```
!rm -rf clone && git clone https://github.com/Bileth/Grayscale-image-colorization clone &&
```

```
Cloning into 'clone'...
remote: Enumerating objects: 14317, done.
remote: Counting objects: 100% (14317/14317), done.
remote: Compressing objects: 100% (14311/14311), done.
remote: Total 14317 (delta 5), reused 14304 (delta 1), pack-reused 0
Receiving objects: 100% (14317/14317), 230.02 MiB | 21.16 MiB/s, done.
Resolving deltas: 100% (5/5), done.
Checking out files: 100% (22296/22296), done.
```

```
from PIL import Image
from sklearn.model_selection import train_test_split
import tensorflow as tf
import numpy as np
from matplotlib import image
from matplotlib import pyplot as plt
import os
from tensorflow import keras

# Veličina serije koju ćemo koristiti za obuku
batch_size = 64

# Size of the image required to train our model
img_size = 120

# Veličina slika potrebnih za treniranje našeg modela
dataset_split = 2500

master_dir = 'train/images/color/'
x = []
y = []
for image_file in os.listdir( master_dir )[ 0 : dataset_split ]:
    rgb_image = Image.open( os.path.join( master_dir , image_file ) ).resize( ( img_size ,
    # Normalize the RGB image array
    rgb_img_array = (np.asarray( rgb_image ) ) / 255
    gray_image = rgb_image.convert( 'L' )
    # Normaliziranje RGB niza slika
    gray_img_array = ( np.asarray( gray_image ).reshape( ( img_size , img_size , 1 ) ) ) /
    # Nadodavnje oba niza slika
    x.append( gray_img_array )
    y.append( rgb_img_array )

# Train-test podjela
train_x, test_x, train_y, test_y = train_test_split( np.array(x) , np.array(y) , test_size

# Konstrukcija tf.data.Dataset object
dataset = tf.data.Dataset.from_tensor_slices( ( train_x , train_y ) )
dataset = dataset.batch( batch_size )
```

```
def get_generator_model():

  inputs = tf.keras.layers.Input( shape=( img_size , img_size , 1 ) )
```

```
    conv1 = tf.keras.layers.Conv2D( 16 , kernel_size=( 5 , 5 ) , strides=1 )( inputs )
    conv1 = tf.keras.layers.LeakyReLU()( conv1 )
    conv1 = tf.keras.layers.Conv2D( 32 , kernel_size=( 3 , 3 ) , strides=1)( conv1 )
    conv1 = tf.keras.layers.LeakyReLU()( conv1 )
    conv1 = tf.keras.layers.Conv2D( 32 , kernel_size=( 3 , 3 ) , strides=1)( conv1 )
    conv1 = tf.keras.layers.LeakyReLU()( conv1 )

    conv2 = tf.keras.layers.Conv2D( 32 , kernel_size=( 5 , 5 ) , strides=1)( conv1 )
    conv2 = tf.keras.layers.LeakyReLU()( conv2 )
    conv2 = tf.keras.layers.Conv2D( 64 , kernel_size=( 3 , 3 ) , strides=1 )( conv2 )
    conv2 = tf.keras.layers.LeakyReLU()( conv2 )
    conv2 = tf.keras.layers.Conv2D( 64 , kernel_size=( 3 , 3 ) , strides=1 )( conv2 )
    conv2 = tf.keras.layers.LeakyReLU()( conv2 )

    conv3 = tf.keras.layers.Conv2D( 64 , kernel_size=( 5 , 5 ) , strides=1 )( conv2 )
    conv3 = tf.keras.layers.LeakyReLU()( conv3 )
    conv3 = tf.keras.layers.Conv2D( 128 , kernel_size=( 3 , 3 ) , strides=1 )( conv3 )
    conv3 = tf.keras.layers.LeakyReLU()( conv3 )
    conv3 = tf.keras.layers.Conv2D( 128 , kernel_size=( 3 , 3 ) , strides=1 )( conv3 )
    conv3 = tf.keras.layers.LeakyReLU()( conv3 )

    bottleneck = tf.keras.layers.Conv2D( 128 , kernel_size=( 3 , 3 ) , strides=1 , activatio

    concat_1 = tf.keras.layers.Concatenate()( [ bottleneck , conv3 ] )
    conv_up_3 = tf.keras.layers.Conv2DTranspose( 128 , kernel_size=( 3 , 3 ) , strides=1 , a
    conv_up_3 = tf.keras.layers.Conv2DTranspose( 128 , kernel_size=( 3 , 3 ) , strides=1 , a
    conv_up_3 = tf.keras.layers.Conv2DTranspose( 64 , kernel_size=( 5 , 5 ) , strides=1 , ac

    concat_2 = tf.keras.layers.Concatenate()( [ conv_up_3 , conv2 ] )
    conv_up_2 = tf.keras.layers.Conv2DTranspose( 64 , kernel_size=( 3 , 3 ) , strides=1 , ac
    conv_up_2 = tf.keras.layers.Conv2DTranspose( 64 , kernel_size=( 3 , 3 ) , strides=1 , ac
    conv_up_2 = tf.keras.layers.Conv2DTranspose( 32 , kernel_size=( 5 , 5 ) , strides=1 , ac

    concat_3 = tf.keras.layers.Concatenate()( [ conv_up_2 , conv1 ] )
    conv_up_1 = tf.keras.layers.Conv2DTranspose( 32 , kernel_size=( 3 , 3 ) , strides=1 , ac
    conv_up_1 = tf.keras.layers.Conv2DTranspose( 32 , kernel_size=( 3 , 3 ) , strides=1 , ac
    conv_up_1 = tf.keras.layers.Conv2DTranspose( 3 , kernel_size=( 5 , 5 ) , strides=1 , act

    model = tf.keras.models.Model( inputs , conv_up_1 )
    return model


def get_discriminator_model():
    layers = [
              tf.keras.layers.Conv2D( 32 , kernel_size=( 7 , 7 ) , strides=1 , activation='r
              tf.keras.layers.Conv2D( 32 , kernel_size=( 7, 7 ) , strides=1, activation='rel
              tf.keras.layers.MaxPooling2D(),
              tf.keras.layers.Conv2D( 64 , kernel_size=( 5 , 5 ) , strides=1, activation='re
              tf.keras.layers.Conv2D( 64 , kernel_size=( 5 , 5 ) , strides=1, activation='re
              tf.keras.layers.MaxPooling2D(),
              tf.keras.layers.Conv2D( 128 , kernel_size=( 3 , 3 ) , strides=1, activation='r
              tf.keras.layers.Conv2D( 128 , kernel_size=( 3 , 3 ) , strides=1, activation='r
              tf.keras.layers.MaxPooling2D(),
```

```
            tf.keras.layers.Conv2D( 256 , kernel_size=( 3 , 3 ) , strides=1, activation='r
            tf.keras.layers.Conv2D( 256 , kernel_size=( 3 , 3 ) , strides=1, activation='r
            tf.keras.layers.MaxPooling2D(),
            tf.keras.layers.Flatten(),
            tf.keras.layers.Dense( 512, activation='relu'  )  ,
            tf.keras.layers.Dense( 128 , activation='relu' ) ,
            tf.keras.layers.Dense( 16 , activation='relu' ) ,
            tf.keras.layers.Dense( 1 , activation='sigmoid' )
          ]
  model = tf.keras.models.Sequential( layers )
  return model

cross_entropy = tf.keras.losses.BinaryCrossentropy()
mse = tf.keras.losses.MeanSquaredError()

def discriminator_loss(real_output, fake_output):
    real_loss = cross_entropy(tf.ones_like(real_output) - tf.random.uniform( shape=real_ou
    fake_loss = cross_entropy(tf.zeros_like(fake_output) + tf.random.uniform( shape=fake_o
    total_loss = real_loss + fake_loss
    return total_loss

def generator_loss(fake_output , real_y):
    real_y = tf.cast( real_y , 'float32' )
    return mse( fake_output , real_y )

generator_optimizer = tf.keras.optimizers.Adam( 0.0005 )
discriminator_optimizer = tf.keras.optimizers.Adam( 0.0005 )

generator = get_generator_model()
discriminator = get_discriminator_model()


@tf.function
def train_step( input_x , real_y ):

    with tf.GradientTape() as gen_tape, tf.GradientTape() as disc_tape:
        # generiranje slike -> G( x )
        generated_images = generator( input_x , training=True)
        # Vjerojatnost da je slika prava (točna) -> D( x )
        real_output = discriminator( real_y, training=True)
        # Vjerojatnost da je slika generirana  -> D( G( x ) )
        generated_output = discriminator(generated_images, training=True)

        # L2 gubitak -> || y - G(x) ||^2
        gen_loss = generator_loss( generated_images , real_y )
        # Log gubitka za diskriminator
        disc_loss = discriminator_loss( real_output, generated_output )

    #tf.keras.backend.print_tensor( tf.keras.backend.mean( gen_loss ) )
    #tf.keras.backend.print_tensor( gen_loss + disc_loss )

    # Računanje gradijenata
    gradients_of_generator = gen_tape.gradient(gen_loss, generator.trainable_variables)
    gradients_of_discriminator = disc_tape.gradient(disc_loss, discriminator.trainable_var
```

```
    # optimizacija sa Adam-om
    generator_optimizer.apply_gradients(zip(gradients_of_generator, generator.trainable_va
    discriminator_optimizer.apply_gradients(zip(gradients_of_discriminator, discriminator.


num_epochs = 150

for e in range( num_epochs ):
    print( e )
    for ( x , y ) in dataset:
        # Ovjde ( x , y ) predstavlja skup iz našeg skupa podataka za obuku.
        print( x.shape )
        train_step( x , y )
```

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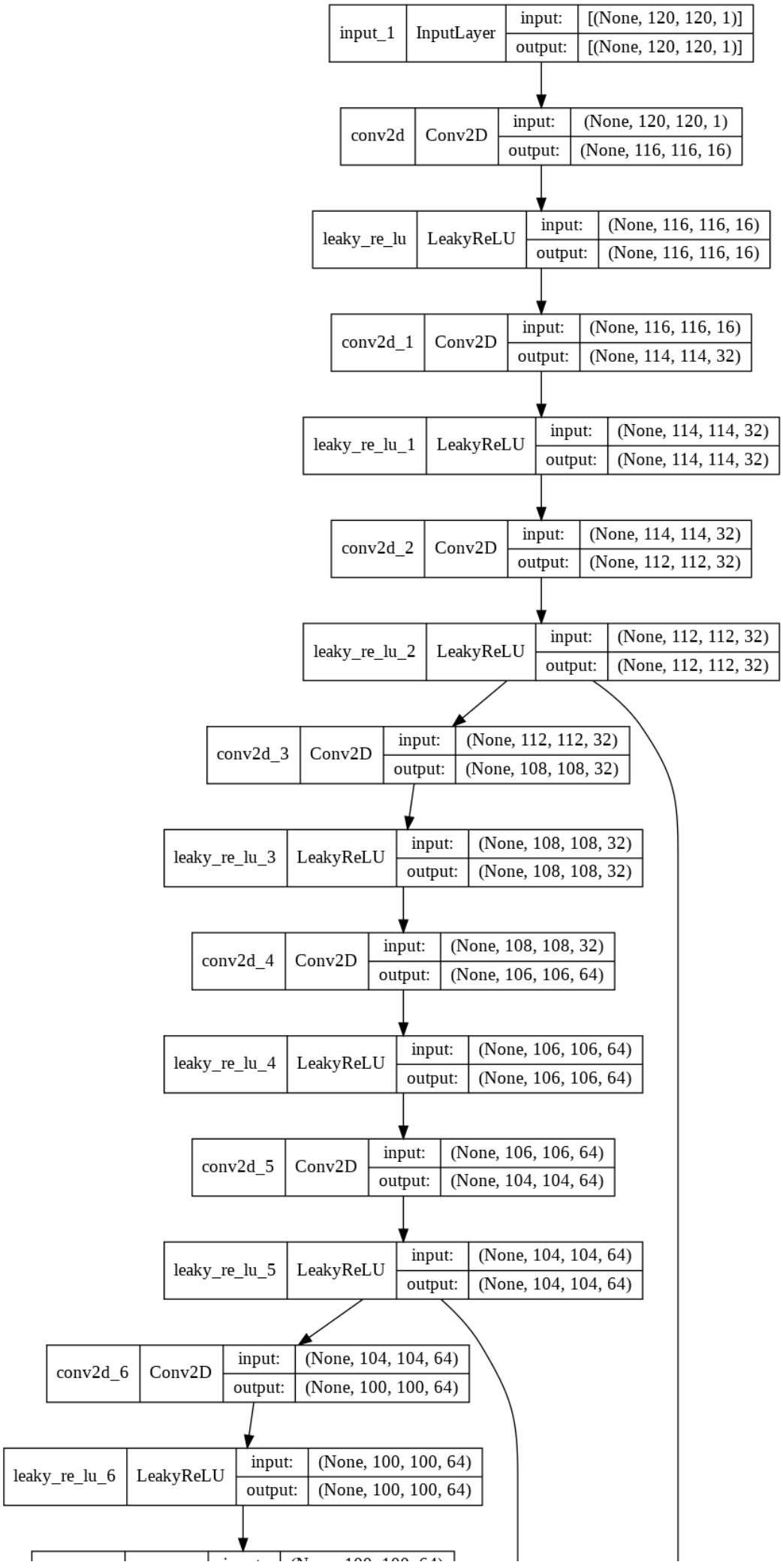
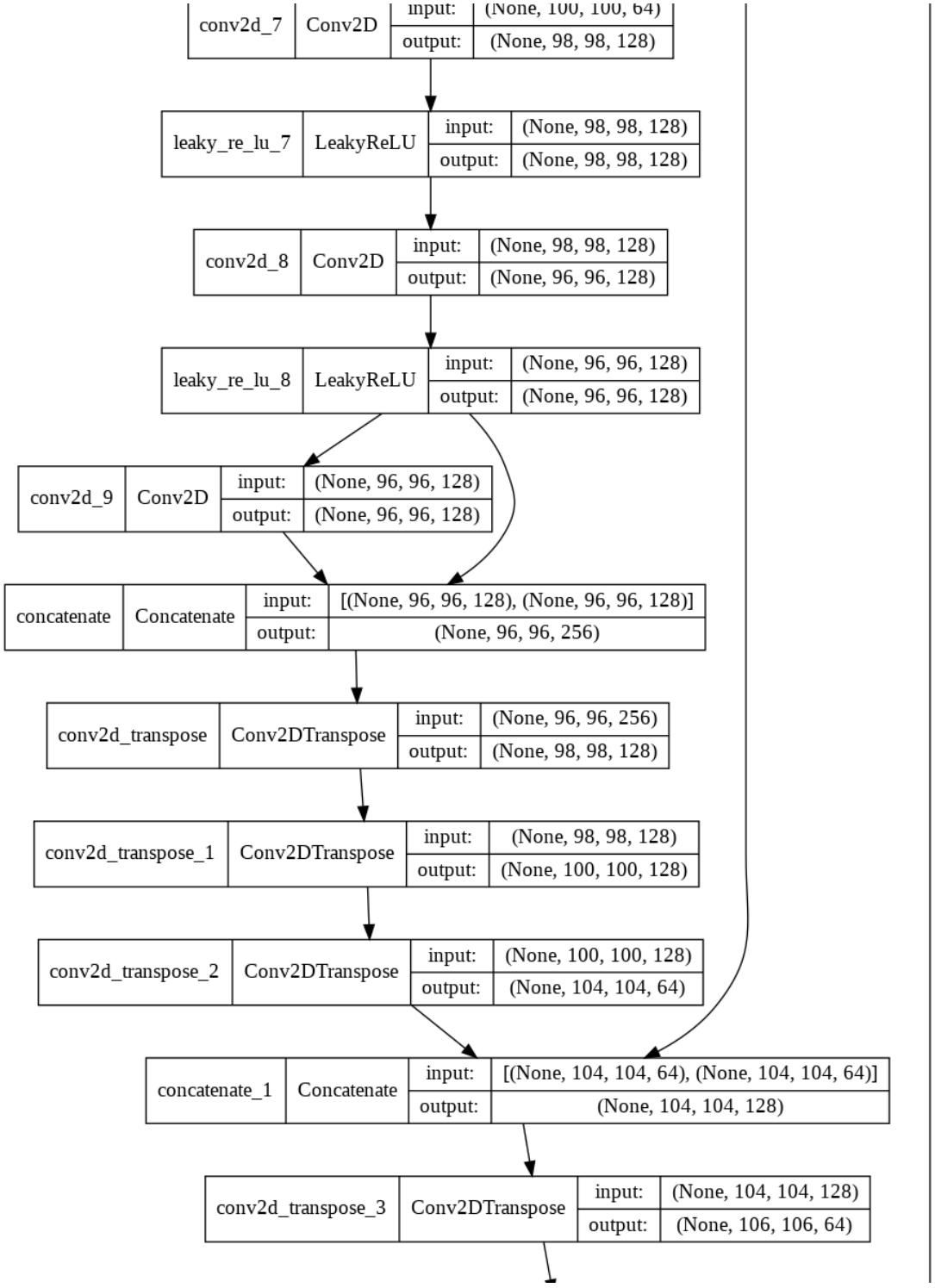
```
generator.compile(optimizer='adam', loss='binary_crossentropy')
tf.keras.utils.plot_model(generator, 'encoder_compress.png', show_shapes=True)
```


input_1 InputLayer input: [(None, 120, 120, 1)] output: [(None, 120, 120, 1)]
conv2d Conv2D input: (None, 120, 120, 1) output: (None, 116, 116, 16)
leaky_re_lu LeakyReLU input: (None, 116, 116, 16) output: (None, 116, 116, 16)
conv2d_1 Conv2D input: (None, 116, 116, 16) output: (None, 114, 114, 32)
leaky_re_lu_1 LeakyReLU input: (None, 114, 114, 32) output: (None, 114, 114, 32)
conv2d_2 Conv2D input: (None, 114, 114, 32) output: (None, 112, 112, 32)
leaky_re_lu_2 LeakyReLU input: (None, 112, 112, 32) output: (None, 112, 112, 32)
conv2d_3 Conv2D input: (None, 112, 112, 32) output: (None, 108, 108, 32)
leaky_re_lu_3 LeakyReLU input: (None, 108, 108, 32) output: (None, 108, 108, 32)
conv2d_4 Conv2D input: (None, 108, 108, 32) output: (None, 106, 106, 64)
leaky_re_lu_4 LeakyReLU input: (None, 106, 106, 64) output: (None, 106, 106, 64)
conv2d_5 Conv2D input: (None, 106, 106, 64) output: (None, 104, 104, 64)
leaky_re_lu_5 LeakyReLU input: (None, 104, 104, 64) output: (None, 104, 104, 64)
conv2d_6 Conv2D input: (None, 104, 104, 64) output: (None, 100, 100, 64)
leaky_re_lu_6 LeakyReLU input: (None, 100, 100, 64) output: (None, 100, 100, 64)




```
generator.save('train/my_model')
```

```
INFO:tensorflow:Assets written to: train/my_model/assets
```

```
y = generator( test_x[0 : ] ).numpy()
```

```
for i in range(len(test_x)):
  plt.figure(figsize=(10,10))
  or_image = plt.subplot(3,3,1)
  or_image.set_title('Grayscale Input', fontsize=16)
  plt.imshow( test_x[i].reshape((120,120)) , cmap='gray' )

  in_image = plt.subplot(3,3,2)
  image = Image.fromarray( ( y[i] * 255 ).astype( 'uint8' ) ).resize( ( 1024 , 1024 ) )
```

```
image = np.asarray( image )
in_image.set_title('Colorized Output', fontsize=16)
plt.imshow( image )

ou_image = plt.subplot(3,3,3)
image = Image.fromarray( ( test_y[i] * 255 ).astype( 'uint8' ) ).resize( ( 1024 , 1024 )
ou_image.set_title('Ground Truth', fontsize=16)
plt.imshow( image )

plt.savefig("plots.pdf")
plt.show()
```