Assignment12

June 2, 2021

[4]:
```
from keras.datasets import mnist
from keras.models import Model
import keras
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()
from pathlib import Path
```

[5]:
```
results_dir = Path('results').joinpath('vae')
results_dir.mkdir(parents=True, exist_ok=True)
```

[6]:
```
import numpy as np
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)
```

[7]:
```
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)
```

[8]:
```
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
```

[9]:
```
y = CustomVariationalLayer()([input_img, z_decoded])
```

[10]:
```
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 (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
60000/60000 [==============================] - ETA: 0s - loss: 3590.0738

/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 [==============================] - 88s 1ms/sample - loss: 3590.0738
- val_loss: 0.1970
Epoch 2/10
60000/60000 [==============================] - 85s 1ms/sample - loss: 0.1932 -
val_loss: 0.1905
Epoch 3/10
60000/60000 [==============================] - 84s 1ms/sample - loss: 0.1887 -
val_loss: 0.1889
Epoch 4/10
60000/60000 [==============================] - 85s 1ms/sample - loss: 0.1863 -
val_loss: 0.1874
Epoch 5/10
60000/60000 [==============================] - 87s 1ms/sample - loss: 0.1846 -
val_loss: 0.1838
Epoch 6/10
60000/60000 [==============================] - 85s 1ms/sample - loss: 0.1835 -
val_loss: 0.1826
Epoch 7/10
60000/60000 [==============================] - 86s 1ms/sample - loss: 0.1825 -
val_loss: 0.1832
Epoch 8/10
60000/60000 [==============================] - 87s 1ms/sample - loss: 0.1819 -
val_loss: 0.1828
Epoch 9/10
60000/60000 [==============================] - 88s 1ms/sample - loss: 0.1812 -
val_loss: 0.1817
```

```
Epoch 10/10
60000/60000 [==============================] - 86s 1ms/sample - loss: 0.1807 -
val_loss: 0.1822
```

[10]:
```
<tensorflow.python.keras.callbacks.History at 0x7f60d13758b0>
```

[11]:
```
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_file = results_dir.joinpath('Assignment_12_15x15_Grid.png')
plt.savefig(img_file)
plt.show()
```

```
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packages/tensorflow/python/keras/engine/training.py:2325: UserWarning:
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```

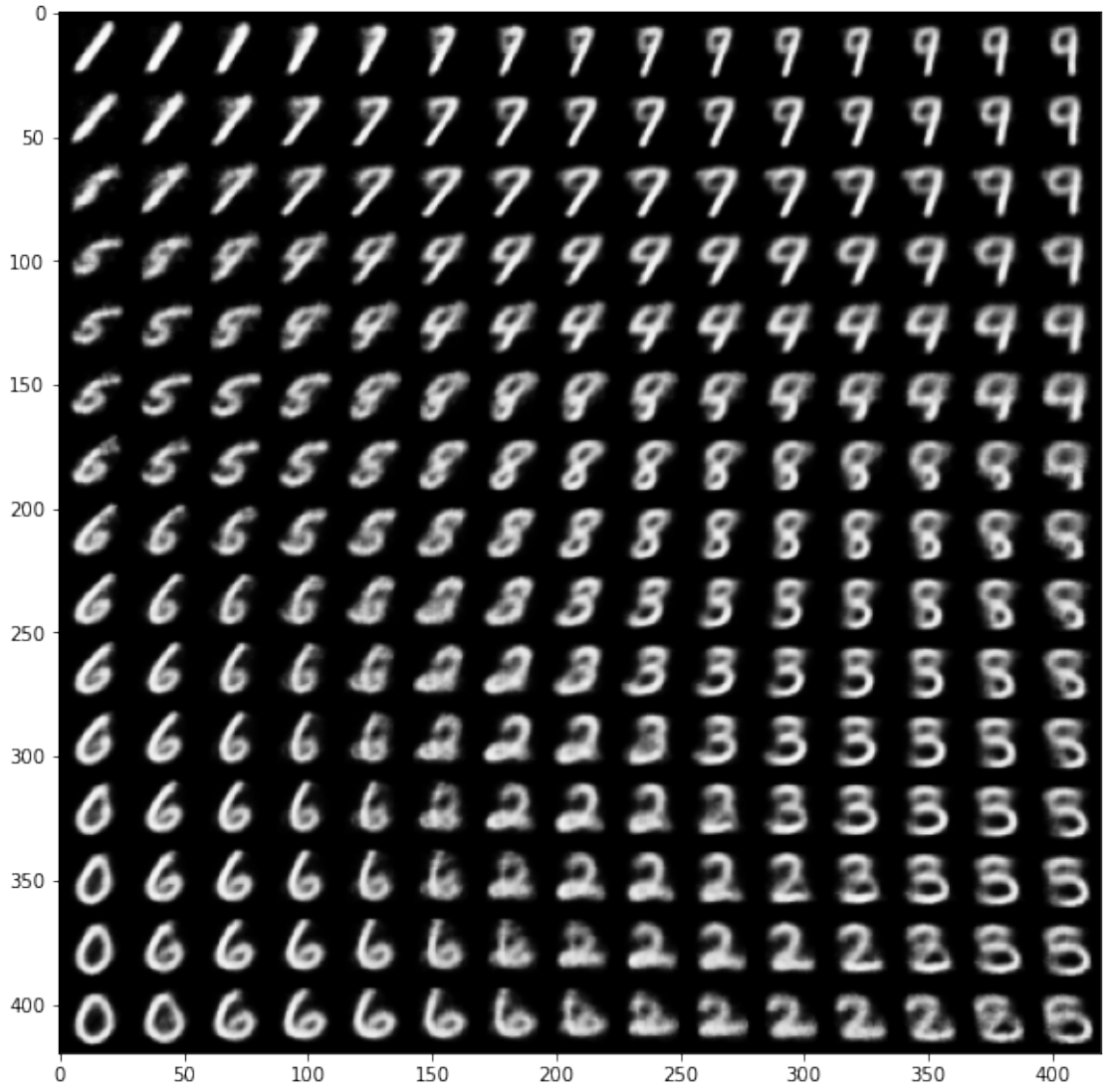
0
50
100
150
200
250
300
350
400
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350
400

[ ]: