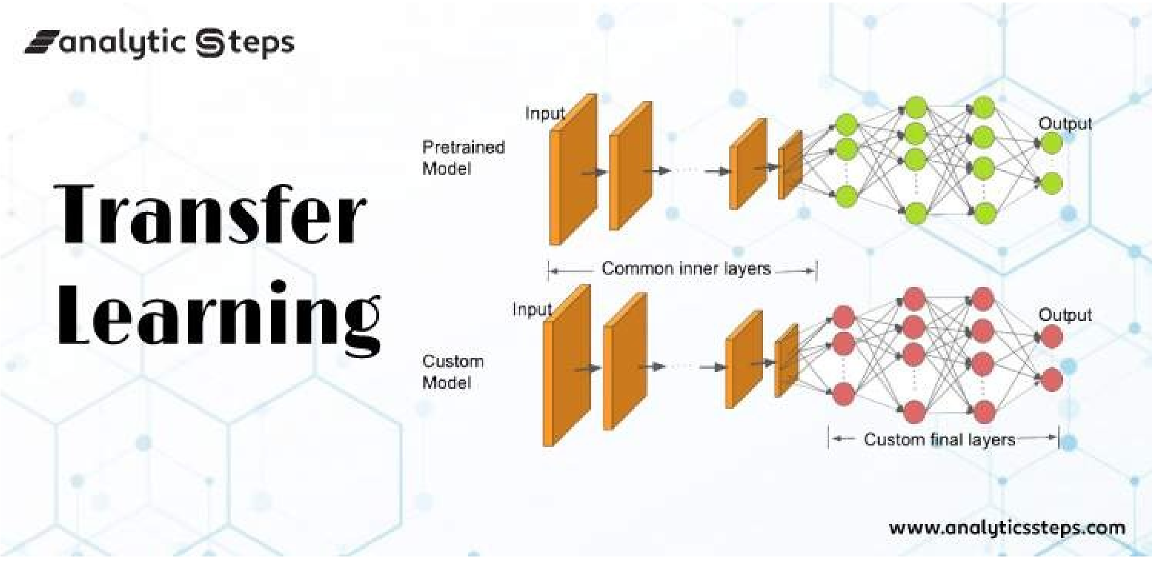
Transfer Learning using Feature Extraction Method -- Without Data Augmentation

Transfer learning is a machine learning `technique that allows a model trained on one task to be reused or adapted for a different task`. There are two main types of transfer learning:

- `Feature Extraction:` In feature extraction, a pre-trained model is used as a fixed feature extractor. The pre-trained model is typically trained on a large dataset, such as ImageNet, and the final layer(s) that output the class predictions are removed. The remaining layers are then used as a feature extractor for a new dataset. These extracted features can be used as input to train a new model on the new dataset.
- `Fine-tuning:` In fine-tuning, a pre-trained model is used as an initialization for a new model. The pre-trained model is typically trained on a large dataset, such as ImageNet, and the final layer(s) that output the class predictions are replaced with new ones for the new task. The new model is then trained on the new dataset while keeping the weights of the pre-trained layers fixed or with a small learning rate.



In [ ]:
```
!mkdir -p ~/.kaggle
!cp kaggle.json ~/.kaggle/
```

Downloading & Loading the dataset

In [ ]:
```
!kaggle datasets download -d salader/dogs-vs-cats
```

```
Warning: Your Kaggle API key is readable by other users on this system! To fix this, you can run 'chmod 600 /ro
ot/.kaggle/kaggle.json'
Downloading dogs-vs-cats.zip to /content
 99% 1.06G/1.06G [00:07<00:00, 141MB/s]
100% 1.06G/1.06G [00:07<00:00, 162MB/s]
```

In [ ]:
```
import zipfile
zip_ref = zipfile.ZipFile('/content/dogs-vs-cats.zip', 'r')
zip_ref.extractall('/content')
zip_ref.close()
```

Import Necessary Libraries

In [ ]:
```
import tensorflow
from tensorflow import keras
from keras import Sequential
from keras.layers import Dense,Flatten
from keras.applications.vgg16 import VGG16
```

Defining the Convolutional Base & Freezing it & discarding the top layer (Dense Layer to train again)

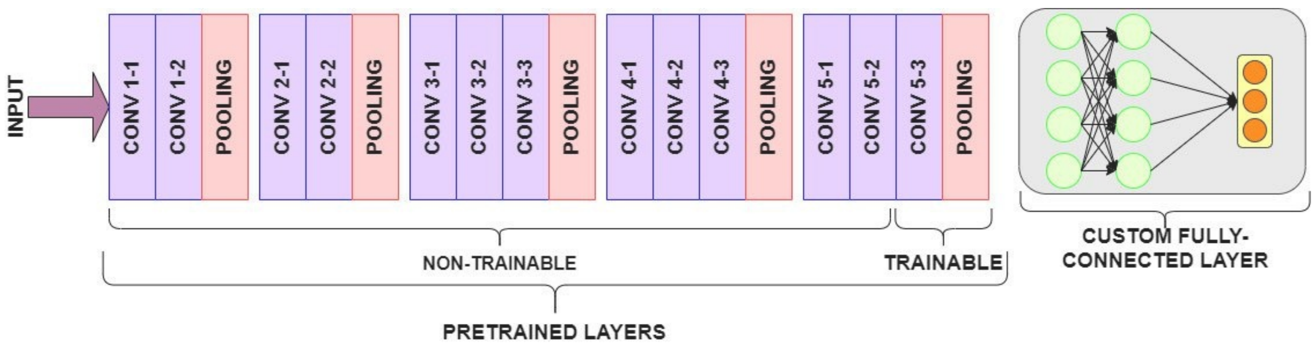
In [ ]:
```
conv_base = VGG16(
    weights='imagenet',
    include_top = False,
    input_shape=(150,150,3)
)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_o
rdering_tf_kernels_notop.h5
58892288/58889256 [==============================] - 0s 0us/step
58900480/58889256 [==============================] - 0s 0us/step
```

In [ ]:
```
conv_base.summary()
```

```
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (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
_________________________________________________________________
```

From the model.summary(), it can be easilty insighted that we're only proceeding with the convolutional layer(conv_base) only.



If we notice that the last block is the block5 ending with the maxpooling layer for block5:

block5_conv1 (Conv2D) (None, 9, 9, 512) 2359808

block5_conv2 (Conv2D) (None, 9, 9, 512) 2359808

block5_conv3 (Conv2D) (None, 9, 9, 512) 2359808

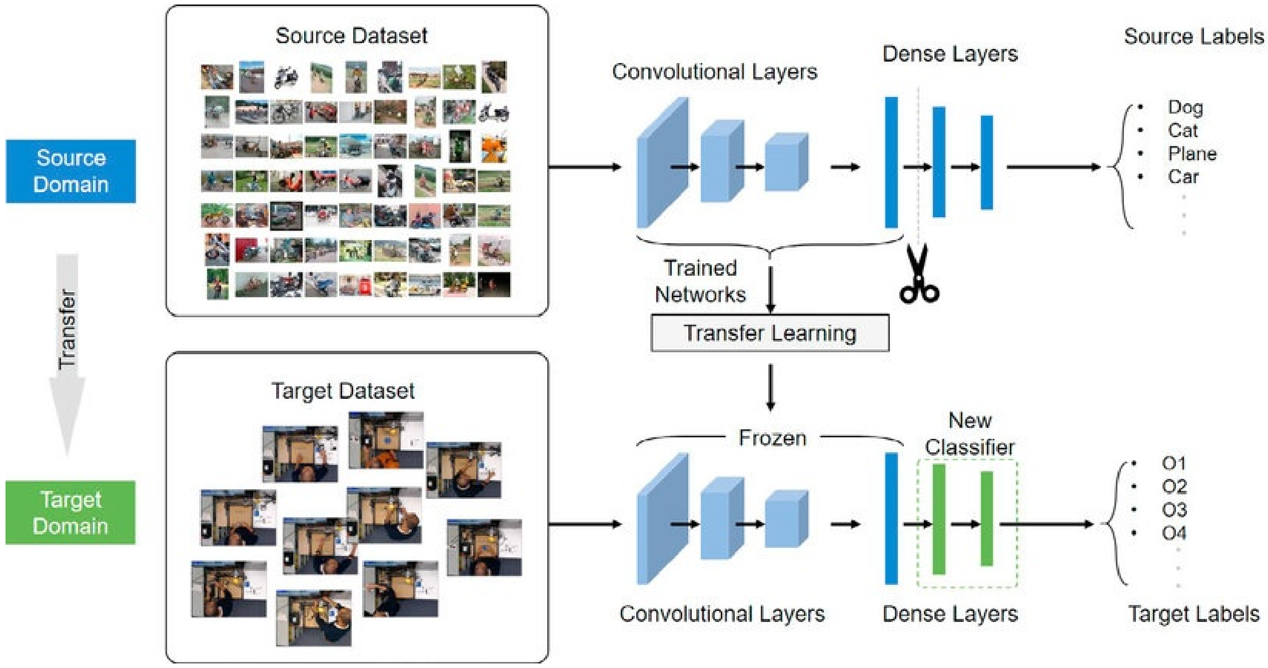
block5_pool (MaxPooling2D) (None, 4, 4, 512) 0

Defining the sequential model & adding the conv_base

```
In [ ]: model = Sequential()

model.add(conv_base)
model.add(Flatten())
model.add(Dense(256,activation='relu'))
model.add(Dense(1,activation='sigmoid'))
```

```
In [ ]: model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg16 (Functional)          (None, 4, 4, 512)         14714688

 flatten (Flatten)           (None, 8192)              0

 dense (Dense)               (None, 256)               2097408

 dense_1 (Dense)             (None, 1)                 257

=================================================================
Total params: 16,812,353
Trainable params: 2,097,665
Non-trainable params: 14,714,688
_________________________________________________________________
```



Here it can be noticed that the Trainable Parameters have been reduced to `2,097,665` from `16,812,353` (After adding the **`dense layer (2,097,665) to the conv_base (14,714,688)`**).

So, this in turn prevents the training of basic features again rather to focus on the classification part to focus on, to give proper output.

```
In [ ]: conv_base.trainable = False
```

Defining Training & Validation set for model training

```
In [ ]: # generators
train_ds = keras.utils.image_dataset_from_directory(
    directory = '/content/train',
    labels='inferred',
    label_mode = 'int',
    batch_size=32,
    image_size=(150,150)
)

validation_ds = keras.utils.image_dataset_from_directory(
    directory = '/content/test',
    labels='inferred',
    label_mode = 'int',
    batch_size=32,
    image_size=(150,150)
)
```

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

Normalizing the dataset for smooth training

In [ ]:

```
# Normalize
def process(image,label):
    image = tensorflow.cast(image/255. ,tensorflow.float32)
    return image,label

train_ds = train_ds.map(process)
validation_ds = validation_ds.map(process)
```

Model Training

In [ ]:

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

In [ ]:

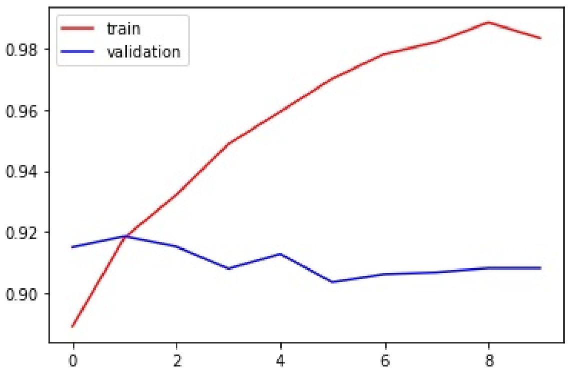
```
history = model.fit(train_ds,epochs=10,validation_data=validation_ds)
```

```
Epoch 1/10
625/625 [==============================] - 78s 105ms/step - loss: 0.2631 - accuracy: 0.8891 - val_loss: 0.2011
- val_accuracy: 0.9150
Epoch 2/10
625/625 [==============================] - 66s 106ms/step - loss: 0.1949 - accuracy: 0.9181 - val_loss: 0.1935
- val_accuracy: 0.9186
Epoch 3/10
625/625 [==============================] - 66s 106ms/step - loss: 0.1594 - accuracy: 0.9322 - val_loss: 0.2044
- val_accuracy: 0.9152
Epoch 4/10
625/625 [==============================] - 67s 107ms/step - loss: 0.1265 - accuracy: 0.9487 - val_loss: 0.2370
- val_accuracy: 0.9080
Epoch 5/10
625/625 [==============================] - 67s 107ms/step - loss: 0.1049 - accuracy: 0.9593 - val_loss: 0.2344
- val_accuracy: 0.9128
Epoch 6/10
625/625 [==============================] - 67s 107ms/step - loss: 0.0798 - accuracy: 0.9700 - val_loss: 0.2662
- val_accuracy: 0.9036
Epoch 7/10
625/625 [==============================] - 66s 105ms/step - loss: 0.0593 - accuracy: 0.9781 - val_loss: 0.2895
- val_accuracy: 0.9062
Epoch 8/10
625/625 [==============================] - 75s 119ms/step - loss: 0.0506 - accuracy: 0.9820 - val_loss: 0.3019
- val_accuracy: 0.9068
Epoch 9/10
625/625 [==============================] - 67s 107ms/step - loss: 0.0338 - accuracy: 0.9884 - val_loss: 0.3378
- val_accuracy: 0.9082
Epoch 10/10
625/625 [==============================] - 66s 105ms/step - loss: 0.0438 - accuracy: 0.9833 - val_loss: 0.3412
- val_accuracy: 0.9082
```

Loss curve for Accuracy

In [ ]:

```
import matplotlib.pyplot as plt

plt.plot(history.history['accuracy'],color='red',label='train')
plt.plot(history.history['val_accuracy'],color='blue',label='validation')
plt.legend()
plt.show()
```



We can see that there is a huge gap between the train & validation curve, indicating the model overfitting.

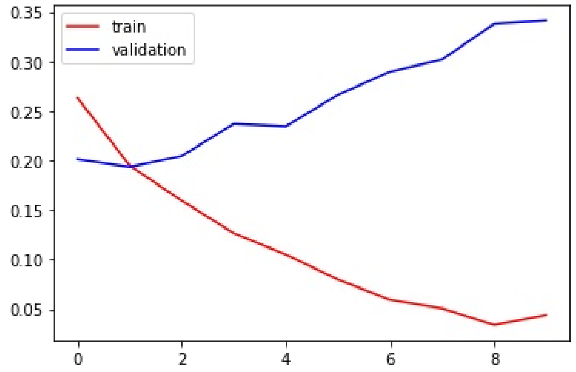
Epoch 10/10

625/625 [==============================] - 66s 105ms/step - loss: 0.0438 - accuracy: 0.9833 - val_loss: 0.3412 - val_accuracy: 0.9082

Just check the accuracy & val_accuracy change, which can be easily be seen in the loss graph as well.
This can be improved by optimizing the parameters or by increasing the no. of epochs or most importantly by using **Data Augmentation**.

Loss curve for training loss

In [ ]:
```
plt.plot(history.history['loss'],color='red',label='train')
plt.plot(history.history['val_loss'],color='blue',label='validation')
plt.legend()
plt.show()
```



Epoch 10/10

625/625 [==============================] - 66s 105ms/step - loss: 0.0438 - accuracy: 0.9833 - val_loss: 0.3412 - val_accuracy: 0.9082

Check the val_loss & the loss values, the gap shows how the model is overfitted.

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In [ ]:

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