In [14]:
```
from google.colab import files
files.upload()
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

Out[14]:
```
Saving kaggle (1).json to kaggle (1).json
{'kaggle (1).json': b'{"username":"bharathchennu","key":"ab164c33ab4621f66848fc0885b5
555a"}'}
```

In [2]:
```
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
!cd ~/.kaggle/
```

In [3]:
```
!kaggle competitions download -c dogs-vs-cats
```

```
Downloading dogs-vs-cats.zip to /content
 99% 805M/812M [00:05<00:00, 177MB/s]
100% 812M/812M [00:05<00:00, 166MB/s]
```

In [4]:
```
!unzip -qq dogs-vs-cats.zip
!unzip -qq train.zip
```

Train sample 1000, Validation 500, Test 500:

- **Initial Setup:**

1. Initially, a training sample of 1000, validation samples of 500, and a test of 500 samples of both cat and dog images each have been taken.
2. A convolution neural network is built with 5 layers of two-dimensional convolutional layers with a filter size of 3 along with 4 max-pooling layers with a pool size of 2 and connected to an output dense layer.
3. The loss function “binary cross-entropy” was used as it was a classification model with optimizer “Adam”.

Copying Images to Train, Test and Validation Folders

In [5]:
```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)
make_subset("validation", start_index=0, end_index=500)
make_subset("test", start_index=500, end_index=1000)
make_subset("train", start_index=1000, end_index=2000)
```

Data Preprocessing

In [6]:
```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
Found 2000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
```

Model Building

In [9]:
```
from tensorflow import keras
from tensorflow.keras import layers
from keras import regularizers
inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32,kernel_size=3,activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128,kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256,kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 180, 180, 3)]     0

 rescaling (Rescaling)       (None, 180, 180, 3)       0

 conv2d (Conv2D)             (None, 178, 178, 32)      896

 max_pooling2d (MaxPooling2  (None, 89, 89, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 87, 87, 64)        18496

 max_pooling2d_1 (MaxPoolin  (None, 43, 43, 64)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 41, 41, 128)       73856

 max_pooling2d_2 (MaxPoolin  (None, 20, 20, 128)       0
 g2D)

 conv2d_3 (Conv2D)           (None, 18, 18, 256)       295168

 max_pooling2d_3 (MaxPoolin  (None, 9, 9, 256)         0
 g2D)

 conv2d_4 (Conv2D)           (None, 7, 7, 256)         590080

 flatten (Flatten)           (None, 12544)             0

 dense (Dense)               (None, 1)                 12545

=================================================================
Total params: 991041 (3.78 MB)
Trainable params: 991041 (3.78 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [ ]:
```
from keras.optimizers import Adam
model.compile(loss="binary_crossentropy",
             optimizer="adam",
              metrics=["accuracy"])
```

In [ ]:
```
for data_batch, labels_batch in train_dataset:
    print("data batch shape:", data_batch.shape)
    print("labels batch shape:", labels_batch.shape)
    break
```

```
data batch shape: (32, 180, 180, 3)
labels batch shape: (32,)
```

In [ ]:
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
```

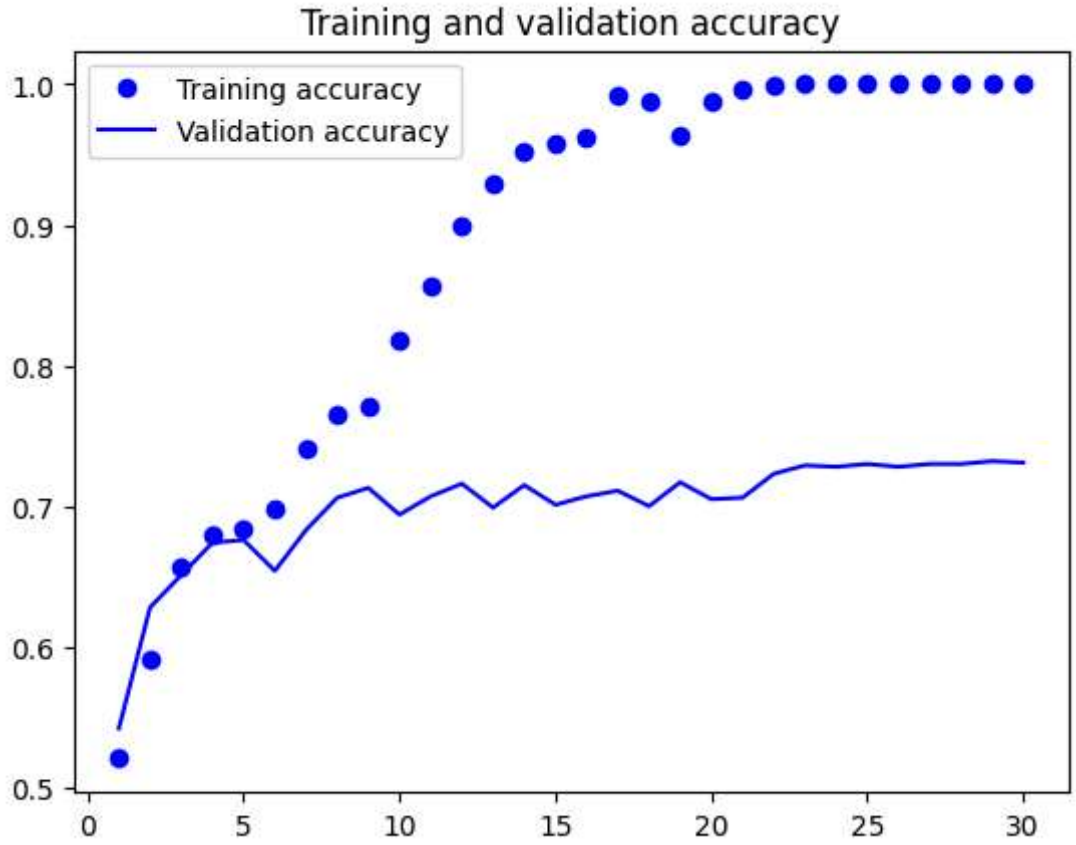
```
    train_dataset,
    epochs=20,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

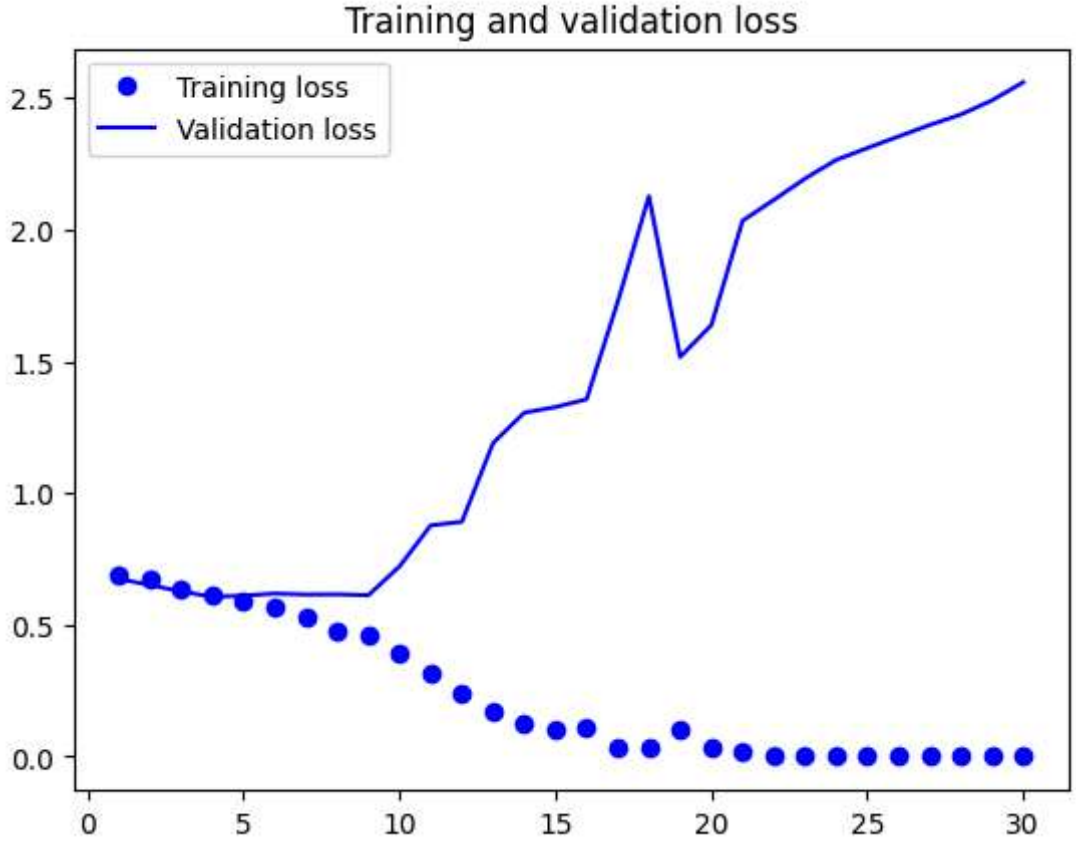
```
Epoch 1/30
63/63 [==============================] - 7s 34ms/step - loss: 0.6906 - accuracy: 0.52
05 - val_loss: 0.6742 - val_accuracy: 0.5420
Epoch 2/30
63/63 [==============================] - 2s 23ms/step - loss: 0.6704 - accuracy: 0.59
05 - val_loss: 0.6512 - val_accuracy: 0.6280
Epoch 3/30
63/63 [==============================] - 1s 23ms/step - loss: 0.6331 - accuracy: 0.65
65 - val_loss: 0.6264 - val_accuracy: 0.6510
Epoch 4/30
63/63 [==============================] - 2s 23ms/step - loss: 0.6097 - accuracy: 0.67
90 - val_loss: 0.6065 - val_accuracy: 0.6740
Epoch 5/30
63/63 [==============================] - 2s 23ms/step - loss: 0.5914 - accuracy: 0.68
45 - val_loss: 0.6108 - val_accuracy: 0.6760
Epoch 6/30
63/63 [==============================] - 1s 22ms/step - loss: 0.5667 - accuracy: 0.69
80 - val_loss: 0.6188 - val_accuracy: 0.6540
Epoch 7/30
63/63 [==============================] - 1s 22ms/step - loss: 0.5297 - accuracy: 0.74
15 - val_loss: 0.6151 - val_accuracy: 0.6830
Epoch 8/30
63/63 [==============================] - 1s 22ms/step - loss: 0.4780 - accuracy: 0.76
55 - val_loss: 0.6159 - val_accuracy: 0.7060
Epoch 9/30
63/63 [==============================] - 1s 21ms/step - loss: 0.4626 - accuracy: 0.77
15 - val_loss: 0.6124 - val_accuracy: 0.7130
Epoch 10/30
63/63 [==============================] - 1s 21ms/step - loss: 0.3951 - accuracy: 0.81
85 - val_loss: 0.7217 - val_accuracy: 0.6940
Epoch 11/30
63/63 [==============================] - 1s 21ms/step - loss: 0.3181 - accuracy: 0.85
60 - val_loss: 0.8775 - val_accuracy: 0.7070
Epoch 12/30
63/63 [==============================] - 1s 21ms/step - loss: 0.2431 - accuracy: 0.89
90 - val_loss: 0.8911 - val_accuracy: 0.7160
Epoch 13/30
63/63 [==============================] - 1s 21ms/step - loss: 0.1739 - accuracy: 0.92
95 - val_loss: 1.1898 - val_accuracy: 0.6990
Epoch 14/30
63/63 [==============================] - 1s 21ms/step - loss: 0.1225 - accuracy: 0.95
15 - val_loss: 1.3050 - val_accuracy: 0.7150
Epoch 15/30
63/63 [==============================] - 1s 21ms/step - loss: 0.1052 - accuracy: 0.95
85 - val_loss: 1.3263 - val_accuracy: 0.7010
Epoch 16/30
63/63 [==============================] - 1s 22ms/step - loss: 0.1075 - accuracy: 0.96
15 - val_loss: 1.3561 - val_accuracy: 0.7070
Epoch 17/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0360 - accuracy: 0.99
20 - val_loss: 1.7265 - val_accuracy: 0.7110
Epoch 18/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0325 - accuracy: 0.98
80 - val_loss: 2.1266 - val_accuracy: 0.7000
Epoch 19/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0997 - accuracy: 0.96
40 - val_loss: 1.5165 - val_accuracy: 0.7170
Epoch 20/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0373 - accuracy: 0.98
75 - val_loss: 1.6372 - val_accuracy: 0.7050
```

```
Epoch 21/30
63/63 [==============================] - 1s 21ms/step - loss: 0.0192 - accuracy: 0.99
60 - val_loss: 2.0332 - val_accuracy: 0.7060
Epoch 22/30
63/63 [==============================] - 1s 21ms/step - loss: 0.0055 - accuracy: 0.99
95 - val_loss: 2.1120 - val_accuracy: 0.7230
Epoch 23/30
63/63 [==============================] - 1s 21ms/step - loss: 0.0020 - accuracy: 1.00
00 - val_loss: 2.1930 - val_accuracy: 0.7290
Epoch 24/30
63/63 [==============================] - 1s 21ms/step - loss: 6.9427e-04 - accuracy:
1.0000 - val_loss: 2.2640 - val_accuracy: 0.7280
Epoch 25/30
63/63 [==============================] - 1s 21ms/step - loss: 4.0110e-04 - accuracy:
1.0000 - val_loss: 2.3091 - val_accuracy: 0.7300
Epoch 26/30
63/63 [==============================] - 1s 21ms/step - loss: 3.1333e-04 - accuracy:
1.0000 - val_loss: 2.3529 - val_accuracy: 0.7280
Epoch 27/30
63/63 [==============================] - 1s 21ms/step - loss: 2.5498e-04 - accuracy:
1.0000 - val_loss: 2.3967 - val_accuracy: 0.7300
Epoch 28/30
63/63 [==============================] - 1s 22ms/step - loss: 2.1239e-04 - accuracy:
1.0000 - val_loss: 2.4364 - val_accuracy: 0.7300
Epoch 29/30
63/63 [==============================] - 1s 22ms/step - loss: 1.7774e-04 - accuracy:
1.0000 - val_loss: 2.4901 - val_accuracy: 0.7320
Epoch 30/30
63/63 [==============================] - 1s 22ms/step - loss: 1.4106e-04 - accuracy:
1.0000 - val_loss: 2.5587 - val_accuracy: 0.7310
```

In [ ]:

```
import matplotlib.pyplot as plt
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
plt.title("Training and validation accuracy")
plt.legend()
plt.figure()
plt.plot(epochs, loss, "bo", label="Training loss")
plt.plot(epochs, val_loss, "b", label="Validation loss")
plt.title("Training and validation loss")
plt.legend()
plt.show()
```





In [12]:
```
import matplotlib.pyplot as plt
```

In [ ]:
```
test_model = keras.models.load_model("convnet_from_scratch.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
```

```
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 10ms/step - loss: 0.6243 - accuracy: 0.65
10
Test accuracy: 0.651
```

Test accuracy of **65.1%** and test loss of **62.43%** have been obtained.

- **Final Optimized setup:**

Below are the techniques used to optimize the model and increase its performance,

1. Added data augmentation to input sample with flip, zoom, and rotation parameters.
2. Added one more dense layer after flattening layer with regularizer L2 of 0.0001.
3. Added a dropout layer with a 50% dropout rate.
4. Along with optimizer Adam, a learning rate of 0.0001 is also added

Adding Data Augmentation

In [10]:
```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.3),
        layers.RandomZoom(0.6),
    ]
)
```

In [13]:
```
import warnings
warnings.filterwarnings("ignore")
plt.figure(figsize=(10, 10))
for images, _ in train_dataset.take(1):
    for i in range(9):
        augmented_images = data_augmentation(images)
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(augmented_images[0].numpy().astype("uint8"))
        plt.axis("off")
```

In [ ]:
```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32,kernel_size=3,activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128,kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256,kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
#x = layers.Conv2D(filters=512,strides=2, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dense(512, activation='relu', kernel_regularizer=regularizers.l2(0.0001))(x
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.summary()
from keras.optimizers import Adam
```

```
model.compile(loss="binary_crossentropy",
              optimizer=Adam(learning_rate=0.0001),
               metrics=["accuracy"])
```

```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 180, 180, 3)]     0

 rescaling_1 (Rescaling)     (None, 180, 180, 3)       0

 conv2d_5 (Conv2D)           (None, 178, 178, 32)      896

 max_pooling2d_4 (MaxPoolin  (None, 89, 89, 32)        0
 g2D)

 conv2d_6 (Conv2D)           (None, 87, 87, 64)        18496

 max_pooling2d_5 (MaxPoolin  (None, 43, 43, 64)        0
 g2D)

 conv2d_7 (Conv2D)           (None, 41, 41, 128)       73856

 max_pooling2d_6 (MaxPoolin  (None, 20, 20, 128)       0
 g2D)

 conv2d_8 (Conv2D)           (None, 18, 18, 256)       295168

 max_pooling2d_7 (MaxPoolin  (None, 9, 9, 256)         0
 g2D)

 conv2d_9 (Conv2D)           (None, 7, 7, 256)         590080

 flatten_1 (Flatten)         (None, 12544)             0

 dense_1 (Dense)             (None, 512)               6423040

 dropout (Dropout)           (None, 512)               0

 dense_2 (Dense)             (None, 1)                 513

=================================================================
Total params: 7402049 (28.24 MB)
Trainable params: 7402049 (28.24 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [ ]:

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/30
63/63 [==============================] - 5s 31ms/step - loss: 0.7761 - accuracy: 0.50
35 - val_loss: 0.7564 - val_accuracy: 0.5000
Epoch 2/30
63/63 [==============================] - 2s 29ms/step - loss: 0.7297 - accuracy: 0.58
20 - val_loss: 0.7165 - val_accuracy: 0.5720
Epoch 3/30
63/63 [==============================] - 2s 30ms/step - loss: 0.7017 - accuracy: 0.62
05 - val_loss: 0.6932 - val_accuracy: 0.6610
Epoch 4/30
63/63 [==============================] - 2s 29ms/step - loss: 0.6748 - accuracy: 0.64
05 - val_loss: 0.6517 - val_accuracy: 0.6600
Epoch 5/30
63/63 [==============================] - 2s 31ms/step - loss: 0.6407 - accuracy: 0.66
25 - val_loss: 0.6266 - val_accuracy: 0.6810
Epoch 6/30
63/63 [==============================] - 2s 29ms/step - loss: 0.6090 - accuracy: 0.70
30 - val_loss: 0.5905 - val_accuracy: 0.7150
Epoch 7/30
63/63 [==============================] - 1s 22ms/step - loss: 0.5872 - accuracy: 0.72
20 - val_loss: 0.5940 - val_accuracy: 0.7160
Epoch 8/30
63/63 [==============================] - 2s 29ms/step - loss: 0.5497 - accuracy: 0.73
90 - val_loss: 0.5710 - val_accuracy: 0.7130
Epoch 9/30
63/63 [==============================] - 1s 22ms/step - loss: 0.5278 - accuracy: 0.75
70 - val_loss: 0.5740 - val_accuracy: 0.7070
Epoch 10/30
63/63 [==============================] - 2s 29ms/step - loss: 0.4969 - accuracy: 0.77
35 - val_loss: 0.5583 - val_accuracy: 0.7270
Epoch 11/30
63/63 [==============================] - 2s 29ms/step - loss: 0.4733 - accuracy: 0.79
80 - val_loss: 0.5515 - val_accuracy: 0.7410
Epoch 12/30
63/63 [==============================] - 2s 23ms/step - loss: 0.4506 - accuracy: 0.80
50 - val_loss: 0.6010 - val_accuracy: 0.7390
Epoch 13/30
63/63 [==============================] - 2s 29ms/step - loss: 0.4281 - accuracy: 0.81
80 - val_loss: 0.5505 - val_accuracy: 0.7550
Epoch 14/30
63/63 [==============================] - 1s 23ms/step - loss: 0.3798 - accuracy: 0.84
65 - val_loss: 0.5605 - val_accuracy: 0.7460
Epoch 15/30
63/63 [==============================] - 1s 22ms/step - loss: 0.3649 - accuracy: 0.85
35 - val_loss: 0.5726 - val_accuracy: 0.7580
Epoch 16/30
63/63 [==============================] - 1s 22ms/step - loss: 0.3540 - accuracy: 0.85
40 - val_loss: 0.5677 - val_accuracy: 0.7630
Epoch 17/30
63/63 [==============================] - 1s 22ms/step - loss: 0.2915 - accuracy: 0.89
10 - val_loss: 0.5734 - val_accuracy: 0.7590
Epoch 18/30
63/63 [==============================] - 1s 22ms/step - loss: 0.2627 - accuracy: 0.90
70 - val_loss: 0.5719 - val_accuracy: 0.7740
Epoch 19/30
63/63 [==============================] - 1s 22ms/step - loss: 0.2228 - accuracy: 0.92
95 - val_loss: 0.5632 - val_accuracy: 0.7850
Epoch 20/30
63/63 [==============================] - 1s 22ms/step - loss: 0.2048 - accuracy: 0.93
90 - val_loss: 0.5720 - val_accuracy: 0.7730
```

```
Epoch 21/30
63/63 [==============================] - 1s 22ms/step - loss: 0.1636 - accuracy: 0.95
05 - val_loss: 0.6330 - val_accuracy: 0.7830
Epoch 22/30
63/63 [==============================] - 2s 23ms/step - loss: 0.1818 - accuracy: 0.94
30 - val_loss: 0.6799 - val_accuracy: 0.7770
Epoch 23/30
63/63 [==============================] - 2s 23ms/step - loss: 0.1473 - accuracy: 0.95
50 - val_loss: 0.7129 - val_accuracy: 0.7740
Epoch 24/30
63/63 [==============================] - 2s 23ms/step - loss: 0.1113 - accuracy: 0.97
65 - val_loss: 0.7209 - val_accuracy: 0.7780
Epoch 25/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0941 - accuracy: 0.98
20 - val_loss: 0.9464 - val_accuracy: 0.7350
Epoch 26/30
63/63 [==============================] - 1s 22ms/step - loss: 0.1007 - accuracy: 0.97
90 - val_loss: 0.7943 - val_accuracy: 0.7700
Epoch 27/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0723 - accuracy: 0.99
10 - val_loss: 0.8400 - val_accuracy: 0.7620
Epoch 28/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0689 - accuracy: 0.99
20 - val_loss: 0.8382 - val_accuracy: 0.7700
Epoch 29/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0574 - accuracy: 0.99
50 - val_loss: 0.8519 - val_accuracy: 0.7810
Epoch 30/30
63/63 [==============================] - 1s 22ms/step - loss: 0.0511 - accuracy: 0.99
70 - val_loss: 0.9228 - val_accuracy: 0.7710
```

In [ ]:

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 9ms/step - loss: 0.5681 - accuracy: 0.741
0
Test accuracy: 0.741
```

With the addition of these techniques, the test accuracy went up to **74.1%**, and the loss was reduced to **56.81%.**

Choosing a Random train sample size

Train sample 2000, Validation 500, Test 500:

In [ ]:

```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_1")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
```

```
                                dst=dir / fname)
make_subset("validation", start_index=0, end_index=500)
make_subset("test", start_index=500, end_index=1000)
make_subset("train", start_index=1000, end_index=3000)
```

In [ ]:
```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
Found 4000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
```

In [ ]:
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation_2000.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=30,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/30
125/125 [==============================] - 3s 23ms/step - loss: 0.4282 - accuracy: 0.
8455 - val_loss: 0.5073 - val_accuracy: 0.7910
Epoch 2/30
125/125 [==============================] - 3s 23ms/step - loss: 0.3188 - accuracy: 0.
8817 - val_loss: 0.5004 - val_accuracy: 0.7980
Epoch 3/30
125/125 [==============================] - 3s 19ms/step - loss: 0.2707 - accuracy: 0.
9115 - val_loss: 0.5062 - val_accuracy: 0.8030
Epoch 4/30
125/125 [==============================] - 2s 19ms/step - loss: 0.2262 - accuracy: 0.
9252 - val_loss: 0.5214 - val_accuracy: 0.7930
Epoch 5/30
125/125 [==============================] - 3s 20ms/step - loss: 0.1878 - accuracy: 0.
9452 - val_loss: 0.5477 - val_accuracy: 0.8050
Epoch 6/30
125/125 [==============================] - 3s 20ms/step - loss: 0.1445 - accuracy: 0.
9595 - val_loss: 0.5830 - val_accuracy: 0.8150
Epoch 7/30
125/125 [==============================] - 3s 20ms/step - loss: 0.1350 - accuracy: 0.
9615 - val_loss: 0.5807 - val_accuracy: 0.8040
Epoch 8/30
125/125 [==============================] - 3s 20ms/step - loss: 0.1042 - accuracy: 0.
9765 - val_loss: 0.6959 - val_accuracy: 0.7950
Epoch 9/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0856 - accuracy: 0.
9858 - val_loss: 0.6770 - val_accuracy: 0.8170
Epoch 10/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0755 - accuracy: 0.
9875 - val_loss: 0.7055 - val_accuracy: 0.7980
Epoch 11/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0584 - accuracy: 0.
9948 - val_loss: 0.7215 - val_accuracy: 0.8170
Epoch 12/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0500 - accuracy: 0.
9970 - val_loss: 0.7941 - val_accuracy: 0.8040
Epoch 13/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0574 - accuracy: 0.
9942 - val_loss: 0.8104 - val_accuracy: 0.7900
Epoch 14/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0727 - accuracy: 0.
9872 - val_loss: 0.8395 - val_accuracy: 0.8000
Epoch 15/30
125/125 [==============================] - 2s 19ms/step - loss: 0.0543 - accuracy: 0.
9937 - val_loss: 0.7983 - val_accuracy: 0.8040
Epoch 16/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0414 - accuracy: 0.
9983 - val_loss: 0.8633 - val_accuracy: 0.8020
Epoch 17/30
125/125 [==============================] - 2s 19ms/step - loss: 0.0405 - accuracy: 0.
9983 - val_loss: 0.9108 - val_accuracy: 0.8080
Epoch 18/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0579 - accuracy: 0.
9912 - val_loss: 0.8319 - val_accuracy: 0.7970
Epoch 19/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0440 - accuracy: 0.
9977 - val_loss: 0.8391 - val_accuracy: 0.7990
Epoch 20/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0445 - accuracy: 0.
9967 - val_loss: 0.9177 - val_accuracy: 0.8100
```

```
Epoch 21/30
125/125 [==============================] - 2s 19ms/step - loss: 0.0385 - accuracy: 0.
9975 - val_loss: 1.3359 - val_accuracy: 0.7650
Epoch 22/30
125/125 [==============================] - 3s 19ms/step - loss: 0.0657 - accuracy: 0.
9872 - val_loss: 0.8737 - val_accuracy: 0.7900
Epoch 23/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0407 - accuracy: 0.
9965 - val_loss: 0.9912 - val_accuracy: 0.7900
Epoch 24/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0362 - accuracy: 0.
9992 - val_loss: 0.9905 - val_accuracy: 0.8000
Epoch 25/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0305 - accuracy: 1.
0000 - val_loss: 1.0272 - val_accuracy: 0.8030
Epoch 26/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0333 - accuracy: 0.
9990 - val_loss: 0.9589 - val_accuracy: 0.8030
Epoch 27/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0381 - accuracy: 0.
9975 - val_loss: 1.1412 - val_accuracy: 0.7770
Epoch 28/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0493 - accuracy: 0.
9930 - val_loss: 1.0767 - val_accuracy: 0.7930
Epoch 29/30
125/125 [==============================] - 3s 19ms/step - loss: 0.0610 - accuracy: 0.
9880 - val_loss: 0.9004 - val_accuracy: 0.8050
Epoch 30/30
125/125 [==============================] - 3s 20ms/step - loss: 0.0362 - accuracy: 0.
9977 - val_loss: 0.9505 - val_accuracy: 0.7920
```

In [ ]:

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation_2000.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 12ms/step - loss: 0.5336 - accuracy: 0.78
10
Test accuracy: 0.781
```

The test accuracy has been increased to **78.1%**, the loss also decreased to **53.33%.**

Train Sample: 3000

In [ ]:

```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_5")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)
make_subset("validation", start_index=0, end_index=500)
```

```
make_subset("test", start_index=500, end_index=1000)
make_subset("train", start_index=2000, end_index=4000)
```

In [ ]:
```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
Found 4000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
```

In [ ]:
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation_30000.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=20,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/20
125/125 [==============================] - 3s 24ms/step - loss: 0.4014 - accuracy: 0.
8595 - val_loss: 0.5851 - val_accuracy: 0.7700
Epoch 2/20
125/125 [==============================] - 3s 23ms/step - loss: 0.2295 - accuracy: 0.
9243 - val_loss: 0.5646 - val_accuracy: 0.8050
Epoch 3/20
125/125 [==============================] - 3s 20ms/step - loss: 0.1613 - accuracy: 0.
9532 - val_loss: 0.6713 - val_accuracy: 0.8070
Epoch 4/20
125/125 [==============================] - 3s 20ms/step - loss: 0.1125 - accuracy: 0.
9730 - val_loss: 0.7232 - val_accuracy: 0.8080
Epoch 5/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0809 - accuracy: 0.
9847 - val_loss: 0.7073 - val_accuracy: 0.8110
Epoch 6/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0596 - accuracy: 0.
9927 - val_loss: 0.8641 - val_accuracy: 0.8060
Epoch 7/20
125/125 [==============================] - 3s 19ms/step - loss: 0.0488 - accuracy: 0.
9960 - val_loss: 0.8803 - val_accuracy: 0.8060
Epoch 8/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0506 - accuracy: 0.
9933 - val_loss: 0.8813 - val_accuracy: 0.8090
Epoch 9/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0458 - accuracy: 0.
9965 - val_loss: 0.8989 - val_accuracy: 0.8060
Epoch 10/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0413 - accuracy: 0.
9977 - val_loss: 0.9687 - val_accuracy: 0.8120
Epoch 11/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0523 - accuracy: 0.
9927 - val_loss: 0.9135 - val_accuracy: 0.8040
Epoch 12/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0414 - accuracy: 0.
9973 - val_loss: 0.8961 - val_accuracy: 0.8080
Epoch 13/20
125/125 [==============================] - 3s 19ms/step - loss: 0.0322 - accuracy: 0.
9995 - val_loss: 0.9677 - val_accuracy: 0.8130
Epoch 14/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0292 - accuracy: 1.
0000 - val_loss: 0.9682 - val_accuracy: 0.8210
Epoch 15/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0289 - accuracy: 0.
9998 - val_loss: 1.0560 - val_accuracy: 0.7950
Epoch 16/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0292 - accuracy: 1.
0000 - val_loss: 1.0084 - val_accuracy: 0.8040
Epoch 17/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0267 - accuracy: 1.
0000 - val_loss: 1.0253 - val_accuracy: 0.8090
Epoch 18/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0257 - accuracy: 1.
0000 - val_loss: 1.0311 - val_accuracy: 0.8130
Epoch 19/20
125/125 [==============================] - 2s 19ms/step - loss: 0.0272 - accuracy: 0.
9992 - val_loss: 1.0240 - val_accuracy: 0.8000
Epoch 20/20
125/125 [==============================] - 3s 20ms/step - loss: 0.0254 - accuracy: 1.
0000 - val_loss: 1.0623 - val_accuracy: 0.8050
```

In [ ]:
```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation_30000.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 9ms/step - loss: 0.5876 - accuracy: 0.788
0
Test accuracy: 0.788
```

The test accuracy has been increased to **78.8%,** the loss also decreased to **58.76%**. Performance has been improved significantly when there is an increase in the sample size.

Train sample 4000, Validation 500, Test 500:

In [ ]:
```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_3")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)
make_subset("validation", start_index=0, end_index=500)
make_subset("test", start_index=500, end_index=1000)
make_subset("train", start_index=1000, end_index=5000)
```

In [ ]:
```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
Found 8000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
```

In [ ]:
```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation_4000.keras",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
```

```
    epochs=20,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/20
250/250 [==============================] - 5s 21ms/step - loss: 0.2585 - accuracy: 0.
9166 - val_loss: 0.4791 - val_accuracy: 0.8240
Epoch 2/20
250/250 [==============================] - 5s 18ms/step - loss: 0.1347 - accuracy: 0.
9644 - val_loss: 0.5674 - val_accuracy: 0.8210
Epoch 3/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0995 - accuracy: 0.
9746 - val_loss: 0.5733 - val_accuracy: 0.8140
Epoch 4/20
250/250 [==============================] - 5s 19ms/step - loss: 0.0594 - accuracy: 0.
9909 - val_loss: 0.7475 - val_accuracy: 0.8150
Epoch 5/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0514 - accuracy: 0.
9934 - val_loss: 0.7044 - val_accuracy: 0.8260
Epoch 6/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0526 - accuracy: 0.
9930 - val_loss: 0.7537 - val_accuracy: 0.8200
Epoch 7/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0362 - accuracy: 0.
9979 - val_loss: 0.8301 - val_accuracy: 0.8090
Epoch 8/20
250/250 [==============================] - 5s 19ms/step - loss: 0.0577 - accuracy: 0.
9893 - val_loss: 0.7506 - val_accuracy: 0.8290
Epoch 9/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0381 - accuracy: 0.
9970 - val_loss: 0.8698 - val_accuracy: 0.8100
Epoch 10/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0386 - accuracy: 0.
9967 - val_loss: 0.8518 - val_accuracy: 0.8190
Epoch 11/20
250/250 [==============================] - 5s 19ms/step - loss: 0.0290 - accuracy: 0.
9998 - val_loss: 0.9072 - val_accuracy: 0.8200
Epoch 12/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0339 - accuracy: 0.
9971 - val_loss: 1.0367 - val_accuracy: 0.7930
Epoch 13/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0351 - accuracy: 0.
9971 - val_loss: 0.9628 - val_accuracy: 0.8230
Epoch 14/20
250/250 [==============================] - 5s 19ms/step - loss: 0.0404 - accuracy: 0.
9948 - val_loss: 0.8865 - val_accuracy: 0.8010
Epoch 15/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0431 - accuracy: 0.
9945 - val_loss: 0.8942 - val_accuracy: 0.8270
Epoch 16/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0460 - accuracy: 0.
9933 - val_loss: 0.7595 - val_accuracy: 0.8390
Epoch 17/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0303 - accuracy: 0.
9987 - val_loss: 0.9124 - val_accuracy: 0.8140
Epoch 18/20
250/250 [==============================] - 5s 19ms/step - loss: 0.0382 - accuracy: 0.
9960 - val_loss: 0.9227 - val_accuracy: 0.8180
Epoch 19/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0416 - accuracy: 0.
9951 - val_loss: 0.9651 - val_accuracy: 0.8100
Epoch 20/20
250/250 [==============================] - 5s 18ms/step - loss: 0.0363 - accuracy: 0.
9969 - val_loss: 0.9699 - val_accuracy: 0.8250
```

In [ ]:
```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation_4000.keras")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 10ms/step - loss: 0.5068 - accuracy: 0.82
50
Test accuracy: 0.825
```

The test accuracy has been increased to **82.5%**, also loss decreased to **50.68%.** Performance has increased significantly when there is an increase in the sample size furthermore.

Defining Optimal Train Sample Size: As the training sample size increases from 1000 to 4000, from the above results it can be observed that,

- The accuracy increased as the sample size is being increased.
- At 3000, accuracy has increased significantly, and the loss increased along with it.
- But at 4000, the model seems to be performing good as the accuracy increased and test loss also decreased along with it.
- we can observe that sample size **4000** will be the optimal sample size for the model with **82.5%** test accuracy and **50.68%** test loss.

Use of Pre-Trained Network VGG-16:

- A pre-trained convolution network vgg16 has been taken for implementation of the model for a train sample size of 4000.
- Data augmentation is done to inputs and freeze the first 4 blocks in the pre-trained vgg16 model.
- Added a dense layer and a dropout rate of 50%.
- Adam optimizer with a learning rate of 0.0001 was used and the model was trained with a sample size of 4000.

In [ ]:
```
conv_base = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False,
    input_shape=(180, 180, 3))
conv_base.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vg
g16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 [==============================] - 2s 0us/step
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_3 (InputLayer)        [(None, 180, 180, 3)]     0

 block1_conv1 (Conv2D)       (None, 180, 180, 64)      1792

 block1_conv2 (Conv2D)       (None, 180, 180, 64)      36928

 block1_pool (MaxPooling2D)  (None, 90, 90, 64)        0

 block2_conv1 (Conv2D)       (None, 90, 90, 128)       73856

 block2_conv2 (Conv2D)       (None, 90, 90, 128)       147584

 block2_pool (MaxPooling2D)  (None, 45, 45, 128)       0

 block3_conv1 (Conv2D)       (None, 45, 45, 256)       295168

 block3_conv2 (Conv2D)       (None, 45, 45, 256)       590080

 block3_conv3 (Conv2D)       (None, 45, 45, 256)       590080

 block3_pool (MaxPooling2D)  (None, 22, 22, 256)       0

 block4_conv1 (Conv2D)       (None, 22, 22, 512)       1180160

 block4_conv2 (Conv2D)       (None, 22, 22, 512)       2359808

 block4_conv3 (Conv2D)       (None, 22, 22, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 11, 11, 512)       0

 block5_conv1 (Conv2D)       (None, 11, 11, 512)       2359808

 block5_conv2 (Conv2D)       (None, 11, 11, 512)       2359808

 block5_conv3 (Conv2D)       (None, 11, 11, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 5, 5, 512)         0

=================================================================
Total params: 14714688 (56.13 MB)
Trainable params: 14714688 (56.13 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [ ]:

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.3),
        layers.RandomZoom(0.6)
    ]
)

conv_base.trainable = True
```

```
for layer in conv_base.layers[:-4]:
    layer.trainable = False

inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
from keras.optimizers import Adam
model.compile(loss="binary_crossentropy",
             optimizer=Adam(learning_rate=0.0001),
              metrics=["accuracy"])
```

In [ ]:

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="vgg16_with_data_augmentation.h5",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=20,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/20
250/250 [==============================] - 11s 43ms/step - loss: 0.2420 - accuracy:
0.9001 - val_loss: 0.0966 - val_accuracy: 0.9630
Epoch 2/20
250/250 [==============================] - 11s 43ms/step - loss: 0.2154 - accuracy:
0.9118 - val_loss: 0.0861 - val_accuracy: 0.9650
Epoch 3/20
250/250 [==============================] - 11s 43ms/step - loss: 0.1925 - accuracy:
0.9212 - val_loss: 0.0774 - val_accuracy: 0.9750
Epoch 4/20
250/250 [==============================] - 11s 43ms/step - loss: 0.2105 - accuracy:
0.9144 - val_loss: 0.0551 - val_accuracy: 0.9790
Epoch 5/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1836 - accuracy:
0.9243 - val_loss: 0.0692 - val_accuracy: 0.9670
Epoch 6/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1704 - accuracy:
0.9289 - val_loss: 0.1031 - val_accuracy: 0.9590
Epoch 7/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1643 - accuracy:
0.9365 - val_loss: 0.0618 - val_accuracy: 0.9770
Epoch 8/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1529 - accuracy:
0.9381 - val_loss: 0.0627 - val_accuracy: 0.9820
Epoch 9/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1346 - accuracy:
0.9460 - val_loss: 0.0615 - val_accuracy: 0.9780
Epoch 10/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1260 - accuracy:
0.9457 - val_loss: 0.0783 - val_accuracy: 0.9770
Epoch 11/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1308 - accuracy:
0.9490 - val_loss: 0.0629 - val_accuracy: 0.9780
Epoch 12/20
250/250 [==============================] - 10s 42ms/step - loss: 0.1327 - accuracy:
0.9481 - val_loss: 0.1300 - val_accuracy: 0.9590
Epoch 13/20
250/250 [==============================] - 11s 43ms/step - loss: 0.1284 - accuracy:
0.9491 - val_loss: 0.0510 - val_accuracy: 0.9820
Epoch 14/20
250/250 [==============================] - 11s 43ms/step - loss: 0.1289 - accuracy:
0.9500 - val_loss: 0.0448 - val_accuracy: 0.9790
Epoch 15/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1220 - accuracy:
0.9536 - val_loss: 0.0606 - val_accuracy: 0.9740
Epoch 16/20
250/250 [==============================] - 10s 42ms/step - loss: 0.1103 - accuracy:
0.9569 - val_loss: 0.0638 - val_accuracy: 0.9750
Epoch 17/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1114 - accuracy:
0.9578 - val_loss: 0.0497 - val_accuracy: 0.9820
Epoch 18/20
250/250 [==============================] - 10s 42ms/step - loss: 0.1060 - accuracy:
0.9556 - val_loss: 0.0604 - val_accuracy: 0.9790
Epoch 19/20
250/250 [==============================] - 11s 42ms/step - loss: 0.1119 - accuracy:
0.9544 - val_loss: 0.0543 - val_accuracy: 0.9780
Epoch 20/20
250/250 [==============================] - 10s 41ms/step - loss: 0.1048 - accuracy:
0.9620 - val_loss: 0.0604 - val_accuracy: 0.9760
```

In [ ]:
```
test_model = keras.models.load_model(
    "vgg16_with_data_augmentation.h5")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 1s 31ms/step - loss: 0.0650 - accuracy: 0.98
30
Test accuracy: 0.983
```

The performance of the model has been increased significantly with a test accuracy of **98.3%** and **6.5%.**

Conclusion

In short, picking the right training sample size and network is tricky and depends on lots of things like the data you have, the type of model you're using, and how you optimize it. Usually, having more data helps, but there's no one-size-fits-all answer. Things like tweaking how you train the model, like adding more data or adjusting settings, can make a big difference.

For our model, we found that with 4000 training samples, we got the best accuracy at 82.5% and less loss at 50.68%. Adding more samples might make the model too specific to the training data. We also tried using a pre-trained model called VGG16, which already learned a lot from big datasets. With that, we got an accuracy of 98.3% and only 6.5% loss, even with fewer samples.

Fine-tuning the pre-trained model for our specific task made it even better. Overall, finding the right balance between sample size and model choice takes some experimenting to get the best results.