清华大学电子工程系

媒体与认知 课堂 2

2021-2022 学年春季学期

作业 2

程书鹏 2022 年 3 月 26 日

理论部分

1 单选题（15 分）

1.1 D

1.2 C

1.3 B

1.4 C

1.5 D

2 计算题（15 分）

2.1 设隐含层为 $\mathbf{z}=\mathbf{x}\mathbf{W}^T+\mathbf{b}$，其中 $\mathbf{x}\in R^{(1\times m)}$，$\mathbf{z}\in R^{(1\times n)}$，$\mathbf{W}\in R^{(n\times m)}$，$\mathbf{b}\in R^{(1\times n)}$ 均为已知，其激活函数如下：

$$\mathbf{y}=\tanh(\mathbf{z})=\frac{e^{\mathbf{z}}-e^{-\mathbf{z}}}{e^{\mathbf{z}}+e^{-\mathbf{z}}}$$

若训练过程中的目标函数为 L，且已知 L 对 y 的导数 $\frac{\partial L}{\partial \mathbf{y}}=[\frac{\partial L}{\partial y_1},\frac{\partial L}{\partial y_2},...,\frac{\partial L}{\partial y_n}]$ 和 $\mathbf{y}=[y_1,y_2,...,y_n]$ 的值。

2.1.1 请使用 y 表示出 $\frac{\partial \mathbf{y}}{\partial \mathbf{z}}$

$\frac{\partial \mathbf{y}}{\partial \mathbf{z}}$=1-y*y，其中 1-y*y 表示用一个全 1 向量减去 y 向量按元素乘得到的向量。

2.1.2 请使用 y 和 $\frac{\partial L}{\partial \mathbf{y}}$ 表示 $\frac{\partial L}{\partial \mathbf{x}}$，$\frac{\partial L}{\partial \mathbf{W}}$，$\frac{\partial L}{\partial \mathbf{b}}$。

提示:$\frac{\partial L}{\partial \mathbf{x}}$，$\frac{\partial L}{\partial \mathbf{W}}$，$\frac{\partial L}{\partial \mathbf{b}}$ 与 x,W,b 具有相同维度。

$\frac{\partial L}{\partial \mathbf{x}}$=$\frac{\partial L}{\partial \mathbf{y}}$(1-y*y)W

$\frac{\partial L}{\partial \mathbf{W}}$=($\frac{\partial L}{\partial \mathbf{y}}$ （1-y*y） $)^T x$

$\frac{\partial L}{\partial \mathbf{b}}=\frac{\partial L}{\partial \mathbf{y}}$（1-y*y）

其中 1-y*y 表示用一个全 1 向量减去 y 向量按元素乘得到的向量。

编程部分

3 编程作业报告

3.1 源程序代码

请见附件

3.2 训练、测试、可视化

3.2.1 SGD 优化器

Epoch 01: loss = 13.855
Epoch 02: loss = 7.624
Epoch 03: loss = 5.015
Epoch 04: loss = 3.885
Epoch 05: loss = 2.870
Epoch 06: loss = 2.331
Epoch 07: loss = 1.870
Epoch 08: loss = 1.354
Epoch 09: loss = 1.291
Epoch 10: loss = 0.948
Epoch 10: validation accuracy = 62.0%
Epoch 11: loss = 0.745
Epoch 12: loss = 0.670
Epoch 13: loss = 0.510
Epoch 14: loss = 0.458
Epoch 15: loss = 0.439
Epoch 16: loss = 0.295
Epoch 17: loss = 0.236
Epoch 18: loss = 0.208
Epoch 19: loss = 0.187
Epoch 20: loss = 0.130

Epoch 20: validation accuracy = 64.8%
Epoch 21: loss = 0.148
Epoch 22: loss = 0.132
Epoch 23: loss = 0.082
Epoch 24: loss = 0.064
Epoch 25: loss = 0.076
Epoch 26: loss = 0.063
Epoch 27: loss = 0.052
Epoch 28: loss = 0.048
Epoch 29: loss = 0.045
Epoch 30: loss = 0.042
Epoch 30: validation accuracy = 67.04%
Epoch 31: loss = 0.038
Epoch 32: loss = 0.042
Epoch 33: loss = 0.036
Epoch 34: loss = 0.033
Epoch 35: loss = 0.028
Epoch 36: loss = 0.029
Epoch 37: loss = 0.025
Epoch 38: loss = 0.025
Epoch 39: loss = 0.022
Epoch 40: loss = 0.022
Epoch 40: validation accuracy = 67.0%
Epoch 41: loss = 0.020
Epoch 42: loss = 0.019
Epoch 43: loss = 0.019
Epoch 44: loss = 0.019
Epoch 45: loss = 0.019
Epoch 46: loss = 0.019
Epoch 47: loss = 0.019
Epoch 48: loss = 0.017
Epoch 49: loss = 0.016
Epoch 50: loss = 0.017
Epoch 50: validation accuracy = 67.2%

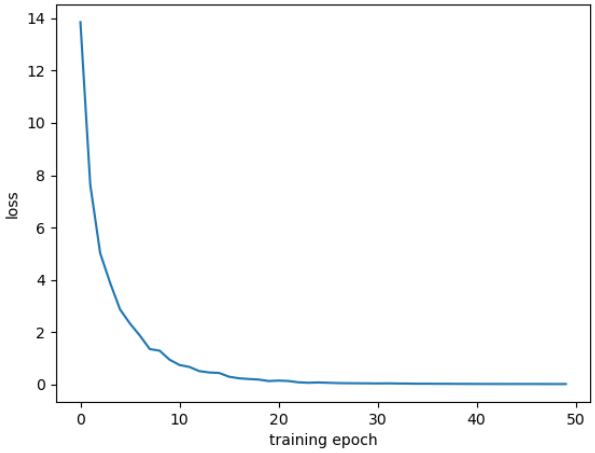

图 1: SGD 优化器 loss 下降曲线

Test accuracy = 73.5%

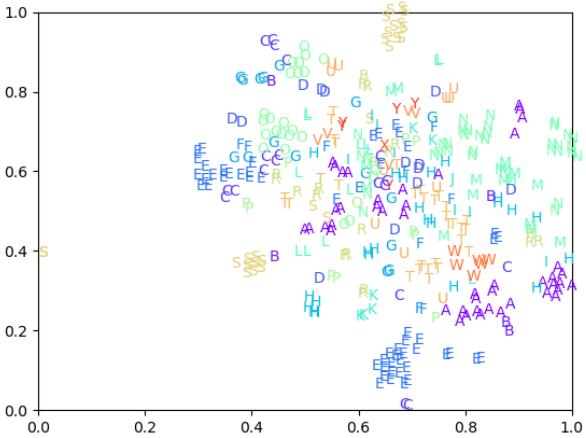

图 2: 测试可视化图像

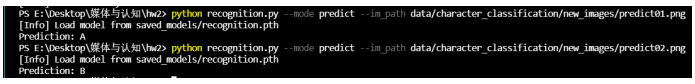

图 3: 对给定图片的预测

3.2.2 Adam 优化器

Epoch 01: loss = 17.492
Epoch 02: loss = 12.819
Epoch 03: loss = 9.864
Epoch 04: loss = 7.521
Epoch 05: loss = 5.842
Epoch 06: loss = 4.422
Epoch 07: loss = 3.834
Epoch 08: loss = 2.882
Epoch 09: loss = 2.294
Epoch 10: loss = 1.958
Epoch 10: validation accuracy = 62.8%
Epoch 11: loss = 1.613
Epoch 12: loss = 1.454
Epoch 13: loss = 1.076
Epoch 14: loss = 0.794
Epoch 15: loss = 0.847
Epoch 16: loss = 0.689
Epoch 17: loss = 0.651
Epoch 18: loss = 0.650
Epoch 19: loss = 0.633
Epoch 20: loss = 0.753
Epoch 20: validation accuracy = 69.5%
Epoch 21: loss = 0.698
Epoch 22: loss = 0.776
Epoch 23: loss = 0.744
Epoch 24: loss = 0.545
Epoch 25: loss = 0.590
Epoch 26: loss = 0.900
Epoch 27: loss = 0.749
Epoch 28: loss = 0.407
Epoch 29: loss = 0.879
Epoch 30: loss = 0.772
Epoch 30: validation accuracy = 75.2%
Epoch 31: loss = 0.583
Epoch 32: loss = 0.566

Epoch 33: loss = 0.580
Epoch 34: loss = 0.354
Epoch 35: loss = 0.369
Epoch 36: loss = 0.517
Epoch 37: loss = 0.567
Epoch 38: loss = 0.593
Epoch 39: loss = 0.518
Epoch 40: loss = 0.333
Epoch 40: validation accuracy = 75.8%
Epoch 41: loss = 0.412
Epoch 42: loss = 0.330
Epoch 43: loss = 0.447
Epoch 44: loss = 0.357
Epoch 45: loss = 0.292
Epoch 46: loss = 0.462
Epoch 47: loss = 0.322
Epoch 48: loss = 0.470
Epoch 49: loss = 0.419
Epoch 50: loss = 0.481
Epoch 50: validation accuracy = 78.2%

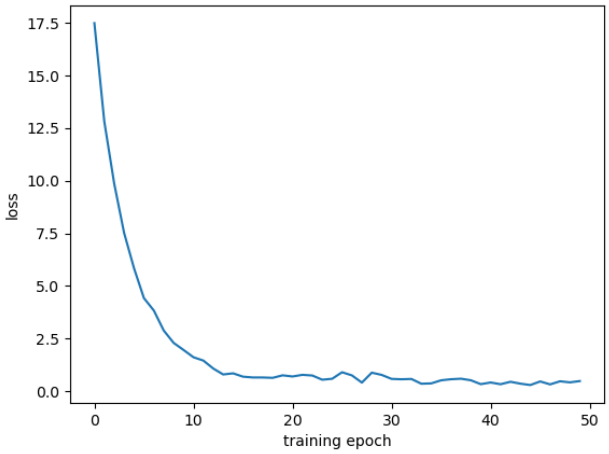

图 4: Adam 优化器 loss 下降曲线

```
PS E:\Desktop\媒体与认知\hw2> python recognition.py --mode test
[Info] Load model from saved_models/recognition.pth
[Info] Test accuracy = 83.0%
```

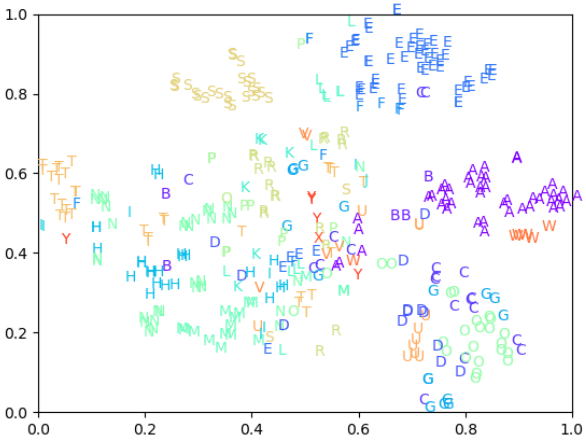

图 5: 测试结果可视化

```
PS E:\Desktop\媒体与认知\hw2> python recognition.py --mode predict --im_path data/character_classification/new_images/predict01.png
[Info] Load model from saved_models/recognition.pth
Prediction: A
PS E:\Desktop\媒体与认知\hw2> python recognition.py --mode predict --im_path data/character_classification/new_images/predict02.png
[Info] Load model from saved_models/recognition.pth
Prediction: D
```

图 6: 给定图片的预测结果

根据结果发现用 Adam 优化器测试集的正确率比 SGD 优化器高，但是对于给定的字母 B 图片给出了错误的 D 预测。可见两种优化器各有优劣，对于不同图片的预测正确率有差异。

3.3 遇到的问题及解决方法

本次作业遇到的最大问题是在写 softmax 函数时虽然理解了其数学原理，但是由于对 tensor 的操作不熟悉导致具体写代码的时候遇到了许多困难，最后我通过对之前发的 tensor 教程以及上网查阅相关资料解决了这个问题。

3.4 意见和建议

本次作业让我进一步熟悉了机器学习的流程步骤、loss 函数的实现等知识，同时我第一次使用机器学习实现了对给定图片的分类，体会到了机

器学习的应用。最后，非常非常感谢老师和助教们在习题课的细致讲解和耐心辅导!