assignment 12

June 3, 2023

0.1 Assignment 12

[ ]:
```
import numpy as np
from keras.datasets import mnist
from keras.models import Model
from keras.layers import Conv2D, Flatten, Dense, Input, Lambda, Reshape,␣
↪Conv2DTranspose, Layer
from keras import metrics
from keras import backend as K
K.clear_session()
import tensorflow._api.v2.compat.v1 as tf
tf.disable_v2_behavior()
import matplotlib.pyplot as plt
```

[ ]:
```
img_shape = (28, 28, 1)
batch_size = 16
latent_dim = 2

input_img = Input(shape=img_shape)

x = Conv2D(32, 3, padding='same', activation='relu')(input_img)
x = Conv2D(64, 3, padding='same', activation='relu', strides=(2, 2))(x)
x = Conv2D(64, 3, padding='same', activation='relu')(x)
x = Conv2D(64, 3, padding='same', activation='relu')(x)

shape_before_flattening = K.int_shape(x)

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

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

[ ]:
```
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 = Lambda(sampling)([z_mean, z_log_var])
```

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


x = Dense(np.prod(shape_before_flattening[1:]),␣
 ↪activation='relu')(decoder_input)
x = Reshape(shape_before_flattening[1:])(x)
x = Conv2DTranspose(32, 3, padding='same', activation='relu', strides=(2, 2))(x)
x = Conv2D(1, 3, padding='same', activation='sigmoid')(x)

decoder = Model(decoder_input, x)

z_decoded = decoder(z)
```

[ ]:
```
class CustomVariationalLayer(Layer):

    def vae_loss(self, x, z_decoded):
        x = K.flatten(x)
        z_decoded = K.flatten(z_decoded)
        xent_loss = 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])
```

[ ]:
```
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]']

 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 (Cust  (None, 28, 28, 1)   0
['input_1[0][0]',
 omVariationalLayer)                                          '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
59952/60000 [============================>.] - ETA: 0s - loss: 342.0744
c:\ProgramData\Anaconda3\lib\site-packages\keras\engine\training_v1.py:2045:
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.
  updates = self.state_updates
60000/60000 [==============================] - 64s 1ms/sample - loss: 341.8009 -
val_loss: 0.1992
Epoch 2/10
60000/60000 [==============================] - 57s 943us/sample - loss: 0.1945 -
val_loss: 0.1901
Epoch 3/10
60000/60000 [==============================] - 89s 1ms/sample - loss: 0.1897 -
val_loss: 0.1879
Epoch 4/10
60000/60000 [==============================] - 58s 962us/sample - loss: 0.1871 -
val_loss: 0.1877
Epoch 5/10
60000/60000 [==============================] - 95s 2ms/sample - loss: 0.1853 -
val_loss: 0.1836
Epoch 6/10
60000/60000 [==============================] - 54s 898us/sample - loss: 0.1840 -
val_loss: 0.1842
Epoch 7/10
60000/60000 [==============================] - 64s 1ms/sample - loss: 0.1829 -
val_loss: 0.1833
Epoch 8/10
60000/60000 [==============================] - 93s 2ms/sample - loss: 0.1821 -
val_loss: 0.1821
Epoch 9/10
60000/60000 [==============================] - 61s 1ms/sample - loss: 0.1815 -
val_loss: 0.1820
Epoch 10/10
60000/60000 [==============================] - 67s 1ms/sample - loss: 0.1809 -
val_loss: 0.1817
```

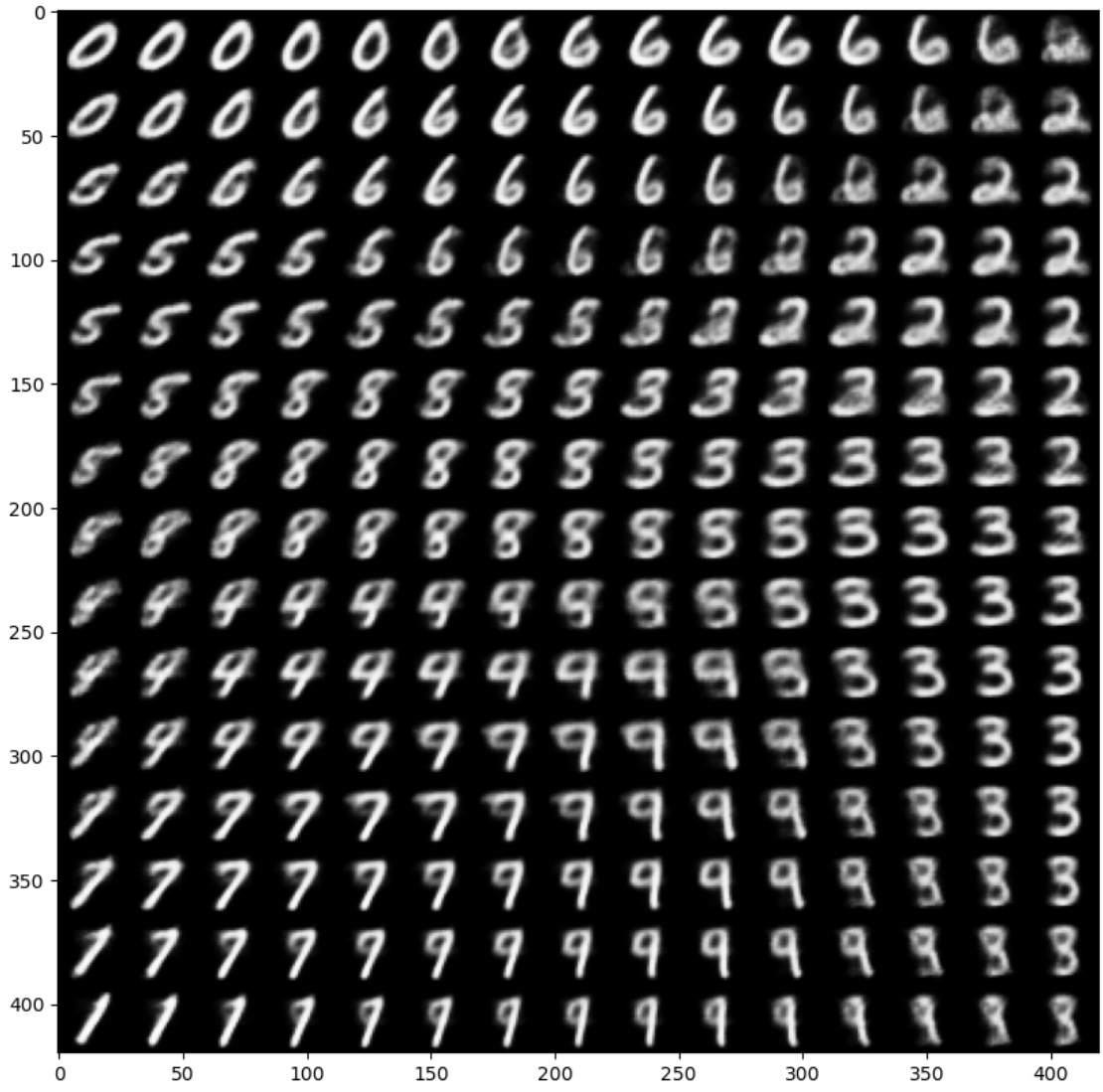
[ ]: <keras.callbacks.History at 0x2555e3ccd30>

[ ]:
```
import matplotlib.pyplot as plt
from scipy.stats import norm
import os
filepath = 'results/vae/'
file = "MNIST_VAE_grid.png"
if not os.path.exists(filepath):
    os.makedirs(filepath)

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')
plt.savefig(os.path.join(filepath, file))
plt.show()
```


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