

✓ Module Name: SE4050 - Deep Learning Assignment

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Import all the Dependencies

```
import tensorflow as tf
from tensorflow.keras import models, layers
import matplotlib.pyplot as plt
```

Set all the Constants

```
BATCH_SIZE = 32
IMAGE_SIZE = 256
CHANNELS=3
EPOCHS=50
```

Import data into tensorflow dataset object

```
import zipfile
import os
import tensorflow as tf

# Step 1: Unzip the file from Google Drive to a local directory
zip_path = '/content/drive/MyDrive/DL_Project/plants.zip'

with zipfile.ZipFile(zip_path, 'r') as zip_ref:
    zip_ref.extractall('temp_dir')

dataset = tf.keras.preprocessing.image_dataset_from_directory(
    'temp_dir',
    seed=123,
    shuffle=True,
    image_size=(IMAGE_SIZE, IMAGE_SIZE),
    batch_size=BATCH_SIZE
)
```

→ Found 2152 files belonging to 1 classes.

```
class_names = dataset.class_names
class_names

→ ['PlantVillage']

import os

# Path to the dataset directory
dataset_dir = '/content/temp_dir/PlantVillage'

# Get the list of subdirectories (class names)
class_names = [d for d in os.listdir(dataset_dir) if os.path.isdir(os.path.join(dataset_dir, d))]

print(class_names)

→ ['Potato__healthy', 'Potato__Late_blight', 'Potato__Early_blight']
```

```
len(dataset)
```

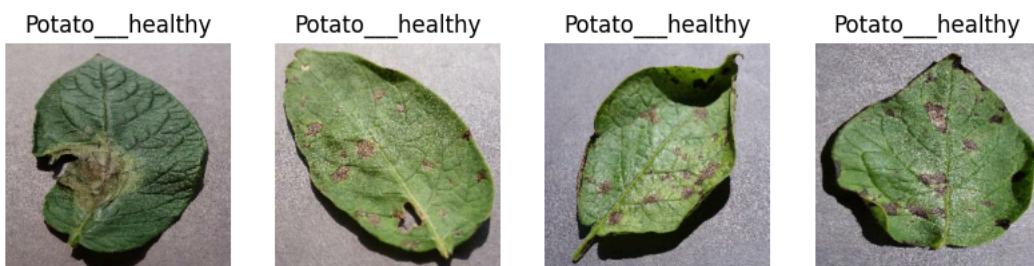
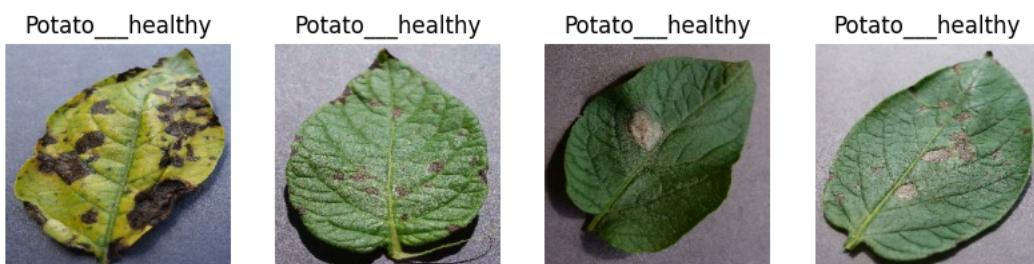
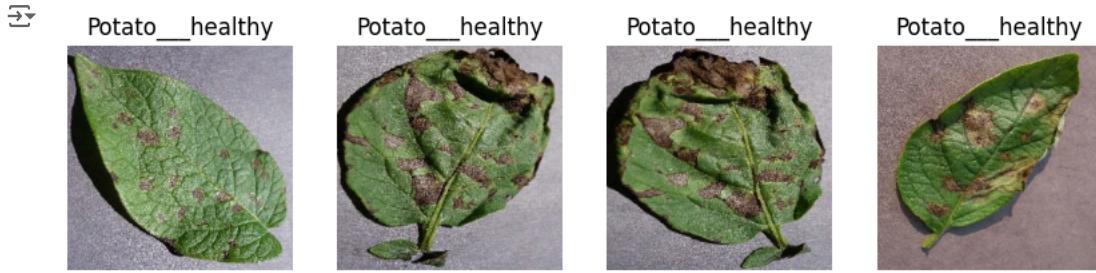
→ 68

```
for image_batch, labels_batch in dataset.take(1):
    print(image_batch.shape)
    print(labels_batch.numpy())

→ (32, 256, 256, 3)
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
```

Visualize some of the images from our dataset

```
plt.figure(figsize=(10, 10))
for image_batch, labels_batch in dataset.take(1):
    for i in range(12):
        ax = plt.subplot(3, 4, i + 1)
        plt.imshow(image_batch[i].numpy().astype("uint8"))
        plt.title(class_names[labels_batch[i]])
        plt.axis("off")
```



Function to Split Dataset Dataset should be bifurcated into 3 subsets, namely: **bold text**

Training: Dataset to be used while training Validation: Dataset to be tested against while training Test: Dataset to be tested against after we trained a model

```
len(dataset)
```

→ 68

```
train_size = 0.8
len(dataset)*train_size
```

```
↳ 54.400000000000006
```

```
train_ds = dataset.take(54)
len(train_ds)
```

```
↳ 54
```

```
test_ds = dataset.skip(54)
len(test_ds)
```

```
↳ 14
```

```
val_size=0.1
len(dataset)*val_size
```

```
↳ 6.800000000000001
```

```
val_ds = test_ds.take(6)
len(val_ds)
```

```
↳ 6
```

```
test_ds = test_ds.skip(6)
len(test_ds)
```

```
↳ 8
```

```
def get_dataset_partitions_tf(ds, train_split=0.8, val_split=0.1, test_split=0.1, shuffle=True, shuffle_size=10000):
    assert (train_split + test_split + val_split) == 1

    ds_size = len(ds)

    if shuffle:
        ds = ds.shuffle(shuffle_size, seed=12)

    train_size = int(train_split * ds_size)
    val_size = int(val_split * ds_size)

    train_ds = ds.take(train_size)
    val_ds = ds.skip(train_size).take(val_size)
    test_ds = ds.skip(train_size).skip(val_size)

    return train_ds, val_ds, test_ds
```

```
train_ds, val_ds, test_ds = get_dataset_partitions_tf(dataset)
```

```
len(train_ds)
```

```
↳ 54
```

```
len(val_ds)
```

```
↳ 6
```

```
len(test_ds)
```

```
↳ 8
```

Cache, Shuffle, and Prefetch the Dataset

```
train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
val_ds = val_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
test_ds = test_ds.cache().shuffle(1000).prefetch(buffer_size=tf.data.AUTOTUNE)
```

IT21302862 - Building the Model

Creating a Layer for Resizing and Normalization

Before feed our images to network, we should be resizing it to the desired size. Moreover, to improve model performance, we should normalize the image pixel value (keeping them in range 0 and 1 by dividing by 256). This should happen while training as well as inference. Hence we can add that as a layer in our Sequential Model.

```
resize_and_rescale = tf.keras.Sequential([
    tf.keras.layers.Resizing(IMAGE_SIZE, IMAGE_SIZE),
    tf.keras.layers.Rescaling(1./255),
])
```

Data Augmentation

This boosts the accuracy of our model by augmenting the data.

```
import tensorflow as tf

data_augmentation = tf.keras.Sequential([
    tf.keras.layers.RandomFlip("horizontal_and_vertical"),
    tf.keras.layers.RandomRotation(0.2),
])
```

Applying Data Augmentation to Train Dataset

```
train_ds = train_ds.map(
    lambda x, y: (data_augmentation(x, training=True), y)
).prefetch(buffer_size=tf.data.AUTOTUNE)
```

IT21302862 - Model Architecture

We use a CNN coupled with a Softmax activation in the output layer. We also add the initial layers for resizing, normalization and Data Augmentation.

```
input_shape = (BATCH_SIZE, IMAGE_SIZE, IMAGE_SIZE, CHANNELS)
n_classes = 3

model = models.Sequential([
    resize_and_rescale,
    layers.Conv2D(32, kernel_size = (3,3), activation='relu', input_shape=input_shape),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Flatten(),
    layers.Dense(64, activation='relu'),
    layers.Dense(n_classes, activation='softmax'),
])

model.build(input_shape)

→ /usr/local/lib/python3.10/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an `input_shape` / `input` to `super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

◀ ▶

```
model.summary()
```

Model: "sequential_2"

| Layer (type) | Output Shape | Param # |
|--------------------------------|--------------------|---------|
| sequential (Sequential) | (32, 256, 256, 3) | 0 |
| conv2d (Conv2D) | (32, 254, 254, 32) | 896 |
| max_pooling2d (MaxPooling2D) | (32, 127, 127, 32) | 0 |
| conv2d_1 (Conv2D) | (32, 125, 125, 64) | 18,496 |
| max_pooling2d_1 (MaxPooling2D) | (32, 62, 62, 64) | 0 |
| conv2d_2 (Conv2D) | (32, 60, 60, 64) | 36,928 |
| max_pooling2d_2 (MaxPooling2D) | (32, 30, 30, 64) | 0 |
| conv2d_3 (Conv2D) | (32, 28, 28, 64) | 36,928 |
| max_pooling2d_3 (MaxPooling2D) | (32, 14, 14, 64) | 0 |
| conv2d_4 (Conv2D) | (32, 12, 12, 64) | 36,928 |
| max_pooling2d_4 (MaxPooling2D) | (32, 6, 6, 64) | 0 |
| conv2d_5 (Conv2D) | (32, 4, 4, 64) | 36,928 |
| max_pooling2d_5 (MaxPooling2D) | (32, 2, 2, 64) | 0 |
| flatten (Flatten) | (32, 256) | 0 |
| dense (Dense) | (32, 64) | 16,448 |
| dense_1 (Dense) | (32, 3) | 195 |

Total params: 183,747 (717.76 KB)

IT21302862 - Compiling the Model

We use adam Optimizer, SparseCategoricalCrossentropy for losses, accuracy as a metric

```
model.compile(
    optimizer='adam',
    loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
    metrics=['accuracy']
)

history = model.fit(
    train_ds,
    batch_size=BATCH_SIZE,
    validation_data=val_ds,
    verbose=1,
    epochs=20,
)

Epoch 1/20
54/54 ━━━━━━━━━━ 236s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 2/20
54/54 ━━━━━━━━━━ 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 3/20
54/54 ━━━━━━━━━━ 233s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 4/20
54/54 ━━━━━━━━━━ 233s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 5/20
54/54 ━━━━━━━━━━ 239s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 6/20
54/54 ━━━━━━━━━━ 237s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 7/20
54/54 ━━━━━━━━━━ 238s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 8/20
54/54 ━━━━━━━━━━ 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 9/20
54/54 ━━━━━━━━━━ 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 10/20
54/54 ━━━━━━━━━━ 237s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 11/20
54/54 ━━━━━━━━━━ 238s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 12/20
54/54 ━━━━━━━━━━ 239s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
```

```

Epoch 13/20
54/54 238s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 14/20
54/54 238s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 15/20
54/54 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 16/20
54/54 262s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 17/20
54/54 261s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 18/20
54/54 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 19/20
54/54 235s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00
Epoch 20/20
54/54 261s 4s/step - accuracy: 1.0000 - loss: 0.0000e+00 - val_accuracy: 1.0000 - val_loss: 0.0000e+00

```

```

scores = model.evaluate(test_ds)

8/8 12s 1s/step - accuracy: 1.0000 - loss: 0.0000e+00

```

```
scores
```

```
[0.0, 1.0]
```

Plotting the Accuracy and Loss Curves

```
history
```

```
[<keras.src.callbacks.history.History at 0x7a113c5d2710>
```

```
history.params
```

```
{'verbose': 1, 'epochs': 20, 'steps': 54}
```

```
history.history.keys()
```

```
[&gt; dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

```
type(history.history['loss'])
```

```
[&gt; list
```

```
len(history.history['loss'])
```

```
[&gt; 20
```

```
history.history['loss'][:5]
```

```
[&gt; [0.0, 0.0, 0.0, 0.0, 0.0]
```

```
acc = history.history['accuracy']
```

```
val_acc = history.history['val_accuracy']
```

```
loss = history.history['loss']
```

```
val_loss = history.history['val_loss']
```

```

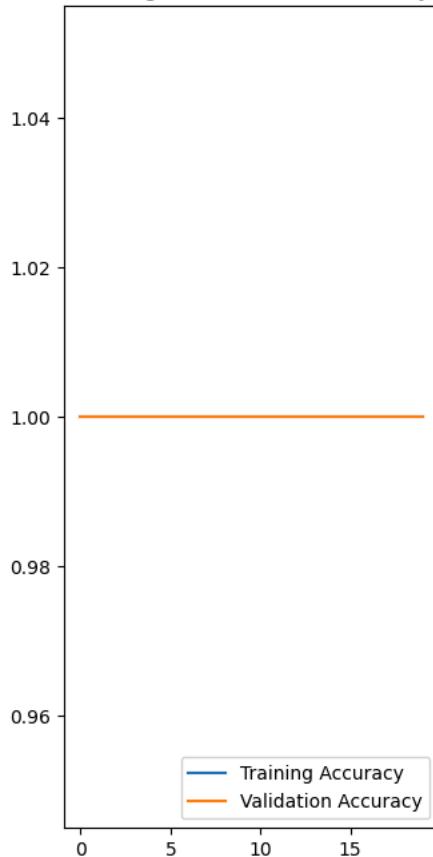
plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(range(len(acc)), acc, label='Training Accuracy')
plt.plot(range(len(val_acc)), val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(range(len(loss)), loss, label='Training Loss')
plt.plot(range(len(val_loss)), val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()

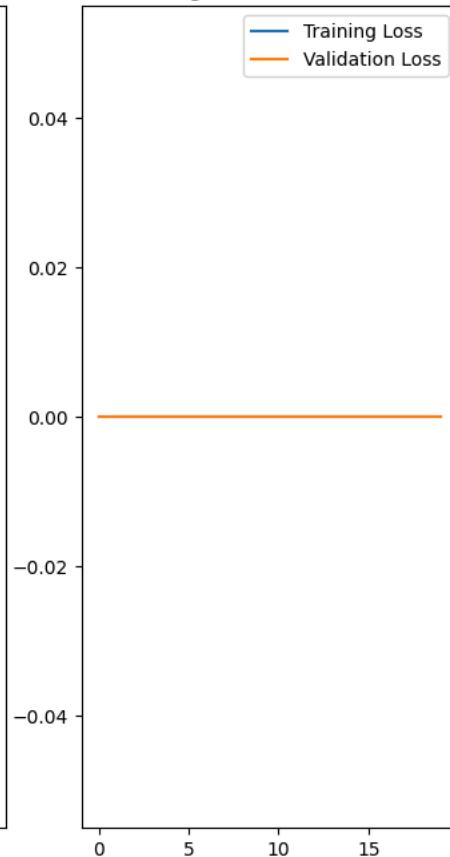
```



Training and Validation Accuracy



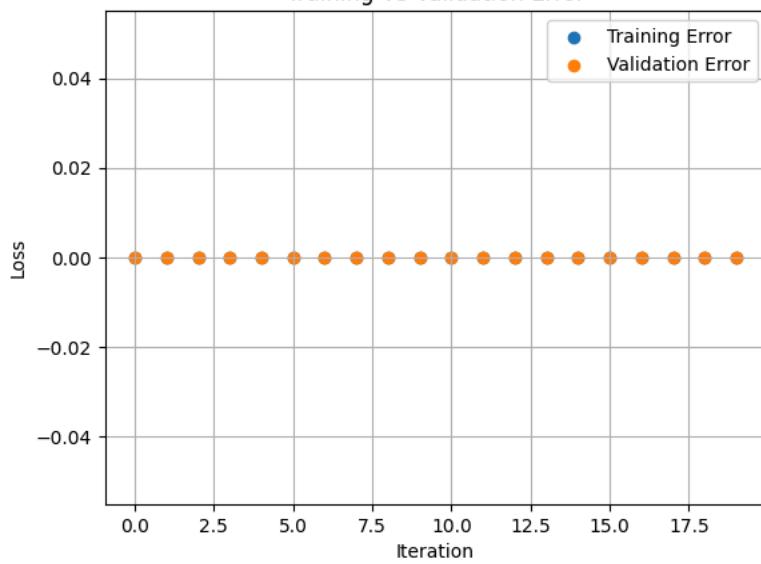
Training and Validation Loss



```
plt.scatter(x=history.epoch,y=history.history['loss'],label='Training Error')
plt.scatter(x=history.epoch,y=history.history['val_loss'],label='Validation Error')
plt.grid(True)
plt.xlabel('Iteration')
plt.ylabel('Loss')
plt.title('Training Vs Validation Error')
plt.legend()
plt.show()
```



Training Vs Validation Error



Run prediction on a sample image

```

import numpy as np
for images_batch, labels_batch in test_ds.take(1):

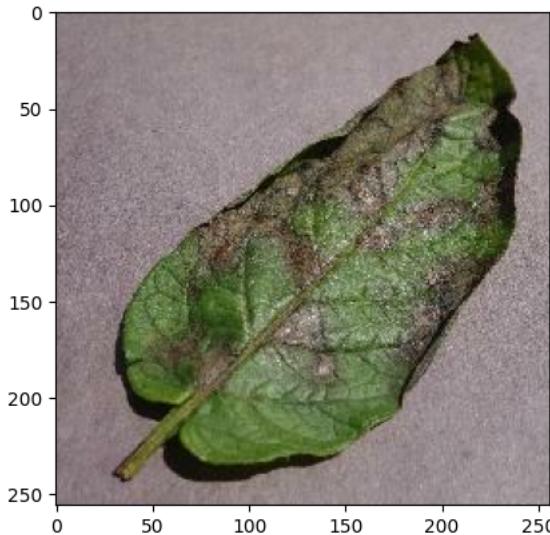
    first_image = images_batch[0].numpy().astype('uint8')
    first_label = labels_batch[0].numpy()

    print("first image to predict")
    plt.imshow(first_image)
    print("actual label:", class_names[first_label])

    batch_prediction = model.predict(images_batch)
    print("predicted label:", class_names[np.argmax(batch_prediction[0])])

```

→ first image to predict
 actual label: Potato__healthy
 1/1 2s 2s/step
 predicted label: Potato__healthy



Write a function for inference

```

def predict(model, img):
    img_array = tf.keras.preprocessing.image.img_to_array(images[i].numpy())
    img_array = tf.expand_dims(img_array, 0)

    predictions = model.predict(img_array)

    predicted_class = class_names[np.argmax(predictions[0])]
    confidence = round(100 * (np.max(predictions[0])), 2)
    return predicted_class, confidence

plt.figure(figsize=(15, 15))
for images, labels in test_ds.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))

        predicted_class, confidence = predict(model, images[i].numpy())
        actual_class = class_names[labels[i]]

        plt.title(f"Actual: {actual_class},\n Predicted: {predicted_class}.\n Confidence: {confidence}%")
        plt.axis("off")

```

| | |
|-----|---------------|
| 1/1 | 0s 247ms/step |
| 1/1 | 0s 70ms/step |
| 1/1 | 0s 76ms/step |
| 1/1 | 0s 79ms/step |
| 1/1 | 0s 100ms/step |
| 1/1 | 0s 74ms/step |
| 1/1 | 0s 79ms/step |
| 1/1 | 0s 73ms/step |
| 1/1 | 0s 73ms/step |

Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Actual: Potato_ healthy,
Predicted: Potato_ healthy.
Confidence: 100.0%



Saving the Model

We append the model to the list of models as a new version

```
import os

# Extract file names without extensions and convert them to integers
model_files = [f for f in os.listdir("../models") if f.endswith(".keras")]
model_versions = [int(f.split('.')[0]) for f in model_files]

# Get the maximum model version, or default to 0 if no models exist
model_version = max(model_versions + [0]) + 1

# Save the new model with the next version number
model.save(f"../models/{model_version}.keras")

model.save("../potatoes.keras")
```

```
import os

model_path = os.path.abspath(f"../models/{model_version}.keras")
print(f"Model saved at: {model_path}")
```

→ Model saved at: /models/2.keras

```
import os
print(os.getcwd())

print(os.path.exists("../models"))
!ls /models
```

→ /content
True
1.keras 2.keras

Double-click (or enter) to edit

```
import tensorflow as tf
from tensorflow.keras import metrics

model.compile(
    optimizer='adam',
    loss='binary_crossentropy',
    metrics=[

        'accuracy',
        metrics.Precision(name='precision'),
        metrics.Recall(name='recall')
    ]
)
```

pip install seaborn

→ Requirement already satisfied: seaborn in /usr/local/lib/python3.10/dist-packages (0.13.1)
Requirement already satisfied: numpy!=1.24.0,>=1.20 in /usr/local/lib/python3.10/dist-packages (from seaborn) (1.26.4)
Requirement already satisfied: pandas>=1.2 in /usr/local/lib/python3.10/dist-packages (from seaborn) (2.1.4)
Requirement already satisfied: matplotlib!=3.6.1,>=3.4 in /usr/local/lib/python3.10/dist-packages (from seaborn) (3.7.1)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (1.3)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (4.5)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (1.4)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (24.1)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (3.1)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.10/dist-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.2->seaborn) (2024.2)
Requirement already satisfied: tzdata>=2022.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.2->seaborn) (2024.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7->matplotlib!=3.6.1,>=3.4->

```

from sklearn.metrics import confusion_matrix
import seaborn as sns

# Step 1: Generate predictions on the test dataset
y_true = []
y_pred = []

for images, labels in test_ds:
    predictions = model.predict(images)
    predicted_classes = np.argmax(predictions, axis=1)

    y_true.extend(labels.numpy())
    y_pred.extend(predicted_classes)

# Step 2: Calculate the confusion matrix
conf_matrix = confusion_matrix(y_true, y_pred)

# Step 3: Plot the confusion matrix
plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues',
            xticklabels=class_names, yticklabels=class_names)
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Confusion Matrix')
plt.show()

```

1/1 2s 2s/step
1/1 1s 1s/step
1/1 2s 2s/step
1/1 2s 2s/step
1/1 2s 2s/step
1/1 2s 2s/step
1/1 4s 4s/step
1/1 3s 3s/step

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:409: UserWarning: A single label was found in 'y_true' and 'y

