In [ ]:
```
!pip install azure-ai-ml azure-identity
```

```
Collecting azure-ai-ml
  Downloading azure_ai_ml-1.29.0-py3-none-any.whl.metadata (40 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 40.1/40.1 kB 3.5 MB/s eta 0:00:00
Collecting azure-identity
  Downloading azure_identity-1.25.1-py3-none-any.whl.metadata (88 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 88.5/88.5 kB 7.9 MB/s eta 0:00:00
Requirement already satisfied: pyyaml<7.0.0,>=5.1.0 in /usr/local/lib/python3.1
2/dist-packages (from azure-ai-ml) (6.0.3)
Collecting azure-core>=1.23.0 (from azure-ai-ml)
  Downloading azure_core-1.36.0-py3-none-any.whl.metadata (47 kB)
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Collecting azure-mgmt-core>=1.3.0 (from azure-ai-ml)
  Downloading azure_mgmt_core-1.6.0-py3-none-any.whl.metadata (4.6 kB)
Collecting marshmallow<4.0.0,>=3.5 (from azure-ai-ml)
  Downloading marshmallow-3.26.1-py3-none-any.whl.metadata (7.3 kB)
Requirement already satisfied: jsonschema<5.0.0,>=4.0.0 in /usr/local/lib/pytho
n3.12/dist-packages (from azure-ai-ml) (4.25.1)
Requirement already satisfied: tqdm<5.0.0 in /usr/local/lib/python3.12/dist-pac
kages (from azure-ai-ml) (4.67.1)
Collecting strictyaml<2.0.0 (from azure-ai-ml)
  Downloading strictyaml-1.7.3-py3-none-any.whl.metadata (11 kB)
Collecting colorama<1.0.0 (from azure-ai-ml)
  Downloading colorama-0.4.6-py2.py3-none-any.whl.metadata (17 kB)
Requirement already satisfied: pyjwt<3.0.0 in /usr/local/lib/python3.12/dist-pa
ckages (from azure-ai-ml) (2.10.1)
Collecting azure-storage-blob>=12.10.0 (from azure-ai-ml)
  Downloading azure_storage_blob-12.27.0-py3-none-any.whl.metadata (26 kB)
Collecting azure-storage-file-share (from azure-ai-ml)
  Downloading azure_storage_file_share-12.23.0-py3-none-any.whl.metadata (52 k
B)
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Collecting azure-storage-file-datalake>=12.2.0 (from azure-ai-ml)
  Downloading azure_storage_file_datalake-12.22.0-py3-none-any.whl.metadata (16
kB)
Collecting pydash<9.0.0,>=6.0.0 (from azure-ai-ml)
  Downloading pydash-8.0.5-py3-none-any.whl.metadata (4.5 kB)
Collecting isodate<1.0.0 (from azure-ai-ml)
  Downloading isodate-0.7.2-py3-none-any.whl.metadata (11 kB)
Collecting azure-common>=1.1 (from azure-ai-ml)
  Downloading azure_common-1.1.28-py2.py3-none-any.whl.metadata (5.0 kB)
Requirement already satisfied: typing-extensions<5.0.0 in /usr/local/lib/python
3.12/dist-packages (from azure-ai-ml) (4.15.0)
Collecting azure-monitor-opentelemetry (from azure-ai-ml)
  Downloading azure_monitor_opentelemetry-1.8.1-py3-none-any.whl.metadata (23 k
B)
Requirement already satisfied: cryptography>=2.5 in /usr/local/lib/python3.12/d
ist-packages (from azure-identity) (43.0.3)
Collecting msal>=1.30.0 (from azure-identity)
  Downloading msal-1.34.0-py3-none-any.whl.metadata (11 kB)
Collecting msal-extensions>=1.2.0 (from azure-identity)
  Downloading msal_extensions-1.3.1-py3-none-any.whl.metadata (7.8 kB)
Requirement already satisfied: requests>=2.21.0 in /usr/local/lib/python3.12/di
st-packages (from azure-core>=1.23.0->azure-ai-ml) (2.32.4)
Requirement already satisfied: cffi>=1.12 in /usr/local/lib/python3.12/dist-pac
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kages (from cryptography>=2.5->azure-identity) (2.0.0)
Requirement already satisfied: attrs>=22.2.0 in /usr/local/lib/python3.12/dist-
packages (from jsonschema<5.0.0,>=4.0.0->azure-ai-ml) (25.4.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in /usr/loc
al/lib/python3.12/dist-packages (from jsonschema<5.0.0,>=4.0.0->azure-ai-ml) (2
025.9.1)
Requirement already satisfied: referencing>=0.28.4 in /usr/local/lib/python3.1
2/dist-packages (from jsonschema<5.0.0,>=4.0.0->azure-ai-ml) (0.36.2)
Requirement already satisfied: rpds-py>=0.7.1 in /usr/local/lib/python3.12/dis
t-packages (from jsonschema<5.0.0,>=4.0.0->azure-ai-ml) (0.27.1)
Requirement already satisfied: packaging>=17.0 in /usr/local/lib/python3.12/dis
t-packages (from marshmallow<4.0.0,>=3.5->azure-ai-ml) (25.0)
Requirement already satisfied: python-dateutil>=2.6.0 in /usr/local/lib/python
3.12/dist-packages (from strictyaml<2.0.0->azure-ai-ml) (2.9.0.post0)
Collecting azure-core-tracing-opentelemetry~=1.0.0b11 (from azure-monitor-opent
elemetry->azure-ai-ml)
  Downloading azure_core_tracing_opentelemetry-1.0.0b12-py3-none-any.whl.metada
ta (11 kB)
Collecting azure-monitor-opentelemetry-exporter~=1.0.0b41 (from azure-monitor-o
pentelemetry->azure-ai-ml)
  Downloading azure_monitor_opentelemetry_exporter-1.0.0b44-py2.py3-none-any.wh
l.metadata (33 kB)
Requirement already satisfied: opentelemetry-sdk~=1.36 in /usr/local/lib/python
3.12/dist-packages (from azure-monitor-opentelemetry->azure-ai-ml) (1.37.0)
Collecting opentelemetry-instrumentation-django~=0.57b0 (from azure-monitor-ope
ntelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_django-0.59b0-py3-none-any.whl.meta
data (2.3 kB)
Collecting opentelemetry-instrumentation-fastapi~=0.57b0 (from azure-monitor-op
entelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_fastapi-0.59b0-py3-none-any.whl.met
adata (2.2 kB)
Collecting opentelemetry-instrumentation-flask~=0.57b0 (from azure-monitor-open
telemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_flask-0.59b0-py3-none-any.whl.metad
ata (2.2 kB)
Collecting opentelemetry-instrumentation-psycopg2~=0.57b0 (from azure-monitor-o
pentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_psycopg2-0.59b0-py3-none-any.whl.me
tadata (2.1 kB)
Collecting opentelemetry-instrumentation-requests~=0.57b0 (from azure-monitor-o
pentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_requests-0.59b0-py3-none-any.whl.me
tadata (2.6 kB)
Collecting opentelemetry-instrumentation-urllib~=0.57b0 (from azure-monitor-ope
ntelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_urllib-0.59b0-py3-none-any.whl.meta
data (3.4 kB)
Collecting opentelemetry-instrumentation-urllib3~=0.57b0 (from azure-monitor-op
entelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_urllib3-0.59b0-py3-none-any.whl.met
adata (4.2 kB)
Collecting opentelemetry-resource-detector-azure~=0.1.5 (from azure-monitor-ope
ntelemetry->azure-ai-ml)
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  Downloading opentelemetry_resource_detector_azure-0.1.5-py3-none-any.whl.meta
data (5.3 kB)
Requirement already satisfied: opentelemetry-api>=1.12.0 in /usr/local/lib/pyth
on3.12/dist-packages (from azure-core-tracing-opentelemetry~=1.0.0b11->azure-mo
nitor-opentelemetry->azure-ai-ml) (1.37.0)
Collecting fixedint==0.1.6 (from azure-monitor-opentelemetry-exporter~=1.0.0b4
1->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading fixedint-0.1.6-py3-none-any.whl.metadata (4.8 kB)
Collecting msrest>=0.6.10 (from azure-monitor-opentelemetry-exporter~=1.0.0b4
1->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading msrest-0.7.1-py3-none-any.whl.metadata (21 kB)
Requirement already satisfied: psutil<8,>=5.9 in /usr/local/lib/python3.12/dis
t-packages (from azure-monitor-opentelemetry-exporter~=1.0.0b41->azure-monitor-
opentelemetry->azure-ai-ml) (5.9.5)
Requirement already satisfied: pycparser in /usr/local/lib/python3.12/dist-pack
ages (from cffi>=1.12->cryptography>=2.5->azure-identity) (2.23)
Collecting opentelemetry-instrumentation-wsgi==0.59b0 (from opentelemetry-instr
umentation-django~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_wsgi-0.59b0-py3-none-any.whl.metada
ta (2.1 kB)
Collecting opentelemetry-instrumentation==0.59b0 (from opentelemetry-instrument
ation-django~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation-0.59b0-py3-none-any.whl.metadata
(7.1 kB)
Collecting opentelemetry-semantic-conventions==0.59b0 (from opentelemetry-instr
umentation-django~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_semantic_conventions-0.59b0-py3-none-any.whl.metada
ta (2.4 kB)
Collecting opentelemetry-util-http==0.59b0 (from opentelemetry-instrumentation-
django~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_util_http-0.59b0-py3-none-any.whl.metadata (2.6 kB)
Requirement already satisfied: wrapt<2.0.0,>=1.0.0 in /usr/local/lib/python3.1
2/dist-packages (from opentelemetry-instrumentation==0.59b0->opentelemetry-inst
rumentation-django~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml) (1.17.3)
Collecting opentelemetry-api>=1.12.0 (from azure-core-tracing-opentelemetr
y~=1.0.0b11->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_api-1.38.0-py3-none-any.whl.metadata (1.5 kB)
Requirement already satisfied: importlib-metadata<8.8.0,>=6.0 in /usr/local/li
b/python3.12/dist-packages (from opentelemetry-api>=1.12.0->azure-core-tracing-
opentelemetry~=1.0.0b11->azure-monitor-opentelemetry->azure-ai-ml) (8.7.0)
Collecting opentelemetry-instrumentation-asgi==0.59b0 (from opentelemetry-instr
umentation-fastapi~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_asgi-0.59b0-py3-none-any.whl.metada
ta (2.0 kB)
Collecting asgiref~=3.0 (from opentelemetry-instrumentation-asgi==0.59b0->opent
elemetry-instrumentation-fastapi~=0.57b0->azure-monitor-opentelemetry->azure-a
i-ml)
  Downloading asgiref-3.10.0-py3-none-any.whl.metadata (9.3 kB)
Collecting opentelemetry-instrumentation-dbapi==0.59b0 (from opentelemetry-inst
rumentation-psycopg2~=0.57b0->azure-monitor-opentelemetry->azure-ai-ml)
  Downloading opentelemetry_instrumentation_dbapi-0.59b0-py3-none-any.whl.metad
ata (2.0 kB)
INFO: pip is looking at multiple versions of opentelemetry-sdk to determine whi
ch version is compatible with other requirements. This could take a while.
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Collecting opentelemetry-sdk~=1.36 (from azure-monitor-opentelemetry->azure-ai-
ml)
  Downloading opentelemetry_sdk-1.38.0-py3-none-any.whl.metadata (1.5 kB)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.12/dist-packa
ges (from python-dateutil>=2.6.0->strictyaml<2.0.0->azure-ai-ml) (1.17.0)
Requirement already satisfied: charset_normalizer<4,>=2 in /usr/local/lib/pytho
n3.12/dist-packages (from requests>=2.21.0->azure-core>=1.23.0->azure-ai-ml)
(3.4.3)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-p
ackages (from requests>=2.21.0->azure-core>=1.23.0->azure-ai-ml) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/
dist-packages (from requests>=2.21.0->azure-core>=1.23.0->azure-ai-ml) (2.5.0)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/
dist-packages (from requests>=2.21.0->azure-core>=1.23.0->azure-ai-ml) (2025.1
0.5)
Requirement already satisfied: requests-oauthlib>=0.5.0 in /usr/local/lib/pytho
n3.12/dist-packages (from msrest>=0.6.10->azure-monitor-opentelemetry-exporte
r~=1.0.0b41->azure-monitor-opentelemetry->azure-ai-ml) (2.0.0)
Requirement already satisfied: zipp>=3.20 in /usr/local/lib/python3.12/dist-pac
kages (from importlib-metadata<8.8.0,>=6.0->opentelemetry-api>=1.12.0->azure-co
re-tracing-opentelemetry~=1.0.0b11->azure-monitor-opentelemetry->azure-ai-ml)
(3.23.0)
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.12/dis
t-packages (from requests-oauthlib>=0.5.0->msrest>=0.6.10->azure-monitor-opente
lemetry-exporter~=1.0.0b41->azure-monitor-opentelemetry->azure-ai-ml) (3.3.1)
Downloading azure_ai_ml-1.29.0-py3-none-any.whl (13.2 MB)
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Downloading azure_identity-1.25.1-py3-none-any.whl (191 kB)
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Downloading azure_common-1.1.28-py2.py3-none-any.whl (14 kB)
Downloading azure_core-1.36.0-py3-none-any.whl (213 kB)
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Downloading azure_mgmt_core-1.6.0-py3-none-any.whl (29 kB)
Downloading azure_storage_blob-12.27.0-py3-none-any.whl (428 kB)
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Downloading azure_storage_file_datalake-12.22.0-py3-none-any.whl (264 kB)
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Downloading colorama-0.4.6-py2.py3-none-any.whl (25 kB)
Downloading isodate-0.7.2-py3-none-any.whl (22 kB)
Downloading marshmallow-3.26.1-py3-none-any.whl (50 kB)
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Downloading msal_extensions-1.3.1-py3-none-any.whl (20 kB)
Downloading pydash-8.0.5-py3-none-any.whl (102 kB)
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Downloading strictyaml-1.7.3-py3-none-any.whl (123 kB)
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Downloading azure_monitor_opentelemetry-1.8.1-py3-none-any.whl (27 kB)
Downloading azure_storage_file_share-12.23.0-py3-none-any.whl (307 kB)
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Downloading azure_core_tracing_opentelemetry-1.0.0b12-py3-none-any.whl (11 kB)
Downloading azure_monitor_opentelemetry_exporter-1.0.0b44-py2.py3-none-any.whl
(198 kB)
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Downloading fixedint-0.1.6-py3-none-any.whl (12 kB)
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B)
Downloading opentelemetry_instrumentation-0.59b0-py3-none-any.whl (33 kB)
Downloading opentelemetry_instrumentation_wsgi-0.59b0-py3-none-any.whl (14 kB)
Downloading opentelemetry_semantic_conventions-0.59b0-py3-none-any.whl (207 kB)
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Downloading opentelemetry_api-1.38.0-py3-none-any.whl (65 kB)
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Downloading opentelemetry_util_http-0.59b0-py3-none-any.whl (7.6 kB)
Downloading opentelemetry_instrumentation_fastapi-0.59b0-py3-none-any.whl (13 k
B)
Downloading opentelemetry_instrumentation_asgi-0.59b0-py3-none-any.whl (16 kB)
Downloading opentelemetry_instrumentation_flask-0.59b0-py3-none-any.whl (14 kB)
Downloading opentelemetry_instrumentation_psycopg2-0.59b0-py3-none-any.whl (10
kB)
Downloading opentelemetry_instrumentation_dbapi-0.59b0-py3-none-any.whl (13 kB)
Downloading opentelemetry_instrumentation_requests-0.59b0-py3-none-any.whl (12
kB)
Downloading opentelemetry_instrumentation_urllib-0.59b0-py3-none-any.whl (12 k
B)
Downloading opentelemetry_instrumentation_urllib3-0.59b0-py3-none-any.whl (13 k
B)
Downloading opentelemetry_resource_detector_azure-0.1.5-py3-none-any.whl (14 k
B)
Downloading opentelemetry_sdk-1.38.0-py3-none-any.whl (132 kB)
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Downloading msrest-0.7.1-py3-none-any.whl (85 kB)
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Downloading asgiref-3.10.0-py3-none-any.whl (24 kB)
Installing collected packages: fixedint, azure-common, pydash, opentelemetry-ut
il-http, marshmallow, isodate, colorama, asgiref, strictyaml, opentelemetry-ap
i, azure-core, opentelemetry-semantic-conventions, msrest, azure-storage-file-s
hare, azure-storage-blob, azure-mgmt-core, azure-core-tracing-opentelemetry, op
entelemetry-sdk, opentelemetry-instrumentation, msal, azure-storage-file-datala
ke, opentelemetry-resource-detector-azure, opentelemetry-instrumentation-wsgi,
opentelemetry-instrumentation-urllib3, opentelemetry-instrumentation-urllib, op
entelemetry-instrumentation-requests, opentelemetry-instrumentation-dbapi, open
telemetry-instrumentation-asgi, msal-extensions, opentelemetry-instrumentation-
psycopg2, opentelemetry-instrumentation-flask, opentelemetry-instrumentation-fa
stapi, opentelemetry-instrumentation-django, azure-identity, azure-monitor-open
telemetry-exporter, azure-monitor-opentelemetry, azure-ai-ml
```

```
  Attempting uninstall: opentelemetry-api
    Found existing installation: opentelemetry-api 1.37.0
    Uninstalling opentelemetry-api-1.37.0:
      Successfully uninstalled opentelemetry-api-1.37.0
  Attempting uninstall: opentelemetry-semantic-conventions
    Found existing installation: opentelemetry-semantic-conventions 0.58b0
    Uninstalling opentelemetry-semantic-conventions-0.58b0:
      Successfully uninstalled opentelemetry-semantic-conventions-0.58b0
  Attempting uninstall: opentelemetry-sdk
    Found existing installation: opentelemetry-sdk 1.37.0
    Uninstalling opentelemetry-sdk-1.37.0:
      Successfully uninstalled opentelemetry-sdk-1.37.0
Successfully installed asgiref-3.10.0 azure-ai-ml-1.29.0 azure-common-1.1.28 az
ure-core-1.36.0 azure-core-tracing-opentelemetry-1.0.0b12 azure-identity-1.25.1
azure-mgmt-core-1.6.0 azure-monitor-opentelemetry-1.8.1 azure-monitor-opentelem
etry-exporter-1.0.0b44 azure-storage-blob-12.27.0 azure-storage-file-datalake-1
2.22.0 azure-storage-file-share-12.23.0 colorama-0.4.6 fixedint-0.1.6 isodat
e-0.7.2 marshmallow-3.26.1 msal-1.34.0 msal-extensions-1.3.1 msrest-0.7.1 opent
elemetry-api-1.38.0 opentelemetry-instrumentation-0.59b0 opentelemetry-instrume
ntation-asgi-0.59b0 opentelemetry-instrumentation-dbapi-0.59b0 opentelemetry-in
strumentation-django-0.59b0 opentelemetry-instrumentation-fastapi-0.59b0 opente
lemetry-instrumentation-flask-0.59b0 opentelemetry-instrumentation-psycopg2-0.5
9b0 opentelemetry-instrumentation-requests-0.59b0 opentelemetry-instrumentatio
n-urllib-0.59b0 opentelemetry-instrumentation-urllib3-0.59b0 opentelemetry-inst
rumentation-wsgi-0.59b0 opentelemetry-resource-detector-azure-0.1.5 opentelemet
ry-sdk-1.38.0 opentelemetry-semantic-conventions-0.59b0 opentelemetry-util-htt
p-0.59b0 pydash-8.0.5 strictyaml-1.7.3
```

In [ ]:
```python
# Set seeds for reproducibility
import random
random.seed(0)

import numpy as np
np.random.seed(0)

import tensorflow as tf
tf.random.set_seed(0)
```

In [ ]:
```python
import os
import json
from zipfile import ZipFile
from PIL import Image

import numpy as np
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import layers, models
```

In [ ]:
```python
!pip install kaggle
```

```
Requirement already satisfied: kaggle in /usr/local/lib/python3.12/dist-package
s (1.7.4.5)
Requirement already satisfied: bleach in /usr/local/lib/python3.12/dist-package
s (from kaggle) (6.2.0)
Requirement already satisfied: certifi>=14.05.14 in /usr/local/lib/python3.12/d
ist-packages (from kaggle) (2025.10.5)
Requirement already satisfied: charset-normalizer in /usr/local/lib/python3.12/
dist-packages (from kaggle) (3.4.3)
Requirement already satisfied: idna in /usr/local/lib/python3.12/dist-packages
(from kaggle) (3.10)
Requirement already satisfied: protobuf in /usr/local/lib/python3.12/dist-packa
ges (from kaggle) (5.29.5)
Requirement already satisfied: python-dateutil>=2.5.3 in /usr/local/lib/python
3.12/dist-packages (from kaggle) (2.9.0.post0)
Requirement already satisfied: python-slugify in /usr/local/lib/python3.12/dis
t-packages (from kaggle) (8.0.4)
Requirement already satisfied: requests in /usr/local/lib/python3.12/dist-packa
ges (from kaggle) (2.32.4)
Requirement already satisfied: setuptools>=21.0.0 in /usr/local/lib/python3.12/
dist-packages (from kaggle) (75.2.0)
Requirement already satisfied: six>=1.10 in /usr/local/lib/python3.12/dist-pack
ages (from kaggle) (1.17.0)
Requirement already satisfied: text-unidecode in /usr/local/lib/python3.12/dis
t-packages (from kaggle) (1.3)
Requirement already satisfied: tqdm in /usr/local/lib/python3.12/dist-packages
(from kaggle) (4.67.1)
Requirement already satisfied: urllib3>=1.15.1 in /usr/local/lib/python3.12/dis
t-packages (from kaggle) (2.5.0)
Requirement already satisfied: webencodings in /usr/local/lib/python3.12/dist-p
ackages (from kaggle) (0.5.1)
```

In [ ]:
```
kaggle_credentails = json.load(open("kaggle.json"))
```

In [ ]:
```
# setup Kaggle API key as environment variables
os.environ['KAGGLE_USERNAME'] = kaggle_credentails["username"]
os.environ['KAGGLE_KEY'] = kaggle_credentails["key"]
```

In [ ]:
```
!kaggle datasets download -d abdallahalidev/plantvillage-dataset
```

```
Dataset URL: https://www.kaggle.com/datasets/abdallahalidev/plantvillage-datase
t
License(s): CC-BY-NC-SA-4.0
Downloading plantvillage-dataset.zip to /content
100% 2.04G/2.04G [00:23<00:00, 201MB/s]
100% 2.04G/2.04G [00:23<00:00, 93.4MB/s]
```

In [ ]:
```
!ls
```

```
kaggle.json  plantvillage-dataset.zip  sample_data
```

In [ ]:
```
# Unzip the downloaded dataset
with ZipFile("plantvillage-dataset.zip", 'r') as zip_ref:
    zip_ref.extractall()
```

In [ ]:
```
print(os.listdir("plantvillage dataset"))


print(len(os.listdir("plantvillage dataset/segmented")))
print(os.listdir("plantvillage dataset/segmented")[:5])

print(len(os.listdir("plantvillage dataset/color")))
print(os.listdir("plantvillage dataset/color")[:5])

print(len(os.listdir("plantvillage dataset/grayscale")))
print(os.listdir("plantvillage dataset/grayscale")[:5])
```

```
['segmented', 'color', 'grayscale']
38
['Potato___Late_blight', 'Peach___healthy', 'Strawberry___healthy', 'Tomato___L
eaf_Mold', 'Corn_(maize)___healthy']
38
['Potato___Late_blight', 'Peach___healthy', 'Strawberry___healthy', 'Tomato___L
eaf_Mold', 'Corn_(maize)___healthy']
38
['Potato___Late_blight', 'Peach___healthy', 'Strawberry___healthy', 'Tomato___L
eaf_Mold', 'Corn_(maize)___healthy']
```

In [ ]:
```
print(len(os.listdir("plantvillage dataset/color/Grape___healthy")))
print(os.listdir("plantvillage dataset/color/Grape___healthy")[:5])
```

```
423
['4a31039d-54b1-4a0f-bc5f-2032f94c27af___Mt.N.V_HL 9040.JPG', '394d4600-121b-4e
cb-9c34-c70f8e3e0377___Mt.N.V_HL 9047.JPG', 'f72e0604-9654-48b4-b153-2e92383970
ce___Mt.N.V_HL 8979.JPG', 'f37f2d8a-9f14-4b68-a680-3f2a483ccb6f___Mt.N.V_HL 907
3.JPG', '73391930-644d-4cee-89cc-cb9c6adf1b4c___Mt.N.V_HL 9036.JPG']
```

In [ ]:
```
# Dataset Path
base_dir = 'plantvillage dataset/color'
```

In [ ]:
```
image_path = '/content/plantvillage dataset/color/Apple___Cedar_apple_rust/025

# Read the image
img = mpimg.imread(image_path)

print(img.shape)
# Display the image
plt.imshow(img)
plt.axis('off')  # Turn off axis numbers
plt.show()
```

```
(256, 256, 3)
```

In [ ]:
```
image_path = '/content/plantvillage dataset/color/Apple___Cedar_apple_rust/025

# Read the image
img = mpimg.imread(image_path)

print(img)
```

```
[[[179 175 176]
  [181 177 178]
  [184 180 181]
  ...
  [115 112 105]
  [108 105  98]
  [101  98  91]]

 [[176 172 173]
  [177 173 174]
  [178 174 175]
  ...
  [113 110 103]
  [111 108 101]
  [109 106  99]]

 [[180 176 177]
  [180 176 177]
  [180 176 177]
  ...
  [108 105  98]
  [111 108 101]
  [114 111 104]]

 ...

 [[137 128 119]
  [131 122 113]
  [125 116 107]
  ...
  [ 74  65  48]
  [ 74  65  48]
  [ 73  64  47]]

 [[136 127 118]
  [132 123 114]
  [128 119 110]
  ...
  [ 77  69  50]
  [ 75  67  48]
  [ 75  67  48]]

 [[133 124 115]
  [133 124 115]
  [132 123 114]
  ...
  [ 81  73  54]
  [ 80  72  53]
  [ 79  71  52]]]
```

In [ ]:
```
# Image Parameters
img_size = 224
batch_size = 32
```

In [ ]:
```
# Image Data Generators
data_gen = ImageDataGenerator(
    rescale=1./255,
    validation_split=0.2  # Use 20% of data for validation
)
```

In [ ]:
```
# Train Generator
train_generator = data_gen.flow_from_directory(
    base_dir,
    target_size=(img_size, img_size),
    batch_size=batch_size,
    subset='training',
    class_mode='categorical'
)
```

```
Found 43456 images belonging to 38 classes.
```

In [ ]:
```
# Validation Generator
validation_generator = data_gen.flow_from_directory(
    base_dir,
    target_size=(img_size, img_size),
    batch_size=batch_size,
    subset='validation',
    class_mode='categorical'
)
```

```
Found 10849 images belonging to 38 classes.
```

In [ ]:
```
# Model Definition
model = models.Sequential()

model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(img_size,
model.add(layers.MaxPooling2D(2, 2))

model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D(2, 2))


model.add(layers.Flatten())
model.add(layers.Dense(256, activation='relu'))
model.add(layers.Dense(train_generator.num_classes, activation='softmax'))
```

```
/usr/local/lib/python3.12/dist-packages/keras/src/layers/convolutional/base_con
v.py:113: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a l
ayer. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

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

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 222, 222, 32)	896
max_pooling2d (MaxPooling2D)	(None, 111, 111, 32)	0
conv2d_1 (Conv2D)	(None, 109, 109, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(None, 54, 54, 64)	0
flatten (Flatten)	(None, 186624)	0
dense (Dense)	(None, 256)	47,776,000
dense_1 (Dense)	(None, 38)	9,766

Total params: 47,805,158 (182.36 MB)

Trainable params: 47,805,158 (182.36 MB)

Non-trainable params: 0 (0.00 B)

In [ ]:
```
# Compile the Model
model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

In [ ]:
```
# Training the Model
history = model.fit(
    train_generator,
    steps_per_epoch=train_generator.samples // batch_size,  # Number of steps
    epochs=5,  # Number of epochs
    validation_data=validation_generator,
    validation_steps=validation_generator.samples // batch_size  # Validation
)
```

```
Epoch 1/5
/usr/local/lib/python3.12/dist-packages/keras/src/trainers/data_adapters/py_dat
aset_adapter.py:121: UserWarning: Your `PyDataset` class should call `supe
r().__init__(**kwargs)` in its constructor. `**kwargs` can include `workers`,
`use_multiprocessing`, `max_queue_size`. Do not pass these arguments to `fi
t()`, as they will be ignored.
  self._warn_if_super_not_called()
```

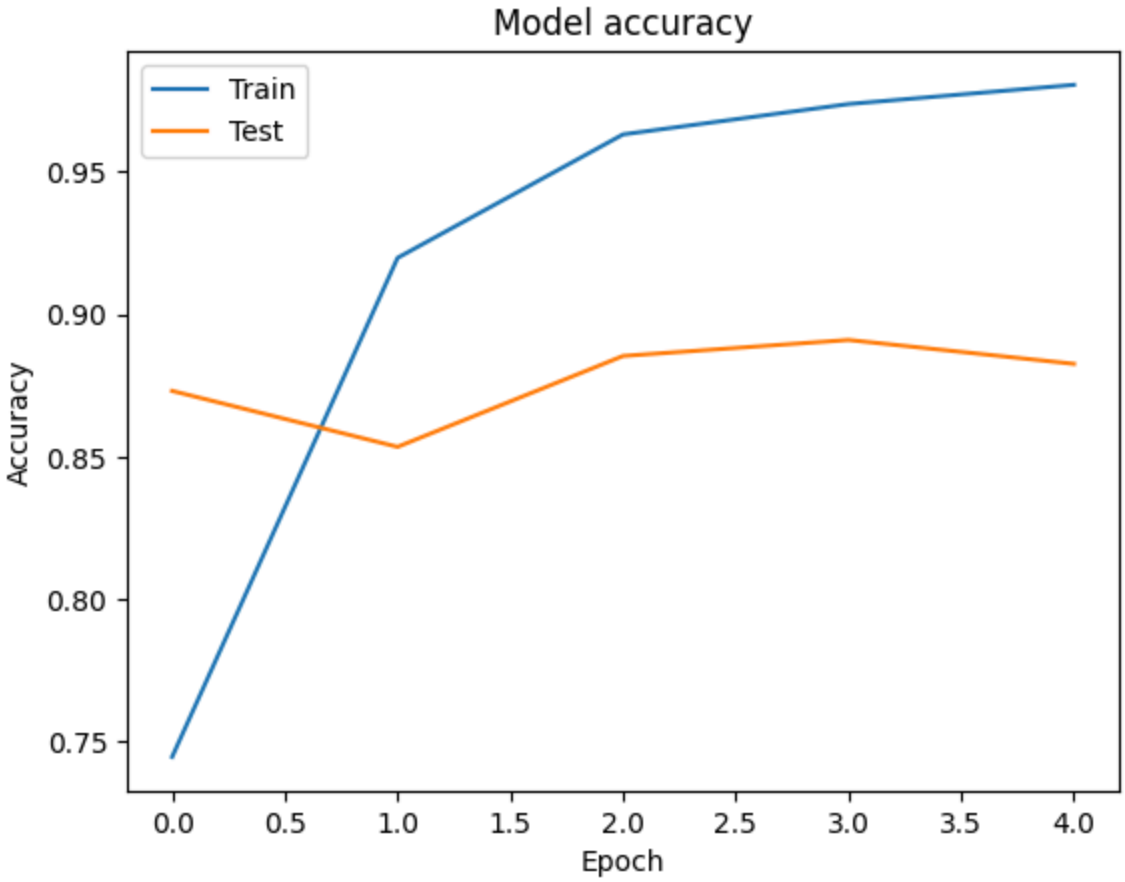
```
1358/1358 ━━━━━━━━━━━━━━━━━━━━ 96s 66ms/step - accuracy: 0.6049 - loss: 1.6192
- val_accuracy: 0.8731 - val_loss: 0.4105
Epoch 2/5
1358/1358 ━━━━━━━━━━━━━━━━━━━━ 137s 66ms/step - accuracy: 0.9219 - loss: 0.2515
- val_accuracy: 0.8534 - val_loss: 0.4760
Epoch 3/5
1358/1358 ━━━━━━━━━━━━━━━━━━━━ 89s 65ms/step - accuracy: 0.9642 - loss: 0.1089
- val_accuracy: 0.8853 - val_loss: 0.4130
Epoch 4/5
1358/1358 ━━━━━━━━━━━━━━━━━━━━ 96s 71ms/step - accuracy: 0.9801 - loss: 0.0653
- val_accuracy: 0.8909 - val_loss: 0.4552
Epoch 5/5
1358/1358 ━━━━━━━━━━━━━━━━━━━━ 90s 67ms/step - accuracy: 0.9841 - loss: 0.0532
- val_accuracy: 0.8826 - val_loss: 0.5242
```

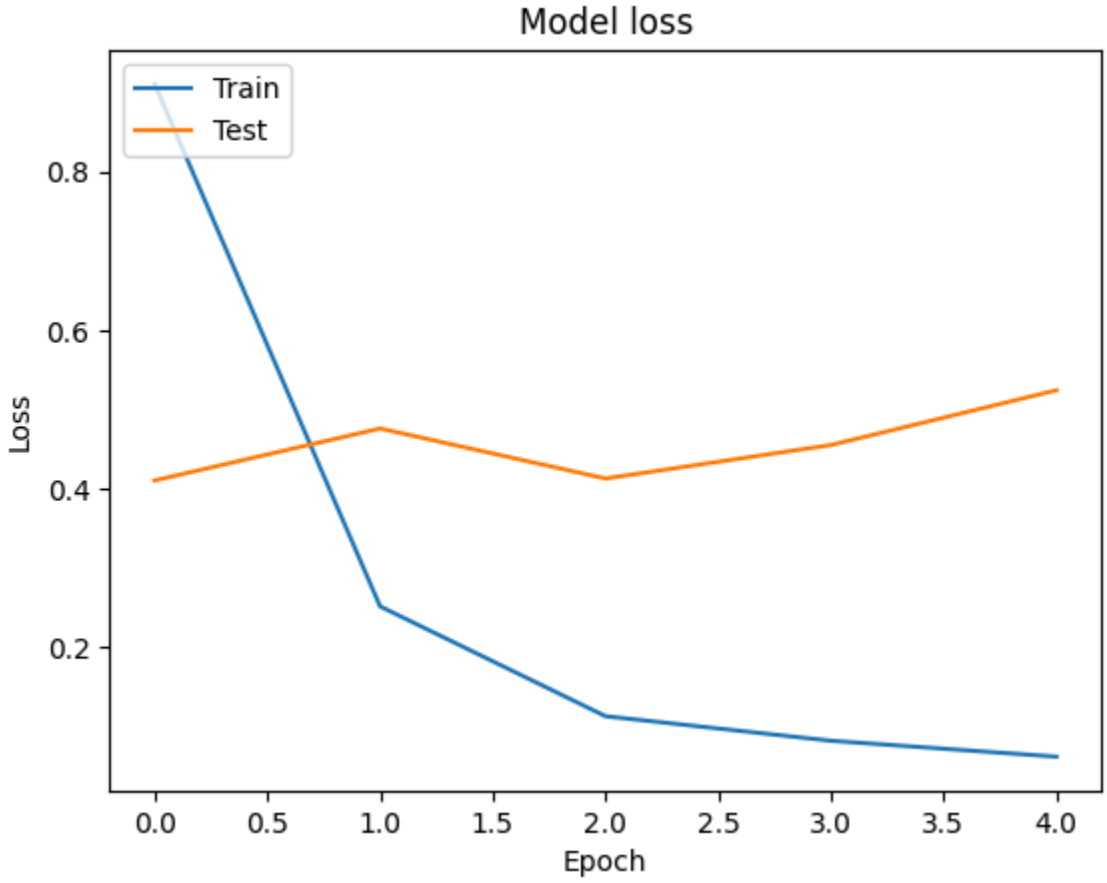
In [ ]:
```python
# Model Evaluation
print("Evaluating model...")
val_loss, val_accuracy = model.evaluate(validation_generator, steps=validation
print(f"Validation Accuracy: {val_accuracy * 100:.2f}%")
```

```
Evaluating model...
339/339 ━━━━━━━━━━━━━━━━━━━━ 17s 49ms/step - accuracy: 0.8830 - loss: 0.4957
Validation Accuracy: 88.26%
```

In [ ]:
```python
# Plot training & validation accuracy values
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```


Model accuracy
Train
Test
Accuracy
0.95
0.90
0.85
0.80
0.75
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Epoch


Model loss
Train
Test
Loss
0.8
0.6
0.4
0.2
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Epoch

In [ ]:
```python
# Function to Load and Preprocess the Image using Pillow
def load_and_preprocess_image(image_path, target_size=(224, 224)):
    # Load the image
    img = Image.open(image_path)
    # Resize the image
    img = img.resize(target_size)
    # Convert the image to a numpy array
    img_array = np.array(img)
    # Add batch dimension
    img_array = np.expand_dims(img_array, axis=0)
    # Scale the image values to [0, 1]
    img_array = img_array.astype('float32') / 255.
    return img_array

# Function to Predict the Class of an Image
def predict_image_class(model, image_path, class_indices):
    preprocessed_img = load_and_preprocess_image(image_path)
    predictions = model.predict(preprocessed_img)
    predicted_class_index = np.argmax(predictions, axis=1)[0]
    predicted_class_name = class_indices[predicted_class_index]
    return predicted_class_name
```

In [ ]:
```python
# Create a mapping from class indices to class names
class_indices = {v: k for k, v in train_generator.class_indices.items()}
```

In [ ]:
```python
class_indices
```

Out[ ]:
```
{0: 'Apple___Apple_scab',
 1: 'Apple___Black_rot',
 2: 'Apple___Cedar_apple_rust',
 3: 'Apple___healthy',
 4: 'Blueberry___healthy',
 5: 'Cherry_(including_sour)___Powdery_mildew',
 6: 'Cherry_(including_sour)___healthy',
 7: 'Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot',
 8: 'Corn_(maize)___Common_rust_',
 9: 'Corn_(maize)___Northern_Leaf_Blight',
 10: 'Corn_(maize)___healthy',
 11: 'Grape___Black_rot',
 12: 'Grape___Esca_(Black_Measles)',
 13: 'Grape___Leaf_blight_(Isariopsis_Leaf_Spot)',
 14: 'Grape___healthy',
 15: 'Orange___Haunglongbing_(Citrus_greening)',
 16: 'Peach___Bacterial_spot',
 17: 'Peach___healthy',
 18: 'Pepper,_bell___Bacterial_spot',
 19: 'Pepper,_bell___healthy',
 20: 'Potato___Early_blight',
 21: 'Potato___Late_blight',
 22: 'Potato___healthy',
 23: 'Raspberry___healthy',
 24: 'Soybean___healthy',
 25: 'Squash___Powdery_mildew',
 26: 'Strawberry___Leaf_scorch',
 27: 'Strawberry___healthy',
 28: 'Tomato___Bacterial_spot',
 29: 'Tomato___Early_blight',
 30: 'Tomato___Late_blight',
 31: 'Tomato___Leaf_Mold',
 32: 'Tomato___Septoria_leaf_spot',
 33: 'Tomato___Spider_mites Two-spotted_spider_mite',
 34: 'Tomato___Target_Spot',
 35: 'Tomato___Tomato_Yellow_Leaf_Curl_Virus',
 36: 'Tomato___Tomato_mosaic_virus',
 37: 'Tomato___healthy'}
```

In [ ]:
```
# saving the class names as json file
json.dump(class_indices, open('class_indices.json', 'w'))
```

In [ ]:
```
# Example Usage
# image_path = '/content/test_apple_black_rot.JPG'
image_path = '/content/test_blueberry_healthy.jpg'
#image_path = '/content/test_potato_early_blight.jpg'
predicted_class_name = predict_image_class(model, image_path, class_indices)

# Output the result
print("Predicted Class Name:", predicted_class_name)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 955ms/step
Predicted Class Name: Blueberry___healthy
```

In [ ]:
```
model.save('plant_disease_prediction_model.h5')
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')` or `keras.saving.save_model(model, 'my_model.keras')`.
```

In [ ]:
```
model.save('drive/MyDrive/plant_disease_prediction_model.h5')
```

In [ ]:
```

```