模式识别第三次作业

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1.

   (a) 矩阵的二范数为最大特征值的开方，且互逆矩阵的特征值互为倒数。

   所以$k_2(X) = \frac{\sigma_1}{\sigma_n}$

   (b) X是满秩的方阵，可以看作线性变化，或者是旋转、缩放、平移这些操作的叠加或单个操作。而通过PCA的学习我们知道X方阵将一块圆形区域变为一个椭圆形，而椭圆形的的轴长与原矩阵的特征值正相关。2范式条件数就是最长轴除以最短轴，椭圆形越扁这个值越大，也代表对输入值a的改变大。

   (c) 正交矩阵逆矩阵就是自己的转置矩阵且特征值为1或-1，所以条件数也是1或-1。这相当于一个旋转变换或一个翻转变化，并不会改变轴长，所以是well-conditioned的

2.

   (a)

3.

   (a) 下载文件后解压并执行make命令完成编译，并安装gnuplot

```
$ sudo apt-get install gnuplot-x11
```

   (b)

   i.

```
$ ./svm-train -t 2 -c 1 svmguide1
optimization finished, #iter = 5371
nu = 0.606150
obj = -1061.528918, rho = -0.495266
nSV = 3053, nBSV = 722
Total nSV = 3053

$ ./svm-predict svmguide1.t svmguide1.model svmguide1.output
Accuracy = 66.925% (2677/4000) (classification)
```

   ii.

   对训练数据进行标准化，并把结果输出至文件

```
$ ./svm-scale -s scale_svmguide1 svmguide1 > new_svmguide1
```

   得到的输出文件`scale_svmguide1`内容为缩放后的最小值与最大值以及缩放前每一维的最小值、最大值

```
x
-1 1
1 0 297.05
2 -4.555206 581.0731
3 -0.7524385 0.7170606
4 8.157474000000001 180
```

同样缩放测试集

```
$ ./svm-scale -s scale_svmguide1.t svmguide1.t > new_svmguide1.t
```

然后进行训练

```
$ ./svm-train -t 2 -c 1 new_svmguide1
optimization finished, #iter = 496
nu = 0.202599
obj = -507.307046, rho = 2.627039
nSV = 630, nBSV = 621
Total nSV = 630

$ ./svm-predict new_svmguide1.t new_svmguide1.model new_svmguide1.output
Accuracy = 95.6% (3824/4000) (classification)
```

iii.

```
$ ./svm-train -t 0 -c 1 svmguide1
optimization finished, #iter = 3509115
nu = 0.121917
obj = -376.234540, rho = 5.887607
nSV = 381, nBSV = 375
Total nSV = 381

$ ./svm-predict svmguide1.t svmguide1.model svmguide1.output
Accuracy = 95.675% (3827/4000) (classification)
```

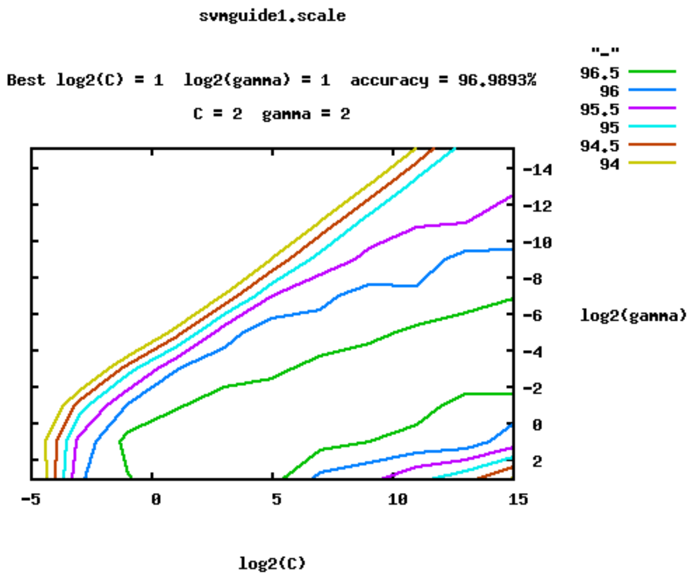
iv

```
$ ./svm-train -t 0 -c 1 svmguide1
optimization finished, #iter = 6383
nu = 0.000721
obj = -1114.038221, rho = -0.407723
nSV = 3001, nBSV = 0
Total nSV = 3001

$ ./svm-predict svmguide1.t svmguide1.model svmguide1.output
Accuracy = 70.475% (2819/4000) (classification)
```

v.

```
$ ./easy.py ../svmguide1 ../svmguide1.t
Scaling training data...
Cross validation...
Best c=2.0, g=2.0 CV rate=96.9893
Training...
Output model: svmguide1.model
Scaling testing data...
Testing...
Accuracy = 96.875% (3875/4000) (classification)
Output prediction: svmguide1.t.predict
```



(c)

svmguide3是一个 imbalanced datasets， 其中'+1'类有296个而'-1'类又947个

如果设置等权重训练，那么得到的结果

```
$ ./svm-train -t 2 -c 1 svmguide3
optimization finished, #iter = 535
nu = 0.452614
obj = -545.901031, rho = -0.985060
nSV = 570, nBSV = 552
Total nSV = 570

$ ./svm-predict svmguide3.t svmguide3.model svmguide3.output
Accuracy = 2.43902% (1/41) (classification)
```

而设置'+1'类权重为3.1993后

```
$ ./svm-train -t 2 -c 1 -w1 3.1993 svmguide3
optimization finished, #iter = 1126
obj = -1402.089020, rho = -3.212808
nSV = 984, nBSV = 973
Total nSV = 984

$ ./svm-predict svmguide3.t svmguide3.model svmguide3.output
Accuracy = 70.7317% (29/41) (classification)
```

有明显提升效果

4.

(a)

(b)

$\theta = \arg\max_{x_m, \alpha} \sum_{i=1}^{n} \log(\frac{\alpha x_m^\alpha}{x^{\alpha+1}}[x \geq x_m])$

(c)

5.

(a) 下载源码文件后，解压进入目录输入命令

```
make
```

就会出现两个可执行文件`train` `predict`

如果要配置matlab接口，则matlab进入源码中/matlab目录下进行make即可

(b)

```
$ ./train mnist
$ ./predict mnist.t mnist.model mnist.output
Accuracy = 80.26% (8026/10000)
```

精确率是80.26%

(c)

```
$ ./train mnist.square
$ ./predict mnist.square.t mnist.square.model mnist.square.output
Accuracy = 87.22% (8722/10000)
```

精确率为87.22%

(d)

可能手写数字集并非一个线性可分的数据集，无法直接使用超平面将数据完美分割开，所以当使用平方根转换后，有可能增加数据的分类精确率

6.

(a) 距离矩阵的性质：对称性、非负性、自反性(主对角元为0)、满足三角不等式(D(i,j) + D(j, k) >= D(i, k))

(b)

得到的KL散度矩阵

$$\begin{bmatrix} 0 & 0.21 & 0.60 \\ 0.19 & 0 & 0.08 \\ 0.46 & 0.07 & 0 \end{bmatrix}$$

KL散度矩阵不是一个距离矩阵，不满足对称性和三角不等式，但是满足非负性和自反性

(c)

```python
import numpy as np

arr = np.array([[1/2, 1/2], [1/4, 3/4], [1/8, 7/8]])
result = np.zeros([3,3])

for i in range(arr.shape[0]):
    p = arr[i]
    for j in range(arr.shape[0]):
        q = arr[j]
        result[i, j] = np.sum(p * (np.log2(p / q))) #KL

for i in range(arr.shape[0]):
    print('%7.4f%7.4f%7.4f'%(result[i,0], result[i, 1], result[i, 2]))
```

7.