

```
In [ ]: import numpy as np
import pandas as pd
import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing import image_dataset_from_directory
from tensorflow.keras.layers.experimental.preprocessing import RandomFlip, Random
```

```
In [38]: BATCH_SIZE = 32
IMG_SIZE = (160, 160)
directory = "C:/Users/varsh/Downloads/dataset" # Update this path

train_dataset = image_dataset_from_directory(directory,
                                              shuffle=True,
                                              batch_size=BATCH_SIZE,
                                              image_size=IMG_SIZE,
                                              validation_split=0.2,
                                              subset='training',
                                              seed=42)

validation_dataset = image_dataset_from_directory(directory,
                                                 shuffle=True,
                                                 batch_size=BATCH_SIZE,
                                                 image_size=IMG_SIZE,
                                                 validation_split=0.2,
                                                 subset='validation', # Fixed:
                                                 seed=42)
```

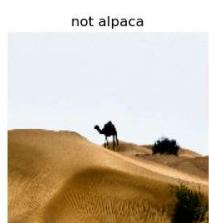
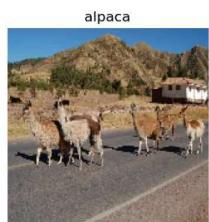
Found 327 files belonging to 2 classes.

Using 262 files for training.

Found 327 files belonging to 2 classes.

Using 65 files for validation.

```
In [40]: class_names = train_dataset.class_names
plt.figure(figsize=(18, 18))
for images, labels in train_dataset.take(1):
    for i in range(10):
        ax = plt.subplot(4, 5, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(class_names[labels[i]])
        plt.axis("off")
```

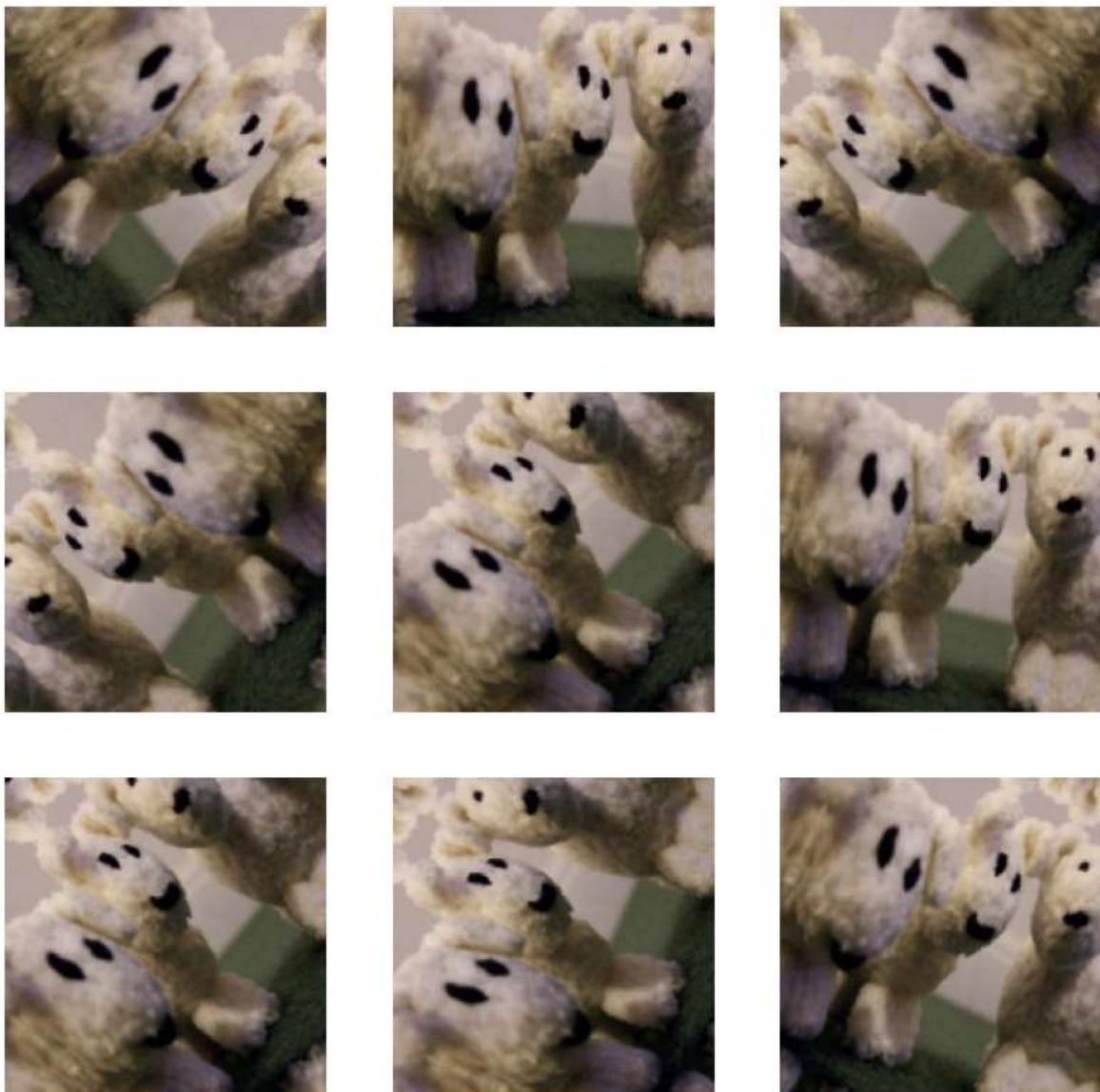


```
In [132...]: def data_augmenter():
    data_augmentation = tf.keras.Sequential()
    data_augmentation.add(RandomFlip("horizontal"))
    data_augmentation.add(RandomRotation(0.2))
    return data_augmentation

data_augmentation = data_augmenter()

# Visualize augmented images
for image, _ in train_dataset.take(1): # Corrected: added a space between '_' and 'an'
    plt.figure(figsize=(10, 10))
    first_image = image[0]
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        augmented_image = data_augmentation(tf.expand_dims(first_image, 0))
        plt.imshow(augmented_image[0] / 255)
        plt.axis('off')

plt.show() # Ensure to display the plot
```



```
base_model.summary()  
weights='imagenet')
```

Model: "mobilenetv2_1.00_160"

Layer (type)	Output Shape	Param #	Connected to
<hr/>			
input_2 (InputLayer)	[(None, 160, 160, 3)]	0	[]
Conv1 (Conv2D) [0]']	(None, 80, 80, 32)	864	['input_2[0]
bn_Conv1 (BatchNormalizati [0]'] on)	(None, 80, 80, 32)	128	['Conv1[0]
Conv1_relu (ReLU) [0]']	(None, 80, 80, 32)	0	['bn_Conv1[0]
expanded_conv_depthwise (D [0][0]'] epthwiseConv2D)	(None, 80, 80, 32)	288	['Conv1_relu
expanded_conv_depthwise_BN v_depthwise[0][0] (BatchNormalization)	(None, 80, 80, 32)	128	['expanded_con]']
expanded_conv_depthwise_re v_depthwise_BN[0 lu (ReLU)	(None, 80, 80, 32)	0	['expanded_con][0]']
expanded_conv_project (Con v_depthwise_relu v2D)	(None, 80, 80, 16)	512	['expanded_con [0][0]']
expanded_conv_project_BN (v _project[0][0]' BatchNormalization)	(None, 80, 80, 16)	64	['expanded_con]
block_1_expand (Conv2D) v_project_BN[0][(None, 80, 80, 96)	1536	['expanded_con 0]']
block_1_expand_BN (BatchNo nd[0][0]'] rmalization)	(None, 80, 80, 96)	384	['block_1_expa r']
block_1_expand_relu (ReLU) nd_BN[0][0]']	(None, 80, 80, 96)	0	['block_1_expa r']
block_1_pad (ZeroPadding2D nd_relu[0][0]'])	(None, 81, 81, 96)	0	['block_1_expa r']
block_1_depthwise (Depthwi [0][0]'] seConv2D)	(None, 40, 40, 96)	864	['block_1_pad ']
block_1_depthwise_BN (Bac hwise[0][0]'] hNormalization)	(None, 40, 40, 96)	384	['block_1_dept ']

block_1_depthwise_relu (ReLU)	(None, 40, 40, 96)	0	['block_1_dept hwise_BN[0][0]'] LU)
block_1_project (Conv2D)	(None, 40, 40, 24)	2304	['block_1_dept hwise_relu[0][0]
block_1_project_BN (BatchNormaliza	(None, 40, 40, 24)	96	['block_1_proj ct[0][0]'] ormalization)
block_2_expand (Conv2D)	(None, 40, 40, 144)	3456	['block_1_proj ect_BN[0][0]']
block_2_expand_BN (BatchNormaliza	(None, 40, 40, 144)	576	['block_2_expa nd[0][0]'] rmalization)
block_2_expand_relu (ReLU)	(None, 40, 40, 144)	0	['block_2_expa nd_BN[0][0]']
block_2_depthwise (DepthwiseConv2D)	(None, 40, 40, 144)	1296	['block_2_expa nd_relu[0][0]'] seConv2D)
block_2_depthwise_BN (BatchNormaliza	(None, 40, 40, 144)	576	['block_2_dept hwise[0][0]'] hNormalization)
block_2_depthwise_relu (ReLU)	(None, 40, 40, 144)	0	['block_2_dept hwise_BN[0][0]'] LU)
block_2_project (Conv2D)	(None, 40, 40, 24)	3456	['block_2_dept hwise_relu[0][0]
block_2_project_BN (BatchNormaliza	(None, 40, 40, 24)	96	['block_2_proj ct[0][0]'] ormalization)
block_2_add (Add)	(None, 40, 40, 24)	0	['block_1_proj ect_BN[0][0]', 'block_2_proj ect_BN[0][0]']
block_3_expand (Conv2D)	(None, 40, 40, 144)	3456	['block_2_add [0][0]']
block_3_expand_BN (BatchNormaliza	(None, 40, 40, 144)	576	['block_3_expa nd[0][0]'] rmalization)
block_3_expand_relu (ReLU)	(None, 40, 40, 144)	0	['block_3_expa nd_BN[0][0]']
block_3_pad (ZeroPadding2D)	(None, 41, 41, 144)	0	['block_3_expa nd_relu[0][0]'])

block_3_depthwise (DepthwiseConv2D)	(None, 20, 20, 144)	1296	['block_3_pad[0][0]']
block_3_depthwise_BN (BatchNormalization[0][0])	(None, 20, 20, 144)	576	['block_3_dept_hNormalization']
block_3_depthwise_relu (ReLU)	(None, 20, 20, 144)	0	['block_3_dept_LU']
block_3_project (Conv2D)	(None, 20, 20, 32)	4608	['block_3_dept_hwise_relu[0][0]']
block_3_project_BN (BatchNormalization[0][0])	(None, 20, 20, 32)	128	['block_3_project_normalization']
block_4_expand (Conv2D)	(None, 20, 20, 192)	6144	['block_3_project_BN[0][0]']
block_4_expand_BN (BatchNormalization[0][0])	(None, 20, 20, 192)	768	['block_4_expand_normalization']
block_4_expand_relu (ReLU)	(None, 20, 20, 192)	0	['block_4_expand_BN[0][0]']
block_4_depthwise (DepthwiseConv2D)	(None, 20, 20, 192)	1728	['block_4_expand_nd_relu[0][0]']
block_4_depthwise_BN (BatchNormalization[0][0])	(None, 20, 20, 192)	768	['block_4_dept_hwise[0][0]']
block_4_depthwise_relu (ReLU)	(None, 20, 20, 192)	0	['block_4_dept_hwise_BN[0][0]']
block_4_project (Conv2D)	(None, 20, 20, 32)	6144	['block_4_dept_hwise_relu[0][0]']
block_4_project_BN (BatchNormalization[0][0])	(None, 20, 20, 32)	128	['block_4_project_normalization']
block_4_add (Add)	(None, 20, 20, 32)	0	['block_3_project_BN[0][0]', 'block_4_project_BN[0][0]']
block_5_expand (Conv2D)	(None, 20, 20, 192)	6144	['block_4_add[0][0]']
block_5_expand_BN (BatchNormalization[0][0])	(None, 20, 20, 192)	768	['block_5_expand_normalization']

block_5_expand_relu (ReLU) (None, 20, 20, 192)	0	['block_5_expa nd_BN[0][0]']
block_5_depthwise (Depthwi (None, 20, 20, 192) nd_relu[0][0]'] seConv2D)	1728	['block_5_expa nd_BN[0][0]']
block_5_depthwise_BN (Batch (None, 20, 20, 192) hwise[0][0]'] hNormalization)	768	['block_5_dept hwise_BN[0][0]']
block_5_depthwise_relu (Re (None, 20, 20, 192) hwise_BN[0][0]'] LU)	0	['block_5_dept hwise_BN[0][0]']
block_5_project (Conv2D) (None, 20, 20, 32) hwise_relu[0][0]	6144	['block_5_dept hwise_relu[0][0]']
block_5_project_BN (BatchN (None, 20, 20, 32) ect[0][0]'] ormalization)	128	['block_5_pro ject_BN[0][0]']
block_5_add (Add) (None, 20, 20, 32) [0][0]', ect_BN[0][0]']	0	['block_4_add ect_BN[0][0]']
block_6_expand (Conv2D) (None, 20, 20, 192) [0][0]'	6144	['block_5_add [0][0]']
block_6_expand_BN (BatchNo (None, 20, 20, 192) nd[0][0]'] rmalization)	768	['block_6_expa nd[0][0]']
block_6_expand_relu (ReLU) (None, 20, 20, 192) nd_BN[0][0]']	0	['block_6_expa nd_BN[0][0]']
block_6_pad (ZeroPadding2D (None, 21, 21, 192) nd_relu[0][0]'])	0	['block_6_expa nd_BN[0][0]']
block_6_depthwise (Depthwi (None, 10, 10, 192) [0][0]'] seConv2D)	1728	['block_6_pad [0][0]']
block_6_depthwise_BN (Batch (None, 10, 10, 192) hwise[0][0]'] hNormalization)	768	['block_6_dept hwise[0][0]']
block_6_depthwise_relu (Re (None, 10, 10, 192) hwise_BN[0][0]'] LU)	0	['block_6_dept hwise_BN[0][0]']
block_6_project (Conv2D) (None, 10, 10, 64) hwise_relu[0][0]	12288	['block_6_dept hwise_relu[0][0]']
block_6_project_BN (BatchN (None, 10, 10, 64) ect[0][0]']	256	['block_6_pro ject_BN[0][0]']

ormalization)			
block_7_expand (Conv2D) (None, 10, 10, 384)	24576	['block_6_proj ect_BN[0][0]']	
block_7_expand_BN (BatchNo nd[0][0]) rnmalization)	1536	['block_7_expa	
block_7_expand_relu (ReLU) (None, 10, 10, 384)	0	nd_BN[0][0]']	['block_7_expa
block_7_depthwise (Depthwi nd_relu[0][0]) seConv2D)	3456	nd[0][0]']	['block_7_expa
block_7_depthwise_BN (Bac hwise[0][0]) hNormalization)	1536	hwise[0][0]']	['block_7_dept
block_7_depthwise_relu (Re hwise_BN[0][0]) LU)	0	hwise[0][0]']	['block_7_dept
block_7_project (Conv2D) (None, 10, 10, 64)	24576	hwise_relu[0][0]	['block_7_dept ']
block_7_project_BN (BatchN ect[0][0]) ormalization)	256	ect[0][0]']	['block_7_proj
block_7_add (Add) (None, 10, 10, 64)	0	ect_BN[0][0]',	['block_6_proj 'block_7_proj
block_7_add_BN (BatchNo nd[0][0])		ect_BN[0][0]']	
block_8_expand (Conv2D) (None, 10, 10, 384)	24576	['block_7_add [0][0]']	
block_8_expand_BN (BatchNo nd[0][0]) rnmalization)	1536	nd[0][0]']	['block_8_expa
block_8_expand_relu (ReLU) (None, 10, 10, 384)	0	nd_BN[0][0]']	['block_8_expa
block_8_depthwise (Depthwi nd_relu[0][0]) seConv2D)	3456	nd[0][0]']	['block_8_expa
block_8_depthwise_BN (Bac hwise[0][0]) hNormalization)	1536	hwise[0][0]']	['block_8_dept
block_8_depthwise_relu (Re hwise_BN[0][0]) LU)	0	hwise[0][0]']	['block_8_dept
block_8_project (Conv2D) (None, 10, 10, 64)	24576	hwise_relu[0][0]	['block_8_dept

			']
block_8_project_BN (BatchN ect[0][0]) ormalization)	(None, 10, 10, 64)	256	['block_8_proj ect_BN[0][0]']
block_8_add (Add) [0][0], ect_BN[0][0])	(None, 10, 10, 64)	0	['block_7_add 'block_8_proj ect_BN[0][0]']
block_9_expand (Conv2D) [0][0])	(None, 10, 10, 384)	24576	['block_8_add [0][0]']
block_9_expand_BN (BatchNo nd[0][0]) rnalization)	(None, 10, 10, 384)	1536	['block_9_expa nd[0][0]']
block_9_expand_relu (ReLU) nd_BN[0][0])	(None, 10, 10, 384)	0	['block_9_expa nd_BN[0][0]']
block_9_depthwise (Depthwi nd_relu[0][0]) seConv2D)	(None, 10, 10, 384)	3456	['block_9_expa nd_relu[0][0]']
block_9_depthwise_BN (Bac hwise[0][0]) hNormalization)	(None, 10, 10, 384)	1536	['block_9_dept hwise[0][0]']
block_9_depthwise_relu (Re hwise_BN[0][0]) LU)	(None, 10, 10, 384)	0	['block_9_dept hwise_BN[0][0]']
block_9_project (Conv2D) hwise_relu[0][0])	(None, 10, 10, 64)	24576	['block_9_dept hwise_relu[0][0]']
block_9_project_BN (BatchN ect[0][0]) ormalization)	(None, 10, 10, 64)	256	['block_9_proj ect_BN[0][0]']
block_9_add (Add) [0][0], ect_BN[0][0])	(None, 10, 10, 64)	0	['block_8_add 'block_9_proj ect_BN[0][0]']
block_10_expand (Conv2D) [0][0])	(None, 10, 10, 384)	24576	['block_9_add [0][0]']
block_10_expand_BN (BatchN and[0][0]) rnalization)	(None, 10, 10, 384)	1536	['block_10_expa nd[0][0]']
block_10_expand_relu (ReLU) and_BN[0][0]))	(None, 10, 10, 384)	0	['block_10_expa nd_BN[0][0]']
block_10_depthwise (Depthw and_relu[0][0]) iseConv2D)	(None, 10, 10, 384)	3456	['block_10_expa nd_relu[0][0]']

block_10_depthwise_BN (BatchNorm (None, 10, 10, 384) depthwise[0][0]) chNormalization)	1536	['block_10_depthwise_BN']
block_10_depthwise_relu (ReLU (None, 10, 10, 384) depthwise_BN[0][0]) eLU)	0	['block_10_depthwise_relu']
block_10_project (Conv2D (None, 10, 10, 96) depthwise_relu[0][0])	36864	['block_10_depthwise_relu[0][0]']
block_10_project_BN (BatchNorm (None, 10, 10, 96) project[0][0]) Normalization)	384	['block_10_depthwise_relu[0][0]', 'block_10_project_BN']
block_11_expand (Conv2D (None, 10, 10, 576) project_BN[0][0])	55296	['block_10_depthwise_relu[0][0]', 'block_10_project_BN', 'block_11_expand']
block_11_expand_BN (BatchNorm (None, 10, 10, 576) and[0][0]) ormalization)	2304	['block_11_expand', 'block_11_expand_BN']
block_11_expand_relu (ReLU (None, 10, 10, 576) and_BN[0][0]))	0	['block_11_expand', 'block_11_expand_BN', 'block_11_expand_relu']
block_11_depthwise (DepthwiseConv2dNative (None, 10, 10, 576) and_relu[0][0]) iseConv2D)	5184	['block_11_depthwise']
block_11_depthwise_BN (BatchNorm (None, 10, 10, 576) depthwise[0][0]) chNormalization)	2304	['block_11_depthwise', 'block_11_depthwise_BN']
block_11_depthwise_relu (ReLU (None, 10, 10, 576) depthwise_BN[0][0]) eLU)	0	['block_11_depthwise', 'block_11_depthwise_BN', 'block_11_depthwise_relu']
block_11_project (Conv2D (None, 10, 10, 96) depthwise_relu[0][0])	55296	['block_11_depthwise', 'block_11_depthwise_BN', 'block_11_depthwise_relu']
block_11_project_BN (BatchNorm (None, 10, 10, 96) project[0][0]) Normalization)	384	['block_11_depthwise', 'block_11_depthwise_BN', 'block_11_depthwise_relu', 'block_11_project_BN']
block_11_add (Add (None, 10, 10, 96) project_BN[0][0], project_BN[0][0])	0	['block_10_depthwise_relu[0][0]', 'block_11_depthwise', 'block_11_depthwise_BN', 'block_11_depthwise_relu', 'block_11_project_BN', 'block_11_add']
block_12_expand (Conv2D (None, 10, 10, 576) [0][0])	55296	['block_11_add', 'block_12_expand']
block_12_expand_BN (BatchNorm (None, 10, 10, 576) and[0][0]) ormalization)	2304	['block_12_expand', 'block_12_expand_BN']
block_12_expand_relu (ReLU (None, 10, 10, 576) and_BN[0][0]))	0	['block_12_expand', 'block_12_expand_BN', 'block_12_expand_relu']

)			
block_12_depthwise (Depthwise (None, 10, 10, 576) and_relu[0][0]') iseConv2D)	5184	['block_12_exp	
block_12_depthwise_BN (Batch (None, 10, 10, 576) thwise[0][0]') chNormalization)	2304	['block_12_dep	
block_12_depthwise_relu (ReLU (None, 10, 10, 576) thwise_BN[0][0]' eLU)	0	['block_12_dep]
block_12_project (Conv2D) (None, 10, 10, 96) thwise_relu[0][0]	55296	['block_12_dep	']']
block_12_project_BN (Batch (None, 10, 10, 96) ject[0][0]') Normalization)	384	['block_12_pro	
block_12_add (Add) (None, 10, 10, 96) [0][0]', ject_BN[0][0]')	0	['block_11_add	'block_12_pro
block_13_expand (Conv2D) (None, 10, 10, 576)	55296	['block_12_add	
[0][0]')			
block_13_expand_BN (BatchNorm (None, 10, 10, 576) and[0][0]') ormalization)	2304	['block_13_exp	
block_13_expand_relu (ReLU (None, 10, 10, 576) and_BN[0][0]'))	0	['block_13_exp	
block_13_pad (ZeroPadding2 (None, 11, 11, 576) and_relu[0][0]') D)	0	['block_13_exp	
block_13_depthwise (Depthwise (None, 5, 5, 576) [0][0]') iseConv2D)	5184	['block_13_pad	
block_13_depthwise_BN (Batch (None, 5, 5, 576) thwise[0][0]') chNormalization)	2304	['block_13_dep	
block_13_depthwise_relu (ReLU (None, 5, 5, 576) thwise_BN[0][0]' eLU)	0	['block_13_dep	']
block_13_project (Conv2D) (None, 5, 5, 160) thwise_relu[0][0]	92160	['block_13_dep	']']
block_13_project_BN (Batch (None, 5, 5, 160) ject[0][0]') Normalization)	640	['block_13_pro	

block_14_expand (Conv2D ject_BN[0][0]')	(None, 5, 5, 960)	153600	['block_13_pro
block_14_expand_BN (BatchN and[0][0]' ormalization)	(None, 5, 5, 960)	3840	['block_14_exp
block_14_expand_relu (ReLU and_BN[0][0]')	(None, 5, 5, 960)	0	['block_14_exp
block_14_depthwise (Depthw and_relu[0][0]' iseConv2D)	(None, 5, 5, 960)	8640	['block_14_exp
block_14_depthwise_BN (Bat hwise[0][0]' chNormalization)	(None, 5, 5, 960)	3840	['block_14_dep
block_14_depthwise_relu (R thwise_BN[0][0]' eLU)	(None, 5, 5, 960)	0	['block_14_dep
block_14_project (Conv2D thwise_relu[0][0]	(None, 5, 5, 160)	153600	['block_14_dep
block_14_project_BN (Batch ject[0][0]' Normalization)	(None, 5, 5, 160)	640	['block_14_pro
block_14_add (Add ject_BN[0][0]', ject_BN[0][0]')	(None, 5, 5, 160)	0	['block_13_pro 'block_14_pro
block_15_expand (Conv2D [0][0]')	(None, 5, 5, 960)	153600	['block_14_add
block_15_expand_BN (BatchN and[0][0]' ormalization)	(None, 5, 5, 960)	3840	['block_15_exp
block_15_expand_relu (ReLU and_BN[0][0]')	(None, 5, 5, 960)	0	['block_15_exp
block_15_depthwise (Depthw and_relu[0][0]' iseConv2D)	(None, 5, 5, 960)	8640	['block_15_exp
block_15_depthwise_BN (Bat hwise[0][0]' chNormalization)	(None, 5, 5, 960)	3840	['block_15_dep
block_15_depthwise_relu (R thwise_BN[0][0]' eLU)	(None, 5, 5, 960)	0	['block_15_dep
block_15_project (Conv2D)	(None, 5, 5, 160)	153600	['block_15_dep

thwise_relu[0][0]		640	['block_15_pro
]	']		
block_15_project_BN (Batch	(None, 5, 5, 160)	640	['block_15_pro
ject[0][0]]			
Normalization)			
block_15_add (Add)	(None, 5, 5, 160)	0	['block_14_add
[0][0]',			'block_15_pro
ject_BN[0][0]']			
block_16_expand (Conv2D)	(None, 5, 5, 960)	153600	['block_15_add
[0][0]']			
block_16_expand_BN (BatchN	(None, 5, 5, 960)	3840	['block_16_exp
and[0][0]]			
ormalization)			
block_16_expand_relu (ReLU	(None, 5, 5, 960)	0	['block_16_exp
and_BN[0][0]']			
)			
block_16_depthwise (Depthw	(None, 5, 5, 960)	8640	['block_16_exp
and_relu[0][0]]			
iseConv2D)			
block_16_depthwise_BN (Bat	(None, 5, 5, 960)	3840	['block_16_dep
thwise[0][0]]			
chNormalization)			
block_16_depthwise_relu (R	(None, 5, 5, 960)	0	['block_16_dep
thwise_BN[0][0]]			
eLU)]
block_16_project (Conv2D)	(None, 5, 5, 320)	307200	['block_16_dep
thwise_relu[0][0]			']]
block_16_project_BN (Batch	(None, 5, 5, 320)	1280	['block_16_pro
ject[0][0]]			
Normalization)			
Conv_1 (Conv2D)	(None, 5, 5, 1280)	409600	['block_16_pro
ject_BN[0][0]']			
Conv_1_bn (BatchNormalizat	(None, 5, 5, 1280)	5120	['Conv_1[0]
[0]]			
ion)			
out_relu (ReLU)	(None, 5, 5, 1280)	0	['Conv_1_bn[0]
[0]]			
global_average_pooling2d_1	(None, 1280)	0	['out_relu[0]
[0]]			
(GlobalAveragePooling2D)			
predictions (Dense)	(None, 1000)	1281000	['global_aver
ge_pooling2d_1[0][0]']

```
=====
=====
Total params: 3538984 (13.50 MB)
Trainable params: 3504872 (13.37 MB)
Non-trainable params: 34112 (133.25 KB)
```

```
In [79]: image_batch, label_batch = next (iter (train_dataset))
feature_batch = base_model(image_batch)
print (feature_batch.shape)

(32, 1000)
```

```
In [82]: base_model.trainable = False
image_var = tf.Variable(image_batch)
pred = base_model(image_var)
```

```
In [92]: def alpaca_model(image_shape=IMG_SIZE, data_augmentation=data_augmenter()):
    input_shape = image_shape + (3,)
    base_model = tf.keras.applications.MobileNetV2(input_shape=input_shape,
                                                    include_top=False,
                                                    weights='imagenet')
    base_model.trainable = False
    inputs = tf.keras.Input(shape=input_shape)
    x = data_augmentation(inputs)
    x = preprocess_input(x)
    x = base_model(x, training=False)
    x = tf.keras.layers.GlobalAveragePooling2D()(x)
    x = tf.keras.layers.Dropout(0.2)(x)
    prediction_layer = tf.keras.layers.Dense(1)

    outputs = prediction_layer(x)
    model = tf.keras.Model(inputs, outputs)
    return model
```

```
In [98]: model2 = alpaca_model(IMG_SIZE, data_augmentation)
```

```
In [110...]: base_learning_rate = 0.01
model2.compile(optimizer=tf.keras.optimizers.Adam(lr=base_learning_rate),
                loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
                metrics=['accuracy'])
```

WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use the legacy optimizer, e.g.,tf.keras.optimizers.legacy.Adam.

```
In [116...]: initial_epochs = 5
history = model2.fit(train_dataset, validation_data=validation_dataset, epochs=initial_epochs)
```

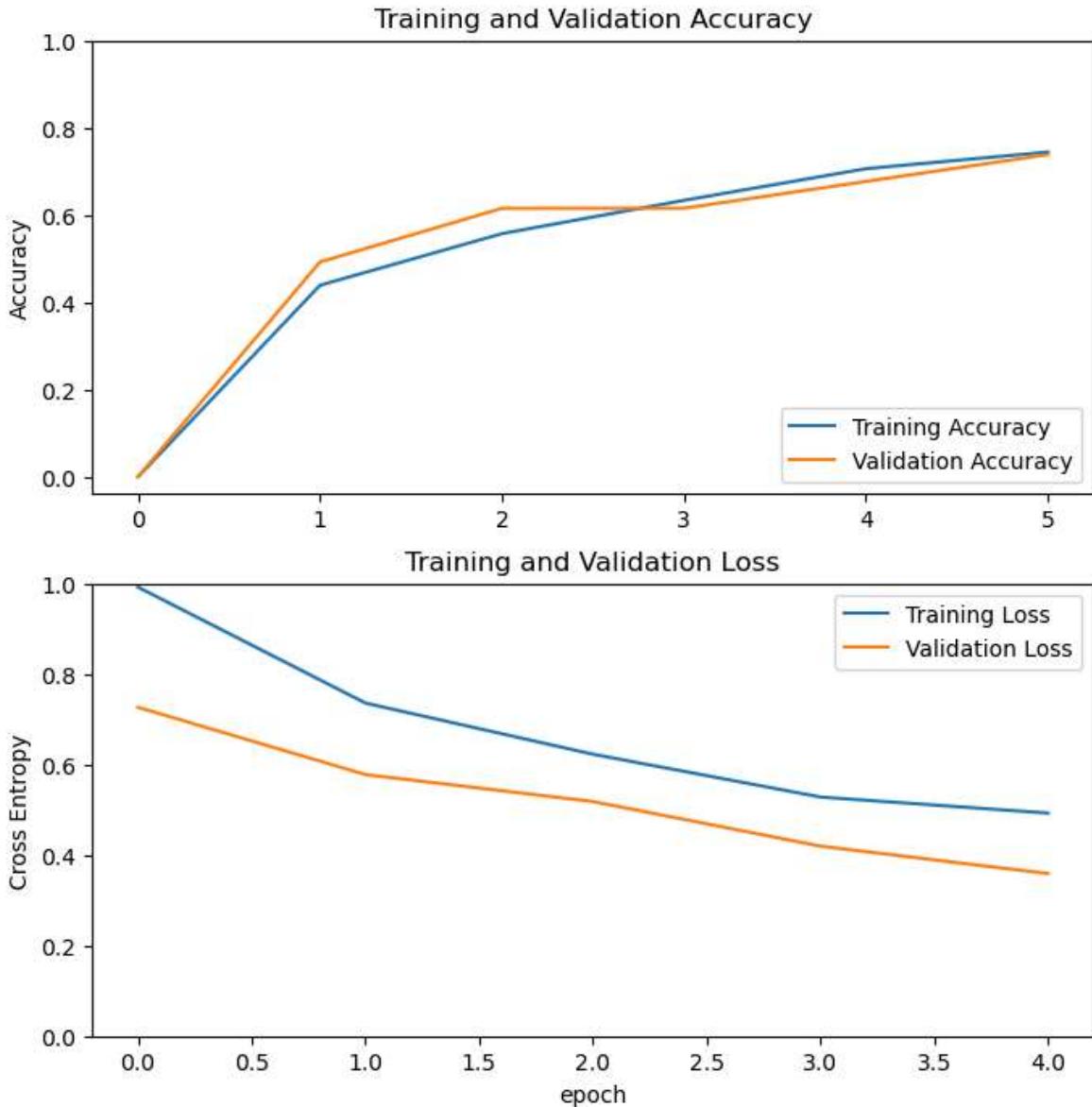
```
Epoch 1/5
9/9 [=====] - 12s 669ms/step - loss: 0.9919 - accuracy: 0.4389 - val_loss: 0.7264 - val_accuracy: 0.4923
Epoch 2/5
9/9 [=====] - 6s 589ms/step - loss: 0.7357 - accuracy: 0.5573 - val_loss: 0.5777 - val_accuracy: 0.6154
Epoch 3/5
9/9 [=====] - 5s 566ms/step - loss: 0.6226 - accuracy: 0.6336 - val_loss: 0.5181 - val_accuracy: 0.6154
Epoch 4/5
9/9 [=====] - 5s 552ms/step - loss: 0.5281 - accuracy: 0.7061 - val_loss: 0.4196 - val_accuracy: 0.6769
Epoch 5/5
9/9 [=====] - 5s 527ms/step - loss: 0.4927 - accuracy: 0.7443 - val_loss: 0.3589 - val_accuracy: 0.7385
```

```
In [130...]: acc = [0.] + history.history['accuracy']
val_acc = [0.] + history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

plt.figure(figsize=(8, 8))
plt.subplot(2, 1, 1)
plt.plot(acc, label='Training Accuracy')
plt.plot(val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.ylabel('Accuracy')
plt.ylim([min(plt.ylim()),1])
plt.title('Training and Validation Accuracy')

plt.subplot(2, 1, 2)
plt.plot(loss, label='Training Loss')
plt.plot(val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.ylabel('Cross Entropy')
plt.ylim([0,1.0])
plt.title('Training and Validation Loss')
plt.xlabel('epoch')
plt.show()
```



```
In [150...]: base_model.trainable = True
fine_tune_at = 126
for layer in base_model.layers[:fine_tune_at]:
    #print('Layer ' + layer.name + ' frozen.')
    layer.trainable = False # Set to False to freeze the Layer

# Define the loss function
loss_function = tf.keras.losses.BinaryCrossentropy(from_logits=True)

# Set up the optimizer
optimizer = tf.keras.optimizers.Adam(learning_rate=base_learning_rate * 0.1) # A

# Define metrics
metrics = ['accuracy']

# Compile the model
model2.compile(loss=loss_function, optimizer=optimizer, metrics=metrics)
```

```
In [164...]: fine_tune_epochs = 5
total_epochs = initial_epochs + fine_tune_epochs
history_fine = model2.fit(train_dataset,
                           epochs=total_epochs,
```

```
initial_epoch=history.epoch[-1],  
validation_data=validation_dataset)  
  
Epoch 5/10  
9/9 [=====] - 14s 721ms/step - loss: 0.4269 - accuracy: 0.7519 - val_loss: 0.3016 - val_accuracy: 0.8308  
Epoch 6/10  
9/9 [=====] - 5s 521ms/step - loss: 0.4274 - accuracy: 0.7939 - val_loss: 0.2733 - val_accuracy: 0.8615  
Epoch 7/10  
9/9 [=====] - 5s 561ms/step - loss: 0.3905 - accuracy: 0.8206 - val_loss: 0.2798 - val_accuracy: 0.8000  
Epoch 8/10  
9/9 [=====] - 5s 508ms/step - loss: 0.3130 - accuracy: 0.8473 - val_loss: 0.2405 - val_accuracy: 0.8923  
Epoch 9/10  
9/9 [=====] - 5s 492ms/step - loss: 0.3004 - accuracy: 0.8473 - val_loss: 0.2306 - val_accuracy: 0.8769  
Epoch 10/10  
9/9 [=====] - 5s 522ms/step - loss: 0.3120 - accuracy: 0.8550 - val_loss: 0.2099 - val_accuracy: 0.9077
```

```
In [168...]: acc += history_fine.history['accuracy']  
val_acc += history_fine.history['val_accuracy']  
  
loss += history_fine.history['loss']  
val_loss += history_fine.history['val_loss']
```

```
In [180...]: plt.figure(figsize=(8, 8))  
plt.subplot(2, 1, 1)  
plt.plot(acc, label='Training Accuracy')  
plt.plot(val_acc, label='Validation Accuracy')  
plt.ylim([0, 1])  
plt.plot([initial_epochs-1, initial_epochs-1],  
         plt.ylim(), label='Start Fine Tuning')  
plt.legend(loc='lower right')  
plt.title('Training and Validation Accuracy')  
  
plt.subplot(2, 1, 2)  
plt.plot(loss, label='Training Loss')  
plt.plot(val_loss, label='Validation Loss')  
plt.ylim([0, 1.0])  
plt.plot([initial_epochs-1, initial_epochs-1],  
         plt.ylim(), label='Start Fine Tuning')  
plt.legend(loc='upper right')  
plt.title('Training and Validation Loss')  
plt.xlabel('epoch')  
plt.show()
```

