人工智能实践：Tensorflow笔记

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tf.keras搭建神经网络八股

六步法

import

自制数据集　train,　test　　数据增强

Sequential / Class

model.compile

断点续训　model.fit

model.summary

参数提取　　acc/loss可视化

前向推理实现应用

本讲目标：神经网络八股功能扩展

① 自制数据集，解决本领域应用

② 数据增强，扩充数据集

③ 断点续训，存取模型

④ 参数提取，把参数存入文本

⑤ acc/loss可视化，查看训练效果

⑥ 应用程序，给图识物

源码：class3\p14_mnist_sequential.py = class4\ MNIST_FC\p4_mnist_train_baseline.py

import

train test

models.Sequential

model.compile

model.fit

model.summary

```python
import tensorflow as tf

mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
              metrics=['sparse_categorical_accuracy'])

model.fit(x_train, y_train, batch_size=32, epochs=5, validation_data=(x_test, y_test), validation_freq=1)
model.summary()
```

import

train, test

Sequential

model.compile

model.fit

model.summary

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观察数据集数据结构，给x_train、y_train、x_test、y_test 赋值

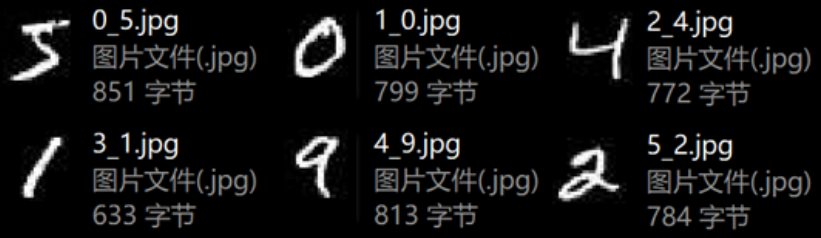
mnist_image_label文件夹：

AI › class4 › MNIST_FC › mnist_image_label

mnist_train_jpg_60000

mnist_test_jpg_10000

图片



mnist_train_jpg_60000.txt

mnist_test_jpg_10000.txt

标签

```
0_5.jpg   5
1_0.jpg   0
2_4.jpg   4
3_1.jpg   1
4_9.jpg   9
```

源码：class3\p13_mnist_datasets.py

```
x_train.shape:
 (60000, 28, 28)
y_train.shape:
 (60000,)
x_test.shape:
 (10000, 28, 28)
y_test.shape:
 (10000,)
```

```
mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

```
def generateds(图片路径, 标签文件):
```

def generateds(图片路径, 标签文件):

用于索引到每张图片 value[0]

每张图片对应标签 value[1]

0_5.jpg	5
1_0.jpg	0
2_4.jpg	4
3_1.jpg	1
4_9.jpg	9

```
def generateds(path, txt):
    f = open(txt, 'r')
    contents = f.readlines()
    f.close()
    x, y_ = [], []
    for content in contents:
        value = content.split()
        img_path = path + value[0]
        img = Image.open(img_path)
        img = np.array(img.convert('L'))
        img = img / 255.
        x.append(img)
        y_.append(value[1])
        print('loading : ' + content)

    x = np.array(x)
    y_ = np.array(y_)
    y_ = y_.astype(np.int64)
    return x, y_
```

图片路径+图片名 拼接出图片的索引路径

读入图片

图片变为8位宽度的灰度值，np.array格式

数据归一化

标签

打印状态提示

源码：p8_mnist_train_ex1.py

import

```python
import tensorflow as tf
from PIL import Image
import numpy as np
import os

train_path = './mnist_image_label/mnist_train_jpg_60000/'
train_txt = './mnist_image_label/mnist_train_jpg_60000.txt'
x_train_savepath = './mnist_image_label/mnist_x_train.npy'
y_train_savepath = './mnist_image_label/mnist_y_train.npy'

test_path = './mnist_image_label/mnist_test_jpg_10000/'
test_txt = './mnist_image_label/mnist_test_jpg_10000.txt'
x_test_savepath = './mnist_image_label/mnist_x_test.npy'
y_test_savepath = './mnist_image_label/mnist_y_test.npy'

def generateds(path, txt):
    f = open(txt, 'r')    #以只读形式打开txt文件
    contents = f.readlines()   # 读取文件中所有行
    f.close()    #关闭txt文件
    x, y_ = [], []   #建立空列表
    for content in contents: #逐行取出
        value = content.split()   # 以空格分开，图片路径为value[0] ，标签文件为value[1] ，存入列表
        img_path = path + value[0]   #拼出图片路径和文件名
        img = Image.open(img_path)   #读入图片
        img = np.array(img.convert('L'))   #图片变为8位宽灰度值的np.array格式
        img = img / 255.    #数据归一化 （实现预处理）
        x.append(img)   #归一化后的数据，贴到列表x
        y_.append(value[1]) #标签贴到列表y_
        print('loading : ' + content)   #打印状态提示

    x = np.array(x) #变为np.array格式
    y_ = np.array(y_) #变为np.array格式
    y_ = y_.astype(np.int64) #变为64位整型
    return x, y   #返回输入特征x，返回标签y_
```

train test

models.Sequential

model.compile

model.fit

model.summary

```
36  if os.path.exists(x_train_savepath) and os.path.exists(y_train_savepath) and os.path.exists(
37          x_test_savepath) and os.path.exists(y_test_savepath):
38      print('-------------Load Datasets-----------------')
39      x_train_save = np.load(x_train_savepath)
40      y_train = np.load(y_train_savepath)
41      x_test_save = np.load(x_test_savepath)
42      y_test = np.load(y_test_savepath)
43      x_train = np.reshape(x_train_save, (len(x_train_save), 28, 28))
44      x_test = np.reshape(x_test_save, (len(x_test_save), 28, 28))
45  else:
46      print('-------------Generate Datasets-----------------')
47      x_train, y_train = generateds(train_path, train_txt)
48      x_test, y_test = generateds(test_path, test_txt)
49
50      print('-------------Save Datasets-----------------')
51      x_train_save = np.reshape(x_train, (len(x_train), -1))
52      x_test_save = np.reshape(x_test, (len(x_test), -1))
53      np.save(x_train_savepath, x_train_save)
54      np.save(y_train_savepath, y_train)
55      np.save(x_test_savepath, x_test_save)
56      np.save(y_test_savepath, y_test)
57
58  model = tf.keras.models.Sequential([
59      tf.keras.layers.Flatten(),
60      tf.keras.layers.Dense(128, activation='relu'),
61      tf.keras.layers.Dense(10, activation='softmax')
62  ])
63
64  model.compile(optimizer='adam',
65                loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
66                metrics=['sparse_categorical_accuracy'])
67
68  model.fit(x_train, y_train, batch_size=32, epochs=5, validation_data=(x_test, y_test), validation_freq=1)
69  model.summary()
```

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数据增强（增大数据量）

image_gen_train = tf.keras.preprocessing.image.ImageDataGenerator(

rescale = 所有数据将乘以该数值　对输入特征的数值大小进行调整

rotation_range = 随机旋转角度数范围　对图像进行角度的随机旋转

width_shift_range = 随机宽度偏移量　对图像进行随机宽度偏移

height_shift_range = 随机高度偏移量

水平翻转：**horizontal_flip =** 是否随机水平翻转

随机缩放：**zoom_range =** 随机缩放的范围 **[1-n，1+n]** **)**　按什么比例随机缩小/放大图片

image_gen_train.fit(x_train)　这里的fit要输入一个四维数据

例：

```
image_gen_train = ImageDataGenerator(
    rescale=1. / 1.,  # 如为图像，分母为255时，可归至0～1
    rotation_range=45,  # 随机45度旋转
    width_shift_range=.15,  # 宽度偏移
    height_shift_range=.15,  # 高度偏移
    horizontal_flip=False,  # 水平翻转
    zoom_range=0.5  # 将图像随机缩放阈量50％)

image_gen_train.fit(x_train)
```

源码：p11_show_augmented _images.py

数据增强（增大数据量）

image_gen_train = tf.keras.preprocessing.image.ImageDataGenerator(

rescale = 所有数据将乘以该数值

rotation_range = 随机旋转角度数范围

width_shift_range = 随机宽度偏移量

height_shift_range = 随机高度偏移量

水平翻转：horizontal_flip = 是否随机水平翻转

随机缩放：zoom_range = 随机缩放的范围 [1-n，1+n])

image_gen_train.fit(x_train)

```
x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
```

(60000, 28, 28) ⇨ (60000, 28, 28, 1)

单通道（灰度值）

model.fit(x_train, y_train,batch_size=32, ……)

⇩

model.fit(image_gen_train.flow(x_train, y_train,batch_size=32), ……)

源码：p13_mnist_train_ex2.py

import

train test

models.Sequential

model.compile

model.fit

model.summary

```
1  import tensorflow as tf
2  from tensorflow.keras.preprocessing.image import ImageDataGenerator
3
4  fashion = tf.keras.datasets.fashion_mnist
5  (x_train, y_train), (x_test, y_test) = fashion.load_data()
6  x_train, x_test = x_train / 255.0, x_test / 255.0
7  x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)  # 给数据增加一个维度，使数据和网络结构匹配
8
9  image_gen_train = ImageDataGenerator(
10     rescale=1. / 1.,  # 如为图像，分母为255时，可归至0～1
11     rotation_range=45,  # 随机45度旋转
12     width_shift_range=.15,  # 宽度偏移
13     height_shift_range=.15,  # 高度偏移
14     horizontal_flip=True,  # 水平翻转
15     zoom_range=0.5  # 将图像随机缩放阈量50%
16 )
17 image_gen_train.fit(x_train)
18
19 model = tf.keras.models.Sequential([
20     tf.keras.layers.Flatten(),
21     tf.keras.layers.Dense(128, activation='relu'),
22     tf.keras.layers.Dense(10, activation='softmax')
23 ])
24
25 model.compile(optimizer='adam',
26               loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
27               metrics=['sparse_categorical_accuracy'])
28
29 model.fit(image_gen_train.flow(x_train, y_train, batch_size=32), epochs=5, validation_data=(x_test, y_test),
30           validation_freq=1)
31 model.summary()
```

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读取保存模型

生成ckpt文件时会同步生成索引表，通过判断是不是有了索引表，就知道是不是已经保存过模型参数了

读取模型：

load_weights(路径文件名）　可以直接读取已有模型参数

```
checkpoint_save_path = "./checkpoint/mnist.ckpt"
if os.path.exists(checkpoint_save_path + '.index'):
    print('-------------load the model-----------------')
    model.load_weights(checkpoint_save_path)
```

定义存放模型的路径和文件名

若有了索引表，就可以调用load_weights函数读取模型参数

保存模型：

tf.keras.callbacks.ModelCheckpoint(　保存模型参数可以使用TensorFlow给出的回调函数，直接保存训练出来的模型参数

filepath=路径文件名,　文件存储路径

save_weights_only=True/False,　是否只保留模型参数

save_best_only=True/False)　是否只保留最优结果

history = model.fit（ callbacks=[cp_callback] ）　执行训练过程时加入callbacks选项，记录到history中

history里储存了loss和metrics结果，用于后面可视化

```
cp_callback = tf.keras.callbacks.ModelCheckpoint(filepath=checkpoint_save_path,
                                                 save_weights_only=True,
                                                 save_best_only=True)
history = model.fit(x_train, y_train, batch_size=32, epochs=5,
                    validation_data=(x_test, y_test), validation_freq=1,
                    callbacks=[cp_callback])
```

在fit函数中加入回调选项，返回给history

源码：p16_mnist_train_ex3.py

import

train test

models.Sequential

model.compile

model.fit

model.summary

```python
import tensorflow as tf
import os

mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
              metrics=['sparse_categorical_accuracy'])

checkpoint_save_path = "./checkpoint/mnist.ckpt"
if os.path.exists(checkpoint_save_path + '.index'):
    print('-------------load the model-----------------')
    model.load_weights(checkpoint_save_path)

cp_callback = tf.keras.callbacks.ModelCheckpoint(filepath=checkpoint_save_path,
                                                 save_weights_only=True,
                                                 save_best_only=True)
history = model.fit(x_train, y_train, batch_size=32, epochs=5,
                    validation_data=(x_test, y_test), validation_freq=1,
                    callbacks=[cp_callback])
model.summary()
```

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提取可训练参数

model.trainable_variables 返回模型中可训练的参数 直接print的话很多数据被省略号替换

设置print输出格式

np.set_printoptions(threshold=超过多少省略显示)

```
np.set_printoptions(threshold=np.inf)  # np.inf表示无限大
```

```
print(model.trainable_variables)
file = open('./weights.txt', 'w')
for v in model.trainable_variables:
    file.write(str(v.name) + '\n')
    file.write(str(v.shape) + '\n')
    file.write(str(v.numpy()) + '\n')
file.close()
```

用for循环把所有可训练参数存入文本

源码：p19_mnist_train_ex4.py

import

train test

models.Sequential

model.compile

model.fit

model.summary

```python
import tensorflow as tf
import os
import numpy as np
np.set_printoptions(threshold=np.inf)
mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0
model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
              metrics=['sparse_categorical_accuracy'])
checkpoint_save_path = "./checkpoint/mnist.ckpt"
if os.path.exists(checkpoint_save_path + '.index'):
    print('-------------load the model-----------------')
    model.load_weights(checkpoint_save_path)
cp_callback = tf.keras.callbacks.ModelCheckpoint(filepath=checkpoint_save_path,
                                                 save_weights_only=True,
                                                 save_best_only=True)
history = model.fit(x_train, y_train, batch_size=32, epochs=5, validation_data=(x_test, y_test), validation_freq=1,
                    callbacks=[cp_callback])
model.summary()
print(model.trainable_variables)
file = open('./weights.txt', 'w')
for v in model.trainable_variables:
    file.write(str(v.name) + '\n')
    file.write(str(v.shape) + '\n')
    file.write(str(v.numpy()) + '\n')
file.close()
```

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acc曲线与loss曲线

执行训练过程

history=model.fit(训练集数据, 训练集标签, batch_size=, epochs=,

validation_split=用作测试数据的比例,validation_data=测试集,

validation_freq=测试频率**)**

history：

训练集loss： loss

测试集loss： val_loss

训练集准确率： sparse_categorical_accuracy

测试集准确率： val_sparse_categorical_accuracy

```
acc = history.history['sparse_categorical_accuracy']
val_acc = history.history['val_sparse_categorical_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']
```

history.history提取出来

```python
# 显示训练集和验证集的acc和loss曲线
acc = history.history['sparse_categorical_accuracy']
val_acc = history.history['val_sparse_categorical_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

plt.subplot(1, 2, 1)
plt.plot(acc, label='Training Accuracy')
plt.plot(val_acc, label='Validation Accuracy')
plt.title('Training and Validation Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.plot(loss, label='Training Loss')
plt.plot(val_loss, label='Validation Loss')
plt.title('Training and Validation Loss')
plt.legend()
plt.show()
```

源码：p23_mnist_train_ex5.py

import

train test

models.Sequential

model.compile

model.fit

model.summary

```python
import tensorflow as tf
import os
import numpy as np
from matplotlib import pyplot as plt

np.set_printoptions(threshold=np.inf)

mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
              metrics=['sparse_categorical_accuracy'])

checkpoint_save_path = "./checkpoint/mnist.ckpt"
if os.path.exists(checkpoint_save_path + '.index'):
    print('-------------load the model-----------------')
    model.load_weights(checkpoint_save_path)

cp_callback = tf.keras.callbacks.ModelCheckpoint(filepath=checkpoint_save_path,
                                                 save_weights_only=True,
                                                 save_best_only=True)

history = model.fit(x_train, y_train, batch_size=32, epochs=5,
                    validation_data=(x_test, y_test), validation_freq=1,
                    callbacks=[cp_callback])
model.summary()

print(model.trainable_variables)
file = open('./weights.txt', 'w')
for v in model.trainable_variables:
    file.write(str(v.name) + '\n')
    file.write(str(v.shape) + '\n')
    file.write(str(v.numpy()) + '\n')
file.close()

######################    show    ############################

# 显示训练集和验证集的acc和loss曲线
acc = history.history['sparse_categorical_accuracy']
val_acc = history.history['val_sparse_categorical_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

plt.subplot(1, 2, 1)
plt.plot(acc, label='Training Accuracy')
plt.plot(val_acc, label='Validation Accuracy')
plt.title('Training and Validation Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.plot(loss, label='Training Loss')
plt.plot(val_loss, label='Validation Loss')
plt.title('Training and Validation Loss')
plt.legend()
plt.show()
```

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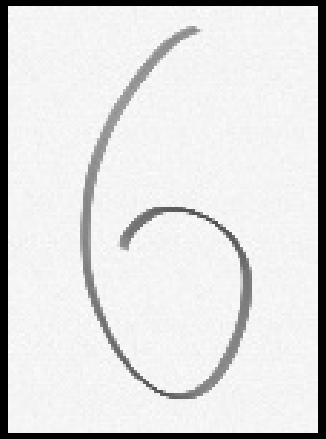
给图识物

输入一张手写数字图片



神经网络自动识别出值

输出识别结果

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前向传播执行应用

predict(输入特征, batch_size=整数)
返回前向传播计算结果

复现模型（前向传播）

```
model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax' )])
```

加载参数

```
model.load_weights(model_save_path)
```

预测结果

```
result = model.predict(x_predict)
```

根据输入特征，输出预测结果

源码：p27_mnist_app.py

```python
from PIL import Image
import numpy as np
import tensorflow as tf

model_save_path = './checkpoint/mnist.ckpt'

model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')])

model.load_weights(model_save_path)

preNum = int(input("input the number of test pictures:"))

for i in range(preNum):
    image_path = input("the path of test picture:")
    img = Image.open(image_path)
    img = img.resize((28, 28), Image.ANTIALIAS)
    img_arr = np.array(img.convert('L'))

    img_arr = 255 - img_arr

    img_arr = img_arr / 255.0
    x_predict = img_arr[tf.newaxis, ...]
    result = model.predict(x_predict)
    pred = tf.argmax(result, axis=1)
    print('\n')
    tf.print(pred)
```

0.png 1.png 2.png 3.png 4.png

5.png 6.png 7.png 8.png 9.png

设计程序将这十张图片识别出来

源码：p28_mnist_app.py

```python
from PIL import Image
import numpy as np
import tensorflow as tf

model_save_path = './checkpoint/mnist.ckpt'

model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.

model.load_we

preNum = int(
```

```
img_arr: (28, 28)
x_predict: (1, 28, 28)
```

0.png 1.png 2.png 3.png 4.png

5.png 6.png 7.png 8.png 9.png

```python
for i in range(preNum):
    image_path = input("the path of test picture:")
    img = Image.open(image_path)
    img = img.resize((28, 28), Image.ANTIALIAS)
    img_arr = np.array(img.convert('L'))

    for i in range(28):
        for j in range(28):
            if img_arr[i][j] < 200:
                img_arr[i][j] = 255
            else:
                img_arr[i][j] = 0

    img_arr = img_arr / 255.0
    x_predict = img_arr[tf.newaxis, ...]
    result = model.predict(x_predict)
    pred = tf.argmax(result, axis=1)
    print('\n')
    tf.print(pred)
```