regression-starterkit

July 3, 2018

1 Training regression model using gradient descent

1.1 Setup

In [1]:
```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from mpl_toolkits.mplot3d import Axes3D # required even though not ref'd!
import random
from matplotlib import rcParams

EXACT_COEFF = [-2977.3484892930505, 113.13288354356122]

rcParams["font.size"] = 12

def line_fit(B, x):
    return B[2-1]*x + B[1-1]
```

1.2 Load data

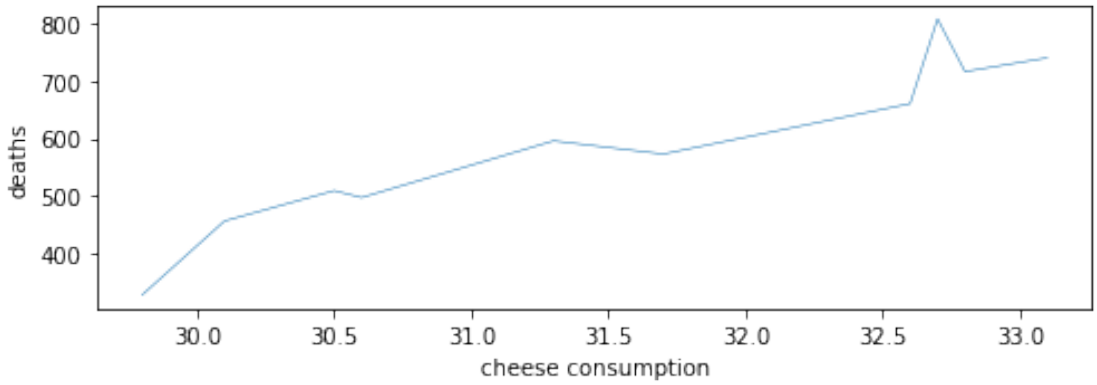
In [2]:
```
df = pd.read_csv('data/cheese_deaths.csv')
df
```

Out[2]:

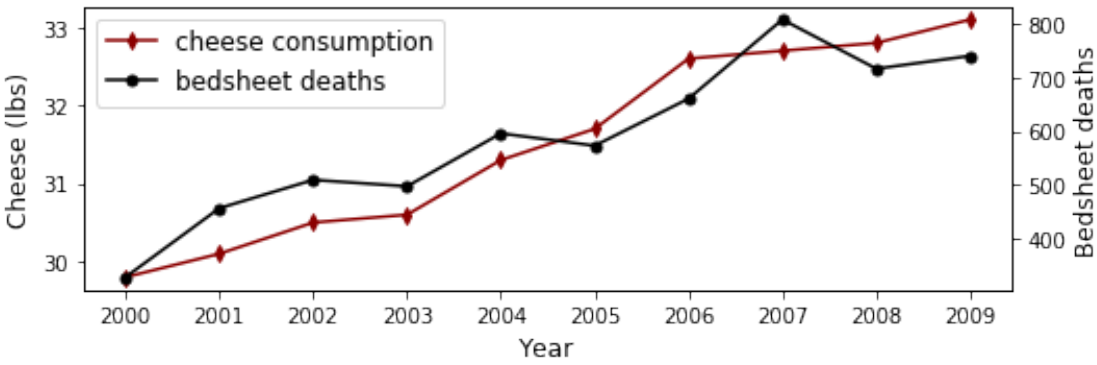
	years	cheese	deaths
0	2000	29.8	327
1	2001	30.1	456
2	2002	30.5	509
3	2003	30.6	497
4	2004	31.3	596
5	2005	31.7	573
6	2006	32.6	661
7	2007	32.7	809
8	2008	32.8	717
9	2009	33.1	741

1.3 Reproduce plots

```
In [4]: fig, ax1 = plt.subplots(figsize=(8,2.5))
        ...
        plt.show()
```




```
In [3]: ...
```



1.4 Define cost function and gradient

```
In [5]: def MSE(B):
            """
            Compute and return the mean squared error with:
            (x_i, y_i) = (df.cheese, df.deaths).
            The line coefficients are B = [y-intercept, slope].
            """
```

```
In [18]: def MSE_gradient(B):
             """
```

```
        Compute and return the gradient vector containing the partial derivatives
        of the MSE cost function with respect to b_1 and b_2. Don't scale by 2
        and divide by the number of observations as it's a waste of computation.
        We can adjust the learning rate to take this into consideration.
        """
```

1.5 Define minimize function

```
In [19]: def minimize(B0, eta, precision):
             """
             Minimize the MSE cost function starting at model parameters B0
             and using learning rate vector eta. The model has converged when
             the change in MSE from one iteration to the next is less than
             precision. Return both the B at which your algorithm converged
             and also the list of B points between B0 and converged B, inclusively.
             """
             trace = []
```

```
In [8]: LEARNING_RATES = [0.02,0.0001]
        PRECISION = 0.000000001 # can't be too small as x-xprev prec is low
        B0 = np.array([random.randrange(-6000, 4000), random.randrange(-200, 300)])
```

```
In [20]: %time B,trace = minimize(B0, LEARNING_RATES, PRECISION)

CPU times: user 7.22 s, sys: 262 ms, total: 7.49 s
Wall time: 7.51 s
```

```
In [9]: print(f"descent gives {B} in {len(trace)} steps")
        print(f"exact   is    {EXACT_COEFF}")
        print(f"cost of approx is {MSE(B):1.10f}")
        print(f"cost of exact  is {MSE(EXACT_COEFF):1.10f}")

descent gives [-2977.30834673   113.13161144] in 47004 steps
exact   is    [-2977.3484892930505, 113.13288354356122]
cost of approx is 2004.4563237107
cost of exact  is 2004.4563215019
```

1.6 Draw heatmap with trace

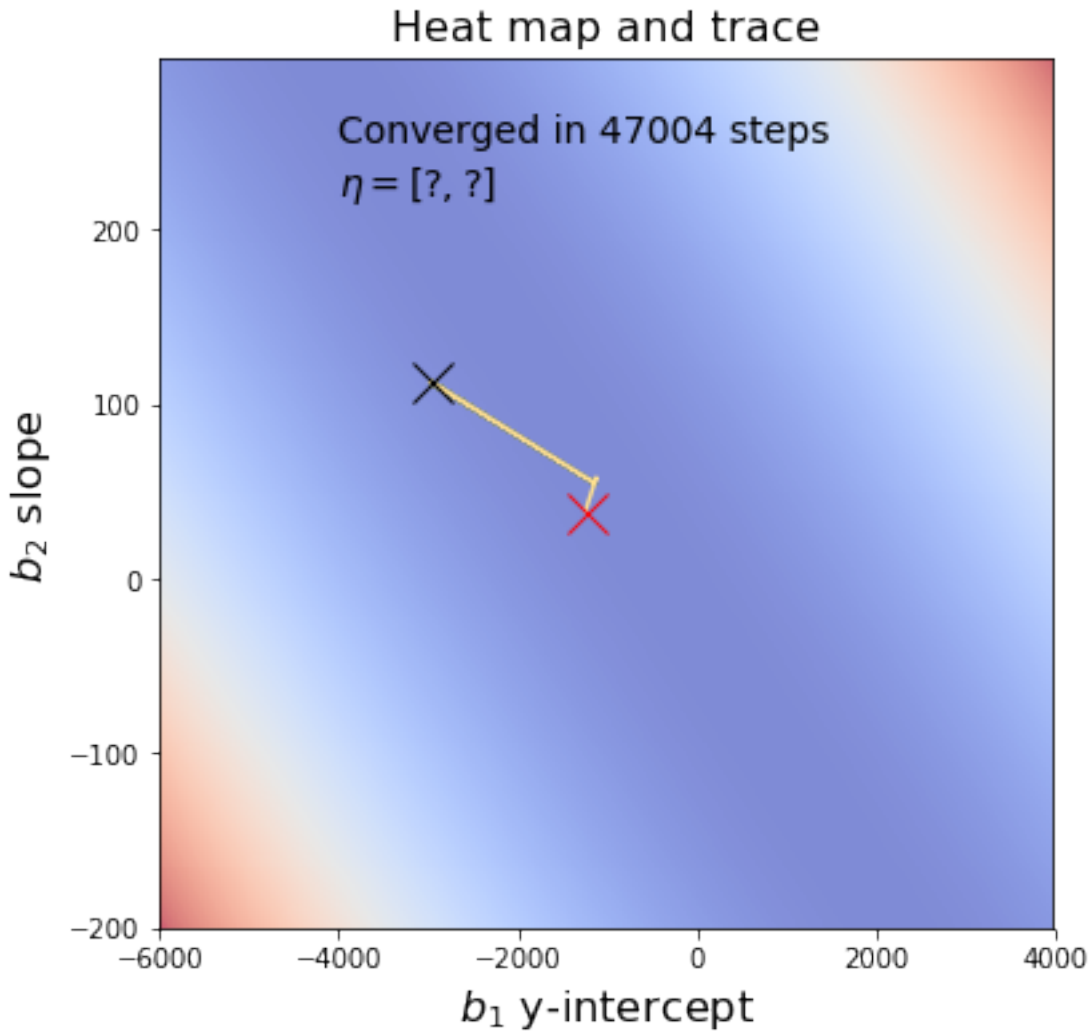
```
In [10]: def get_surface(Cost, b1, b2):
             """
             Given an arbitrary function of two scalar parameters, f,
             return a list of lists, C, containing f evaluated at f(b1[i],b2[j]). i is the
             b_1 coordinate and j is the b_2 coordinate. b_1 is the np.arange of
             y-intercept values and b_2 is the np.arange of slope values.
             """
```

```
In [13]: def heatmap(b0, b1, C, trace): # trace is a list of [b1, b2] pairs
             """
             Given b0 and b1, y-intercept and slope values, and cost 2D matrix, plot
             a heatmap using plt.imshow(). Make the heat map look like those in
             the project description.

             Once the heat map is displayed, plot the trace coordinates in color
             #FEE08F. Plot the first coordinate in color #FB060B and the last
             coordinate in black.

             Returns nothing.
             """
             fig = plt.figure(figsize=(6,6))
             ...
             plt.imshow(C,
                 origin='lower',
                 cmap='coolwarm',
                 alpha=0.65,
                 ...
             )
             ...
             # Plot all trace cordinates at once instead of using a Python loop
             # (MUCH faster this way)
             ax.plot(trace[:,0], trace[:,1], color='#FEE08F', marker='.', markersize=.1)
             ...

In [14]: b1 = np.arange(-6000, 4000, 30)  # y intercept
         b2 = np.arange(-200, 300, 1)     # slope
         C = get_surface(MSE, b1, b2)
         heatmap(b1, b2, C, trace)
```


Heat map and trace
Converged in 47004 steps
$\eta = [?, ?]$
200
100
0
−100
−200
b_2 slope
−6000
−4000
−2000
0
2000
4000
b_1 y-intercept