2d_11 (Conv2D) (None, None, None, 9 82944 activation_10[0][0]

conv2d_12 (Conv2D) (None, None, None, 3 6144 average_pooling2d_1[0][0]

batch_normalization_6 (BatchNor (None, None, None, 6 192 conv2d_6[0][0]

batch_normalization_8 (BatchNor (None, None, None, 6 192 conv2d_8[0][0]

batch_normalization_11 (BatchNo (None, None, None, 9 288 conv2d_11[0][0]

batch_normalization_12 (BatchNo (None, None, None, 3 96 conv2d_12[0][0]

activation_6 (Activation) (None, None, None, 6 0 batch_normalization_6[0][0]

activation_8 (Activation) (None, None, None, 6 0 batch_normalization_8[0][0]

activation_11 (Activation) (None, None, None, 9 0 batch_normalization_11[0][0]

activation_12 (Activation) (None, None, None, 3 0 batch_normalization_12[0][0]

mixed0 (Concatenate) (None, None, None, 2 0 activation_6[0][0]
activation_8[0][0]
activation_11[0][0]
activation_12[0][0]

conv2d_16 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

batch_normalization_16 (BatchNo (None, None, None, 6 192 conv2d_16[0][0]

activation_16 (Activation) (None, None, None, 6 0 batch_normalization_16[0][0]

conv2d_14 (Conv2D) (None, None, None, 4 12288 mixed0[0][0]

conv2d_17 (Conv2D) (None, None, None, 9 55296 activation_16[0][0]

batch_normalization_14 (BatchNo (None, None, None, 4 144 conv2d_14[0][0]

batch_normalization_17 (BatchNo (None, None, None, 9 288 conv2d_17[0][0]

activation_14 (Activation) (None, None, None, 4 0 batch_normalization_14[0][0]

activation_17 (Activation) (None, None, None, 9 0 batch_normalization_17[0][0]

average_pooling2d_2 (AveragePoo (None, None, None, 2 0 mixed0[0][0]

conv2d_13 (Conv2D) (None, None, None, 6 16384 mixed0[0][0]

conv2d_15 (Conv2D) (None, None, None, 6 76800 activation_14[0][0]

conv2d_18 (Conv2D) (None, None, None, 9 82944 activation_17[0][0]

conv2d_19 (Conv2D)	(None, None, None, 6	16384	average_pooling2d_2[0][0]
batch_normalization_13 (BatchNo	(None, None, None, 6	192	conv2d_13[0][0]
batch_normalization_15 (BatchNo	(None, None, None, 6	192	conv2d_15[0][0]
batch_normalization_18 (BatchNo	(None, None, None, 9	288	conv2d_18[0][0]
batch_normalization_19 (BatchNo	(None, None, None, 6	192	conv2d_19[0][0]
activation_13 (Activation)	(None, None, None, 6	0	batch_normalization_13[0][0]
activation_15 (Activation)	(None, None, None, 6	0	batch_normalization_15[0][0]
activation_18 (Activation)	(None, None, None, 9	0	batch_normalization_18[0][0]
activation_19 (Activation)	(None, None, None, 6	0	batch_normalization_19[0][0]
mixed1 (Concatenate)	(None, None, None, 2	0	activation_13[0][0] activation_15[0][0] activation_18[0][0] activation_19[0][0]
conv2d_23 (Conv2D)	(None, None, None, 6	18432	mixed1[0][0]
batch_normalization_23 (BatchNo	(None, None, None, 6	192	conv2d_23[0][0]
activation_23 (Activation)	(None, None, None, 6	0	batch_normalization_23[0][0]
conv2d_21 (Conv2D)	(None, None, None, 4	13824	mixed1[0][0]
conv2d_24 (Conv2D)	(None, None, None, 9	55296	activation_23[0][0]
batch_normalization_21 (BatchNo	(None, None, None, 4	144	conv2d_21[0][0]
batch_normalization_24 (BatchNo	(None, None, None, 9	288	conv2d_24[0][0]
activation_21 (Activation)	(None, None, None, 4	0	batch_normalization_21[0][0]
activation_24 (Activation)	(None, None, None, 9	0	batch_normalization_24[0][0]
average_pooling2d_3 (AveragePoo	(None, None, None, 2	0	mixed1[0][0]

conv2d_20 (Conv2D)	(None, None, None, 6	18432	mixed1[0][0]
conv2d_22 (Conv2D)	(None, None, None, 6	76800	activation_21[0][0]
conv2d_25 (Conv2D)	(None, None, None, 9	82944	activation_24[0][0]
conv2d_26 (Conv2D)	(None, None, None, 6	18432	average_pooling2d_3[0][0]
batch_normalization_20 (BatchNo	(None, None, None, 6	192	conv2d_20[0][0]
batch_normalization_22 (BatchNo	(None, None, None, 6	192	conv2d_22[0][0]
batch_normalization_25 (BatchNo	(None, None, None, 9	288	conv2d_25[0][0]
batch_normalization_26 (BatchNo	(None, None, None, 6	192	conv2d_26[0][0]
activation_20 (Activation)	(None, None, None, 6	0	batch_normalization_20[0][0]
activation_22 (Activation)	(None, None, None, 6	0	batch_normalization_22[0][0]
activation_25 (Activation)	(None, None, None, 9	0	batch_normalization_25[0][0]
activation_26 (Activation)	(None, None, None, 6	0	batch_normalization_26[0][0]
mixed2 (Concatenate)	(None, None, None, 2	0	activation_20[0][0] activation_22[0][0] activation_25[0][0] activation_26[0][0]
conv2d_28 (Conv2D)	(None, None, None, 6	18432	mixed2[0][0]
batch_normalization_28 (BatchNo	(None, None, None, 6	192	conv2d_28[0][0]
activation_28 (Activation)	(None, None, None, 6	0	batch_normalization_28[0][0]
conv2d_29 (Conv2D)	(None, None, None, 9	55296	activation_28[0][0]
batch_normalization_29 (BatchNo	(None, None, None, 9	288	conv2d_29[0][0]
activation_29 (Activation)	(None, None, None, 9	0	batch_normalization_29[0][0]

conv2d_27 (Conv2D) (None, None, None, 3 995328 mixed2[0][0]

conv2d_30 (Conv2D) (None, None, None, 9 82944 activation_29[0][0]

batch_normalization_27 (BatchNo (None, None, None, 3 1152 conv2d_27[0][0]

batch_normalization_30 (BatchNo (None, None, None, 9 288 conv2d_30[0][0]

activation_27 (Activation) (None, None, None, 3 0 batch_normalization_27[0][0]

activation_30 (Activation) (None, None, None, 9 0 batch_normalization_30[0][0]

max_pooling2d_3 (MaxPooling2D) (None, None, None, 2 0 mixed2[0][0]

mixed3 (Concatenate) (None, None, None, 7 0 activation_27[0][0]
activation_30[0][0]
max_pooling2d_3[0][0]

conv2d_35 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

batch_normalization_35 (BatchNo (None, None, None, 1 384 conv2d_35[0][0]

activation_35 (Activation) (None, None, None, 1 0 batch_normalization_35[0][0]

conv2d_36 (Conv2D) (None, None, None, 1 114688 activation_35[0][0]

batch_normalization_36 (BatchNo (None, None, None, 1 384 conv2d_36[0][0]

activation_36 (Activation) (None, None, None, 1 0 batch_normalization_36[0][0]

conv2d_32 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

conv2d_37 (Conv2D) (None, None, None, 1 114688 activation_36[0][0]

batch_normalization_32 (BatchNo (None, None, None, 1 384 conv2d_32[0][0]

batch_normalization_37 (BatchNo (None, None, None, 1 384 conv2d_37[0][0]

activation_32 (Activation) (None, None, None, 1 0 batch_normalization_32[0][0]

activation_37 (Activation) (None, None, None, 1 0 batch_normalization_37[0][0]

conv2d_33 (Conv2D) (None, None, None, 1 114688 activation_32[0][0]

conv2d_38 (Conv2D) (None, None, None, 1 114688 activation_37[0][0]

batch_normalization_33 (BatchNo (None, None, None, 1 384 conv2d_33[0][0]

batch_normalization_38 (BatchNo (None, None, None, 1 384 conv2d_38[0][0]

activation_33 (Activation) (None, None, None, 1 0 batch_normalization_33[0][0]

activation_38 (Activation) (None, None, None, 1 0 batch_normalization_38[0][0]

average_pooling2d_4 (AveragePoo (None, None, None, 7 0 mixed3[0][0]

conv2d_31 (Conv2D) (None, None, None, 1 147456 mixed3[0][0]

conv2d_34 (Conv2D) (None, None, None, 1 172032 activation_33[0][0]

conv2d_39 (Conv2D) (None, None, None, 1 172032 activation_38[0][0]

conv2d_40 (Conv2D) (None, None, None, 1 147456 average_pooling2d_4[0][0]

batch_normalization_31 (BatchNo (None, None, None, 1 576 conv2d_31[0][0]

batch_normalization_34 (BatchNo (None, None, None, 1 576 conv2d_34[0][0]

batch_normalization_39 (BatchNo (None, None, None, 1 576 conv2d_39[0][0]

batch_normalization_40 (BatchNo (None, None, None, 1 576 conv2d_40[0][0]

activation_31 (Activation) (None, None, None, 1 0 batch_normalization_31[0][0]

activation_34 (Activation) (None, None, None, 1 0 batch_normalization_34[0][0]

activation_39 (Activation) (None, None, None, 1 0 batch_normalization_39[0][0]

activation_40 (Activation) (None, None, None, 1 0 batch_normalization_40[0][0]

mixed4 (Concatenate) (None, None, None, 7 0 activation_31[0][0]
activation_34[0][0]
activation_39[0][0]
activation_40[0][0]

conv2d_45 (Conv2D)	(None, None, None, 1	122880	mixed4[0][0]
batch_normalization_45 (BatchNo	(None, None, None, 1	480	conv2d_45[0][0]
activation_45 (Activation)	(None, None, None, 1	0	batch_normalization_45[0][0]
conv2d_46 (Conv2D)	(None, None, None, 1	179200	activation_45[0][0]
batch_normalization_46 (BatchNo	(None, None, None, 1	480	conv2d_46[0][0]
activation_46 (Activation)	(None, None, None, 1	0	batch_normalization_46[0][0]
conv2d_42 (Conv2D)	(None, None, None, 1	122880	mixed4[0][0]
conv2d_47 (Conv2D)	(None, None, None, 1	179200	activation_46[0][0]
batch_normalization_42 (BatchNo	(None, None, None, 1	480	conv2d_42[0][0]
batch_normalization_47 (BatchNo	(None, None, None, 1	480	conv2d_47[0][0]
activation_42 (Activation)	(None, None, None, 1	0	batch_normalization_42[0][0]
activation_47 (Activation)	(None, None, None, 1	0	batch_normalization_47[0][0]
conv2d_43 (Conv2D)	(None, None, None, 1	179200	activation_42[0][0]
conv2d_48 (Conv2D)	(None, None, None, 1	179200	activation_47[0][0]
batch_normalization_43 (BatchNo	(None, None, None, 1	480	conv2d_43[0][0]
batch_normalization_48 (BatchNo	(None, None, None, 1	480	conv2d_48[0][0]
activation_43 (Activation)	(None, None, None, 1	0	batch_normalization_43[0][0]
activation_48 (Activation)	(None, None, None, 1	0	batch_normalization_48[0][0]
average_pooling2d_5 (AveragePoo	(None, None, None, 7	0	mixed4[0][0]
conv2d_41 (Conv2D)	(None, None, None, 1	147456	mixed4[0][0]
conv2d_44 (Conv2D)	(None, None, None, 1	215040	activation_43[0][0]

conv2d_44 (Conv2D) (None, None, None, 1 215040 activation_43[0][0]

conv2d_49 (Conv2D) (None, None, None, 1 215040 activation_48[0][0]

conv2d_50 (Conv2D) (None, None, None, 1 147456 average_pooling2d_5[0][0]

batch_normalization_41 (BatchNo (None, None, None, 1 576 conv2d_41[0][0]

batch_normalization_44 (BatchNo (None, None, None, 1 576 conv2d_44[0][0]

batch_normalization_49 (BatchNo (None, None, None, 1 576 conv2d_49[0][0]

batch_normalization_50 (BatchNo (None, None, None, 1 576 conv2d_50[0][0]

activation_41 (Activation) (None, None, None, 1 0 batch_normalization_41[0][0]

activation_44 (Activation) (None, None, None, 1 0 batch_normalization_44[0][0]

activation_49 (Activation) (None, None, None, 1 0 batch_normalization_49[0][0]

activation_50 (Activation) (None, None, None, 1 0 batch_normalization_50[0][0]

mixed5 (Concatenate) (None, None, None, 7 0 activation_41[0][0]
activation_44[0][0]
activation_49[0][0]
activation_50[0][0]

conv2d_55 (Conv2D) (None, None, None, 1 122880 mixed5[0][0]

batch_normalization_55 (BatchNo (None, None, None, 1 480 conv2d_55[0][0]

activation_55 (Activation) (None, None, None, 1 0 batch_normalization_55[0][0]

conv2d_56 (Conv2D) (None, None, None, 1 179200 activation_55[0][0]

batch_normalization_56 (BatchNo (None, None, None, 1 480 conv2d_56[0][0]

activation_56 (Activation) (None, None, None, 1 0 batch_normalization_56[0][0]

conv2d_52 (Conv2D) (None, None, None, 1 122880 mixed5[0][0]

conv2d_57 (Conv2D) (None, None, None, 1 179200 activation_56[0][0]

batch_normalization_52 (BatchNo	(None, None, None, 1	480	conv2d_52[0][0]
batch_normalization_57 (BatchNo	(None, None, None, 1	480	conv2d_57[0][0]
activation_52 (Activation)	(None, None, None, 1	0	batch_normalization_52[0][0]
activation_57 (Activation)	(None, None, None, 1	0	batch_normalization_57[0][0]
conv2d_53 (Conv2D)	(None, None, None, 1	179200	activation_52[0][0]
conv2d_58 (Conv2D)	(None, None, None, 1	179200	activation_57[0][0]
batch_normalization_53 (BatchNo	(None, None, None, 1	480	conv2d_53[0][0]
batch_normalization_58 (BatchNo	(None, None, None, 1	480	conv2d_58[0][0]
activation_53 (Activation)	(None, None, None, 1	0	batch_normalization_53[0][0]
activation_58 (Activation)	(None, None, None, 1	0	batch_normalization_58[0][0]
average_pooling2d_6 (AveragePoo	(None, None, None, 7	0	mixed5[0][0]
conv2d_51 (Conv2D)	(None, None, None, 1	147456	mixed5[0][0]
conv2d_54 (Conv2D)	(None, None, None, 1	215040	activation_53[0][0]
conv2d_59 (Conv2D)	(None, None, None, 1	215040	activation_58[0][0]
conv2d_60 (Conv2D)	(None, None, None, 1	147456	average_pooling2d_6[0][0]
batch_normalization_51 (BatchNo	(None, None, None, 1	576	conv2d_51[0][0]
batch_normalization_54 (BatchNo	(None, None, None, 1	576	conv2d_54[0][0]
batch_normalization_59 (BatchNo	(None, None, None, 1	576	conv2d_59[0][0]
batch_normalization_60 (BatchNo	(None, None, None, 1	576	conv2d_60[0][0]
activation_51 (Activation)	(None, None, None, 1	0	batch_normalization_51[0][0]
activation_54 (Activation)	(None, None, None, 1	0	batch_normalization_54[0][0]

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__________
activation_59 (Activation)      (None, None, None, 1 0          batch_normalization_59[0][0]
__________
activation_60 (Activation)      (None, None, None, 1 0          batch_normalization_60[0][0]
__________
mixed6 (Concatenate)            (None, None, None, 7 0          activation_51[0][0]
                                                                activation_54[0][0]
                                                                activation_59[0][0]
                                                                activation_60[0][0]
__________
conv2d_65 (Conv2D)              (None, None, None, 1 147456     mixed6[0][0]
__________
batch_normalization_65 (BatchNo (None, None, None, 1 576        conv2d_65[0][0]
__________
activation_65 (Activation)      (None, None, None, 1 0          batch_normalization_65[0][0]
__________
conv2d_66 (Conv2D)              (None, None, None, 1 258048     activation_65[0][0]
__________
batch_normalization_66 (BatchNo (None, None, None, 1 576        conv2d_66[0][0]
__________
activation_66 (Activation)      (None, None, None, 1 0          batch_normalization_66[0][0]
__________
conv2d_62 (Conv2D)              (None, None, None, 1 147456     mixed6[0][0]
__________
conv2d_67 (Conv2D)              (None, None, None, 1 258048     activation_66[0][0]
__________
batch_normalization_62 (BatchNo (None, None, None, 1 576        conv2d_62[0][0]
__________
batch_normalization_67 (BatchNo (None, None, None, 1 576        conv2d_67[0][0]
__________
activation_62 (Activation)      (None, None, None, 1 0          batch_normalization_62[0][0]
__________
activation_67 (Activation)      (None, None, None, 1 0          batch_normalization_67[0][0]
__________
conv2d_63 (Conv2D)              (None, None, None, 1 258048     activation_62[0][0]
__________
conv2d_68 (Conv2D)              (None, None, None, 1 258048     activation_67[0][0]
__________
batch_normalization_63 (BatchNo (None, None, None, 1 576        conv2d_63[0][0]
__________
batch_normalization_68 (BatchNo (None, None, None, 1 576        conv2d_68[0][0]
__________
```

activation_63 (Activation) (None, None, None, 1 0 batch_normalization_63[0][0]

activation_68 (Activation) (None, None, None, 1 0 batch_normalization_68[0][0]

average_pooling2d_7 (AveragePoo (None, None, None, 7 0 mixed6[0][0]

conv2d_61 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

conv2d_64 (Conv2D) (None, None, None, 1 258048 activation_63[0][0]

conv2d_69 (Conv2D) (None, None, None, 1 258048 activation_68[0][0]

conv2d_70 (Conv2D) (None, None, None, 1 147456 average_pooling2d_7[0][0]

batch_normalization_61 (BatchNo (None, None, None, 1 576 conv2d_61[0][0]

batch_normalization_64 (BatchNo (None, None, None, 1 576 conv2d_64[0][0]

batch_normalization_69 (BatchNo (None, None, None, 1 576 conv2d_69[0][0]

batch_normalization_70 (BatchNo (None, None, None, 1 576 conv2d_70[0][0]

activation_61 (Activation) (None, None, None, 1 0 batch_normalization_61[0][0]

activation_64 (Activation) (None, None, None, 1 0 batch_normalization_64[0][0]

activation_69 (Activation) (None, None, None, 1 0 batch_normalization_69[0][0]

activation_70 (Activation) (None, None, None, 1 0 batch_normalization_70[0][0]

mixed7 (Concatenate) (None, None, None, 7 0 activation_61[0][0]
activation_64[0][0]
activation_69[0][0]
activation_70[0][0]

conv2d_73 (Conv2D) (None, None, None, 1 147456 mixed7[0][0]

batch_normalization_73 (BatchNo (None, None, None, 1 576 conv2d_73[0][0]

activation_73 (Activation) (None, None, None, 1 0 batch_normalization_73[0][0]

conv2d_74 (Conv2D) (None, None, None, 1 258048 activation_73[0][0]

batch_normalization_74 (BatchNo	(None, None, None, 1	576	conv2d_74[0][0]
activation_74 (Activation)	(None, None, None, 1	0	batch_normalization_74[0][0]
conv2d_71 (Conv2D)	(None, None, None, 1	147456	mixed7[0][0]
conv2d_75 (Conv2D)	(None, None, None, 1	258048	activation_74[0][0]
batch_normalization_71 (BatchNo	(None, None, None, 1	576	conv2d_71[0][0]
batch_normalization_75 (BatchNo	(None, None, None, 1	576	conv2d_75[0][0]
activation_71 (Activation)	(None, None, None, 1	0	batch_normalization_71[0][0]
activation_75 (Activation)	(None, None, None, 1	0	batch_normalization_75[0][0]
conv2d_72 (Conv2D)	(None, None, None, 3	552960	activation_71[0][0]
conv2d_76 (Conv2D)	(None, None, None, 1	331776	activation_75[0][0]
batch_normalization_72 (BatchNo	(None, None, None, 3	960	conv2d_72[0][0]
batch_normalization_76 (BatchNo	(None, None, None, 1	576	conv2d_76[0][0]
activation_72 (Activation)	(None, None, None, 3	0	batch_normalization_72[0][0]
activation_76 (Activation)	(None, None, None, 1	0	batch_normalization_76[0][0]
max_pooling2d_4 (MaxPooling2D)	(None, None, None, 7	0	mixed7[0][0]
mixed8 (Concatenate)	(None, None, None, 1	0	activation_72[0][0] activation_76[0][0] max_pooling2d_4[0][0]
conv2d_81 (Conv2D)	(None, None, None, 4	573440	mixed8[0][0]
batch_normalization_81 (BatchNo	(None, None, None, 4	1344	conv2d_81[0][0]
activation_81 (Activation)	(None, None, None, 4	0	batch_normalization_81[0][0]
conv2d_78 (Conv2D)	(None, None, None, 3	491520	mixed8[0][0]

conv2d_82 (Conv2D)	(None, None, None, 3	1548288	activation_81[0][0]
batch_normalization_78 (BatchNo	(None, None, None, 3	1152	conv2d_78[0][0]
batch_normalization_82 (BatchNo	(None, None, None, 3	1152	conv2d_82[0][0]
activation_78 (Activation)	(None, None, None, 3	0	batch_normalization_78[0][0]
activation_82 (Activation)	(None, None, None, 3	0	batch_normalization_82[0][0]
conv2d_79 (Conv2D)	(None, None, None, 3	442368	activation_78[0][0]
conv2d_80 (Conv2D)	(None, None, None, 3	442368	activation_78[0][0]
conv2d_83 (Conv2D)	(None, None, None, 3	442368	activation_82[0][0]
conv2d_84 (Conv2D)	(None, None, None, 3	442368	activation_82[0][0]
average_pooling2d_8 (AveragePoo	(None, None, None, 1	0	mixed8[0][0]
conv2d_77 (Conv2D)	(None, None, None, 3	409600	mixed8[0][0]
batch_normalization_79 (BatchNo	(None, None, None, 3	1152	conv2d_79[0][0]
batch_normalization_80 (BatchNo	(None, None, None, 3	1152	conv2d_80[0][0]
batch_normalization_83 (BatchNo	(None, None, None, 3	1152	conv2d_83[0][0]
batch_normalization_84 (BatchNo	(None, None, None, 3	1152	conv2d_84[0][0]
conv2d_85 (Conv2D)	(None, None, None, 1	245760	average_pooling2d_8[0][0]
batch_normalization_77 (BatchNo	(None, None, None, 3	960	conv2d_77[0][0]
activation_79 (Activation)	(None, None, None, 3	0	batch_normalization_79[0][0]
activation_80 (Activation)	(None, None, None, 3	0	batch_normalization_80[0][0]
activation_83 (Activation)	(None, None, None, 3	0	batch_normalization_83[0][0]
activation_84 (Activation)	(None, None, None, 3	0	batch_normalization_84[0][0]

batch_normalization_85 (BatchNo	(None, None, None, 1	576	conv2d_85[0][0]
activation_77 (Activation)	(None, None, None, 3	0	batch_normalization_77[0][0]
mixed9_0 (Concatenate)	(None, None, None, 7	0	activation_79[0][0] activation_80[0][0]
concatenate_1 (Concatenate)	(None, None, None, 7	0	activation_83[0][0] activation_84[0][0]
activation_85 (Activation)	(None, None, None, 1	0	batch_normalization_85[0][0]
mixed9 (Concatenate)	(None, None, None, 2	0	activation_77[0][0] mixed9_0[0][0] concatenate_1[0][0] activation_85[0][0]
conv2d_90 (Conv2D)	(None, None, None, 4	917504	mixed9[0][0]
batch_normalization_90 (BatchNo	(None, None, None, 4	1344	conv2d_90[0][0]
activation_90 (Activation)	(None, None, None, 4	0	batch_normalization_90[0][0]
conv2d_87 (Conv2D)	(None, None, None, 3	786432	mixed9[0][0]
conv2d_91 (Conv2D)	(None, None, None, 3	1548288	activation_90[0][0]
batch_normalization_87 (BatchNo	(None, None, None, 3	1152	conv2d_87[0][0]
batch_normalization_91 (BatchNo	(None, None, None, 3	1152	conv2d_91[0][0]
activation_87 (Activation)	(None, None, None, 3	0	batch_normalization_87[0][0]
activation_91 (Activation)	(None, None, None, 3	0	batch_normalization_91[0][0]
conv2d_88 (Conv2D)	(None, None, None, 3	442368	activation_87[0][0]
conv2d_89 (Conv2D)	(None, None, None, 3	442368	activation_87[0][0]
conv2d_92 (Conv2D)	(None, None, None, 3	442368	activation_91[0][0]
conv2d_93 (Conv2D)	(None, None, None, 3	442368	activation_91[0][0]

conv2d_93 (Conv2D) (None, None, None, 3 114432 activation_93[0][0]

---

average_pooling2d_9 (AveragePoo (None, None, None, 2 0 mixed9[0][0]

---

conv2d_86 (Conv2D) (None, None, None, 3 655360 mixed9[0][0]

---

batch_normalization_88 (BatchNo (None, None, None, 3 1152 conv2d_88[0][0]

---

batch_normalization_89 (BatchNo (None, None, None, 3 1152 conv2d_89[0][0]

---

batch_normalization_92 (BatchNo (None, None, None, 3 1152 conv2d_92[0][0]

---

batch_normalization_93 (BatchNo (None, None, None, 3 1152 conv2d_93[0][0]

---

conv2d_94 (Conv2D) (None, None, None, 1 393216 average_pooling2d_9[0][0]

---

batch_normalization_86 (BatchNo (None, None, None, 3 960 conv2d_86[0][0]

---

activation_88 (Activation) (None, None, None, 3 0 batch_normalization_88[0][0]

---

activation_89 (Activation) (None, None, None, 3 0 batch_normalization_89[0][0]

---

activation_92 (Activation) (None, None, None, 3 0 batch_normalization_92[0][0]

---

activation_93 (Activation) (None, None, None, 3 0 batch_normalization_93[0][0]

---

batch_normalization_94 (BatchNo (None, None, None, 1 576 conv2d_94[0][0]

---

activation_86 (Activation) (None, None, None, 3 0 batch_normalization_86[0][0]

---

mixed9_1 (Concatenate) (None, None, None, 7 0 activation_88[0][0]
activation_89[0][0]

---

concatenate_2 (Concatenate) (None, None, None, 7 0 activation_92[0][0]
activation_93[0][0]

---

activation_94 (Activation) (None, None, None, 1 0 batch_normalization_94[0][0]

---

mixed10 (Concatenate) (None, None, None, 2 0 activation_86[0][0]
mixed9_1[0][0]
concatenate_2[0][0]
activation_94[0][0]

---

global_average_pooling2d_1 (Glo (None, 2048) 0 mixed10[0][0]

```
global_average_pooling2d_1 (Glo (None, 2048)         0           mixed10[0][0]
__________________________________________________________________________________________
__________
dense_1 (Dense)                 (None, 2)            4098        global_average_pooling2d_1[0][0]
==========================================================================================
==========
Total params: 21,806,882
Trainable params: 4,098
Non-trainable params: 21,802,784
__________________________________________________________________________________________
__________
```

模型拟合结果

In [6]:

```
from keras.optimizers import Adam     # 导入优化器Adam
model.compile(loss='categorical_crossentropy',optimizer=Adam(lr=0.001),metrics=['accuracy'])
#模型编译，损失函数为交叉熵；优化器为Adam；学习速率为0.001 ；衡量指标为精度
model.fit_generator(train_generator,epochs=1,validation_data=validation_generator)
# 训练1轮；模型训练，用训练集
```

```
Epoch 1/1
100/100 [==============================] - 708s 7s/step - loss: 0.2286 - accuracy: 0.9173 - val_loss: 0.0
582 - val_accuracy: 0.9815
```

Out[6]:

```
<keras.callbacks.callbacks.History at 0x7fcd57688f10>
```

思考问题：迁移其他模型？？

In [3]:

```
import os
os.environ['TF_CPP_MIN_LOG_LEVEL'] = '2'
import numpy as np
from keras import callbacks
from keras.models import Sequential, model_from_yaml, load_model
from keras.layers import Dense, Conv2D, Flatten, Dropout, MaxPool2D
from keras.optimizers import Adam, SGD
from keras.preprocessing import image
from keras.utils import np_utils, plot_model
from sklearn.model_selection import train_test_split
from keras.applications.resnet50 import preprocess_input, decode_predictions
```

In [4]:

```
from keras.preprocessing.image import ImageDataGenerator # 图片预处理

IMSIZE=128  # 图片像素

validation_generator = ImageDataGenerator(
    preprocessing_function=preprocess_input).flow_from_directory(
    'F:/大三（上）/深度学习/TASK5.1：DL核心技术 - BN + DA/dogs-vs-cats/train/test',  # 数据路径
    target_size=(IMSIZE, IMSIZE),  # 数据像素（目标大小）
    batch_size=150,class_mode='categorical')            # 批处理大小 # 生成验证数据集

train_generator = ImageDataGenerator(
```

```
    preprocessing_function=preprocess_input,  # 数据预处理
    shear_range=0.3,  # 一定角度下的斜方向拉伸强度不超过0.3
    rotation_range=20,  # 图片右旋转不超过20°
    zoom_range=0.3,    # 定义放大或缩小比例不超多0.3
    width_shift_range=0.2,  # 水平方向上平移不超过0.2的宽度
    height_shift_range=0.2,  # 垂直方向的平移不超过0.2的高度
    horizontal_flip=True).flow_from_directory(
    'F:/大三（上）/深度学习/TASK5.1：DL核心技术 - BN + DA/dogs-vs-cats/train/train',
    target_size=(IMSIZE, IMSIZE),
    batch_size=150)
```

```
Found 2500 images belonging to 2 classes.
Found 22500 images belonging to 2 classes.
```

In [5]:

```
import numpy as np  # 导入库
X,Y=next(validation_generator)  # 分批吐出数据
print(X.shape)
print(Y.shape)
Y[:,0]          # 矩阵
```

```
(150, 128, 128, 3)
(150, 2)
```

Out[5]:

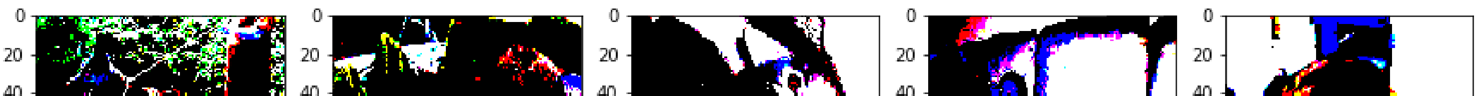
```
array([0., 0., 1., 0., 0., 0., 0., 0., 0., 1., 1., 0., 1., 0., 1., 0., 1.,
       0., 0., 1., 1., 0., 1., 1., 1., 0., 0., 1., 1., 1., 1., 0., 1., 0.,
       1., 0., 0., 0., 1., 0., 1., 0., 1., 0., 1., 0., 1., 0., 0., 0., 1.,
       0., 0., 1., 0., 0., 0., 1., 1., 1., 0., 0., 0., 0., 1., 1., 0., 1.,
       1., 1., 0., 0., 0., 1., 1., 0., 1., 0., 1., 0., 0., 1., 1., 1., 0.,
       1., 1., 1., 0., 1., 0., 1., 0., 0., 1., 0., 1., 1., 0., 1., 0., 0.,
       0., 1., 1., 0., 0., 1., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1.,
       1., 1., 1., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 1., 0., 1.,
       1., 1., 0., 0., 1., 0., 1., 1., 0., 1., 1., 1., 0., 1.],
      dtype=float32)
```

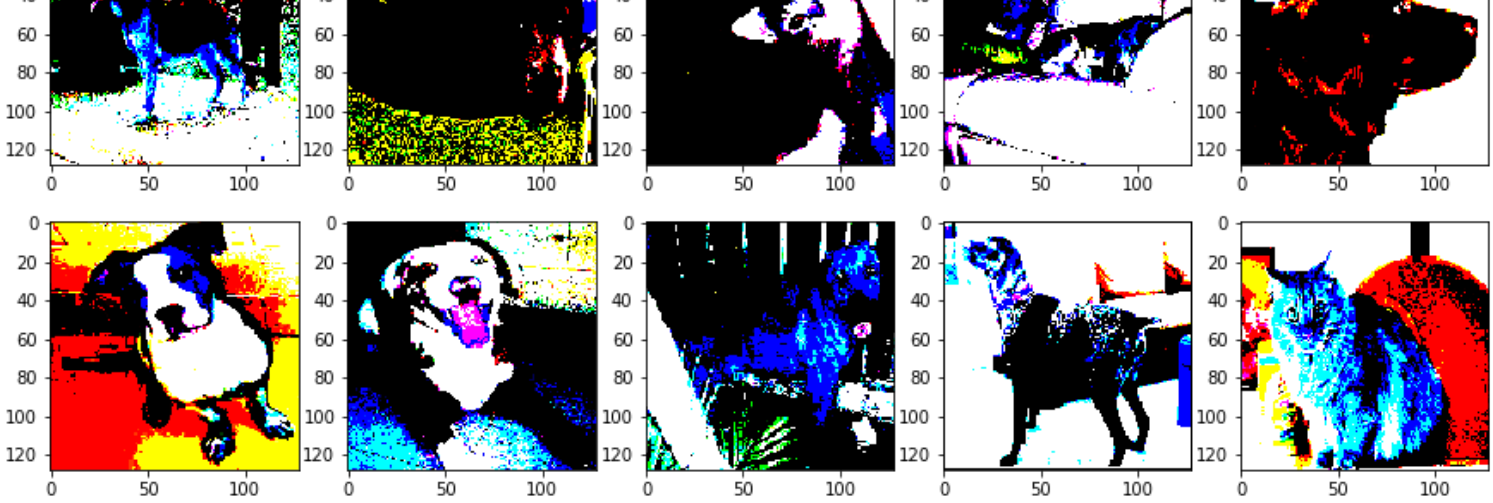
In [6]:

```
from matplotlib import pyplot as plt    # 导入画板
plt.figure()               # 创建画板
fig,ax = plt.subplots(2,5)    # 将面板切分成2行5列
fig.set_figheight(6)          # 高为6
fig.set_figwidth(15)          # 宽为15
ax=ax.flatten()             # 拉直
for i in range(10): ax[i].imshow(X[i,:,:,:])   # 展示
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).

<Figure size 432x288 with 0 Axes>
```





案例改编版

In [14]:

```
from shutil import copy2
from keras.preprocessing.image import ImageDataGenerator
from keras.applications.inception_v3 import InceptionV3
from keras.models import Model
from keras.layers import Dense, GlobalAveragePooling2D
import tensorflow as tf
tf.compat.v1.logging.set_verbosity(tf.compat.v1.logging.ERROR)
```

In [16]:

```
# 构建不带分类器的预训练模型
base_model = InceptionV3(weights='imagenet', include_top=False)

# 添加全局平均池化层
x = base_model.output
x = GlobalAveragePooling2D()(x)

# 添加一个全连接层
x = Dense(1024, activation='relu')(x)

# 添加一个分类器，假设我们有200个类
prediction = Dense(1, activation='sigmoid')(x)

# 首先，我们只训练顶部的几层（随机初始化的层）
# 锁住所有 InceptionV3 的卷积层
for layer in base_model.layers:
    layer.trainable = False
model = Model(inputs=base_model.input, outputs=prediction)
# 编译模型
model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])
model.summary()    # 模型结构
```

```
Model: "functional_3"
__________________________________________________________________________________________
Layer (type)                 Output Shape              Param #   Connected to
==========================================================================================
input_4 (InputLayer)         [(None, None, None,  0
```

```
__________
conv2d_97 (Conv2D)              (None, None, None, 3 864         input_4[0][0]
____________________________________________________________________________________
__________
batch_normalization_94 (BatchNo (None, None, None, 3 96          conv2d_97[0][0]
____________________________________________________________________________________
__________
activation_94 (Activation)      (None, None, None, 3 0           batch_normalization_94[0][0]
____________________________________________________________________________________
__________
conv2d_98 (Conv2D)              (None, None, None, 3 9216        activation_94[0][0]
____________________________________________________________________________________
__________
batch_normalization_95 (BatchNo (None, None, None, 3 96          conv2d_98[0][0]
____________________________________________________________________________________
__________
activation_95 (Activation)      (None, None, None, 3 0           batch_normalization_95[0][0]
____________________________________________________________________________________
__________
conv2d_99 (Conv2D)              (None, None, None, 6 18432       activation_95[0][0]
____________________________________________________________________________________
__________
batch_normalization_96 (BatchNo (None, None, None, 6 192         conv2d_99[0][0]
____________________________________________________________________________________
__________
activation_96 (Activation)      (None, None, None, 6 0           batch_normalization_96[0][0]
____________________________________________________________________________________
__________
max_pooling2d_7 (MaxPooling2D)  (None, None, None, 6 0           activation_96[0][0]
____________________________________________________________________________________
__________
conv2d_100 (Conv2D)             (None, None, None, 8 5120        max_pooling2d_7[0][0]
____________________________________________________________________________________
__________
batch_normalization_97 (BatchNo (None, None, None, 8 240         conv2d_100[0][0]
____________________________________________________________________________________
__________
activation_97 (Activation)      (None, None, None, 8 0           batch_normalization_97[0][0]
____________________________________________________________________________________
__________
conv2d_101 (Conv2D)             (None, None, None, 1 138240      activation_97[0][0]
____________________________________________________________________________________
__________
batch_normalization_98 (BatchNo (None, None, None, 1 576         conv2d_101[0][0]
____________________________________________________________________________________
__________
activation_98 (Activation)      (None, None, None, 1 0           batch_normalization_98[0][0]
____________________________________________________________________________________
__________
max_pooling2d_8 (MaxPooling2D)  (None, None, None, 1 0           activation_98[0][0]
____________________________________________________________________________________
__________
conv2d_105 (Conv2D)             (None, None, None, 6 12288       max_pooling2d_8[0][0]
____________________________________________________________________________________
__________
batch_normalization_102 (BatchN (None, None, None, 6 192         conv2d_105[0][0]
____________________________________________________________________________________
__________
activation_102 (Activation)     (None, None, None, 6 0           batch_normalization_102[0][0]
____________________________________________________________________________________
__________
```

conv2d_103 (Conv2D) (None, None, None, 4 9216 max_pooling2d_8[0][0]

conv2d_106 (Conv2D) (None, None, None, 9 55296 activation_102[0][0]

batch_normalization_100 (BatchN (None, None, None, 4 144 conv2d_103[0][0]

batch_normalization_103 (BatchN (None, None, None, 9 288 conv2d_106[0][0]

activation_100 (Activation) (None, None, None, 4 0 batch_normalization_100[0][0]

activation_103 (Activation) (None, None, None, 9 0 batch_normalization_103[0][0]

average_pooling2d_9 (AveragePoo (None, None, None, 1 0 max_pooling2d_8[0][0]

conv2d_102 (Conv2D) (None, None, None, 6 12288 max_pooling2d_8[0][0]

conv2d_104 (Conv2D) (None, None, None, 6 76800 activation_100[0][0]

conv2d_107 (Conv2D) (None, None, None, 9 82944 activation_103[0][0]

conv2d_108 (Conv2D) (None, None, None, 3 6144 average_pooling2d_9[0][0]

batch_normalization_99 (BatchNo (None, None, None, 6 192 conv2d_102[0][0]

batch_normalization_101 (BatchN (None, None, None, 6 192 conv2d_104[0][0]

batch_normalization_104 (BatchN (None, None, None, 9 288 conv2d_107[0][0]

batch_normalization_105 (BatchN (None, None, None, 3 96 conv2d_108[0][0]

activation_99 (Activation) (None, None, None, 6 0 batch_normalization_99[0][0]

activation_101 (Activation) (None, None, None, 6 0 batch_normalization_101[0][0]

activation_104 (Activation) (None, None, None, 9 0 batch_normalization_104[0][0]

activation_105 (Activation) (None, None, None, 3 0 batch_normalization_105[0][0]

mixed0 (Concatenate) (None, None, None, 2 0 activation_99[0][0]
activation_101[0][0]
activation_104[0][0]
activation_105[0][0]

conv2d_112 (Conv2D)	(None, None, None, 6	16384	mixed0[0][0]
batch_normalization_109 (BatchN	(None, None, None, 6	192	conv2d_112[0][0]
activation_109 (Activation)	(None, None, None, 6	0	batch_normalization_109[0][0]
conv2d_110 (Conv2D)	(None, None, None, 4	12288	mixed0[0][0]
conv2d_113 (Conv2D)	(None, None, None, 9	55296	activation_109[0][0]
batch_normalization_107 (BatchN	(None, None, None, 4	144	conv2d_110[0][0]
batch_normalization_110 (BatchN	(None, None, None, 9	288	conv2d_113[0][0]
activation_107 (Activation)	(None, None, None, 4	0	batch_normalization_107[0][0]
activation_110 (Activation)	(None, None, None, 9	0	batch_normalization_110[0][0]
average_pooling2d_10 (AveragePo	(None, None, None, 2	0	mixed0[0][0]
conv2d_109 (Conv2D)	(None, None, None, 6	16384	mixed0[0][0]
conv2d_111 (Conv2D)	(None, None, None, 6	76800	activation_107[0][0]
conv2d_114 (Conv2D)	(None, None, None, 9	82944	activation_110[0][0]
conv2d_115 (Conv2D)	(None, None, None, 6	16384	average_pooling2d_10[0][0]
batch_normalization_106 (BatchN	(None, None, None, 6	192	conv2d_109[0][0]
batch_normalization_108 (BatchN	(None, None, None, 6	192	conv2d_111[0][0]
batch_normalization_111 (BatchN	(None, None, None, 9	288	conv2d_114[0][0]
batch_normalization_112 (BatchN	(None, None, None, 6	192	conv2d_115[0][0]
activation_106 (Activation)	(None, None, None, 6	0	batch_normalization_106[0][0]
activation_108 (Activation)	(None, None, None, 6	0	batch_normalization_108[0][0]
activation_111 (Activation)	(None, None, None, 9	0	batch_normalization_111[0][0]

activation_112 (Activation)	(None, None, None, 6	0	batch_normalization_112[0][0]
mixed1 (Concatenate)	(None, None, None, 2	0	activation_106[0][0] activation_108[0][0] activation_111[0][0] activation_112[0][0]
conv2d_119 (Conv2D)	(None, None, None, 6	18432	mixed1[0][0]
batch_normalization_116 (BatchN	(None, None, None, 6	192	conv2d_119[0][0]
activation_116 (Activation)	(None, None, None, 6	0	batch_normalization_116[0][0]
conv2d_117 (Conv2D)	(None, None, None, 4	13824	mixed1[0][0]
conv2d_120 (Conv2D)	(None, None, None, 9	55296	activation_116[0][0]
batch_normalization_114 (BatchN	(None, None, None, 4	144	conv2d_117[0][0]
batch_normalization_117 (BatchN	(None, None, None, 9	288	conv2d_120[0][0]
activation_114 (Activation)	(None, None, None, 4	0	batch_normalization_114[0][0]
activation_117 (Activation)	(None, None, None, 9	0	batch_normalization_117[0][0]
average_pooling2d_11 (AveragePo	(None, None, None, 2	0	mixed1[0][0]
conv2d_116 (Conv2D)	(None, None, None, 6	18432	mixed1[0][0]
conv2d_118 (Conv2D)	(None, None, None, 6	76800	activation_114[0][0]
conv2d_121 (Conv2D)	(None, None, None, 9	82944	activation_117[0][0]
conv2d_122 (Conv2D)	(None, None, None, 6	18432	average_pooling2d_11[0][0]
batch_normalization_113 (BatchN	(None, None, None, 6	192	conv2d_116[0][0]
batch_normalization_115 (BatchN	(None, None, None, 6	192	conv2d_118[0][0]
batch_normalization_118 (BatchN	(None, None, None, 9	288	conv2d_121[0][0]

batch_normalization_119 (BatchN (None, None, None, 6 192 conv2d_122[0][0]

activation_113 (Activation) (None, None, None, 6 0 batch_normalization_113[0][0]

activation_115 (Activation) (None, None, None, 6 0 batch_normalization_115[0][0]

activation_118 (Activation) (None, None, None, 9 0 batch_normalization_118[0][0]

activation_119 (Activation) (None, None, None, 6 0 batch_normalization_119[0][0]

mixed2 (Concatenate) (None, None, None, 2 0 activation_113[0][0]
activation_115[0][0]
activation_118[0][0]
activation_119[0][0]

conv2d_124 (Conv2D) (None, None, None, 6 18432 mixed2[0][0]

batch_normalization_121 (BatchN (None, None, None, 6 192 conv2d_124[0][0]

activation_121 (Activation) (None, None, None, 6 0 batch_normalization_121[0][0]

conv2d_125 (Conv2D) (None, None, None, 9 55296 activation_121[0][0]

batch_normalization_122 (BatchN (None, None, None, 9 288 conv2d_125[0][0]

activation_122 (Activation) (None, None, None, 9 0 batch_normalization_122[0][0]

conv2d_123 (Conv2D) (None, None, None, 3 995328 mixed2[0][0]

conv2d_126 (Conv2D) (None, None, None, 9 82944 activation_122[0][0]

batch_normalization_120 (BatchN (None, None, None, 3 1152 conv2d_123[0][0]

batch_normalization_123 (BatchN (None, None, None, 9 288 conv2d_126[0][0]

activation_120 (Activation) (None, None, None, 3 0 batch_normalization_120[0][0]

activation_123 (Activation) (None, None, None, 9 0 batch_normalization_123[0][0]

max_pooling2d_9 (MaxPooling2D) (None, None, None, 2 0 mixed2[0][0]

mixed3 (Concatenate) (None, None, None, 7 0 activation_120[0][0]
activation_123[0][0]

activation_123[0][0]
max_pooling2d_9[0][0]

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conv2d_131 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

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batch_normalization_128 (BatchN (None, None, None, 1 384 conv2d_131[0][0]

---

activation_128 (Activation) (None, None, None, 1 0 batch_normalization_128[0][0]

---

conv2d_132 (Conv2D) (None, None, None, 1 114688 activation_128[0][0]

---

batch_normalization_129 (BatchN (None, None, None, 1 384 conv2d_132[0][0]

---

activation_129 (Activation) (None, None, None, 1 0 batch_normalization_129[0][0]

---

conv2d_128 (Conv2D) (None, None, None, 1 98304 mixed3[0][0]

---

conv2d_133 (Conv2D) (None, None, None, 1 114688 activation_129[0][0]

---

batch_normalization_125 (BatchN (None, None, None, 1 384 conv2d_128[0][0]

---

batch_normalization_130 (BatchN (None, None, None, 1 384 conv2d_133[0][0]

---

activation_125 (Activation) (None, None, None, 1 0 batch_normalization_125[0][0]

---

activation_130 (Activation) (None, None, None, 1 0 batch_normalization_130[0][0]

---

conv2d_129 (Conv2D) (None, None, None, 1 114688 activation_125[0][0]

---

conv2d_134 (Conv2D) (None, None, None, 1 114688 activation_130[0][0]

---

batch_normalization_126 (BatchN (None, None, None, 1 384 conv2d_129[0][0]

---

batch_normalization_131 (BatchN (None, None, None, 1 384 conv2d_134[0][0]

---

activation_126 (Activation) (None, None, None, 1 0 batch_normalization_126[0][0]

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activation_131 (Activation) (None, None, None, 1 0 batch_normalization_131[0][0]

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average_pooling2d_12 (AveragePo (None, None, None, 7 0 mixed3[0][0]

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conv2d_127 (Conv2D) (None, None, None, 1 147456 mixed3[0][0]

conv2d_130 (Conv2D)	(None, None, None, 1	172032	activation_126[0][0]
conv2d_135 (Conv2D)	(None, None, None, 1	172032	activation_131[0][0]
conv2d_136 (Conv2D)	(None, None, None, 1	147456	average_pooling2d_12[0][0]
batch_normalization_124 (BatchN	(None, None, None, 1	576	conv2d_127[0][0]
batch_normalization_127 (BatchN	(None, None, None, 1	576	conv2d_130[0][0]
batch_normalization_132 (BatchN	(None, None, None, 1	576	conv2d_135[0][0]
batch_normalization_133 (BatchN	(None, None, None, 1	576	conv2d_136[0][0]
activation_124 (Activation)	(None, None, None, 1	0	batch_normalization_124[0][0]
activation_127 (Activation)	(None, None, None, 1	0	batch_normalization_127[0][0]
activation_132 (Activation)	(None, None, None, 1	0	batch_normalization_132[0][0]
activation_133 (Activation)	(None, None, None, 1	0	batch_normalization_133[0][0]
mixed4 (Concatenate)	(None, None, None, 7	0	activation_124[0][0] activation_127[0][0] activation_132[0][0] activation_133[0][0]
conv2d_141 (Conv2D)	(None, None, None, 1	122880	mixed4[0][0]
batch_normalization_138 (BatchN	(None, None, None, 1	480	conv2d_141[0][0]
activation_138 (Activation)	(None, None, None, 1	0	batch_normalization_138[0][0]
conv2d_142 (Conv2D)	(None, None, None, 1	179200	activation_138[0][0]
batch_normalization_139 (BatchN	(None, None, None, 1	480	conv2d_142[0][0]
activation_139 (Activation)	(None, None, None, 1	0	batch_normalization_139[0][0]
conv2d_138 (Conv2D)	(None, None, None, 1	122880	mixed4[0][0]

conv2d_143 (Conv2D) (None, None, None, 1 179200 activation_139[0][0]

batch_normalization_135 (BatchN (None, None, None, 1 480 conv2d_138[0][0]

batch_normalization_140 (BatchN (None, None, None, 1 480 conv2d_143[0][0]

activation_135 (Activation) (None, None, None, 1 0 batch_normalization_135[0][0]

activation_140 (Activation) (None, None, None, 1 0 batch_normalization_140[0][0]

conv2d_139 (Conv2D) (None, None, None, 1 179200 activation_135[0][0]

conv2d_144 (Conv2D) (None, None, None, 1 179200 activation_140[0][0]

batch_normalization_136 (BatchN (None, None, None, 1 480 conv2d_139[0][0]

batch_normalization_141 (BatchN (None, None, None, 1 480 conv2d_144[0][0]

activation_136 (Activation) (None, None, None, 1 0 batch_normalization_136[0][0]

activation_141 (Activation) (None, None, None, 1 0 batch_normalization_141[0][0]

average_pooling2d_13 (AveragePo (None, None, None, 7 0 mixed4[0][0]

conv2d_137 (Conv2D) (None, None, None, 1 147456 mixed4[0][0]

conv2d_140 (Conv2D) (None, None, None, 1 215040 activation_136[0][0]

conv2d_145 (Conv2D) (None, None, None, 1 215040 activation_141[0][0]

conv2d_146 (Conv2D) (None, None, None, 1 147456 average_pooling2d_13[0][0]

batch_normalization_134 (BatchN (None, None, None, 1 576 conv2d_137[0][0]

batch_normalization_137 (BatchN (None, None, None, 1 576 conv2d_140[0][0]

batch_normalization_142 (BatchN (None, None, None, 1 576 conv2d_145[0][0]

batch_normalization_143 (BatchN (None, None, None, 1 576 conv2d_146[0][0]

activation_134 (Activation) (None, None, None, 1 0 batch_normalization_134[0][0]

activation_137 (Activation) (None, None, None, 1 0 batch_normalization_137[0][0]

activation_142 (Activation) (None, None, None, 1 0 batch_normalization_142[0][0]

activation_143 (Activation) (None, None, None, 1 0 batch_normalization_143[0][0]

mixed5 (Concatenate) (None, None, None, 7 0 activation_134[0][0]
activation_137[0][0]
activation_142[0][0]
activation_143[0][0]

conv2d_151 (Conv2D) (None, None, None, 1 122880 mixed5[0][0]

batch_normalization_148 (BatchN (None, None, None, 1 480 conv2d_151[0][0]

activation_148 (Activation) (None, None, None, 1 0 batch_normalization_148[0][0]

conv2d_152 (Conv2D) (None, None, None, 1 179200 activation_148[0][0]

batch_normalization_149 (BatchN (None, None, None, 1 480 conv2d_152[0][0]

activation_149 (Activation) (None, None, None, 1 0 batch_normalization_149[0][0]

conv2d_148 (Conv2D) (None, None, None, 1 122880 mixed5[0][0]

conv2d_153 (Conv2D) (None, None, None, 1 179200 activation_149[0][0]

batch_normalization_145 (BatchN (None, None, None, 1 480 conv2d_148[0][0]

batch_normalization_150 (BatchN (None, None, None, 1 480 conv2d_153[0][0]

activation_145 (Activation) (None, None, None, 1 0 batch_normalization_145[0][0]

activation_150 (Activation) (None, None, None, 1 0 batch_normalization_150[0][0]

conv2d_149 (Conv2D) (None, None, None, 1 179200 activation_145[0][0]

conv2d_154 (Conv2D) (None, None, None, 1 179200 activation_150[0][0]

batch_normalization_146 (BatchN (None, None, None, 1 480 conv2d_149[0][0]

batch_normalization_151 (BatchN (None, None, None, 1 480 conv2d_154[0][0]

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__________
activation_146 (Activation)     (None, None, None, 1 0          batch_normalization_146[0][0]
__________
activation_151 (Activation)     (None, None, None, 1 0          batch_normalization_151[0][0]
__________
average_pooling2d_14 (AveragePo (None, None, None, 7 0          mixed5[0][0]
__________
conv2d_147 (Conv2D)             (None, None, None, 1 147456     mixed5[0][0]
__________
conv2d_150 (Conv2D)             (None, None, None, 1 215040     activation_146[0][0]
__________
conv2d_155 (Conv2D)             (None, None, None, 1 215040     activation_151[0][0]
__________
conv2d_156 (Conv2D)             (None, None, None, 1 147456     average_pooling2d_14[0][0]
__________
batch_normalization_144 (BatchN (None, None, None, 1 576        conv2d_147[0][0]
__________
batch_normalization_147 (BatchN (None, None, None, 1 576        conv2d_150[0][0]
__________
batch_normalization_152 (BatchN (None, None, None, 1 576        conv2d_155[0][0]
__________
batch_normalization_153 (BatchN (None, None, None, 1 576        conv2d_156[0][0]
__________
activation_144 (Activation)     (None, None, None, 1 0          batch_normalization_144[0][0]
__________
activation_147 (Activation)     (None, None, None, 1 0          batch_normalization_147[0][0]
__________
activation_152 (Activation)     (None, None, None, 1 0          batch_normalization_152[0][0]
__________
activation_153 (Activation)     (None, None, None, 1 0          batch_normalization_153[0][0]
__________
mixed6 (Concatenate)            (None, None, None, 7 0          activation_144[0][0]
                                                                activation_147[0][0]
                                                                activation_152[0][0]
                                                                activation_153[0][0]
__________
conv2d_161 (Conv2D)             (None, None, None, 1 147456     mixed6[0][0]
__________
batch_normalization_158 (BatchN (None, None, None, 1 576        conv2d_161[0][0]
__________
activation_158 (Activation)     (None, None, None, 1 0          batch_normalization_158[0][0]
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conv2d_162 (Conv2D) (None, None, None, 1 258048 activation_158[0][0]

batch_normalization_159 (BatchN (None, None, None, 1 576 conv2d_162[0][0]

activation_159 (Activation) (None, None, None, 1 0 batch_normalization_159[0][0]

conv2d_158 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

conv2d_163 (Conv2D) (None, None, None, 1 258048 activation_159[0][0]

batch_normalization_155 (BatchN (None, None, None, 1 576 conv2d_158[0][0]

batch_normalization_160 (BatchN (None, None, None, 1 576 conv2d_163[0][0]

activation_155 (Activation) (None, None, None, 1 0 batch_normalization_155[0][0]

activation_160 (Activation) (None, None, None, 1 0 batch_normalization_160[0][0]

conv2d_159 (Conv2D) (None, None, None, 1 258048 activation_155[0][0]

conv2d_164 (Conv2D) (None, None, None, 1 258048 activation_160[0][0]

batch_normalization_156 (BatchN (None, None, None, 1 576 conv2d_159[0][0]

batch_normalization_161 (BatchN (None, None, None, 1 576 conv2d_164[0][0]

activation_156 (Activation) (None, None, None, 1 0 batch_normalization_156[0][0]

activation_161 (Activation) (None, None, None, 1 0 batch_normalization_161[0][0]

average_pooling2d_15 (AveragePo (None, None, None, 7 0 mixed6[0][0]

conv2d_157 (Conv2D) (None, None, None, 1 147456 mixed6[0][0]

conv2d_160 (Conv2D) (None, None, None, 1 258048 activation_156[0][0]

conv2d_165 (Conv2D) (None, None, None, 1 258048 activation_161[0][0]

conv2d_166 (Conv2D) (None, None, None, 1 147456 average_pooling2d_15[0][0]

batch_normalization_154 (BatchN (None, None, None, 1 576 conv2d_157[0][0]

batch_normalization_157 (BatchN	(None, None, None, 1	576	conv2d_160[0][0]
batch_normalization_162 (BatchN	(None, None, None, 1	576	conv2d_165[0][0]
batch_normalization_163 (BatchN	(None, None, None, 1	576	conv2d_166[0][0]
activation_154 (Activation)	(None, None, None, 1	0	batch_normalization_154[0][0]
activation_157 (Activation)	(None, None, None, 1	0	batch_normalization_157[0][0]
activation_162 (Activation)	(None, None, None, 1	0	batch_normalization_162[0][0]
activation_163 (Activation)	(None, None, None, 1	0	batch_normalization_163[0][0]
mixed7 (Concatenate)	(None, None, None, 7	0	activation_154[0][0] activation_157[0][0] activation_162[0][0] activation_163[0][0]
conv2d_169 (Conv2D)	(None, None, None, 1	147456	mixed7[0][0]
batch_normalization_166 (BatchN	(None, None, None, 1	576	conv2d_169[0][0]
activation_166 (Activation)	(None, None, None, 1	0	batch_normalization_166[0][0]
conv2d_170 (Conv2D)	(None, None, None, 1	258048	activation_166[0][0]
batch_normalization_167 (BatchN	(None, None, None, 1	576	conv2d_170[0][0]
activation_167 (Activation)	(None, None, None, 1	0	batch_normalization_167[0][0]
conv2d_167 (Conv2D)	(None, None, None, 1	147456	mixed7[0][0]
conv2d_171 (Conv2D)	(None, None, None, 1	258048	activation_167[0][0]
batch_normalization_164 (BatchN	(None, None, None, 1	576	conv2d_167[0][0]
batch_normalization_168 (BatchN	(None, None, None, 1	576	conv2d_171[0][0]
activation_164 (Activation)	(None, None, None, 1	0	batch_normalization_164[0][0]
activation_168 (Activation)	(None, None, None, 1	0	batch_normalization_168[0][0]

activation_163 (Activation) (None, None, None, 1 0 batch_normalization_163[0][0]

conv2d_168 (Conv2D) (None, None, None, 3 552960 activation_164[0][0]

conv2d_172 (Conv2D) (None, None, None, 1 331776 activation_168[0][0]

batch_normalization_165 (BatchN (None, None, None, 3 960 conv2d_168[0][0]

batch_normalization_169 (BatchN (None, None, None, 1 576 conv2d_172[0][0]

activation_165 (Activation) (None, None, None, 3 0 batch_normalization_165[0][0]

activation_169 (Activation) (None, None, None, 1 0 batch_normalization_169[0][0]

max_pooling2d_10 (MaxPooling2D) (None, None, None, 7 0 mixed7[0][0]

mixed8 (Concatenate) (None, None, None, 1 0 activation_165[0][0]
activation_169[0][0]
max_pooling2d_10[0][0]

conv2d_177 (Conv2D) (None, None, None, 4 573440 mixed8[0][0]

batch_normalization_174 (BatchN (None, None, None, 4 1344 conv2d_177[0][0]

activation_174 (Activation) (None, None, None, 4 0 batch_normalization_174[0][0]

conv2d_174 (Conv2D) (None, None, None, 3 491520 mixed8[0][0]

conv2d_178 (Conv2D) (None, None, None, 3 1548288 activation_174[0][0]

batch_normalization_171 (BatchN (None, None, None, 3 1152 conv2d_174[0][0]

batch_normalization_175 (BatchN (None, None, None, 3 1152 conv2d_178[0][0]

activation_171 (Activation) (None, None, None, 3 0 batch_normalization_171[0][0]

activation_175 (Activation) (None, None, None, 3 0 batch_normalization_175[0][0]

conv2d_175 (Conv2D) (None, None, None, 3 442368 activation_171[0][0]

conv2d_176 (Conv2D) (None, None, None, 3 442368 activation_171[0][0]

conv2d_179 (Conv2D) (None, None, None, 3 442368 activation_175[0][0]

conv2d_179 (Conv2D) (None, None, None, 3 442368 activation_175[0][0]

conv2d_180 (Conv2D) (None, None, None, 3 442368 activation_175[0][0]

average_pooling2d_16 (AveragePo (None, None, None, 1 0 mixed8[0][0]

conv2d_173 (Conv2D) (None, None, None, 3 409600 mixed8[0][0]

batch_normalization_172 (BatchN (None, None, None, 3 1152 conv2d_175[0][0]

batch_normalization_173 (BatchN (None, None, None, 3 1152 conv2d_176[0][0]

batch_normalization_176 (BatchN (None, None, None, 3 1152 conv2d_179[0][0]

batch_normalization_177 (BatchN (None, None, None, 3 1152 conv2d_180[0][0]

conv2d_181 (Conv2D) (None, None, None, 1 245760 average_pooling2d_16[0][0]

batch_normalization_170 (BatchN (None, None, None, 3 960 conv2d_173[0][0]

activation_172 (Activation) (None, None, None, 3 0 batch_normalization_172[0][0]

activation_173 (Activation) (None, None, None, 3 0 batch_normalization_173[0][0]

activation_176 (Activation) (None, None, None, 3 0 batch_normalization_176[0][0]

activation_177 (Activation) (None, None, None, 3 0 batch_normalization_177[0][0]

batch_normalization_178 (BatchN (None, None, None, 1 576 conv2d_181[0][0]

activation_170 (Activation) (None, None, None, 3 0 batch_normalization_170[0][0]

mixed9_0 (Concatenate) (None, None, None, 7 0 activation_172[0][0]
activation_173[0][0]

concatenate_2 (Concatenate) (None, None, None, 7 0 activation_176[0][0]
activation_177[0][0]

activation_178 (Activation) (None, None, None, 1 0 batch_normalization_178[0][0]

mixed9 (Concatenate) (None, None, None, 2 0 activation_170[0][0]
mixed9_0[0][0]
concatenate_2[0][0]

activation_178[0][0]

conv2d_186 (Conv2D)	(None, None, None, 4	917504	mixed9[0][0]
batch_normalization_183 (BatchN	(None, None, None, 4	1344	conv2d_186[0][0]
activation_183 (Activation)	(None, None, None, 4	0	batch_normalization_183[0][0]
conv2d_183 (Conv2D)	(None, None, None, 3	786432	mixed9[0][0]
conv2d_187 (Conv2D)	(None, None, None, 3	1548288	activation_183[0][0]
batch_normalization_180 (BatchN	(None, None, None, 3	1152	conv2d_183[0][0]
batch_normalization_184 (BatchN	(None, None, None, 3	1152	conv2d_187[0][0]
activation_180 (Activation)	(None, None, None, 3	0	batch_normalization_180[0][0]
activation_184 (Activation)	(None, None, None, 3	0	batch_normalization_184[0][0]
conv2d_184 (Conv2D)	(None, None, None, 3	442368	activation_180[0][0]
conv2d_185 (Conv2D)	(None, None, None, 3	442368	activation_180[0][0]
conv2d_188 (Conv2D)	(None, None, None, 3	442368	activation_184[0][0]
conv2d_189 (Conv2D)	(None, None, None, 3	442368	activation_184[0][0]
average_pooling2d_17 (AveragePo	(None, None, None, 2	0	mixed9[0][0]
conv2d_182 (Conv2D)	(None, None, None, 3	655360	mixed9[0][0]
batch_normalization_181 (BatchN	(None, None, None, 3	1152	conv2d_184[0][0]
batch_normalization_182 (BatchN	(None, None, None, 3	1152	conv2d_185[0][0]
batch_normalization_185 (BatchN	(None, None, None, 3	1152	conv2d_188[0][0]
batch_normalization_186 (BatchN	(None, None, None, 3	1152	conv2d_189[0][0]
conv2d_190 (Conv2D)	(None, None, None, 1	393216	average_pooling2d_17[0][0]

```
__________
batch_normalization_179 (BatchN (None, None, None, 3 960         conv2d_182[0][0]
__________________________________________________________________________________________
__________
activation_181 (Activation)     (None, None, None, 3 0           batch_normalization_181[0][0]
__________________________________________________________________________________________
__________
activation_182 (Activation)     (None, None, None, 3 0           batch_normalization_182[0][0]
__________________________________________________________________________________________
__________
activation_185 (Activation)     (None, None, None, 3 0           batch_normalization_185[0][0]
__________________________________________________________________________________________
__________
activation_186 (Activation)     (None, None, None, 3 0           batch_normalization_186[0][0]
__________________________________________________________________________________________
__________
batch_normalization_187 (BatchN (None, None, None, 1 576         conv2d_190[0][0]
__________________________________________________________________________________________
__________
activation_179 (Activation)     (None, None, None, 3 0           batch_normalization_179[0][0]
__________________________________________________________________________________________
__________
mixed9_1 (Concatenate)          (None, None, None, 7 0           activation_181[0][0]
                                                                 activation_182[0][0]
__________________________________________________________________________________________
__________
concatenate_3 (Concatenate)     (None, None, None, 7 0           activation_185[0][0]
                                                                 activation_186[0][0]
__________________________________________________________________________________________
__________
activation_187 (Activation)     (None, None, None, 1 0           batch_normalization_187[0][0]
__________________________________________________________________________________________
__________
mixed10 (Concatenate)           (None, None, None, 2 0           activation_179[0][0]
                                                                 mixed9_1[0][0]
                                                                 concatenate_3[0][0]
                                                                 activation_187[0][0]
__________________________________________________________________________________________
__________
global_average_pooling2d_2 (Glo (None, 2048)         0           mixed10[0][0]
__________________________________________________________________________________________
__________
dense_2 (Dense)                 (None, 1024)         2098176     global_average_pooling2d_2[0][0]
__________________________________________________________________________________________
__________
dense_3 (Dense)                 (None, 1)            1025        dense_2[0][0]
==========================================================================================
==========
Total params: 23,901,985
Trainable params: 2,099,201
Non-trainable params: 21,802,784
__________________________________________________________________________________________
__________
```

In [18]:

```
from keras.optimizers import Adam     # 导入优化器Adam
model.compile(loss='categorical_crossentropy',optimizer=Adam(lr=0.001),metrics=['accuracy'])
#模型编译，损失函数为交叉熵；优化器为Adam；学习速率为0.001 ；衡量指标为精度
model.fit_generator(train_generator,epochs=1,validation_data=validation_generator)
# 训练1轮；模型训练，用训练集
```

```
150/150 [                              ] - 968s 6s/step - loss: 1.1021e-07 - accuracy: 0.5000 - val_loss
```

150/150 [==============================] - 968s 6s/step - loss: 1.1921e-07 - accuracy: 0.5000 - val_loss: 1.1921e-07 - val_accuracy: 0.5000

Out[18]:

<tensorflow.python.keras.callbacks.History at 0x1d7c3cbd108>

VGG16

In [26]:

```
from keras.applications.vgg16 import VGG16
from keras.models import Sequential
from keras.layers import Conv2D,MaxPool2D,Activation,Dropout,Flatten,Dense
from keras.optimizers import SGD
from keras.preprocessing.image import ImageDataGenerator,img_to_array,load_img
```

In [27]:

```
vgg16_model = VGG16(weights='imagenet',include_top=False, input_shape=(150,150,3))
```

In [28]:

```
vgg16_model.summary()
```

Model: "vgg16"

Layer (type)	Output Shape	Param #
input_5 (InputLayer)	[(None, 150, 150, 3)]	0
block1_conv1 (Conv2D)	(None, 150, 150, 64)	1792
block1_conv2 (Conv2D)	(None, 150, 150, 64)	36928
block1_pool (MaxPooling2D)	(None, 75, 75, 64)	0
block2_conv1 (Conv2D)	(None, 75, 75, 128)	73856
block2_conv2 (Conv2D)	(None, 75, 75, 128)	147584
block2_pool (MaxPooling2D)	(None, 37, 37, 128)	0
block3_conv1 (Conv2D)	(None, 37, 37, 256)	295168
block3_conv2 (Conv2D)	(None, 37, 37, 256)	590080
block3_conv3 (Conv2D)	(None, 37, 37, 256)	590080
block3_pool (MaxPooling2D)	(None, 18, 18, 256)	0
block4_conv1 (Conv2D)	(None, 18, 18, 512)	1180160
block4_conv2 (Conv2D)	(None, 18, 18, 512)	2359808
block4_conv3 (Conv2D)	(None, 18, 18, 512)	2359808
block4_pool (MaxPooling2D)	(None, 9, 9, 512)	0
block5_conv1 (Conv2D)	(None, 9, 9, 512)	2359808

```
block5_conv2 (Conv2D)        (None, 9, 9, 512)         2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 9, 9, 512)         2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 4, 4, 512)         0
=================================================================
Total params: 14,714,688
Trainable params: 14,714,688
Non-trainable params: 0
_________________________________________________________________
```

In [30]:

```
# 搭建全连接层
top_model = Sequential()
top_model.add(Flatten(input_shape=vgg16_model.output_shape[1:]))
top_model.add(Dense(256,activation='relu'))
top_model.add(Dropout(0.5))
top_model.add(Dense(2,activation='softmax'))
model1 = Sequential()
model1.add(vgg16_model)
model1.add(top_model)
```

In [ ]:

```
# 定义优化器，代价函数，训练过程中计算准确率
model1.compile(loss='categorical_crossentropy',optimizer=Adam(lr=0.001),metrics=['accuracy'])
model1.fit_generator(train_generator,epochs=1,validation_data=validation_generator)
```

```
 95/150 [==================>.....] - ETA: 54:57 - loss: 10.1764 - accuracy: 0.5481
```

In [ ]: