Untitled4

September 29, 2019

1 Problem 3

In [8]:
```
import pandas as pd
import numpy as np

Xtrain = pd.read_csv("Q3_X_train.csv")
ytrain = pd.read_csv("Q3_Y_train.csv")
Xtest  = pd.read_csv("Q3_X_test.csv")
ytest  = pd.read_csv("Q3_y_test.csv")

X = Xtrain.as_matrix()
y = ytrain.as_matrix()
Xt = Xtest.as_matrix()
yt = ytest.as_matrix()

ones = np.ones(500).reshape((500,1))
X = np.hstack((ones,X))
ones = np.ones(250).reshape((250,1))
Xt= np.hstack((ones,Xt))


# Ordinary Least Square
k1 = np.linalg.inv(np.matmul(X.T,X)).dot(X.T).dot(y)
y_pred = Xt.dot(k1)
pred_error = np.mean((yt-y_pred)**2)
print ("Prediction error for ols = ",pred_error)


# Ridge regression
from sklearn.model_selection import KFold
kfold = KFold(5,True,1)
u = np.mean(X,axis=0)
X_cent0 = X-u
I = np.identity(51)
a = [1e-15, 1e-10, 1e-8, 1e-4, 1e-3, 1e-2, 1]
b = np.linspace(2,500)
alpha = np.hstack((a,b))
```

```
data = np.hstack((X_cent0,y))

Error = []
for i in range(len(alpha)):
    pred_error = 0
    for train, test in kfold.split(data):
        X_cent = data[train][:,:-1]
        y_cent = data[train][:,-1]
        X_vald = data[test][:,:-1]
        y_vald = data[test][:,-1]
        k2 = np.linalg.inv(np.matmul(X_cent.T,X_cent)+alpha[i]*I).dot(X_cent.T).dot(y_
        y_pred = X_vald.dot(k2)
        pred_error += np.mean((y_vald-y_pred)**2)

    pred_error1 = pred_error/5
    Error.append(pred_error1)
import matplotlib.pyplot as plt
#plt.plot(alpha,Error)
#plt.show()

optAlpha = alpha[Error.index(np.min(Error))]

k2 = np.linalg.inv(np.matmul(X_cent0.T,X_cent0)+optAlpha*I).dot(X_cent0.T).dot(y)
y_pred = Xt.dot(k2)
pred_error = np.mean((yt-y_pred)**2)
print ("Prediction error for ridge = ",pred_error)



# Lasso Regression

from sklearn.linear_model import LassoCV, Lasso

Xtrain = pd.read_csv("Q3_X_train.csv")
ytrain = pd.read_csv("Q3_Y_train.csv")
Xtest  = pd.read_csv("Q3_X_test.csv")
ytest  = pd.read_csv("Q3_y_test.csv")

X = Xtrain.as_matrix()
y = ytrain.as_matrix()
Xt = Xtest.as_matrix()
yt = ytest.as_matrix()

ones = np.ones(500).reshape((500,1))
X = np.hstack((ones,X))
ones = np.ones(250).reshape((250,1))
Xt= np.hstack((ones,Xt))
```

```
        u = np.mean(X,axis=0)
        X = X-u

        model = LassoCV(cv=5,max_iter=3000)
        model.fit(X,y)
        ynew = model.predict(Xt)
        pred_error = np.mean((yt-ynew)**2)
        print ("Prediction error for lasso = ",pred_error)
```

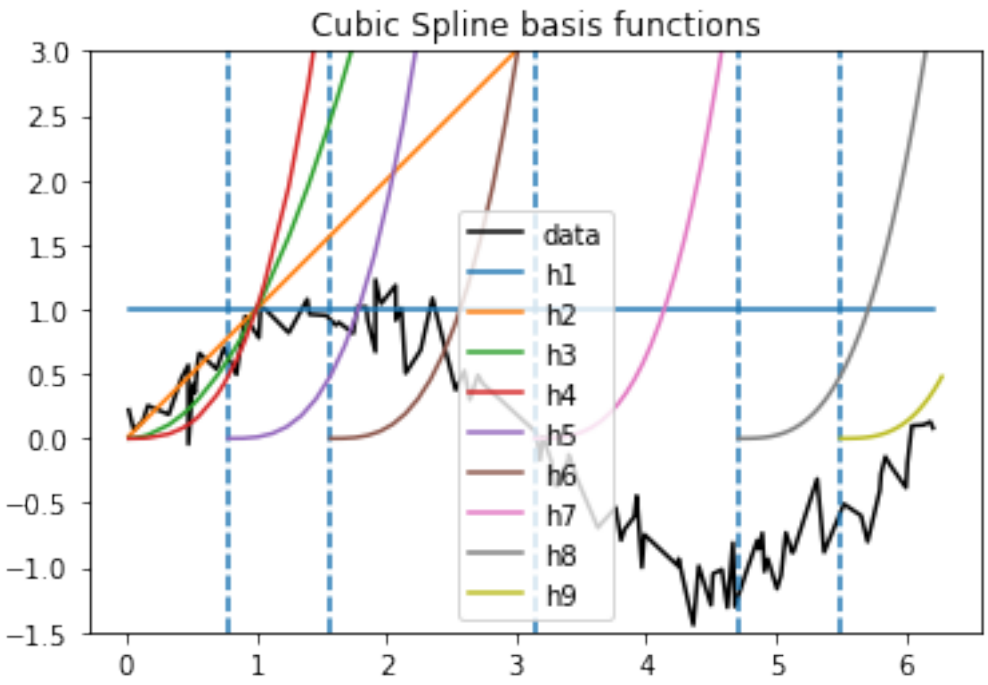
```
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:9: FutureWarning: Method .as_matri
  if __name__ == '__main__':
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:10: FutureWarning: Method .as_matr
  # Remove the CWD from sys.path while we load stuff.
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:11: FutureWarning: Method .as_matr
  # This is added back by InteractiveShellApp.init_path()
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:12: FutureWarning: Method .as_matr
  if sys.path[0] == '':
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:74: FutureWarning: Method .as_matr
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:75: FutureWarning: Method .as_matr
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:76: FutureWarning: Method .as_matr
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:77: FutureWarning: Method .as_matr
/anaconda3/lib/python3.7/site-packages/sklearn/linear_model/coordinate_descent.py:1109: DataCon
  y = column_or_1d(y, warn=True)


Prediction error for ols =  30.037394792483873
Prediction error for ridge =  25.856854295473653
Prediction error for lasso =  148.39318958116104
```

2 Problem 4a

```
In [287]: import numpy as np
          import matplotlib.pyplot as plt
          xi1 = np.pi/4
          xi2 = np.pi/2
          xi3 = np.pi
          xi4 = np.pi*3/2
          xi5 = np.pi*7/4

          X = pd.read_csv("Q4_X.csv").as_matrix().reshape(-1)
          y = pd.read_csv("Q4_Y.csv").as_matrix().reshape(-1)
          plt.plot(X,y,'k',label="data")
          plt.axvline(x=xi1,linestyle="--")
          plt.axvline(x=xi2,linestyle="--")
          plt.axvline(x=xi3,linestyle="--")
          plt.axvline(x=xi4,linestyle="--")
          plt.axvline(x=xi5,linestyle="--")
```

```
        h1 = np.ones(len(X))
        plt.plot(X,h1,label="h1")
        h2 = X
        plt.plot(X,h2,label="h2")
        h3 = X**2
        plt.plot(X,h3,label="h3")
        h4 = X**3
        plt.plot(X,h4,label="h4")

        X5 = np.linspace(xi1,6.28)
        h5 = (X5-xi1)**3
        plt.plot(X5,h5,label="h5")

        X6 = np.linspace(xi2,6.28)
        h6 = (X6-xi2)**3
        plt.plot(X6,h6,label="h6")

        X7 = np.linspace(xi3,6.28)
        h7 = (X7-xi3)**3
        plt.plot(X7,h7,label="h7")

        X8 = np.linspace(xi4,6.28)
        h8 = (X8-xi4)**3
        plt.plot(X8,h8,label="h8")

        X9 = np.linspace(xi5,6.28)
        h9 = (X9-xi5)**3
        plt.plot(X9,h9,label="h9")

        plt.ylim(-1.5,3)
        plt.legend()
        plt.title("Cubic Spline basis functions")
        plt.show()
```

```
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:9: FutureWarning: Method .as_matri
  if __name__ == '__main__':
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:10: FutureWarning: Method .as_mati
  # Remove the CWD from sys.path while we load stuff.
```

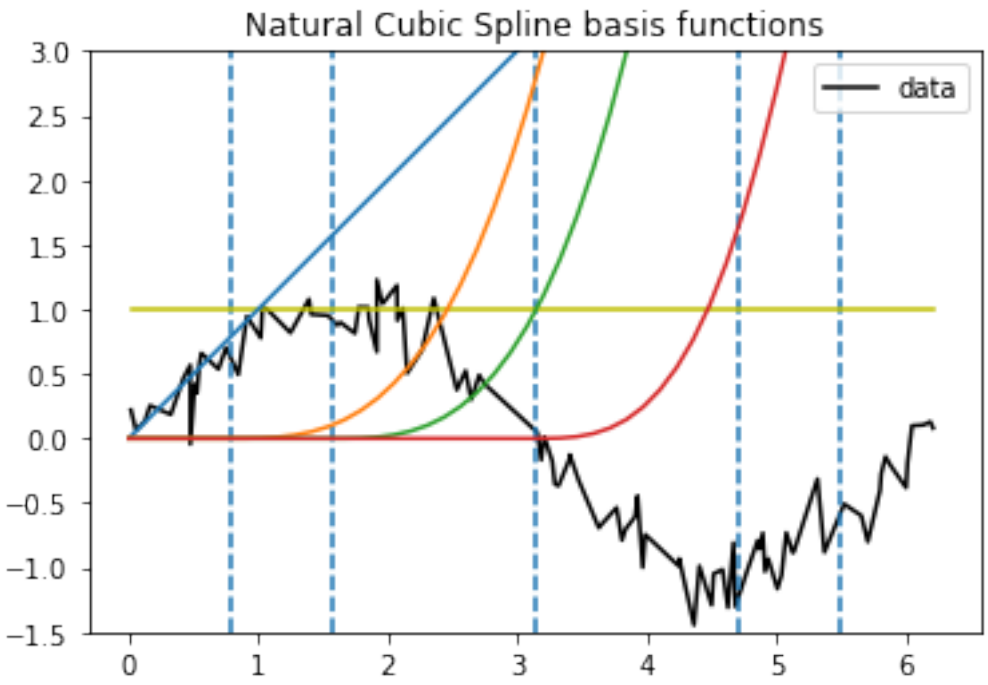


3 Problem 4b

```
In [319]: import numpy as np
          import matplotlib.pyplot as plt
          xi1 = np.pi/4
          xi2 = np.pi/2
          xi3 = np.pi
          xi4 = np.pi*3/2
          xi5 = np.pi*7/4

          X = pd.read_csv("Q4_X.csv").as_matrix().reshape(-1)
          y = pd.read_csv("Q4_Y.csv").as_matrix().reshape(-1)
          plt.plot(X,y,'k',label="data")
          plt.axvline(x=xi1,linestyle="--")
          plt.axvline(x=xi2,linestyle="--")
          plt.axvline(x=xi3,linestyle="--")
          plt.axvline(x=xi4,linestyle="--")
          plt.axvline(x=xi5,linestyle="--")

          h1 = np.ones(len(X))
          plt.plot(X,h1,'y')
          h2 = X
          plt.plot(X,h2)
```

```
x = np.linspace(0,6.28)
b1 = np.piecewise(x,[x<xi1,x>=xi1],[lambda x:0,lambda x: (x-xi1)**3])
b2 = np.piecewise(x,[x<xi2,x>=xi2],[lambda x:0,lambda x: (x-xi2)**3])
b3 = np.piecewise(x,[x<xi3,x>=xi3],[lambda x:0,lambda x: (x-xi3)**3])
b4 = np.piecewise(x,[x<xi4,x>=xi4],[lambda x:0,lambda x: (x-xi4)**3])
b5 = np.piecewise(x,[x<xi5,x>=xi5],[lambda x:0,lambda x: (x-xi5)**3])

d1 = (b1-b5)/(xi5-xi1)
d2 = (b2-b5)/(xi5-xi2)
d3 = (b3-b5)/(xi5-xi3)
d4 = (b4-b5)/(xi5-xi4)

h3 = d1-d4
plt.plot(x,h3)
h4 = d2-d4
plt.plot(x,h4)
h5 = d3-d4
plt.plot(x,h5)



plt.legend()
plt.ylim(-1.5,3)
plt.title("Natural Cubic Spline basis functions")
plt.show()
```

```
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:9: FutureWarning: Method .as_matri
  if __name__ == '__main__':
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:10: FutureWarning: Method .as_mat
  # Remove the CWD from sys.path while we load stuff.
```



In [318]:
```
X = pd.read_csv("Q4_X.csv").as_matrix().reshape(-1)
y = pd.read_csv("Q4_Y.csv").as_matrix().reshape(-1)
plt.plot(X,y,'k',label="data")
y_ture = np.sin(X)
plt.plot(X,y_ture,'rs',label="true")

from scipy.interpolate import CubicSpline, interp1d
import matplotlib.pyplot as plt
import numpy as np

xnew = np.linspace(0,2*np.pi,num=7,endpoint=True)
y1 = np.sin(xnew)

f = interp1d(xnew,y1,kind='cubic')
xxnew = np.linspace(-1,7,num=100)
#plt.plot(xxnew,f(xxnew),label="cubic")
cs = CubicSpline(xnew,y1,extrapolate=True)
plt.plot(xxnew,cs(xxnew),'g',label='cubic')

cs = CubicSpline(xnew,y1,bc_type='natural',extrapolate=True)
plt.plot(xxnew,cs(xxnew),'y',label='natural')

#plt.plot(xnew,y1,'ko')

plt.axvline(x=xi1,linestyle="-.")
```

```
plt.axvline(x=xi2,linestyle="-.")
plt.axvline(x=xi3,linestyle="-.")
plt.axvline(x=xi4,linestyle="-.")
plt.axvline(x=xi5,linestyle="-.")

plt.title("Natural Cubic Spline fitting")
plt.legend()
plt.show()
```

```
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:1: FutureWarning: Method .as_matri
  """Entry point for launching an IPython kernel.
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:2: FutureWarning: Method .as_matri
```