Lab3_js85773_asm3539

February 12, 2018

1 Problem 1

1.1 Part 1

We can consider S = span{v1, v2, v3, v4}. The explanations are printed out with the answers below

```
In [2]: import sympy
        from scipy import linalg
        import numpy as np
        import scipy
```

```
In [41]: # Setup Problem
         v1 = np.array([1, 2, 3, 4])
         v2 = np.array([0, 1, 0, 1])
         v3 = np.array([1, 4, 3, 6])
         v4 = np.array([2, 11, 6, 15])
         A = np.column_stack((v1, v2, v3, v4))

         # Create a vector inside S different from v1, v2, ...
         s = np.add(np.add(2 * v1, 2 * v2), np.add(2 * v3, 2 * v4))
         print("A vector in S that is not any of the given vectors is: {}".format(s))
         print("")

         # Create a vector not in S
         print("Any vector x with dim(x) > 4 is not in S")
         print("For example, x = [1, 1, 1, 1, 1]")
         print("")

         # Create a vector x perpendicular to S.
         # (any vector u s.t. v1 dot u, v2 dot u, ... etc are all equal to zero)
         A_transpose = sympy.Matrix(A.T)
         null_A = A_transpose.nullspace()
         null_A_ = np.array(null_A)
         #print(null_A_.T)
         print("Null(A^T) = {}".format(null_A_.T))
         # x = some vector orthogonal to S
         b = np.ones(2)
         x = np.dot(null_A_.T , b)
         x = np.array(x, dtype="int")
         print("A vector perpendicular to S is any vector in Null(A^T)")
         print("So any linear combination, for instance: {}".format(x))
```

```
A vector in S that is not any of the given vectors is: [ 8 36 24 52]

Any vector x with dim(x) > 4 is not in S
For example, x = [1, 1, 1, 1, 1]

Null(A^T) = [[-3 -2]
 [0 -1]
 [1 0]
 [0 1]]
A vector perpendicular to S is any vector in Null(A^T)
So any linear combination, for instance: [-5 -1  1  1]
```

The answer to the question $u \in S$ for some new vector u is equivalent to asking if there is a solution to $Ax = u$. This can be solved using numpy or by hand with row reduction.

1.2 Part 2

Find the dimension of the subspace S.

```
In [35]: dim = np.linalg.matrix_rank(A)
         print(dim)
```

```
2
```

1.3 Part 3

Construct an orthonormal basis. Notice only two vectors are required because the dimension of S is only 2.

```
In [36]: vectors = []
         vectors.append(v1)
         vectors.append(v3)
         vectors.append(v2)
         vectors.append(v4)
         vectors = np.array(vectors)
         #sympy.Matrix(vectors).rref()
         vectors = vectors.T
         orth = scipy.linalg.orth(vectors)
         print(orth)
         print(np.dot(orth[:,0], orth[:,1]))
```

```
[[-0.1098991   0.2669373 ]
 [-0.54396107 -0.53613402]
 [-0.32969731  0.80081189]
 [-0.76375927 -0.00225943]]
7.502679033599691e-17
```

1.4 Part 4

```
We are asked to solve

$$\min_{x\in S} \|\pmb{x}-\pmb{z}^{*}\|_2 $$
$$\Rightarrow \min_{x\in S} \sqrt{(\sum_{i}^{n} x_i \, - \, (1,0,0,0)^{T})^{2}}$$
$$\Rightarrow \min_{x\in S} (\sum_{i}^{n} x_i \, - \, (1,0,0,0)^{T})^{2}$$

This is a convex function, so we set the derivative and set it equal to 0:

$$\sum_i^n (x_i - (1,0,0,0)^{T}) = 0$$
$$\Rightarrow \sum_i^n x_i = (1,0,0,0)^{T}$$

Obviously we want $\pmb{x} = \pmb{z}^{*}$

Since $\pmb{z}^* \notin S$ ,this becomes equivalent to finding the shortest distance to $\pm

We find this distance by projecting the vector $\pmb{z}^*$ onto S:
```

In [37]:

```python
min_dist = np.zeros(4)
z_star = np.array([1, 0, 0, 0])
col_1 = np.dot(orth[:,0], z_star)
col_2 = np.dot(orth[:,1], z_star)
min_dist = np.add(col_1, col_2)
print("The minimum distance is: {}".format(min_dist))
```

```
The minimum distance is: 0.15703819557191717
```

In [38]:

```python
# Project u onto v
#def proj(u, v):
    #assert type(u) &&
#    assert type(v) == np.ndarray, "Invalid input"
#    a = (np.dot(u, v))/(np.dot(u,u))
#    w = a * v
#    return w

#z_star = sympy.Matrix(z_star)
#space = sympy.Matrix(orth)
#print(orth.shape[:][0])
#print(z_star.T.shape)
#space.project(z_star_)
#min_dist = np.add(proj(z_star, orth[:][i]), min_dist)
```

1.5 Problem 2

1.5.1 Part 1 Most Common Words

```
In [118]: import requests as req
          from bs4 import BeautifulSoup
          from urllib.request import urlretrieve,urlopen
          import PyPDF2
          import io
          import pdfminer
          import os
          import numpy as np
          import nltk
          from math import log2
          from nltk.corpus import stopwords
          from nltk.tokenize import word_tokenize
          from io import StringIO
          from pdfminer.pdfinterp import PDFResourceManager, PDFPageInterpreter
          from pdfminer.converter import TextConverter
          from pdfminer.layout import LAParams
          from pdfminer.pdfpage import PDFPage
          import re
          from nltk.tokenize import RegexpTokenizer
          from collections import Counter
```

```
In [3]: #getting html from http://proceedings.mlr.press/v70/
        html_content = req.get("http://proceedings.mlr.press/v70/").content
        content = BeautifulSoup(html_content,'html.parser')

        #getting all the links
        links_pdf =[]

        #getting all the classes with id links
        links_paper = content.find_all(class_="links")

        #iterate over all the classes obtained and get link and keep only pdf links
        for link_paper in links_paper:
            links = link_paper.find_all('a')
            links_pdf.append(links[1].get('href'))

        i=0

        for link_pdf in links_pdf:
            content=urlopen(link_pdf).read()
            i = i+1
            filename = str(i)+".pdf"
            fout=open(filename, "wb")
            fout.write(content)
            fout.close()
        print("downloaded {} files".format(i))
```

```
downloaded 434 files
```

```
In [15]: # function to convert text from pdf
         def convert_pdf_to_txt(path):
             rsrcmgr = PDFResourceManager()
             retstr = io.StringIO()
             codec = 'utf-8'
             laparams = LAParams()
             device = TextConverter(rsrcmgr, retstr, codec=codec, laparams=laparams)
             fp = open(path, 'rb')
             interpreter = PDFPageInterpreter(rsrcmgr, device)
             password = ""
             maxpages = 0
             caching = True
             pagenos = set()

             for page in PDFPage.get_pages(fp, pagenos, maxpages=maxpages,
                                           password=password,
                                           caching=caching,
                                           check_extractable=True):
                 interpreter.process_page(page)

             text = retstr.getvalue()

             fp.close()
             device.close()
             retstr.close()
             return text
```

```
In [73]: nltk.download('punkt')
         nltk.download('stopwords')
```

```
[nltk_data] Downloading package punkt to /home/humble-
[nltk_data]     fool/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to /home/humble-
[nltk_data]     fool/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

```
Out[73]: True
```

```
In [75]: path = '/home/humble-fool/school_work/Spring_18/Data-Science-Lab-ee379k/lab3/src/'

         data_list = []
         for i in range(1,435):
```

```
        # loads the pdf and sends it to the function ofr conversion
        print(i)
        t = convert_pdf_to_txt(path+str(i)+".pdf")
        t_lower = t.lower()
        ## tokenizes and removes punctuation
        tokenizer = RegexpTokenizer(r'\w+')
        tokens = tokenizer.tokenize(t_lower)

        #another filter to remove stop words
        filtered_tokens = tokens[:]
        for token in tokens:
            if token in stopwords.words('english'):
                filtered_tokens.remove(token)
        #another filter to remove unnecessary element of length lesser than three


        count_filter = []
        for token in filtered_tokens:
            if (len(token) >=3):
                count_filter.append(token)
        data_list.append(count_filter)
```

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```
    ---------------------------------------------------------------------------

    KeyboardInterrupt                         Traceback (most recent call last)

    <ipython-input-75-394b78917016> in <module>()
      5     # loads the pdf and sends it to the function ofr conversion
      6     print(i)
----> 7     t = convert_pdf_to_txt(path+str(i)+".pdf")
      8     t_lower = t.lower()
      9     ## tokenizes and removes punctuation


    <ipython-input-15-e97870ead6f1> in convert_pdf_to_txt(path)
     16                                   caching=caching,
     17                                   check_extractable=True):
---> 18         interpreter.process_page(page)
     19
     20     text = retstr.getvalue()


    ~/school_work/Spring_18/Data-Science-Lab-ee379k/lib/python3.5/site-packages/pdfminer/pdf
    851         self.device.begin_page(page, ctm)
    852         self.render_contents(page.resources, page.contents, ctm=ctm)
--> 853         self.device.end_page(page)
    854         return
    855


    ~/school_work/Spring_18/Data-Science-Lab-ee379k/lib/python3.5/site-packages/pdfminer/con
     52         assert isinstance(self.cur_item, LTPage), str(type(self.cur_item))
     53         if self.laparams is not None:
---> 54             self.cur_item.analyze(self.laparams)
     55         self.pageno += 1
     56         self.receive_layout(self.cur_item)


    ~/school_work/Spring_18/Data-Science-Lab-ee379k/lib/python3.5/site-packages/pdfminer/lay
    684         textboxes = list(self.group_textlines(laparams, textlines))
    685         if -1 <= laparams.boxes_flow and laparams.boxes_flow <= +1 and textboxes:
--> 686             self.groups = self.group_textboxes(laparams, textboxes)
    687             assigner = IndexAssigner()
    688             for group in self.groups:


    ~/school_work/Spring_18/Data-Science-Lab-ee379k/lib/python3.5/site-packages/pdfminer/lay
    661             plane.remove(obj1)
    662             plane.remove(obj2)
--> 663             dists = [ (c,d,obj1,obj2) for (c,d,obj1,obj2) in dists
    664                     if (obj1 in plane and obj2 in plane) ]
    665             for other in plane:


    ~/school_work/Spring_18/Data-Science-Lab-ee379k/lib/python3.5/site-packages/pdfminer/lay
    662             plane.remove(obj2)
    663             dists = [ (c,d,obj1,obj2) for (c,d,obj1,obj2) in dists
--> 664                     if (obj1 in plane and obj2 in plane) ]
    665             for other in plane:
    666                 dists.append((0, dist(group, other), group, other))


    KeyboardInterrupt:
```

```
In [80]: print(len(data_list))
         print(len(data_list[50]))
```

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200
2888
```

```
In [82]: ## pdf number 201 didn't load for some reason

         path = '/home/humble-fool/school_work/Spring_18/Data-Science-Lab-ee379k/lab3/src/'

         for i in range(202,435):
             # loads the pdf and sends it to the function ofr conversion
             print(i)
             t = convert_pdf_to_txt(path+str(i)+".pdf")
             t_lower = t.lower()
             ## tokenizes and removes punctuation
             tokenizer = RegexpTokenizer(r'\w+')
             tokens = tokenizer.tokenize(t_lower)

             #another filter to remove stop words
             filtered_tokens = tokens[:]
             for token in tokens:
                 if token in stopwords.words('english'):
                     filtered_tokens.remove(token)
             #another filter to remove unnecessary element of length lesser than three


             count_filter = []
             for token in filtered_tokens:
                 if (len(token) >=3):
                     count_filter.append(token)
             data_list.append(count_filter)
```

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```
In [84]: print(len(data_list))
```

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433
```

```
In [87]: one_list = []
         for data in data_list:
             one_list = one_list+data
         print(len(one_list))
```

```
1648762
```

```
In [91]: most_common_words= [word for word, word_count in Counter(one_list).most_common(10)]
         print (most_common_words)
```

```
['cid', 'learning', 'model', 'data', 'algorithm', '2016', '107', 'set', 'function', '2015']
```

1.5.2 Part 2 Estimate the Entropy

```
In [125]: ## randomly choosing a list corresponding to an ICML paper
          rand_list = np.random.choice(data_list)
          rand_word = np.random.choice(rand_list)
          freq =0
          for word in rand_list:
              if word == rand_word:
                  freq+=1

          prob = freq/len(rand_list)
          entropy = -(prob*log2(prob)+(1-prob)*log2(1-prob))

          print(entropy)


          ## need to figure out the entropy formula they want
```

```
0.0012351778656126482
0.013714018232625748
```

1.5.3 Part 3 Random Paragraph

```
In [105]: unique_words = set(one_list)
          corresponding_prob = []

          for word in unique_words:
              #calculate number of occurences
              num_occurences = one_list.count(word)
              #calc prob
              probability = num_occurences/len(one_list)
              corresponding_prob.append(probability)
```

```
In [104]: print(len(corresponding_prob))
```

```
131
```

```
In [113]: a = np.random.choice(one_list, 500, corresponding_prob)
          para = ""
          for word in a:
              para = para +word
              para += " "
```

```
In [114]: print(para)
```

```
lan sition ieee increase riemannian iot note nfsic abilistic matrix tion getting ference values
```

1.6 Problem 3

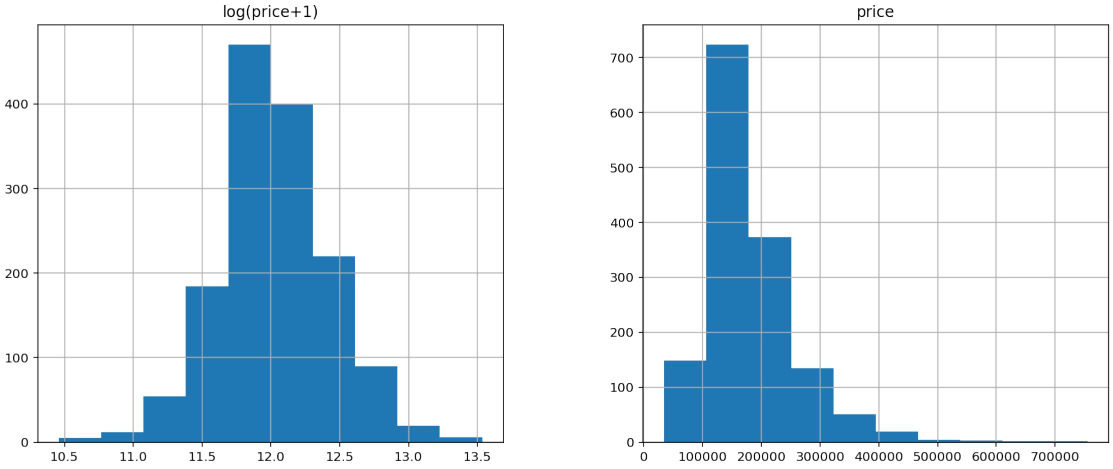
1.6.1 Part 2 Following the tutorial

```
In [52]: import pandas as pd
         import numpy as np
         import seaborn as sns
         import matplotlib
         import os
         from sklearn.linear_model import Ridge
         from sklearn.model_selection import cross_val_score
         import matplotlib.pyplot as plt
         from scipy.stats import skew
         from scipy.stats.stats import pearsonr
         from sklearn.metrics import mean_squared_error
         from math import sqrt

         %config InlineBackend.figure_format = 'retina' #set 'png' here when working on notebook
         %matplotlib inline
```

```
In [38]: train = pd.read_csv("train.csv")
         test = pd.read_csv("test.csv")
         all_data = pd.concat((train.loc[:,'MSSubClass':'SaleCondition'],test.loc[:,'MSSubClass'
```

```
In [39]: matplotlib.rcParams['figure.figsize'] = (15.0, 6.0)
         prices = pd.DataFrame({'price':train["SalePrice"],"log(price+1)":np.log1p(train["SalePr
         _ = prices.hist()
```



```
In [40]: train['SalePrice'] = np.log1p(train["SalePrice"])
         numeric_feats = all_data.dtypes[(all_data.dtypes != 'object')].index
         skewed_feats = train[numeric_feats].apply(lambda x: skew(x.dropna()))
         skewed_feats = skewed_feats[skewed_feats>0.75]
         skewed_feats = skewed_feats.index
         all_data[skewed_feats] = np.log1p(all_data[skewed_feats])
         all_data = pd.get_dummies(all_data)
         all_data = all_data.fillna(all_data.mean())
         X_train = all_data[:train.shape[0]]
         X_test = all_data[train.shape[0]:]
         y_train = train.SalePrice
```

```
In [41]: model = Ridge(alpha = 0.1)
         model.fit(X_train,y_train)
```

```
Out[41]: Ridge(alpha=0.1, copy_X=True, fit_intercept=True, max_iter=None,
            normalize=False, random_state=None, solver='auto', tol=0.001)
```

```
In [42]: arr = np.expm1(model.predict(X_test))
         pd.DataFrame(arr).to_csv("kaggle_results.csv")
```

```
In [43]: rmse_train = sqrt(mean_squared_error(model.predict(X_train), y_train))
         print("The training RMSE is: {}".format(rmse_train))
```

```
The training RMSE is: 0.09211955585640522
```

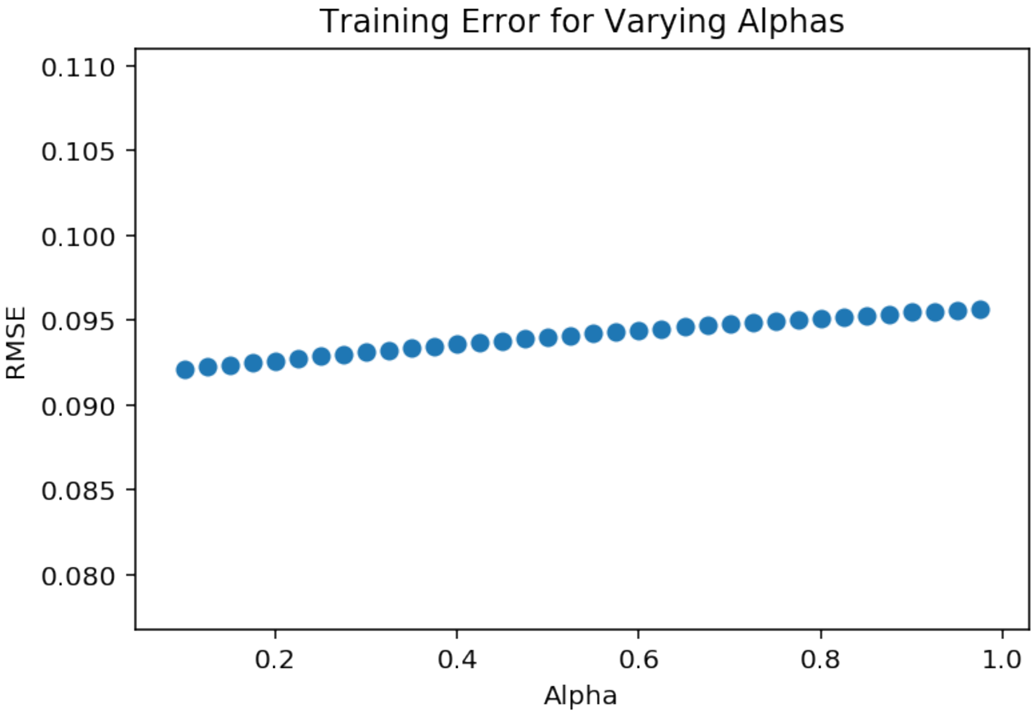
1.6.2 Part 3 Trying a different model

```
In [72]: # Naive model- find best training error

         X_train = np.array(X_train)
         y_train = np.array(y_train)
         alphas = np.arange(0.1, 1, 0.025)
         rmses = []

         for alpha in alphas:
             model = Ridge(alpha)
             model.fit(X_train, y_train)
             rmse_train = sqrt(mean_squared_error(model.predict(X_train), y_train))
             rmses.append(rmse_train)

         _ = plt.scatter(alphas, rmses)
         _ = plt.title("Training Error for Varying Alphas")
         _ = plt.ylabel("RMSE")
         _ = plt.xlabel("Alpha")
```



The alpha we chose originally has the lowest training error. Without cross-validation, this is the best ridge regression we can choose.