

```
# Install required libraries
```

```
!pip install tensorflow keras matplotlib scikit-image tensorflow-addons gdown
```

```
# Create project directories
```

```
!mkdir -p SRGAN_Improved_Project/models SRGAN_Improved_Project/utils SRGAN_Improved_Project/results DIV2K
```

```
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.32.3)
Requirement already satisfied: setuptools in /usr/local/lib/python3.11/dist-packages (from tensorflow) (75.2.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.0.1)
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (4.13.2)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.2)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.71.0)
Requirement already satisfied: tensorboard<2.19,>=2.18 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.18.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.0.2)
Requirement already satisfied: h5py>=3.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.13.0)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.4.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow)
Requirement already satisfied: rich in /usr/local/lib/python3.11/dist-packages (from keras) (13.9.4)
Requirement already satisfied: namex in /usr/local/lib/python3.11/dist-packages (from keras) (0.0.9)
Requirement already satisfied: optree in /usr/local/lib/python3.11/dist-packages (from keras) (0.15.0)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.57.0)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.1.0)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (2.8.2)
Requirement already satisfied: scipy>=1.11.4 in /usr/local/lib/python3.11/dist-packages (from scikit-image) (1.14.1)
Requirement already satisfied: networkx>=3.0 in /usr/local/lib/python3.11/dist-packages (from scikit-image) (3.4.2)
Requirement already satisfied: imageio!=2.35.0,>=2.33 in /usr/local/lib/python3.11/dist-packages (from scikit-image) (2.37.0)
Requirement already satisfied: tifffile>=2022.8.12 in /usr/local/lib/python3.11/dist-packages (from scikit-image) (2025.3.30)
Requirement already satisfied: lazy-loader>=0.4 in /usr/local/lib/python3.11/dist-packages (from scikit-image) (0.4)
Collecting typeguard<3.0.0,>=2.7 (from tensorflow-addons)
  Downloading typeguard-2.13.3-py3-none-any.whl.metadata (3.6 kB)
Requirement already satisfied: beautifulsoup4 in /usr/local/lib/python3.11/dist-packages (from gdown) (4.13.4)
Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-packages (from gdown) (3.18.0)
Requirement already satisfied: tqdm in /usr/local/lib/python3.11/dist-packages (from gdown) (4.67.1)
Requirement already satisfied: wheel<1.0,>=0.23.0 in /usr/local/lib/python3.11/dist-packages (from astunparse>=1.6.0->tensorflow)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->ten
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (3.
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensoflo
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensoflo
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensofl
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.11/dist-packages (from tensorboard
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensofl
Requirement already satisfied: soupsieve>1.2 in /usr/local/lib/python3.11/dist-packages (from beautifulsoup4->gdown) (2.7)
Requirement already satisfied: PySocks!=1.5.7,>=1.5.6 in /usr/local/lib/python3.11/dist-packages (from requests[socks]->gdown) (1
Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras) (2.18.0)
Requirement already satisfied: mdurl~=0.1 in /usr/local/lib/python3.11/dist-packages (from markdown-it-py>=2.2.0->rich->keras) (0
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.11/dist-packages (from werkzeug>=1.0.1->tensorboard<2.
Downloading tensorflow-addons-0.23.0-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (611 kB)
611.8/611.8 kB 9.3 MB/s eta 0:00:00
Downloading typeguard-2.13.3-py3-none-any.whl (17 kB)
Installing collected packages: typeguard, tensorflow-addons
  Attempting uninstall: typeguard
    Found existing installation: typeguard 4.4.2
    Uninstalling typeguard-4.4.2:
      Successfully uninstalled typeguard-4.4.2
  ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the
  inflect 7.5.0 requires typeguard>=4.0.1, but you have typeguard 2.13.3 which is incompatible.
  Successfully installed tensorflow-addons-0.23.0 typeguard-2.13.3
```

```
import os
import cv2
import numpy as np
import matplotlib.pyplot as plt
from glob import glob
from sklearn.model_selection import train_test_split
```

```
import tensorflow as tf
from tensorflow.keras.layers import Input, Conv2D, BatchNormalization, PReLU, Add, LeakyReLU, Dense, Flatten, UpSampling2D
from tensorflow.keras.models import Model, Sequential
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.applications import VGG19
from tensorflow.keras.losses import BinaryCrossentropy, MeanSquaredError
from skimage.metrics import peak_signal_noise_ratio, structural_similarity
```

```
# Download DIV2K high-resolution images
```

```
!wget -c https://data.vision.ee.ethz.ch/cv1/DIV2K/DIV2K_train_HR.zip -O DIV2K/DIV2K_train_HR.zip
```

```
# Unzip
!unzip -q DIV2K/DIV2K_train_HR.zip -d DIV2K/
```

 --2025-04-27 06:46:31-- https://data.vision.ee.ethz.ch/cv1/DIV2K/DIV2K_train_HR.zip
Resolving data.vision.ee.ethz.ch (data.vision.ee.ethz.ch)... 129.132.52.178, 2001:67c:10ec:36c2::178
Connecting to data.vision.ee.ethz.ch (data.vision.ee.ethz.ch)[129.132.52.178]:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 3530603713 (3.3G) [application/zip]
Saving to: 'DIV2K/DIV2K_train_HR.zip'

DIV2K/DIV2K_train_H 100%[=====] 3.29G 19.2MB/s in 3m 9s

2025-04-27 06:49:41 (17.8 MB/s) - 'DIV2K/DIV2K_train_HR.zip' saved [3530603713/3530603713]


```
def preprocess_div2k(hr_folder, hr_size=(256, 256), lr_size=(64, 64), limit=800):
    hr_images, lr_images = [], []
    hr_paths = sorted(glob(f"{hr_folder}/DIV2K_train_HR/*.png"))[:limit]

    for path in hr_paths:
        img = cv2.imread(path)
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        hr = cv2.resize(img, hr_size)
        lr = cv2.resize(hr, lr_size, interpolation=cv2.INTER_CUBIC)
        hr_images.append(hr / 255.0)
        lr_images.append(lr / 255.0)


    return np.array(lr_images), np.array(hr_images)

# Load and split
x_lr, x_hr = preprocess_div2k("DIV2K")
x_hr_train, x_hr_val, x_lr_train, x_lr_val = train_test_split(x_hr, x_lr, test_size=0.1)

print(f"Dataset Loaded → HR: {x_hr.shape}, LR: {x_lr.shape}")
```

 Dataset Loaded → HR: (800, 256, 256, 3), LR: (800, 64, 64, 3)

```
from tensorflow.keras.layers import Concatenate

def dense_block(x, growth_rate=32):
    for _ in range(5):
        tmp = Conv2D(growth_rate, 3, padding='same')(x)
        tmp = PReLU(shared_axes=[1, 2])(tmp)
        x = Concatenate()([x, tmp]) #  Correct way (instead of tf.concat)
    return x

def RRDB(x_input, filters=64):
    x = dense_block(x_input)
    x = dense_block(x)
    x = dense_block(x)
    x = Conv2D(filters, 3, padding='same')(x)
    x = x * 0.2 # scaled residual
    x = Add()([x_input, x])
    return x

def build_generator():
    inputs = Input(shape=(64, 64, 3))
    x = Conv2D(64, 3, padding='same')(inputs)
    x = PReLU(shared_axes=[1, 2])(x)

    residual = x
    for _ in range(5): # using 5 RRDB blocks
        residual = RRDB(residual)

    x = Conv2D(64, 3, padding='same')(residual)
    x = Add()([x, residual])

    x = UpSampling2D()(x)
    x = Conv2D(256, 3, padding='same')(x)
    x = PReLU(shared_axes=[1, 2])(x)

    x = UpSampling2D()(x)
    x = Conv2D(256, 3, padding='same')(x)
    x = PReLU(shared_axes=[1, 2])(x)

    outputs = Conv2D(3, 9, padding='same', activation='tanh')(x)
    return Model(inputs, outputs, name="Improved_SRGenerator")

generator = build_generator()
generator.summary()
```




concatenate_3 (Concatenate)	(None, 64, 64, 192)	0	concatenate_2[0]... p_re_lu_6[0][0]
conv2d_7 (Conv2D)	(None, 64, 64, 32)	55,328	concatenate_3[0]...
p_re_lu_7 (PReLU)	(None, 64, 64, 32)	32	conv2d_7[0][0]
concatenate_4 (Concatenate)	(None, 64, 64, 224)	0	concatenate_3[0]... p_re_lu_7[0][0]
conv2d_8 (Conv2D)	(None, 64, 64, 32)	64,544	concatenate_4[0]...
p_re_lu_8 (PReLU)	(None, 64, 64, 32)	32	conv2d_8[0][0]
concatenate_5 (Concatenate)	(None, 64, 64, 256)	0	concatenate_4[0]... p_re_lu_8[0][0]
conv2d_9 (Conv2D)	(None, 64, 64, 32)	73,760	concatenate_5[0]...
p_re_lu_9 (PReLU)	(None, 64, 64, 32)	32	conv2d_9[0][0]
concatenate_6 (Concatenate)	(None, 64, 64, 288)	0	concatenate_5[0]... p_re_lu_9[0][0]
conv2d_10 (Conv2D)	(None, 64, 64, 32)	82,976	concatenate_6[0]...
p_re_lu_10 (PReLU)	(None, 64, 64, 32)	32	conv2d_10[0][0]
concatenate_7 (Concatenate)	(None, 64, 64, 320)	0	concatenate_6[0]... p_re_lu_10[0][0]
conv2d_11 (Conv2D)	(None, 64, 64, 32)	92,192	concatenate_7[0]...
p_re_lu_11 (PReLU)	(None, 64, 64, 32)	32	conv2d_11[0][0]
concatenate_8	(None, 64, 64,	0	concatenate_7[0]...

(Concatenate)	352)		p_re_lu_11[0][0]
conv2d_12 (Conv2D)	(None, 64, 64, 32)	101,408	concatenate_8[0]...
p_re_lu_12 (PReLU)	(None, 64, 64, 32)	32	conv2d_12[0][0]
concatenate_9 (Concatenate)	(None, 64, 64, 384)	0	concatenate_8[0]... p_re_lu_12[0][0]
conv2d_13 (Conv2D)	(None, 64, 64, 32)	110,624	concatenate_9[0]...
p_re_lu_13 (PReLU)	(None, 64, 64, 32)	32	conv2d_13[0][0]
concatenate_10 (Concatenate)	(None, 64, 64, 416)	0	concatenate_9[0]... p_re_lu_13[0][0]
conv2d_14 (Conv2D)	(None, 64, 64, 32)	119,840	concatenate_10[0]...
p_re_lu_14 (PReLU)	(None, 64, 64, 32)	32	conv2d_14[0][0]
concatenate_11 (Concatenate)	(None, 64, 64, 448)	0	concatenate_10[0]... p_re_lu_14[0][0]
conv2d_15 (Conv2D)	(None, 64, 64, 32)	129,056	concatenate_11[0]...
p_re_lu_15 (PReLU)	(None, 64, 64, 32)	32	conv2d_15[0][0]
concatenate_12 (Concatenate)	(None, 64, 64, 480)	0	concatenate_11[0]... p_re_lu_15[0][0]
conv2d_16 (Conv2D)	(None, 64, 64, 32)	138,272	concatenate_12[0]...
p_re_lu_16 (PReLU)	(None, 64, 64, 32)	32	conv2d_16[0][0]
concatenate_13 (Concatenate)	(None, 64, 64, 512)	0	concatenate_12[0]... p_re_lu_16[0][0]
conv2d_17 (Conv2D)	(None, 64, 64, 32)	147,488	concatenate_13[0]...
p_re_lu_17 (PReLU)	(None, 64, 64, 32)	32	conv2d_17[0][0]
concatenate_14 (Concatenate)	(None, 64, 64, 544)	0	concatenate_13[0]... p_re_lu_17[0][0]
conv2d_18 (Conv2D)	(None, 64, 64, 64)	313,408	concatenate_14[0]...
multiply (Multiply)	(None, 64, 64, 64)	0	conv2d_18[0][0]
add (Add)	(None, 64, 64, 64)	0	p_re_lu_2[0][0], multiply[0][0]
conv2d_19 (Conv2D)	(None, 64, 64, 32)	18,464	add[0][0]
p_re_lu_18 (PReLU)	(None, 64, 64, 32)	32	conv2d_19[0][0]
concatenate_15 (Concatenate)	(None, 64, 64, 96)	0	add[0][0], p_re_lu_18[0][0]
conv2d_20 (Conv2D)	(None, 64, 64, 32)	27,680	concatenate_15[0]...
p_re_lu_19 (PReLU)	(None, 64, 64, 32)	32	conv2d_20[0][0]
concatenate_16 (Concatenate)	(None, 64, 64, 128)	0	concatenate_15[0]... p_re_lu_19[0][0]
conv2d_21 (Conv2D)	(None, 64, 64, 32)	36,896	concatenate_16[0]...
p_re_lu_20 (PReLU)	(None, 64, 64, 32)	32	conv2d_21[0][0]
concatenate_17 (Concatenate)	(None, 64, 64, 160)	0	concatenate_16[0]... p_re_lu_20[0][0]

conv2d_22 (Conv2D)	(None, 64, 64, 32)	46,112	concatenate_17[0...]
p_re_lu_21 (PReLU)	(None, 64, 64, 32)	32	conv2d_22[0][0]
concatenate_18 (Concatenate)	(None, 64, 64, 192)	0	concatenate_17[0...] p_re_lu_21[0][0]
conv2d_23 (Conv2D)	(None, 64, 64, 32)	55,328	concatenate_18[0...]
p_re_lu_22 (PReLU)	(None, 64, 64, 32)	32	conv2d_23[0][0]
concatenate_19 (Concatenate)	(None, 64, 64, 224)	0	concatenate_18[0...] p_re_lu_22[0][0]
conv2d_24 (Conv2D)	(None, 64, 64, 32)	64,544	concatenate_19[0...]
p_re_lu_23 (PReLU)	(None, 64, 64, 32)	32	conv2d_24[0][0]
concatenate_20 (Concatenate)	(None, 64, 64, 256)	0	concatenate_19[0...] p_re_lu_23[0][0]
conv2d_25 (Conv2D)	(None, 64, 64, 32)	73,760	concatenate_20[0...]
p_re_lu_24 (PReLU)	(None, 64, 64, 32)	32	conv2d_25[0][0]
concatenate_21 (Concatenate)	(None, 64, 64, 288)	0	concatenate_20[0...] p_re_lu_24[0][0]
conv2d_26 (Conv2D)	(None, 64, 64, 32)	82,976	concatenate_21[0...]
p_re_lu_25 (PReLU)	(None, 64, 64, 32)	32	conv2d_26[0][0]
concatenate_22 (Concatenate)	(None, 64, 64, 320)	0	concatenate_21[0...] p_re_lu_25[0][0]
conv2d_27 (Conv2D)	(None, 64, 64, 32)	92,192	concatenate_22[0...]
p_re_lu_26 (PReLU)	(None, 64, 64, 32)	32	conv2d_27[0][0]
concatenate_23 (Concatenate)	(None, 64, 64, 352)	0	concatenate_22[0...] p_re_lu_26[0][0]
conv2d_28 (Conv2D)	(None, 64, 64, 32)	101,408	concatenate_23[0...]
p_re_lu_27 (PReLU)	(None, 64, 64, 32)	32	conv2d_28[0][0]
concatenate_24 (Concatenate)	(None, 64, 64, 384)	0	concatenate_23[0...] p_re_lu_27[0][0]
conv2d_29 (Conv2D)	(None, 64, 64, 32)	110,624	concatenate_24[0...]
p_re_lu_28 (PReLU)	(None, 64, 64, 32)	32	conv2d_29[0][0]
concatenate_25 (Concatenate)	(None, 64, 64, 416)	0	concatenate_24[0...] p_re_lu_28[0][0]
conv2d_30 (Conv2D)	(None, 64, 64, 32)	119,840	concatenate_25[0...]
p_re_lu_29 (PReLU)	(None, 64, 64, 32)	32	conv2d_30[0][0]
concatenate_26 (Concatenate)	(None, 64, 64, 448)	0	concatenate_25[0...] p_re_lu_29[0][0]
conv2d_31 (Conv2D)	(None, 64, 64, 32)	129,056	concatenate_26[0...]
p_re_lu_30 (PReLU)	(None, 64, 64, 32)	32	conv2d_31[0][0]
concatenate_27 (Concatenate)	(None, 64, 64, 480)	0	concatenate_26[0...] p_re_lu_30[0][0]
conv2d_32 (Conv2D)	(None, 64, 64, 32)	138,272	concatenate_27[0...]