In [1]:
```python
# import libraries
import tensorflow as tf
print("Num GPUs Available: ", len(tf.config.list_physical_devices('GPU')))
print('tensorflow version:',tf.__version__)
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing import image

import PIL
print('PIL version:',PIL.__version__)
import os
import numpy as np
print('numpy version:',np.__version__)
import matplotlib
import matplotlib.pyplot as plt
print('matplotlib version:',matplotlib.__version__)
```

```
Num GPUs Available:  1
tensorflow version: 2.5.0
PIL version: 8.2.0
numpy version: 1.20.2
matplotlib version: 3.3.4
```

In [2]:
```python
# define the image size and batch size
batch_size = 32
img_height = 224
img_width = 224
```

In [3]:
```python
# preprocessing
train = ImageDataGenerator(rescale = 1/255)
validation = ImageDataGenerator(rescale = 1/255)
```

In [4]:
```python
# spilting of dataset for trainig purpose
train_dataset = tf.keras.preprocessing.image_dataset_from_directory('D:/materials
                                          validation_split = 0.2,
                                          subset = 'training',
                                          seed = 123,
                                          image_size = (img_height, img_width),
                                          batch_size = batch_size)
```

```
Found 3398 files belonging to 2 classes.
Using 2719 files for training.
```

In [5]:
```python
# spilting of dataset for testing purpose
validation_dataset = tf.keras.preprocessing.image_dataset_from_directory('D:/mate
                                            validation_split = 0.2,
                                            subset = 'validation',
                                            seed = 123,
                                            image_size = (img_height, img_width),
                                            batch_size = batch_size)
```

```
Found 3398 files belonging to 2 classes.
Using 679 files for validation.
```

In [6]:
```python
class_names_train = train_dataset.class_names
print(class_names_train)
class_names_validation = validation_dataset.class_names
print(class_names_validation)
```

```
['d_r', 'non dendrites_full_&_final']
['d_r', 'non dendrites_full_&_final']
```

In [7]:
```python
for image_batch, label_batch in train_dataset:
    print(image_batch.shape)
    print(label_batch.shape)
    break
```

```
(32, 224, 224, 3)
(32,)
```

In [8]:
```python
normalization_layers = layers.experimental.preprocessing.Rescaling(1/255)
```

In [9]:
```python
normalized_dataset = train_dataset.map(lambda x, y: (normalization_layers(x), y))
image_batch, labels_batch = next(iter(normalized_dataset))
first_image = image_batch[0]
#pixel value now b/w 0 - 1
print(np.min(first_image), np.max(first_image))
```

```
0.0 0.9176471
```

In [10]:
```python
num_classes = 2
model = Sequential([
    layers.experimental.preprocessing.Rescaling(1/255, input_shape = (img_height,
    layers.Conv2D(32, 5, padding='same', activation = 'relu'),
    layers.MaxPooling2D( pool_size = (2,2), strides = (2,2)),
    layers.Conv2D(32, 3, padding='same', activation = 'relu'),
    layers.MaxPooling2D( pool_size = (2,2), strides = (2,2)),
    layers.Conv2D(32, 2, padding='same', activation = 'relu'),
    layers.MaxPooling2D( pool_size = (2,2), strides = (2,2)),
    layers.Flatten(),
    layers.Dense(128, activation = 'relu'),
    layers.Dense(num_classes)
    ])
```

In [11]:
```python
optimizers = tf.keras.optimizers.Adam(learning_rate = 0.0005)
model.compile(optimizers,
              loss = tf.keras.losses.SparseCategoricalCrossentropy(from_logits = 1
              metrics = ['accuracy'])
```

In [12]:
```python
model.summary()
```

```
Model: "sequential"
_____
Layer (type)                 Output Shape              Param #
=================================================================
rescaling_1 (Rescaling)      (None, 224, 224, 3)       0
_____
conv2d (Conv2D)              (None, 224, 224, 32)      2432
_____
max_pooling2d (MaxPooling2D) (None, 112, 112, 32)      0
_____
conv2d_1 (Conv2D)            (None, 112, 112, 32)      9248
_____
max_pooling2d_1 (MaxPooling2 (None, 56, 56, 32)        0
_____
conv2d_2 (Conv2D)            (None, 56, 56, 32)        4128
_____
max_pooling2d_2 (MaxPooling2 (None, 28, 28, 32)        0
_____
flatten (Flatten)            (None, 25088)             0
_____
dense (Dense)                (None, 128)               3211392
_____
dense_1 (Dense)              (None, 2)                 258
=================================================================
Total params: 3,227,458
Trainable params: 3,227,458
Non-trainable params: 0
_____
```

```
In [13]: epochs = 30
         history = model.fit(
         train_dataset,
         epochs = epochs
         )
```

```
Epoch 1/30
85/85 [==============================] - 12s 100ms/step - loss: 0.3354 - accura
cy: 0.8827
Epoch 2/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1813 - accurac
y: 0.8830
Epoch 3/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1687 - accurac
y: 0.9139
Epoch 4/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1440 - accurac
y: 0.9522
Epoch 5/30
85/85 [==============================] - 7s 85ms/step - loss: 0.1427 - accurac
y: 0.9478
Epoch 6/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1234 - accurac
y: 0.9606
Epoch 7/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1228 - accurac
y: 0.9603
Epoch 8/30
85/85 [==============================] - 7s 85ms/step - loss: 0.1184 - accurac
y: 0.9636
Epoch 9/30
85/85 [==============================] - 7s 84ms/step - loss: 0.1024 - accurac
y: 0.9724
Epoch 10/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0695 - accurac
y: 0.9750
Epoch 11/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0668 - accurac
y: 0.9757
Epoch 12/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0556 - accurac
y: 0.9798
Epoch 13/30
85/85 [==============================] - 7s 86ms/step - loss: 0.0681 - accurac
y: 0.9779
Epoch 14/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0510 - accurac
y: 0.9846
Epoch 15/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0307 - accurac
y: 0.9930
Epoch 16/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0223 - accurac
y: 0.9937
Epoch 17/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0198 - accurac
```

```
y: 0.9926
Epoch 18/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0201 - accurac
y: 0.9930
Epoch 19/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0135 - accurac
y: 0.9960
Epoch 20/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0098 - accurac
y: 0.9967
Epoch 21/30
85/85 [==============================] - 7s 86ms/step - loss: 0.0478 - accurac
y: 0.9875
Epoch 22/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0656 - accurac
y: 0.9798
Epoch 23/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0103 - accurac
y: 0.9978
Epoch 24/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0067 - accurac
y: 0.9978
Epoch 25/30
85/85 [==============================] - 7s 86ms/step - loss: 0.0054 - accurac
y: 0.9978
Epoch 26/30
85/85 [==============================] - 7s 85ms/step - loss: 0.0023 - accurac
y: 1.0000
Epoch 27/30
85/85 [==============================] - 7s 86ms/step - loss: 0.0014 - accurac
y: 0.9996
Epoch 28/30
85/85 [==============================] - 7s 85ms/step - loss: 7.4799e-04 - accu
racy: 1.0000
Epoch 29/30
85/85 [==============================] - 7s 85ms/step - loss: 5.5645e-04 - accu
racy: 1.0000
Epoch 30/30
85/85 [==============================] - 7s 84ms/step - loss: 4.9694e-04 - accu
racy: 1.0000
```

In [14]: `model.evaluate(validation_dataset)`

```
22/22 [==============================] - 2s 53ms/step - loss: 0.1478 - accurac
y: 0.9632
```

Out[14]: `[0.14775948226451874, 0.9631811380386353]`

In [ ]: