CPSC-340 Machine Learning and Data Mining 2005

Homework # 1
Due Friday, Sep 19 1pm.

NAME:_____

Signature:_____

STD. NUM: _____

General guidelines for homeworks:

You are encouraged to discuss the problems with others in the class, but all write-ups are to be done on your own.
Homework grades will be based not only on getting the "correct answer," but also on good writing style and clear presentation of your solution. It is your responsibility to make sure that the graders can easily follow your line of reasoning.
Try every problem. Even if you can't solve the problem, you will receive partial credit for explaining why you got stuck on a promising line of attack. More importantly, you will get valuable feedback that will help you learn the material.
Please acknowledge the people with whom you discussed the problems and what sources you used to help you solve the problem (e.g. books from the library). This won't affect your grade but is important as academic honesty.
When dealing with python exercises, please attach a printout with all your code and show your results clearly.

1. **(Learning pylab)**

   (i) Explain briefly what the following python scrip does. Your answer should consist of this brief explanation and the plot generated by the program. Add a title to the plot consisting of your name. Label the axes appropriately.

```
from pylab import *

def f(t):
    s1 = cos(2*pi*t)
    e1 = exp(-t)
    return multiply(s1,e1)

t1 = arange(0.0, 5.0, 0.1)
t2 = arange(0.0, 5.0, 0.02)
figure(1)
subplot(211)
plot(t1, f(t1), 'bo', t2, f(t2), 'k')
subplot(212)
plot(t2, cos(2*pi*t2), 'r--')
show()
```

   Explanation:

(ii) Explain briefly what the following python scrip does. Your answer should consist of this brief explanation and the plot generated by the program.

```
from matplotlib.pyplot import figure, show
import numpy

fig = figure()
ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)
x = numpy.random.randn(20,20)
x[5] = 0.
x[:,12] = 0.
ax1.spy(x, markersize=5)
ax2.spy(x, precision=0.1, markersize=5)
ax3.spy(x)
ax4.spy(x, precision=0.1)
show()
```

Explanation:

(iii) Explain briefly what the following python scrip does. Your answer should consist of this brief explanation and the plot generated by the program.

```
from matplotlib import rcParams
from pylab import *

mu, sigma = 100, 15
x = mu + sigma*randn(10000)
n, bins, patches = hist(x, 100, normed=1)
y = normpdf( bins, mu, sigma)
l = plot(bins, y, 'r--', linewidth=2)
xlim(40, 160)
figure(1)
title(r'$\rm{Gaussian:}\/ \mu=100,\/ \sigma=15$')
show()
```

Explanation:

(iv) Explain briefly what the following python scrip does. Your answer should consist of this brief explanation and the plot generated by the program.

```
from pylab import *

x = arange(0.,1.,0.04)
noise = 0.3*randn(len(x))
y = 7 - 3*x + noise
m,b = polyfit(x,y,1)
figure(1)
plot(x,y,'ro',x,m*x+b,'-k',linewidth=3)
ylabel('Linear fit')
grid(True)
```

Explanation:

2. **(Image processing)**

   (i) Using your own photo as input, generate a edge-map of your photo. Edge detection is an import computer vision operation. If you are a Windows user, you could use the Python imaging library (PIL) at:

   `http://www.pythonware.com/products/pil/`

   If you're a unix user, you can use scipy and xplt as explained in the scipy tutorial:

   `http://www.tau.ac.il/~kineret/amit/scipy_tutorial/`

   Hand in both images.

3. **(Eigenproblems)**

(i) Suppose the matrix $\mathbf{A} \in \mathbb{R}^{\mathbf{n}\times\mathbf{n}}$ has n linearly independent eigenvectors $\mathbf{x_1}, \ldots, \mathbf{x_n}$. Define the matrix $\mathbf{Q}$ having these vectors as columns, i.e. $\mathbf{Q} = [\mathbf{x_1} \quad \mathbf{x_2} \quad \ldots \quad \mathbf{x_n}]$. Let $\mathbf{D}$ be a diagonal matrix with the eigenvalues λ_i in the diagonal. Show that

$$\mathbf{A} = \mathbf{QDQ^{-1}}$$

(ii) Prove the spectral mapping theorem.

(iii) Compute the eigenvalues and eigenvectors of the following matrix by hand and using numpy:

$$\mathbf{A} = \begin{pmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{pmatrix}$$