metal-detection-1

July 10, 2024

Data Collection & Loading

[1]:
```
!pip install --upgrade pip
!pip install tensorflow
!pip install tensorflow-gpu
!pip install opencv-python
!pip install matplotlib
!pip install --upgrade setuptools
import tensorflow as tf
import os
```

```
Requirement already satisfied: pip in /usr/local/lib/python3.10/dist-packages
(24.1.2)
WARNING: Running pip as the 'root' user can result in broken permissions
and conflicting behaviour with the system package manager, possibly rendering
your system unusable.It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv. Use the --root-user-action option if you know
what you are doing and want to suppress this warning.
Requirement already satisfied: tensorflow in /usr/local/lib/python3.10/dist-
packages (2.15.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=23.5.26 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (24.3.25)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (0.2.0)
Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow) (3.9.0)
Requirement already satisfied: libclang>=13.0.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (18.1.1)
Requirement already satisfied: ml-dtypes~=0.2.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (0.2.0)
```

```
Requirement already satisfied: numpy<2.0.0,>=1.23.5 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (1.25.2)
Requirement already satisfied: opt-einsum>=2.3.2 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (3.3.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-
packages (from tensorflow) (24.1)
Requirement already satisfied:
protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3
in /usr/local/lib/python3.10/dist-packages (from tensorflow) (3.20.3)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-
packages (from tensorflow) (70.3.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow) (1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (2.4.0)
Requirement already satisfied: typing-extensions>=3.6.6 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (4.12.2)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (1.14.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (0.37.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (1.64.1)
Requirement already satisfied: tensorboard<2.16,>=2.15 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (2.15.2)
Requirement already satisfied: tensorflow-estimator<2.16,>=2.15.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (2.15.0)
Requirement already satisfied: keras<2.16,>=2.15.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow) (2.15.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in
/usr/local/lib/python3.10/dist-packages (from astunparse>=1.6.0->tensorflow)
(0.43.0)
Requirement already satisfied: google-auth<3,>=1.6.3 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (2.27.0)
Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (1.2.0)
Requirement already satisfied: markdown>=2.6.8 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (3.6)
Requirement already satisfied: requests<3,>=2.21.0 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (2.31.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in
```

```
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.16,>=2.15->tensorflow) (3.0.3)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow) (5.3.3)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow) (0.4.0)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.10/dist-
packages (from google-auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow) (4.9)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/usr/local/lib/python3.10/dist-packages (from google-auth-
oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow) (1.3.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-
packages (from requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow) (2024.6.2)
Requirement already satisfied: MarkupSafe>=2.1.1 in
/usr/local/lib/python3.10/dist-packages (from
werkzeug>=1.0.1->tensorboard<2.16,>=2.15->tensorflow) (2.1.5)
Requirement already satisfied: pyasn1<0.7.0,>=0.4.6 in
/usr/local/lib/python3.10/dist-packages (from pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow) (0.6.0)
Requirement already satisfied: oauthlib>=3.0.0 in
/usr/local/lib/python3.10/dist-packages (from requests-oauthlib>=0.7.0->google-
auth-oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow) (3.2.2)
WARNING: Running pip as the 'root' user can result in broken permissions
and conflicting behaviour with the system package manager, possibly rendering
your system unusable.It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv. Use the --root-user-action option if you know
what you are doing and want to suppress this warning.

Collecting tensorflow-gpu
  Using cached tensorflow-gpu-2.12.0.tar.gz (2.6 kB)
  error: subprocess-exited-with-error

  × python setup.py egg_info did not run successfully.
    exit code: 1
   > See above for output.
```

```
  note: This error originates from a subprocess, and is likely not a
problem with pip.
  Preparing metadata (setup.py) … error
error: metadata-generation-failed

× Encountered error while generating package metadata.
 > See above for output.

note: This is an issue with the package mentioned above, not pip.
hint: See above for details.
Requirement already satisfied: opencv-python in /usr/local/lib/python3.10/dist-
packages (4.8.0.76)
Requirement already satisfied: numpy>=1.21.2 in /usr/local/lib/python3.10/dist-
packages (from opencv-python) (1.25.2)
WARNING: Running pip as the 'root' user can result in broken permissions
and conflicting behaviour with the system package manager, possibly rendering
your system unusable.It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv. Use the --root-user-action option if you know
what you are doing and want to suppress this warning.
Requirement already satisfied: matplotlib in /usr/local/lib/python3.10/dist-
packages (3.7.1)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (1.2.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-
packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (4.53.0)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (1.4.5)
Requirement already satisfied: numpy>=1.20 in /usr/local/lib/python3.10/dist-
packages (from matplotlib) (1.25.2)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (24.1)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.10/dist-
packages (from matplotlib) (9.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (3.1.2)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.10/dist-packages (from matplotlib) (2.8.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-
packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
```

```
WARNING: Running pip as the 'root' user can result in broken permissions
and conflicting behaviour with the system package manager, possibly rendering
your system unusable.It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv. Use the --root-user-action option if you know
what you are doing and want to suppress this warning.
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-
packages (70.3.0)
WARNING: Running pip as the 'root' user can result in broken permissions
and conflicting behaviour with the system package manager, possibly rendering
your system unusable.It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv. Use the --root-user-action option if you know
what you are doing and want to suppress this warning.
```

[2]:
```
tf.config.list_physical_devices('GPU')
```

[2]:
```
[PhysicalDevice(name='/physical_device:GPU:0', device_type='GPU')]
```

Data Preperation (Removing Dodgy Images)

[3]:
```
import cv2
import imghdr
```

[4]:
```
data_dir = '/content/drive/MyDrive/Dataset_Metal/Dataset'
```

[5]:
```
data_dir
```

[5]:
```
'/content/drive/MyDrive/Dataset_Metal/Dataset'
```

[6]:
```
image_exts = ['jpeg','jpg', 'bmp', 'png']
```

[7]:
```
for image_class in os.listdir(data_dir):
    for image in os.listdir(os.path.join(data_dir, image_class)):
        image_path = os.path.join(data_dir, image_class, image)
        try:
            img = cv2.imread(image_path)
            tip = imghdr.what(image_path)
            if tip not in image_exts:
                print('Image not in ext list {}'.format(image_path))
                os.remove(image_path)
        except Exception as e:
            print('Issue with image {}'.format(image_path))
```

[9]:
```
import numpy as np
from matplotlib import pyplot as plt
import tensorflow as tf
```

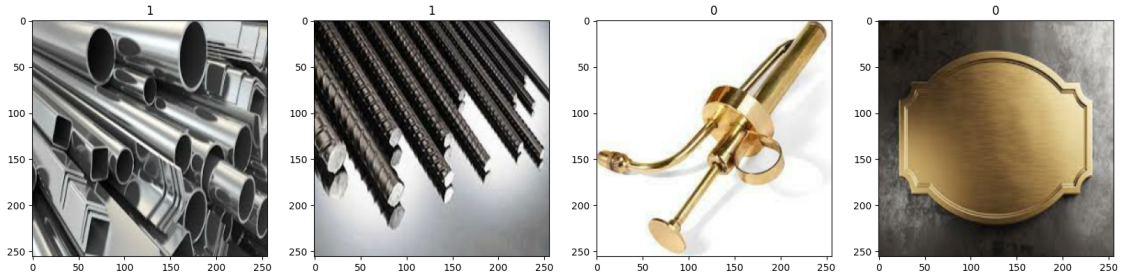
[10]:
```
data = tf.keras.utils.image_dataset_from_directory('/content/drive/MyDrive/
↪Dataset_Metal/Dataset')
```

```
Found 322 files belonging to 2 classes.
```

[11]:
```
data_iterator = data.as_numpy_iterator()
```

[12]:
```
batch = data_iterator.next()
```

[13]:
```
fig, ax = plt.subplots(ncols=4, figsize=(20,20))
for idx, img in enumerate(batch[0][:4]):
    ax[idx].imshow(img.astype(int))
    ax[idx].title.set_text(batch[1][idx])
```



[14]:
```
data = data.map(lambda x,y: (x/255, y))
```

[15]:
```
data.as_numpy_iterator().next()
```

[15]:
```
(array([[[[0.31764707, 0.27058825, 0.20784314],
          [0.31721047, 0.27015164, 0.20740655],
          [0.31227022, 0.2652114 , 0.2024663 ],
          …,
          [0.18342525, 0.17238818, 0.14129902],
          [0.18867187, 0.17690717, 0.14945619],
          [0.1882353 , 0.1764706 , 0.14901961]],

         [[0.34703597, 0.29997715, 0.23723204],
          [0.34391156, 0.29685274, 0.23410764],
          [0.3345211 , 0.2874623 , 0.2247172 ],
          …,
          [0.15514335, 0.14410628, 0.10932413],
          [0.15642688, 0.14466217, 0.1167064 ],
```

```
  [0.15867813, 0.14691341, 0.11946244]],

 [[0.3742598 , 0.32720098, 0.26445588],
  [0.368053  , 0.32099417, 0.25824907],
  [0.35519913, 0.3081403 , 0.2453952 ],
  …,
  [0.14485127, 0.1338142 , 0.09633717],
  [0.14453891, 0.1327742 , 0.10445006],
  [0.14875153, 0.13698682, 0.10953584]],

 …,

 [[0.44949797, 0.39459598, 0.29128227],
  [0.36702234, 0.31212038, 0.2039096 ],
  [0.48605585, 0.4311539 , 0.3219199 ],
  …,
  [0.44820833, 0.37281314, 0.2786955 ],
  [0.45319286, 0.38724616, 0.2976481 ],
  [0.4505358 , 0.38770428, 0.29755142]],

 [[0.43033627, 0.3754343 , 0.2733894 ],
  [0.4210496 , 0.36614764, 0.2617355 ],
  [0.50533134, 0.4504294 , 0.3430918 ],
  …,
  [0.52130413, 0.4484193 , 0.3539947 ],
  [0.5140559 , 0.45043766, 0.359805  ],
  [0.4923104 , 0.43115833, 0.34096226]],

 [[0.36922488, 0.31432292, 0.21236213],
  [0.5829963 , 0.52809435, 0.425697  ],
  [0.5433594 , 0.4884574 , 0.3811198 ],
  …,
  [0.6145144 , 0.5424709 , 0.4476256 ],
  [0.5986979 , 0.53507966, 0.444447  ],
  [0.5696461 , 0.5106771 , 0.420481  ]]],


[[[0.01930147, 0.078125  , 0.05067402],
  [0.01130515, 0.07012868, 0.0426777 ],
  [0.009375  , 0.06819853, 0.04074755],
  …,
  [0.34050244, 0.37971812, 0.38210785],
  [0.39010417, 0.42931986, 0.43324143],
  [0.4488358 , 0.48805147, 0.49197304]],

 [[0.01734057, 0.0761641 , 0.04871311],
  [0.01678874, 0.07561227, 0.04816129],
```

```
  [0.02487135, 0.08369488, 0.0562439 ],
  …,
  [0.34640253, 0.3856182 , 0.38443315],
  [0.4110147 , 0.4502304 , 0.45363134],
  [0.4582412 , 0.49745688, 0.49710956]],

 [[0.02031741, 0.07696569, 0.04951471],
  [0.02923716, 0.08575799, 0.05868937],
  [0.05084767, 0.10640834, 0.08222022],
  …,
  [0.33903176, 0.3791226 , 0.37257546],
  [0.4260024 , 0.46534556, 0.4660453 ],
  [0.45708007, 0.4973409 , 0.49050534]],

 …,

 [[0.2561003 , 0.26394343, 0.25217873],
  [0.25974265, 0.26712623, 0.2544424 ],
  [0.26764503, 0.2715666 , 0.2511928 ],
  …,
  [0.6136142 , 0.62700266, 0.63800144],
  [0.61646694, 0.6321532 , 0.6439179 ],
  [0.6197269 , 0.63541317, 0.6471779 ]],

 [[0.25498873, 0.26283187, 0.25106716],
  [0.25804228, 0.26542586, 0.25274202],
  [0.26573223, 0.2696538 , 0.24928002],
  …,
  [0.61782044, 0.63120896, 0.64220774],
  [0.62581176, 0.641498  , 0.65326273],
  [0.63396645, 0.6496527 , 0.6614174 ]],

 [[0.25490198, 0.2627451 , 0.2509804 ],
  [0.25582108, 0.26320466, 0.25052083],
  [0.26351103, 0.2674326 , 0.24705882],
  …,
  [0.61960787, 0.6329963 , 0.6439951 ],
  [0.62999386, 0.6456801 , 0.65744483],
  [0.6426777 , 0.658364  , 0.6701287 ]]],


[[[0.67233455, 0.5782169 , 0.48409927],
  [0.7176471 , 0.62352943, 0.5294118 ],
  [0.6914522 , 0.59733456, 0.5032169 ],
  …,
  [0.71182597, 0.5888021 , 0.4736213 ],
  [0.71416205, 0.59259343, 0.47886795],
```

```
  [0.7137255 , 0.5921569 , 0.47843137]],

 [[0.5880507 , 0.4939331 , 0.39981547],
  [0.6024488 , 0.5083312 , 0.4142135 ],
  [0.6023776 , 0.50825995, 0.41414228],
  …,
  [0.6923691 , 0.56934524, 0.45416445],
  [0.69845283, 0.5768842 , 0.4631587 ],
  [0.6980162 , 0.5764476 , 0.46272212]],

 [[0.5499074 , 0.45578974, 0.35942027],
  [0.54211354, 0.44799593, 0.35162643],
  [0.55072683, 0.45660922, 0.3602397 ],
  …,
  [0.6462412 , 0.5232173 , 0.40803653],
  [0.6428003 , 0.5212316 , 0.40750614],
  [0.6412795 , 0.5197109 , 0.4059854 ]],

 …,

 [[0.627664  , 0.5257032 , 0.39629146],
  [0.6161373 , 0.51373994, 0.3856379 ],
  [0.58741313, 0.48153073, 0.36388367],
  …,
  [0.490982  , 0.3936704 , 0.30448538],
  [0.48381868, 0.39623442, 0.30647492],
  [0.48012826, 0.39385375, 0.30365768]],

 [[0.6430062 , 0.5410454 , 0.41163367],
  [0.65455693, 0.55215955, 0.42405754],
  [0.65298593, 0.5471036 , 0.42945653],
  …,
  [0.5145484 , 0.41723686, 0.3280518 ],
  [0.5112209 , 0.42363665, 0.33387715],
  [0.5065717 , 0.42029718, 0.3301011 ]],

 [[0.6480775 , 0.5461167 , 0.41670495],
  [0.6780025 , 0.5756051 , 0.44750306],
  [0.69569546, 0.5898131 , 0.47216606],
  …,
  [0.52868414, 0.43137255, 0.3421875 ],
  [0.5224418 , 0.43485755, 0.34509805],
  [0.5177926 , 0.43151808, 0.341322  ]]],


…,
```

```
[[[0.6969669 , 0.6695159 , 0.63814336],
  [0.7532858 , 0.72583485, 0.6944623 ],
  [0.8209023 , 0.7934513 , 0.76207876],
  …,
  [0.9074295 , 0.89649206, 0.86001074],
  [0.8841299 , 0.8684436 , 0.8331495 ],
  [0.8231694 , 0.79643077, 0.76482075]],

 [[0.754165  , 0.726714  , 0.69534147],
  [0.7875713 , 0.76012033, 0.7287478 ],
  [0.82375056, 0.7962996 , 0.764927  ],
  …,
  [0.89271194, 0.87988234, 0.8440317 ],
  [0.8492788 , 0.83359253, 0.7982984 ],
  [0.80328417, 0.7765455 , 0.7449355 ]],

 [[0.80060434, 0.77315336, 0.7417808 ],
  [0.81875813, 0.79130715, 0.7599346 ],
  [0.8324496 , 0.80499864, 0.7736261 ],
  …,
  [0.87390184, 0.8591431 , 0.82384896],
  [0.80675095, 0.7889586 , 0.7543665 ],
  [0.7720648 , 0.7435585 , 0.71280634]],

 …,

 [[0.5523483 , 0.48176005, 0.43470123],
  [0.5115727 , 0.44098452, 0.3939257 ],
  [0.40694675, 0.33635852, 0.2892997 ],
  …,
  [0.87238604, 0.85976344, 0.8244693 ],
  [0.87459934, 0.87020046, 0.83239913],
  [0.8852465 , 0.88267297, 0.8443151 ]],

 [[0.57929903, 0.5087108 , 0.46165198],
  [0.46758363, 0.3969954 , 0.34993657],
  [0.4033098 , 0.33272153, 0.2856627 ],
  …,
  [0.8654132 , 0.8574937 , 0.82091784],
  [0.8748791 , 0.8737439 , 0.8349066 ],
  [0.8859186 , 0.88937247, 0.84842986]],

 [[0.6202129 , 0.5496247 , 0.50256586],
  [0.4370864 , 0.36649817, 0.31943935],
  [0.4075904 , 0.33700216, 0.2899433 ],
  …,
```

```
  [0.8564491 , 0.8528876 , 0.8148591 ],
  [0.87166053, 0.87166053, 0.83244485],
  [0.8818781 , 0.88924634, 0.8463465 ]]],


[[[0.99607843, 0.99607843, 1.        ],
  [0.99607843, 0.99607843, 1.        ],
  [0.9999234 , 0.99607843, 1.        ],
  …,
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  [1.        , 1.        , 0.99215686],
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  …,
```

```
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```

Data Splitting

[16]:
```
train_size = int(len(data)*.7)
val_size = int(len(data)*.2)
test_size = int(len(data)*.1)
```

[17]:
```
train_size
```

[17]: 7

[18]:
```
train = data.take(train_size)
val = data.skip(train_size).take(val_size)
test = data.skip(train_size+val_size).take(test_size)
```

Model Building & Training

[19]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Dense, Flatten,␣
 ↪Dropout
```

[20]:
```
model = Sequential()
```

[21]:
```
model.add(Conv2D(16, (3,3), 1, activation='relu', input_shape=(256,256,3)))
model.add(MaxPooling2D())
model.add(Conv2D(32, (3,3), 1, activation='relu'))
model.add(MaxPooling2D())
model.add(Conv2D(16, (3,3), 1, activation='relu'))
model.add(MaxPooling2D())
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dense(1, activation='sigmoid'))
```

[23]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 254, 254, 16)      448

 max_pooling2d (MaxPooling2  (None, 127, 127, 16)      0
 D)

 conv2d_1 (Conv2D)           (None, 125, 125, 32)      4640

 max_pooling2d_1 (MaxPoolin  (None, 62, 62, 32)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 60, 60, 16)        4624

 max_pooling2d_2 (MaxPoolin  (None, 30, 30, 16)        0
 g2D)

 flatten (Flatten)           (None, 14400)             0

 dense (Dense)               (None, 256)               3686656

 dense_1 (Dense)             (None, 1)                 257

=================================================================
Total params: 3696625 (14.10 MB)
Trainable params: 3696625 (14.10 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

[22]:
```
model.compile('adam', loss=tf.losses.BinaryCrossentropy(), metrics=['accuracy'])
```

[26]:
```
history = model.fit(train, epochs=30, validation_data=val)
```

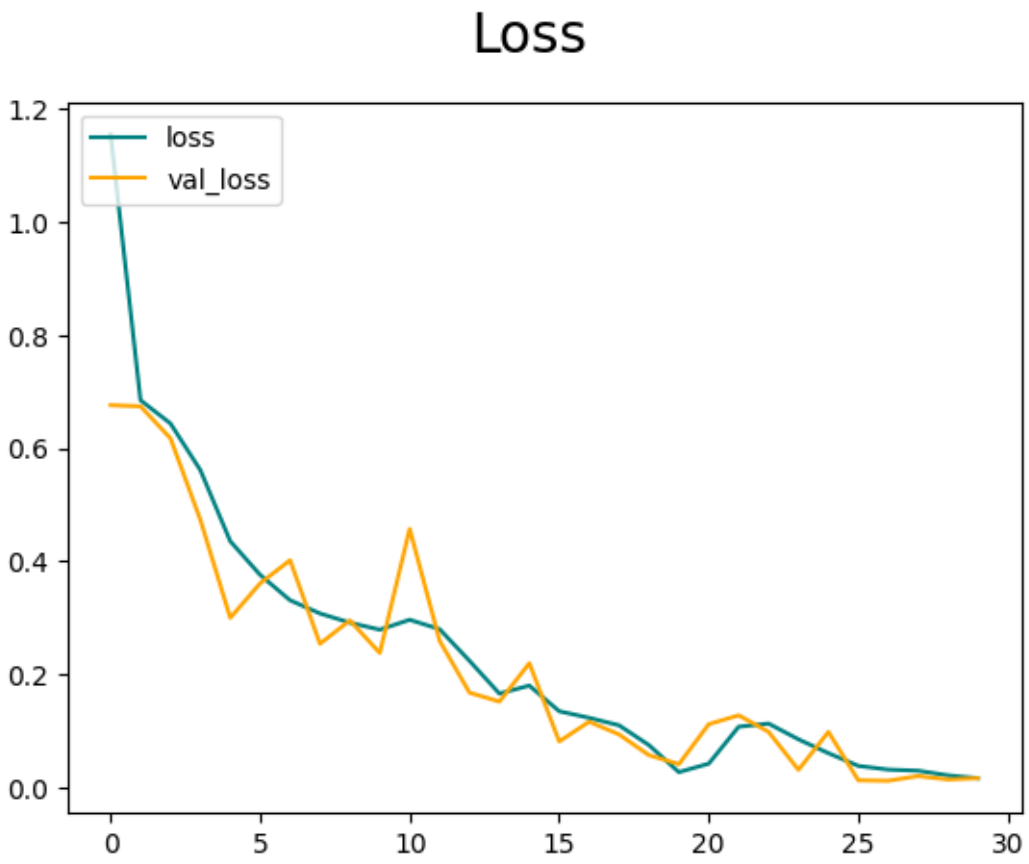
```
Epoch 1/30
7/7 [==============================] - 8s 212ms/step - loss: 1.1548 - accuracy:
0.5268 - val_loss: 0.6760 - val_accuracy: 0.6094
Epoch 2/30
7/7 [==============================] - 4s 481ms/step - loss: 0.6847 - accuracy:
0.5536 - val_loss: 0.6739 - val_accuracy: 0.7969
Epoch 3/30
7/7 [==============================] - 2s 207ms/step - loss: 0.6437 - accuracy:
0.6429 - val_loss: 0.6175 - val_accuracy: 0.6094
Epoch 4/30
7/7 [==============================] - 2s 268ms/step - loss: 0.5614 - accuracy:
0.6741 - val_loss: 0.4736 - val_accuracy: 0.7656
Epoch 5/30
```

```
7/7 [==============================] - 2s 266ms/step - loss: 0.4355 - accuracy:
0.8125 - val_loss: 0.3000 - val_accuracy: 0.8438
Epoch 6/30
7/7 [==============================] - 2s 264ms/step - loss: 0.3760 - accuracy:
0.8393 - val_loss: 0.3611 - val_accuracy: 0.8438
Epoch 7/30
7/7 [==============================] - 3s 288ms/step - loss: 0.3311 - accuracy:
0.8482 - val_loss: 0.4020 - val_accuracy: 0.7969
Epoch 8/30
7/7 [==============================] - 2s 207ms/step - loss: 0.3078 - accuracy:
0.8438 - val_loss: 0.2542 - val_accuracy: 0.9219
Epoch 9/30
7/7 [==============================] - 2s 202ms/step - loss: 0.2915 - accuracy:
0.8705 - val_loss: 0.2956 - val_accuracy: 0.8594
Epoch 10/30
7/7 [==============================] - 2s 207ms/step - loss: 0.2792 - accuracy:
0.8750 - val_loss: 0.2380 - val_accuracy: 0.8906
Epoch 11/30
7/7 [==============================] - 2s 263ms/step - loss: 0.2967 - accuracy:
0.8795 - val_loss: 0.4573 - val_accuracy: 0.7500
Epoch 12/30
7/7 [==============================] - 3s 276ms/step - loss: 0.2801 - accuracy:
0.8795 - val_loss: 0.2596 - val_accuracy: 0.8906
Epoch 13/30
7/7 [==============================] - 2s 210ms/step - loss: 0.2241 - accuracy:
0.9107 - val_loss: 0.1678 - val_accuracy: 0.9375
Epoch 14/30
7/7 [==============================] - 2s 215ms/step - loss: 0.1662 - accuracy:
0.9509 - val_loss: 0.1520 - val_accuracy: 0.9375
Epoch 15/30
7/7 [==============================] - 2s 197ms/step - loss: 0.1803 - accuracy:
0.9330 - val_loss: 0.2199 - val_accuracy: 0.8906
Epoch 16/30
7/7 [==============================] - 2s 272ms/step - loss: 0.1350 - accuracy:
0.9554 - val_loss: 0.0816 - val_accuracy: 0.9844
Epoch 17/30
7/7 [==============================] - 2s 275ms/step - loss: 0.1233 - accuracy:
0.9554 - val_loss: 0.1165 - val_accuracy: 0.9688
Epoch 18/30
7/7 [==============================] - 3s 244ms/step - loss: 0.1101 - accuracy:
0.9688 - val_loss: 0.0940 - val_accuracy: 0.9688
Epoch 19/30
7/7 [==============================] - 2s 267ms/step - loss: 0.0751 - accuracy:
0.9777 - val_loss: 0.0573 - val_accuracy: 0.9688
Epoch 20/30
7/7 [==============================] - 2s 268ms/step - loss: 0.0273 - accuracy:
0.9955 - val_loss: 0.0414 - val_accuracy: 0.9844
Epoch 21/30
```

```
7/7 [==============================] - 2s 268ms/step - loss: 0.0423 - accuracy:
0.9911 - val_loss: 0.1121 - val_accuracy: 0.9531
Epoch 22/30
7/7 [==============================] - 2s 269ms/step - loss: 0.1076 - accuracy:
0.9598 - val_loss: 0.1278 - val_accuracy: 0.9375
Epoch 23/30
7/7 [==============================] - 4s 500ms/step - loss: 0.1132 - accuracy:
0.9598 - val_loss: 0.0985 - val_accuracy: 0.9531
Epoch 24/30
7/7 [==============================] - 2s 215ms/step - loss: 0.0853 - accuracy:
0.9732 - val_loss: 0.0314 - val_accuracy: 1.0000
Epoch 25/30
7/7 [==============================] - 2s 218ms/step - loss: 0.0609 - accuracy:
0.9777 - val_loss: 0.0984 - val_accuracy: 0.9844
Epoch 26/30
7/7 [==============================] - 2s 213ms/step - loss: 0.0384 - accuracy:
0.9911 - val_loss: 0.0129 - val_accuracy: 1.0000
Epoch 27/30
7/7 [==============================] - 4s 500ms/step - loss: 0.0319 - accuracy:
0.9866 - val_loss: 0.0121 - val_accuracy: 1.0000
Epoch 28/30
7/7 [==============================] - 2s 213ms/step - loss: 0.0298 - accuracy:
0.9955 - val_loss: 0.0204 - val_accuracy: 1.0000
Epoch 29/30
7/7 [==============================] - 2s 208ms/step - loss: 0.0216 - accuracy:
0.9955 - val_loss: 0.0143 - val_accuracy: 1.0000
Epoch 30/30
7/7 [==============================] - 2s 212ms/step - loss: 0.0166 - accuracy:
0.9911 - val_loss: 0.0166 - val_accuracy: 1.0000
```

Data Validation

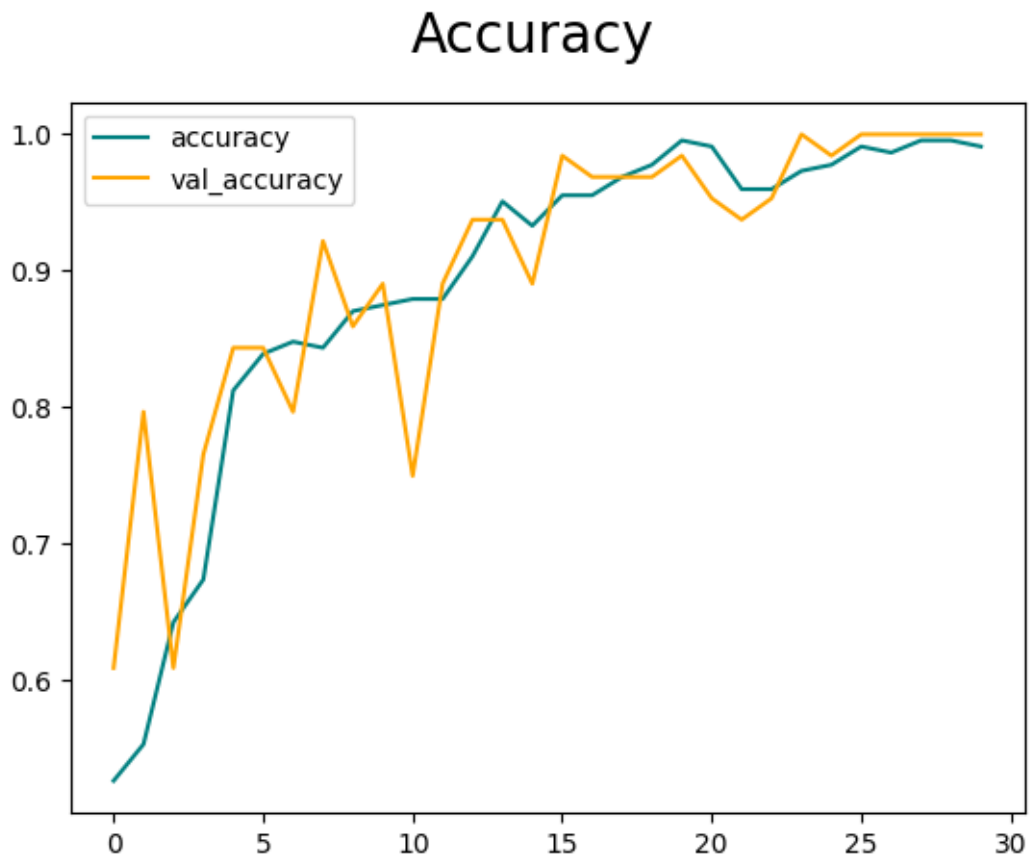
[28]:
```python
import matplotlib.pyplot as plt

# Plot training & validation loss values
fig = plt.figure()
plt.plot(history.history['loss'], color='teal', label='loss')
plt.plot(history.history['val_loss'], color='orange', label='val_loss')
fig.suptitle('Loss', fontsize=20)
plt.legend(loc="upper left")
plt.show()
```



[29]:
```
test_loss, test_acc = model.evaluate(test)
print(f'Test accuracy: {test_acc}')
```

```
1/1 [==============================] - 1s 1s/step - loss: 0.0017 - accuracy:
1.0000
Test accuracy: 1.0
```

[32]:
```
fig = plt.figure()
plt.plot(history.history['accuracy'], color='teal', label='accuracy')
plt.plot(history.history['val_accuracy'], color='orange', label='val_accuracy')
fig.suptitle('Accuracy', fontsize=20)
plt.legend(loc="upper left")
plt.show()
```



[33]:
```
from tensorflow.keras.metrics import Precision, Recall, BinaryAccuracy
```

[34]:
```
pre = Precision()
re = Recall()
acc = BinaryAccuracy()
```

[35]:
```
for batch in test.as_numpy_iterator():
    X, y = batch
    yhat = model.predict(X)
    pre.update_state(y, yhat)
    re.update_state(y, yhat)
    acc.update_state(y, yhat)
```

```
1/1 [==============================] - 0s 134ms/step
```

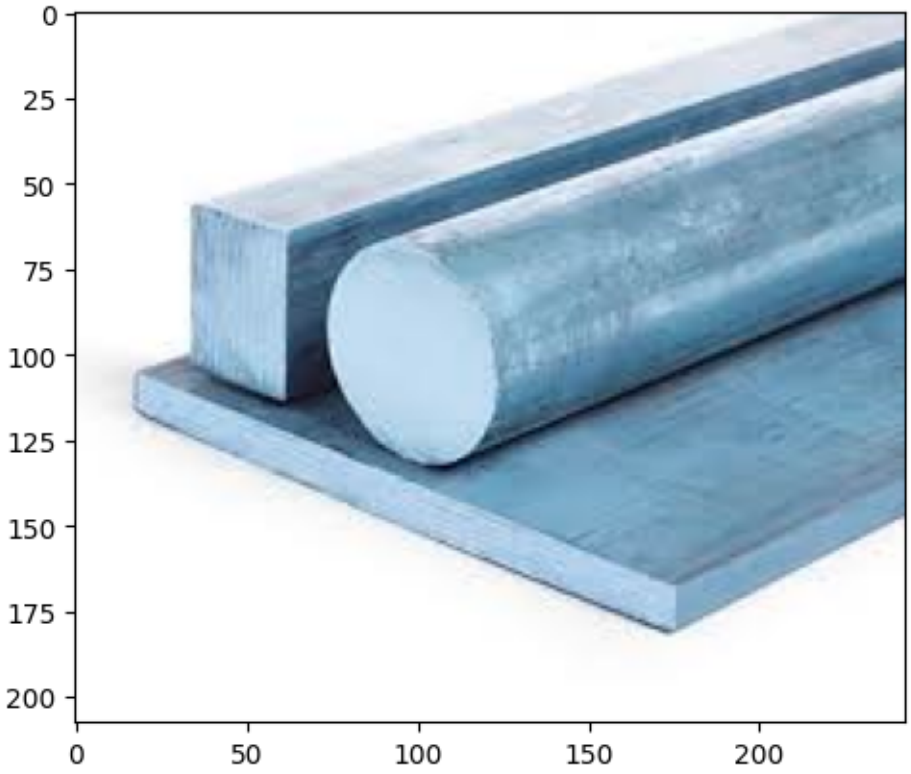
[36]:
```
print(pre.result(), re.result(), acc.result())
```

```
tf.Tensor(1.0, shape=(), dtype=float32) tf.Tensor(1.0, shape=(), dtype=float32)
tf.Tensor(1.0, shape=(), dtype=float32)
```

Testing

[37]:
```
import cv2
```

[39]:
```
img = cv2.imread('/content/drive/MyDrive/Dataset_Metal/Dataset/Copper_Brass/12.
↪jpeg')
plt.imshow(img)
plt.show()
```



[40]:
```
resize = tf.image.resize(img, (256,256))
plt.imshow(resize.numpy().astype(int))
plt.imshow(cv2.cvtColor(resize.numpy().astype('uint8'), cv2.COLOR_BGR2RGB))
plt.axis('off')  # Turn off axis labels
plt.show()
```

[41]:
```
yhat = model.predict(np.expand_dims(resize/255, 0))
```

```
1/1 [==============================] - 0s 345ms/step
```

[42]:
```
if yhat > 0.5:
    print(f'Detected class is Copper/Brass')
else:
    print(f'Detected class is Steel/Other')
```

```
Detected class is Copper/Brass
```

[ ]:
```

```