assginment12_muley_tushar

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Assignment: Week 12 Assignment 12

Date: March 5, 2022

Using section 8.4 in Deep Learning with Python as a guide, implement a variational autoencoder using the MNIST data set and save a grid of 15 x 15 digits to the results/vae directory. If you would rather work on a more interesting dataset, you can use the CelebFaces Attributes Dataset instead.

0.0.1 VAE encoder network

[1]:
```
import keras
from keras import layers
#from keras import backend as K
from keras.models import Model
import numpy as np
import tensorflow.compat.v1.keras.backend as K
import tensorflow as tf
tf.compat.v1.disable_eager_execution()
```

[2]:
```
from pathlib import Path
results_dir = Path('results').joinpath('vae')
results_dir.mkdir(parents=True, exist_ok=True)
```

[3]:
```
img_shape = (28, 28, 1)
batch_size = 16
latent_dim = 2
input_img = keras.Input(shape=img_shape)
x = layers.Conv2D(32, 3,
                  padding='same', activation='relu')(input_img)
x = layers.Conv2D(64, 3,
                  padding='same', activation='relu',
 strides=(2, 2))(x)
x = layers.Conv2D(64, 3,
                  padding='same', activation='relu')(x)
x = layers.Conv2D(64, 3,
                  padding='same', activation='relu')(x)
```

```
shape_before_flattening = K.int_shape(x)

x = layers.Flatten()(x)
x = layers.Dense(32, activation='relu')(x)

z_mean = layers.Dense(latent_dim)(x)
z_log_var = layers.Dense(latent_dim)(x)
```

```
WARNING:tensorflow:From /opt/conda/lib/python3.8/site-
packages/tensorflow/python/ops/resource_variable_ops.py:1659: calling
BaseResourceVariable.__init__ (from tensorflow.python.ops.resource_variable_ops)
with constraint is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
```

0.0.2 Latent-space-sampling function

[4]:
```
def sampling(args):
    z_mean, z_log_var = args
    epsilon = K.random_normal(shape=(K.shape(z_mean)[0], latent_dim),
                              mean=0., stddev=1.)
    return z_mean + K.exp(z_log_var) * epsilon

z = layers.Lambda(sampling)([z_mean, z_log_var])
```

0.0.3 VAE decoder network, mapping latent space points to images

[5]:
```
decoder_input = layers.Input(K.int_shape(z)[1:])

x = layers.Dense(np.prod(shape_before_flattening[1:]),
                 activation='relu')(decoder_input)

x = layers.Reshape(shape_before_flattening[1:])(x)

x = layers.Conv2DTranspose(32, 3,padding='same',activation='relu',strides=(2,␣
↪2))(x)

x = layers.Conv2D(1, 3,padding='same',activation='sigmoid')(x)

decoder = Model(decoder_input, x)

z_decoded = decoder(z)
```

0.0.4 Custom layer used to compute the VAE loss

[6]:
```
class CustomVariationalLayer(keras.layers.Layer):

    def vae_loss(self, x, z_decoded):
        x = K.flatten(x)
        z_decoded = K.flatten(z_decoded)
        xent_loss = keras.metrics.binary_crossentropy(x, z_decoded)
        kl_loss = -5e-4 * K.mean(1 + z_log_var - K.square(z_mean) - K.
 ↪exp(z_log_var), axis=-1)
        return K.mean(xent_loss + kl_loss)

    def call(self, inputs):
        x = inputs[0]
        z_decoded = inputs[1]
        loss = self.vae_loss(x, z_decoded)
        self.add_loss(loss, inputs=inputs)
        return x

y = CustomVariationalLayer()([input_img, z_decoded])
```

0.0.5 Training the VAE

[7]:
```
from keras.datasets import mnist
vae = Model(input_img, y)
vae.compile(optimizer='rmsprop', loss=None)
vae.summary()

(x_train, _), (x_test, y_test) = mnist.load_data()

x_train = x_train.astype('float32') / 255.
x_train = x_train.reshape(x_train.shape + (1,))
x_test = x_test.astype('float32') / 255.
x_test = x_test.reshape(x_test.shape + (1,))

vae.fit(x=x_train,␣
 ↪y=None,shuffle=True,epochs=10,batch_size=batch_size,validation_data=(x_test,␣
 ↪None))
```

```
WARNING:tensorflow:Output custom_variational_layer missing from loss dictionary.
We assume this was done on purpose. The fit and evaluate APIs will not be
expecting any data to be passed to custom_variational_layer.
Model: "model_1"
_________________________________________________________________________________
__________________
Layer (type)                 Output Shape              Param #     Connected to
=================================================================================
```

```
==================
input_1 (InputLayer)            [(None, 28, 28, 1)]  0
__________________________________________________________________________________
__________________
conv2d (Conv2D)                 (None, 28, 28, 32)   320         input_1[0][0]
__________________________________________________________________________________
__________________
conv2d_1 (Conv2D)               (None, 14, 14, 64)   18496       conv2d[0][0]
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conv2d_2 (Conv2D)               (None, 14, 14, 64)   36928       conv2d_1[0][0]
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conv2d_3 (Conv2D)               (None, 14, 14, 64)   36928       conv2d_2[0][0]
__________________________________________________________________________________
__________________
flatten (Flatten)               (None, 12544)        0           conv2d_3[0][0]
__________________________________________________________________________________
__________________
dense (Dense)                   (None, 32)           401440      flatten[0][0]
__________________________________________________________________________________
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dense_1 (Dense)                 (None, 2)            66          dense[0][0]
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dense_2 (Dense)                 (None, 2)            66          dense[0][0]
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lambda (Lambda)                 (None, 2)            0           dense_1[0][0]
                                                                 dense_2[0][0]
__________________________________________________________________________________
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model (Model)                   (None, 28, 28, 1)    56385       lambda[0][0]
__________________________________________________________________________________
__________________
custom_variational_layer (Custo (None, 28, 28, 1)    0           input_1[0][0]
                                                                 model[1][0]
==================================================================================
==================
Total params: 550,629
Trainable params: 550,629
Non-trainable params: 0
__________________________________________________________________________________
__________________
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
11493376/11490434 [==============================] - 2s 0us/step
Train on 60000 samples, validate on 10000 samples
```

```
Epoch 1/10
60000/60000 [==============================] - 91s 2ms/sample - loss: 0.2132 -
val_loss: 0.1964
Epoch 2/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1942 -
val_loss: 0.1938
Epoch 3/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1901 -
val_loss: 0.1892
Epoch 4/10
60000/60000 [==============================] - 88s 1ms/sample - loss: 0.1878 -
val_loss: 0.1867
Epoch 5/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1861 -
val_loss: 0.1860
Epoch 6/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1849 -
val_loss: 0.1844
Epoch 7/10
60000/60000 [==============================] - 90s 1ms/sample - loss: 0.1839 -
val_loss: 0.1836
Epoch 8/10
60000/60000 [==============================] - 90s 1ms/sample - loss: 0.1832 -
val_loss: 0.1848
Epoch 9/10
60000/60000 [==============================] - 90s 1ms/sample - loss: 0.1825 -
val_loss: 0.1824
Epoch 10/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1821 -
val_loss: 0.1821
```

[7]:
```
<tensorflow.python.keras.callbacks.History at 0x7fb8961f3640>
```

0.0.6 Smpling a grid of points from the 2D latent space and decoding them to images

[8]:
```
import matplotlib.pyplot as plt
from scipy.stats import norm

n = 15
digit_size = 28
figure = np.zeros((digit_size * n, digit_size * n))
grid_x = norm.ppf(np.linspace(0.05, 0.95, n))
grid_y = norm.ppf(np.linspace(0.05, 0.95, n))


for i, yi in enumerate(grid_x):
    for j, xi in enumerate(grid_y):
```

```
        z_sample = np.array([[xi, yi]])
        z_sample = np.tile(z_sample, batch_size).reshape(batch_size, 2)
        x_decoded = decoder.predict(z_sample, batch_size=batch_size)
        digit = x_decoded[0].reshape(digit_size, digit_size)
        figure[i * digit_size: (i + 1) * digit_size,
               j * digit_size: (j + 1) * digit_size] = digit


        plt.figure(figsize=(10, 10))
plt.imshow(figure, cmap='Greys_r')
img = results_dir.joinpath('Assignment_12_Grid.png')
plt.savefig(img)
plt.show()
```

```
<ipython-input-8-26c53b57dd52>:21: RuntimeWarning: More than 20 figures have
been opened. Figures created through the pyplot interface
(`matplotlib.pyplot.figure`) are retained until explicitly closed and may
consume too much memory. (To control this warning, see the rcParam
`figure.max_open_warning`).
  plt.figure(figsize=(10, 10))
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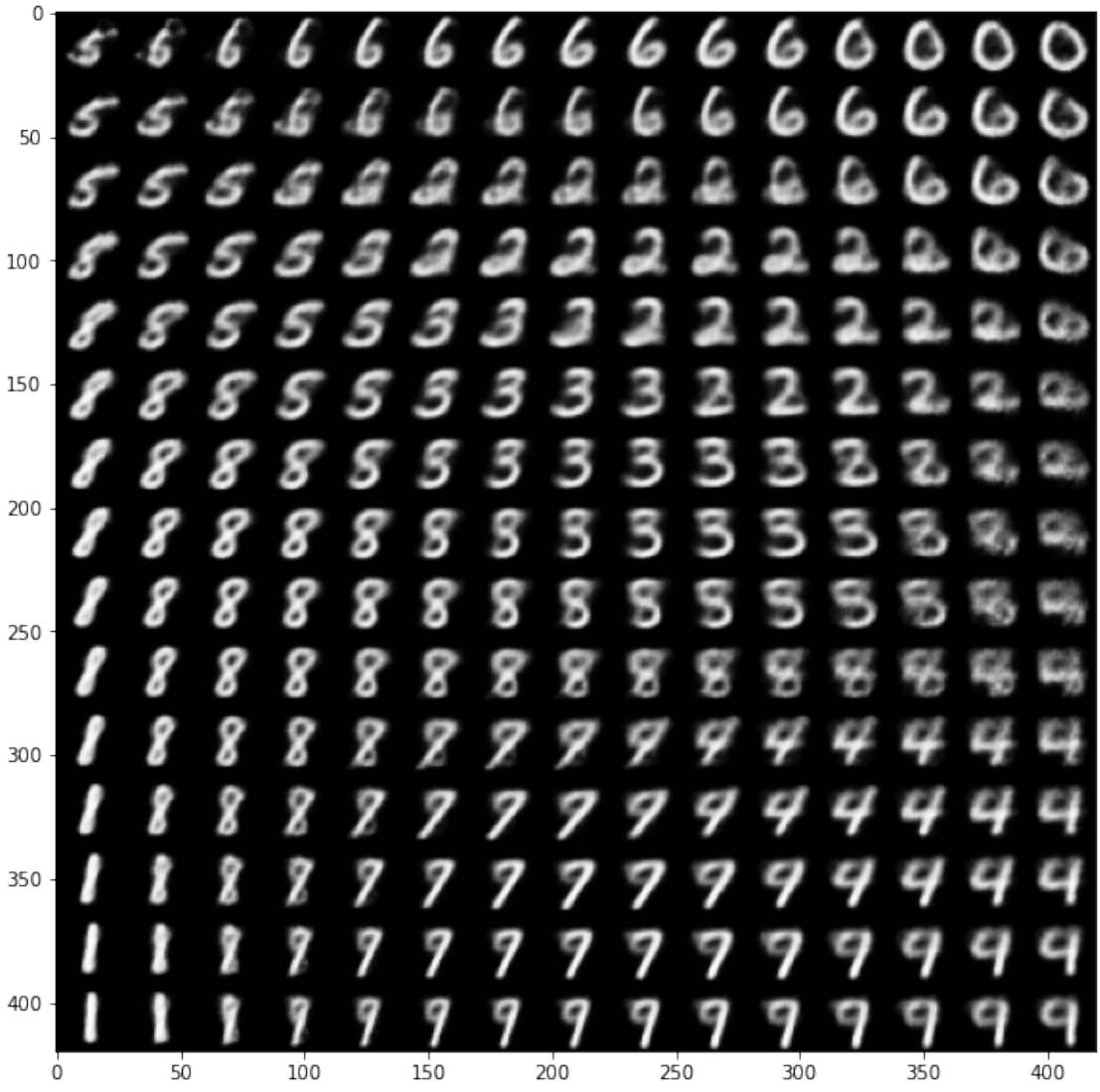

[ ]: