VRANJAN_Week12

June 4, 2021

[1]:

```
# Course - DSC 650 - Data Mining
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# Assignment - Assignment 12 - Implement a variational autoencoder using the MNIST data set and save a grid of 15 x 15 digits to the results/vae directory.
```

[2]:

```
# import required libraries
import numpy as np
import matplotlib.pyplot as plt
from scipy.stats import norm
from pathlib import Path
import keras
from keras.datasets import mnist
from keras.models import Model
from keras import layers
from keras import backend as K
from keras.models import Model
#from tensorflow.keras.models import Model
import tensorflow.compat.v1.keras.backend as K
import tensorflow as tf
tf.compat.v1.disable_eager_execution()
```

[3]:

```
results_dir = Path('results').joinpath('vae')
results_dir.mkdir(parents=True, exist_ok=True)
```

[4]:

```
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)
```

[5]:

```
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])
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)
```

[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
```

[7]:

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

[8]:

```
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]

--------------------------------------------------------------------------------
------------------
conv2d_2 (Conv2D)               (None, 14, 14, 64)   36928       conv2d_1[0][0]

--------------------------------------------------------------------------------
------------------
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]

--------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 2)            66          dense[0][0]

--------------------------------------------------------------------------------
------------------
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]
--------------------------------------------------------------------------------
------------------
model (Functional)              (None, 28, 28, 1)    56385       lambda[0][0]
--------------------------------------------------------------------------------
------------------
custom_variational_layer (Custo (None, 28, 28, 1)    0           input_1[0][0]
                                                                 model[0][0]
================================================================================
==================
Total params: 550,629
Trainable params: 550,629
Non-trainable params: 0
--------------------------------------------------------------------------------
------------------
Train on 60000 samples, validate on 10000 samples
Epoch 1/10
59984/60000 [============================>.] - ETA: 0s - loss: 0.2118
```

```
/opt/conda/lib/python3.8/site-
packages/tensorflow/python/keras/engine/training.py:2325: UserWarning:
`Model.state_updates` will be removed in a future version. This property should
not be used in TensorFlow 2.0, as `updates` are applied automatically.
  warnings.warn('`Model.state_updates` will be removed in a future version. '
```

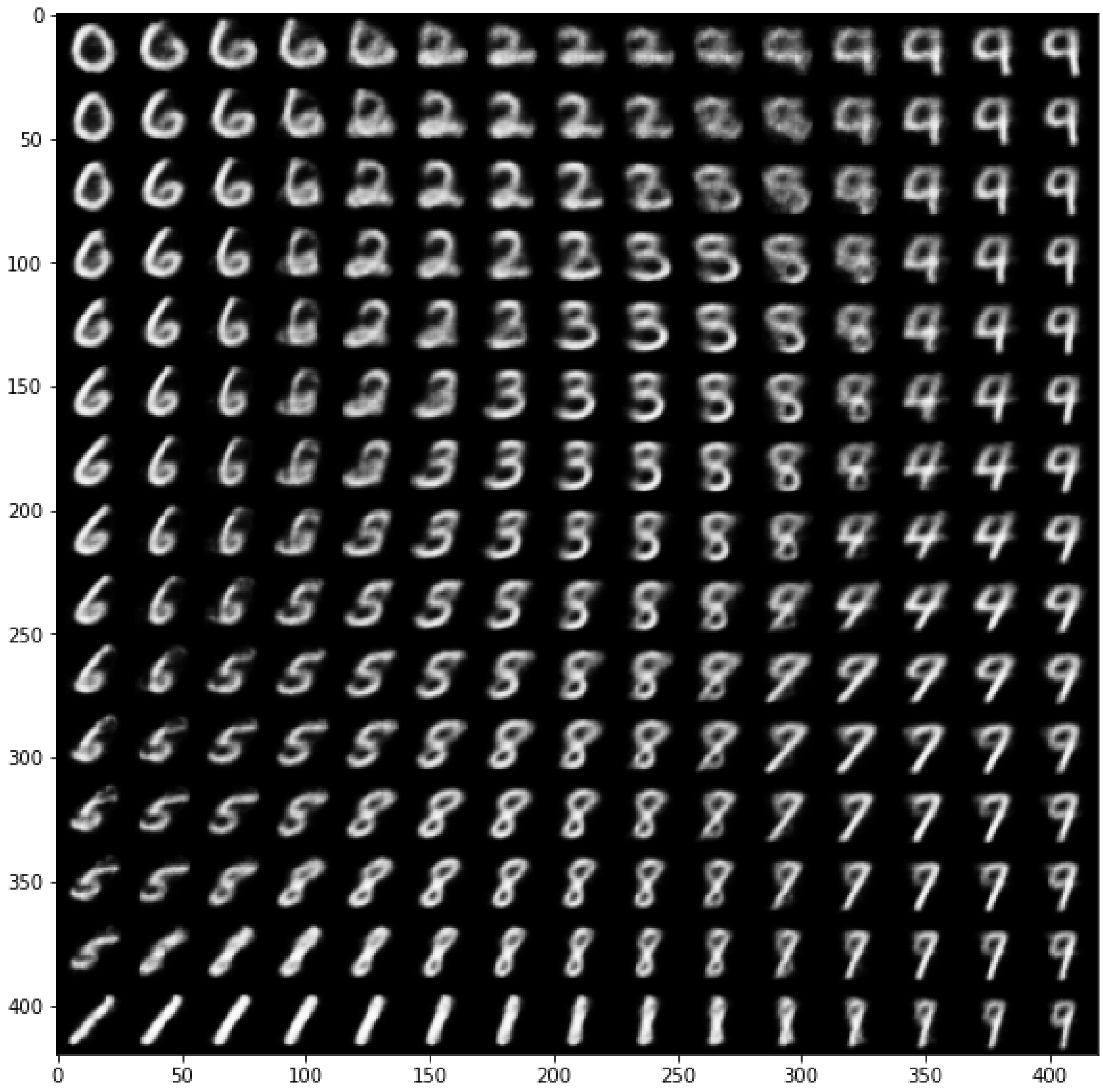
```
60000/60000 [==============================] - 85s 1ms/sample - loss: 0.2118 -
val_loss: 0.1965
Epoch 2/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1930 -
val_loss: 0.1889
Epoch 3/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1886 -
val_loss: 0.1878
Epoch 4/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1862 -
val_loss: 0.1884
Epoch 5/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1845 -
val_loss: 0.1844
Epoch 6/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1833 -
val_loss: 0.1829
Epoch 7/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1823 -
val_loss: 0.1817
Epoch 8/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1815 -
```

```
val_loss: 0.1815
Epoch 9/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1809 -
val_loss: 0.1814
Epoch 10/10
60000/60000 [==============================] - 82s 1ms/sample - loss: 0.1804 -
val_loss: 0.1815
```

[8]:
```
<tensorflow.python.keras.callbacks.History at 0x7f31595169d0>
```

[9]:
```
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_file = results_dir.joinpath('Assignment_12_15x15_Grid.png')
plt.savefig(img_file)
plt.show()
```


0
50
100
150
200
250
300
350
400
0
50
100
150
200
250
300
350
400

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[ ]:
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