Lab Course Machine Learning

Exercise Sheet 2

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Part A: (Interesting stats)

Maximum sale recorded

In [2]:
```
import pandas as pd

c =pd.read_csv('train.csv',low_memory=False)
td =pd.DataFrame(c)

#store with max sales
maxStoreId = td['Sales'].idxmax()
print (td.iloc[[maxStoreId],[0,1,3,4]])
```

```
       Store  DayOfWeek  Sales  Customers
44393    909          1  41551       1721
```

least possible and maximum possible competition distance

In [4]:
```
c =pd.read_csv('store.csv',low_memory=False)
sd =pd.DataFrame(c)

#store with max competitionDistance
maxcompId = sd['CompetitionDistance'].idxmax()
print ('maximum possible competition distance')
print (sd.iloc[[maxcompId],[0,1,3]])
```

```
maximum possible competition distance
     Store StoreType  CompetitionDistance
452    453         a              75860.0
```

In [8]:
```
#store with min competitionDistance
print ('Least possible competition distance')
min = sd['CompetitionDistance'].idxmin()
print ('maximum possible competition distance')
print (sd.iloc[[min],[0,1,3]])
```

```
Least possible competition distance
maximum possible competition distance
     Store StoreType  CompetitionDistance
515    516         a                 20.0
```

Difference in the mean of sales (across all stores) when offering a Promo and not?

In [10]:
```
promoData = td[td["Promo"]==1]
promoData.groupby(['Store']).agg(['mean', 'count'])
#mean sales when promotion is running
promoData = td[td["Promo"]==1]
meanpromot = promoData['Sales'].mean()

noPromoData = td[td["Promo"]==0]
meanNopromot = noPromoData['Sales'].mean()

print ('Difference in the mean of sales::',(meanpromot-meanNopromot))
```

```
Difference in the mean of sales:: 3585.1012408091174
```

Are there any anomalies in the data as in where the store was "Open" but had no sales recorded?

In [13]:
```
nd = td.query('Open == 1 & Sales == 0')
df = nd.reindex(sorted(nd.columns), axis=1)
nd.sort_values(by=['Date']).head()
```

Out[13]:

	Store	DayOfWeek	Date	Sales	Customers	Open	Promo	StateHoliday	SchoolHoliday
999016	762	4	2013-01-17	0	0	1	0	0	0
990681	232	4	2013-01-24	0	0	1	1	0	0
984098	339	3	2013-01-30	0	0	1	0	0	0
982983	339	4	2013-01-31	0	0	1	0	0	0
975098	259	4	2013-02-07	0	0	1	1	0	0

In [14]:
```
nd = td.query('Open == 0 & Sales != 0')
df = nd.reindex(sorted(nd.columns), axis=1)
nd.sort_values(by=['Date']).head()
```

Out[14]:

Store	DayOfWeek	Date	Sales	Customers	Open	Promo	StateHoliday	SchoolHoliday

Yes, there exist anamoly, when the store is open and there were no sales recored. but anamoly for vice versa not exist()

Which store type ('a','b' etc.) has had the most sales?

In [17]:
```
td =pd.read_csv('train.csv',low_memory=False)
sd =pd.read_csv('store.csv',low_memory=False)
df = sd.append(td, sort=False)
df = pd.merge(td, sd, how="left", on=["Store"])
print(df.groupby(['StoreType'])['Sales'].sum())
```

```
StoreType
a    3165334859
b     159231395
c     783221426
d    1765392943
Name: Sales, dtype: int64
```

Part B: (Plotting)

Monthly mean of sales

In [96]:
```
td['Month']= pd.DatetimeIndex(td['Date']).month
```

In [18]:
```
td
```

Out[18]:

	Store	DayOfWeek	Date	Sales	Customers	Open	Promo	StateHoliday	SchoolHoliday
0	1	5	2015-07-31	5263	555	1	1	0	1
1	2	5	2015-07-31	6064	625	1	1	0	1
2	3	5	2015-07-31	8314	821	1	1	0	1
3	4	5	2015-07-31	13995	1498	1	1	0	1
4	5	5	2015-07-31	4822	559	1	1	0	1
...	...	...	...	...	...	...	...	...	...
1017204	1111	2	2013-01-01	0	0	0	0	a	1
1017205	1112	2	2013-01-01	0	0	0	0	a	1
1017206	1113	2	2013-01-01	0	0	0	0	a	1
1017207	1114	2	2013-01-01	0	0	0	0	a	1
1017208	1115	2	2013-01-01	0	0	0	0	a	1

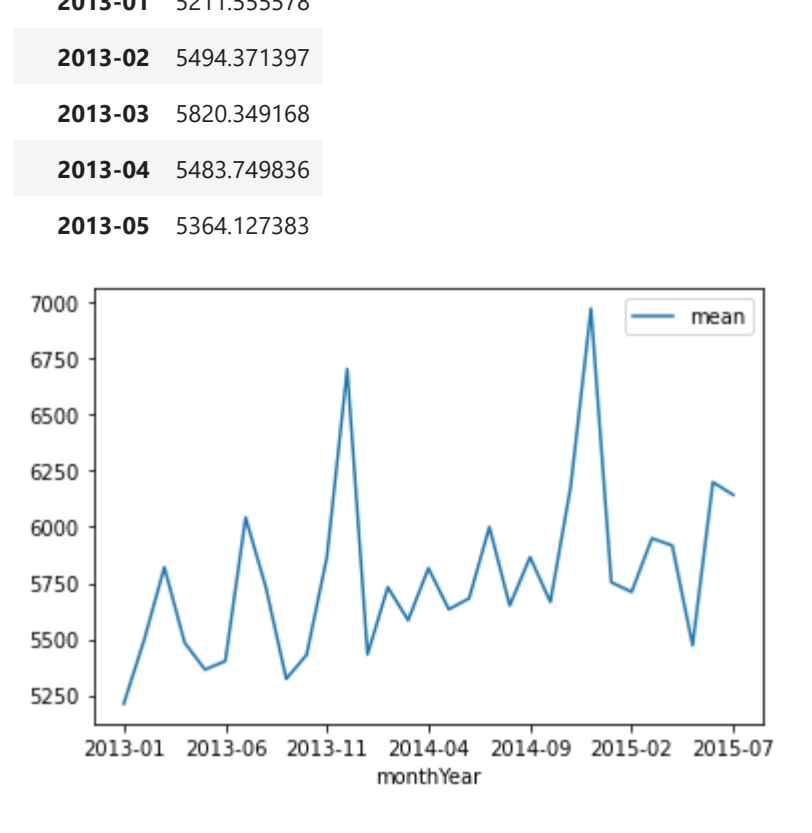
1017209 rows × 9 columns

In [98]:
```
import matplotlib as plt
%matplotlib inline
td["monthYear"] = (td["Date"].astype("datetime64")).dt.strftime('%Y-%m')
monthData = pd.DataFrame(td.groupby(td["monthYear"])['Sales'].agg(['mean']))

monthData.plot(kind='line')
monthData.head()
```

Out[98]:

monthYear	mean
2013-01	5211.555578
2013-02	5494.371397
2013-03	5820.349168
2013-04	5483.749836
2013-05	5364.127383



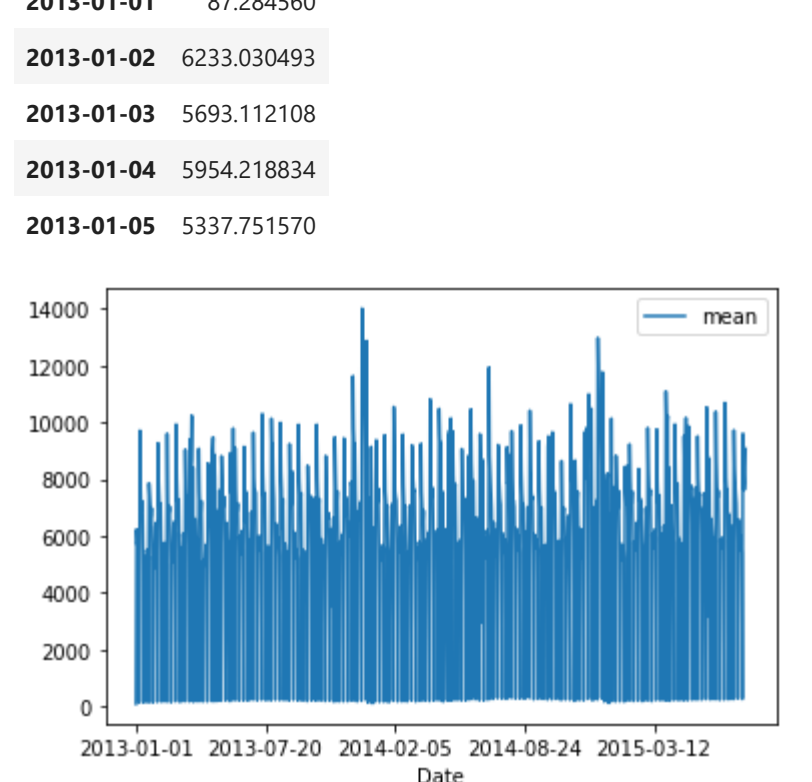
Daily mean of sales

In [99]:
```
monthData = pd.DataFrame(td.groupby(td["Date"])['Sales'].agg(['mean']))

monthData.plot(kind='line')
monthData.head()
```

Out[99]:

Date	mean
2013-01-01	87.284560
2013-01-02	6233.030493
2013-01-03	5693.112108
2013-01-04	5954.218834
2013-01-05	5337.751570



Cumulative sales for the first year.

In [24]:
```
td["Year"] = (td["Date"].astype("datetime64")).dt.strftime('%Y')
td["Day"] = (td["Date"].astype("datetime64")).dt.strftime('%d')


ss =td.query("Store==1 & Year == '"+td["Year"].min()+"'")
ps = ss.sort_values(by=['Date'])
dd = ps[['Date','Sales']]

#.groupby(['Month', 'Day']).sum().groupby(level=0).cumsum()
#data = ss[['Month','Day','Sales']].groupby(['Month', 'Day']).sum().groupby(level=1).cumsum().reset_index()
# data['date'] = pd.to_datetime(data[['Month','Day']].assign(YEAR=td["Year"].min()))
# data.query('Month == 1 | Month == 2')
```

In [25]:
```
dd['CumulativeSales'] = dd.Sales.cumsum()
```

```
<ipython-input-25-7362b1a414da>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#ret
urning-a-view-versus-a-copy
  dd['CumulativeSales'] = dd.Sales.cumsum()
```

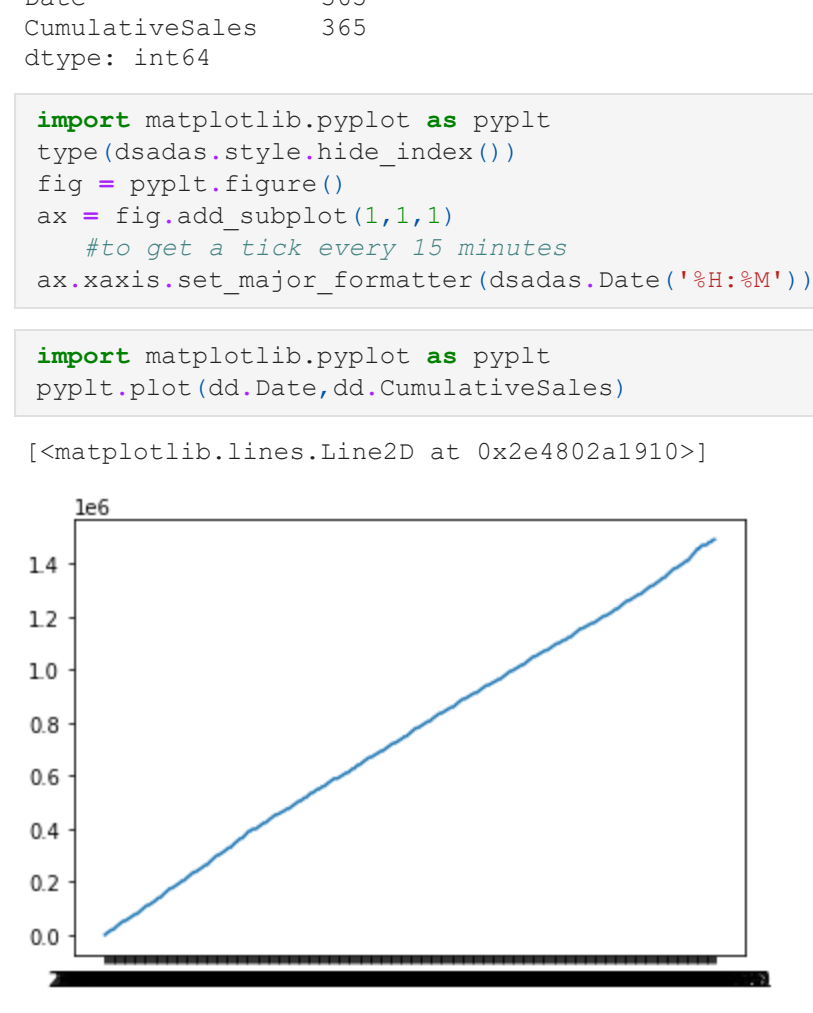
In [26]:
```
dd= dd[['Date','CumulativeSales']]
dd.count()
```

Out[26]:
```
Date               365
CumulativeSales    365
dtype: int64
```

In [19]:
```
import matplotlib.pyplot as pyplt
type(dsadas.style.hide_index())
fig = pyplt.figure()
ax = fig.add_subplot(1,1,1)
   #to get a tick every 15 minutes
ax.xaxis.set_major_formatter(dsadas.Date('%H:%M'))
```

In [27]:
```
import matplotlib.pyplot as pyplt
pyplt.plot(dd.Date,dd.CumulativeSales)
```

Out[27]:
```
[<matplotlib.lines.Line2D at 0x2e4802a1910>]
```



Exercise 2: Linear Regression

Part A: (Implementing Gaussian Elimination)

After writing the funcitons from sudo code provided for gausian elimiantionm, forward elimination and backward solve, i passed x_transposex *to gaussian function, and then result of gaussian elimation and x_transpose*y are passed to forward elimination, and result from forward elimnation is then passed to backward solve function, which gives the B parameters matrix.

In [32]:
```
import numpy as np
rows = 100
col = 10
mean, sd = 2, 0.01
def transpose(matrix):
    return [[row[i] for row in matrix] for i in range(len(matrix[0]))]


def multiplyMatrix(X, Y):
    return [[sum(a*b for a,b in zip(X_row,Y_col)) for Y_col in zip(*Y)] for X_row in X]

x = np.random.normal(mean, sd, (rows,col))
y = np.random.uniform(1,2,(rows,1))
bias_column = np.ones(shape=(rows,1))
A = np.append(bias_column,x,axis=1)


x_tran = np.transpose(A)
x_tran_x = np.dot(x_tran,A)

x_tran_y = np.dot(x_tran,y)
print(x_tran_y)


def Gaussian(mat):
    r,c =mat.shape
    if(r==c):
        for k in range (0,r-1):
            for i in range (k+1,r):
                mat[i][k]= mat[i][k]/mat[k][k]

                for j in range (k+1,r):
                    mat[i][j]= mat[i][j]-mat[i][k]*mat[k][j]

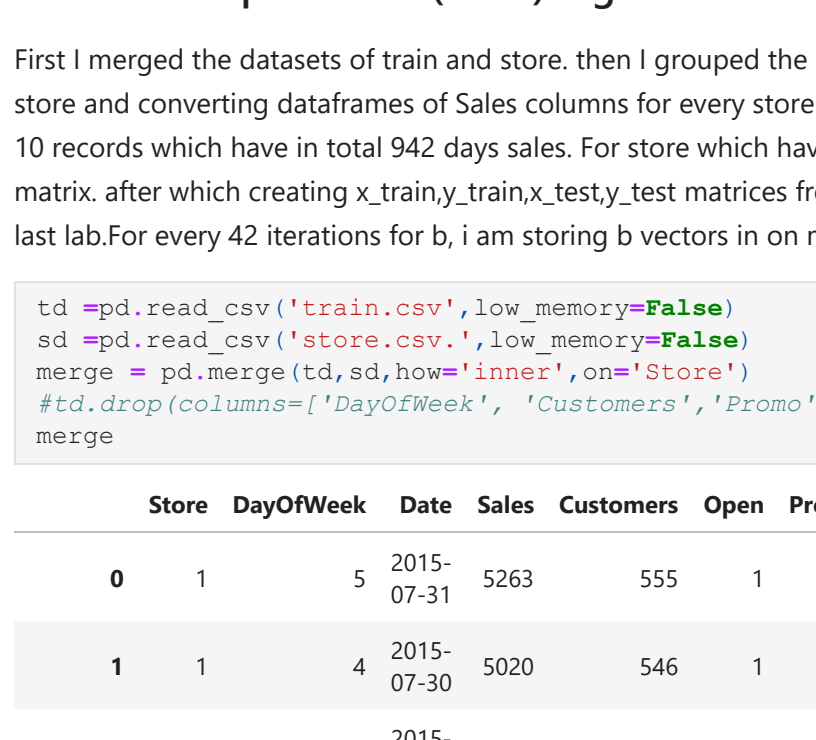
    else:
        print ('Dimensions of matrices are not correct for Gaussian Elimination')
    return mat
def forward(mat,b):
    r,c =mat.shape

    for k in range (0,r-1):
        for i in range (k+1,r):
            b[i]= b[i]-mat[i][k]*b[i]
    return b
def backward(mat,b):
    r,c =mat.shape
    x = np.zeros(shape=(r,1))
    for i in range(r-1, -1, -1):
        s = b[i]
        for j in range (i+1,r):
            s =s-mat[i][j]*x[j]
        x[i]=s/mat[i][i]
    return b
B=backward(Gaussian(x_tran_x),forward(Gaussian(x_tran_x),x_tran_y))


y_hat= np.dot(A,B)
print('y_hat',y_hat)
```

```
[[153.27294451]
 [306.17380561]
 [306.37557661]
 [306.60361307]
 [306.41872061]
 [306.39530509]
 [306.59043897]
 [306.49979969]
 [306.39079483]
 [306.52310091]
 [306.78997405]]
y_hat [[-2398773.39223729]
 [-2403784.49158563]
 [-2418072.59814438]
 [-2395371.19241301]
 [-2380451.16580477]
 [-2392287.68617898]
 [-2388807.4381774 ]
 [-2395998.9911305 ]
 [-2387229.03871097]
 [-2401302.3057517 ]
 [-2422441.867165  ]
 [-2407159.45915848]
 [-2407687.83033668]
 [-2404607.76824108]
 [-2384151.59261865]
 [-2386348.63171726]
 [-2413701.83099992]
 [-2394220.66988416]
 [-2390835.45684557]
 [-2425580.58916502]
 [-2403179.00413475]
 [-2426614.76968767]
 [-2392677.6845118 ]
 [-2404985.43616723]
 [-2390383.65609907]
 [-2380876.2449235 ]
 [-2396098.75123243]
 [-2375618.75736636]
 [-2407797.68558379]
 [-2395032.78079963]
 [-2407903.53513572]
 [-2399052.43754873]
 [-2391324.98440729]
 [-2391231.41578494]
 [-2406592.56437425]
 [-2393798.26711161]
 [-2396643.12315594]
 [-2397382.17746941]
 [-2419269.58364105]
 [-2417307.59954118]
 [-2397680.64369447]
 [-2417899.24682773]
 [-2393141.24132567]
 [-2409383.66866789]
 [-2390608.4150301 ]
 [-2402092.12800221]
 [-2372406.58080215]
 [-2413434.6620304 ]
 [-2399531.27005681]
 [-2387730.64251461]
 [-2385490.39016484]
 [-2403136.04836872]
 [-2371759.70222767]
 [-2397322.78240401]
 [-2414006.68399411]
 [-2383446.13034541]
 [-2399891.53525747]
 [-2398104.42029671]
 [-2395247.41835434]
 [-2388699.55976699]
 [-2401126.2957042 ]
 [-2415182.59316823]
 [-2399164.53605238]
 [-2409335.45651809]
 [-2392688.01692832]
 [-2395433.20655266]
 [-2375961.00367086]
 [-2416569.27989177]
 [-2399569.6929945 ]
 [-2402014.91284942]
 [-2414939.73714255]
 [-2411916.23190889]
 [-2409252.21339811]
 [-2398821.44482914]
 [-2378077.50323884]
 [-2400428.33545187]
 [-2421823.8081093 ]
 [-2380411.13406952]
 [-2383733.5110024 ]
 [-2394784.86629732]
 [-2379844.54765447]
 [-2389576.58900697]
 [-2416137.168585  ]
 [-2405247.89603803]
 [-2391015.55409316]
 [-2393182.86325146]
 [-2383477.12301829]
 [-2400502.08289389]
 [-2403170.34866473]
 [-2430444.79322164]
 [-2411023.42350956]
 [-2403932.54286206]
 [-2403996.45349238]
 [-2390270.79360889]
 [-2405869.59791777]
 [-2427888.80213353]
 [-2407955.48708516]
 [-2398145.37283535]
 [-2416177.94661667]
 [-2386160.19769473]]
```

In [33]:
```
import matplotlib.pyplot as plt
axis = np.linspace(0, 1, 100)
plt.scatter(axis, y, c='b', marker='o', label='Y')
plt.scatter(axis, y_hat, c='g', marker='s', label='Y_hat')
plt.show()
```



In [34]:
```
B = np.linalg.lstsq(A, y, rcond=None)[0]
y_hat= np.dot(A,B)

import matplotlib.pyplot as plt
axis = np.linspace(0, 1, 100)
plt.scatter(axis, y, c='b', marker='o', label='Y')
plt.scatter(axis, y_hat, c='g', marker='s', label='Y_hat')
plt.show()
```

Part B: Multiple Linear (Auto)Regression

First I merged the datasets of train and store. then I grouped the dataframe by store and date columns.I am then looping through for every store and converting dataframes of Sales columns for every store into first row of matrix which is already sorted by days. There were only 10 records which have in total 942 days sales. For store which have less than 942 records, I am appending zeros and in this way creating x matrix. after which creating x_train,y_train,x_test,y_test matrices from x. and finding values of B matric from solving for linear regression as last lab.For every 42 iterations for b, i am storing b vectors in on matrix. After that finding RMSE.

In [27]:
```
td =pd.read_csv('train.csv',low_memory=False)
sd =pd.read_csv('store.csv.',low_memory=False)
merge = pd.merge(td,sd,how='inner',on='Store')
#td.drop(columns=['DayOfWeek', 'Customers','Promo','SchoolHoliday','StateHoliday','Open'])
merge
```

Out[27]:

	Store	DayOfWeek	Date	Sales	Customers	Open	Promo	StateHoliday	SchoolHoliday	StoreType	Assortment	CompetitionDistanc
0	1	5	2015-07-31	5263	555	1	1	0	1	c	a	1270.
1	1	4	2015-07-30	5020	546	1	1	0	1	c	a	1270.
2	1	3	2015-07-29	4782	523	1	1	0	1	c	a	1270.
3	1	2	2015-07-28	5011	560	1	1	0	1	c	a	1270.
4	1	1	2015-07-27	6102	612	1	1	0	1	c	a	1270.
...	...	...	...	...	...	...	...	...	...	...	...	
1017204	1115	6	2013-01-05	4771	339	1	0	0	1	d	c	5350.
1017205	1115	5	2013-01-04	4540	326	1	0	0	1	d	c	5350.
1017206	1115	4	2013-01-03	4297	300	1	0	0	1	d	c	5350.
1017207	1115	3	2013-01-02	3697	305	1	0	0	1	d	c	5350.
1017208	1115	2	2013-01-01	0	0	0	0	a	1	d	c	5350.

1017209 rows × 18 columns

In [ ]:
```
9import matplotlib as plt
%matplotlib inline
td["monthYear"] =
monthData = pd.DataFrame(td.groupby(td["monthYear"])['Sales'].agg(['mean']))
monthData.plot(kind='line')
```

In [142...
```
#td.groupby(['Store']).count()

#nd = td.drop(columns=['DayOfWeek', 'Customers','Promo','SchoolHoliday','Open'])
#td = td.sort_values(["Store", "Date"], ascending = (True, True)).reset_index()
nd = merge.groupby(['Store','Date']).sum()
```

In [143...
```
nd
```

Out[143...

Store	Date	DayOfWeek	Sales	Customers	Open	Promo	SchoolHoliday	CompetitionDistance	CompetitionOpenSinceMonth	CompetitionOp
1	**2013-01-01**	2	0	0	0	0	1	1270.0	9.0	
	2013-01-02	3	5530	668	1	0	1	1270.0	9.0	
	2013-01-03	4	4327	578	1	0	1	1270.0	9.0	
	2013-01-04	5	4486	619	1	0	1	1270.0	9.0	
	2013-01-05	6	4997	635	1	0	1	1270.0	9.0	
...	**...**	...	...	...	...	...	...	...	...	
1115	**2015-07-27**	1	10712	608	1	1	1	5350.0	0.0	
	2015-07-28	2	8093	500	1	1	1	5350.0	0.0	
	2015-07-29	3	7661	473	1	1	1	5350.0	0.0	
	2015-07-30	4	8405	502	1	1	1	5350.0	0.0	
	2015-07-31	5	8680	538	1	1	1	5350.0	0.0	

1017209 rows × 12 columns

In [145...
```
rows = len(nd.index)
x = np.zeros(shape=(rows,942))
print(rows)
index = 0
for store, new_df in nd.groupby(level=0):
    number_column = new_df.loc[:,'Sales']
    b= np.zeros(shape=(1,942))
    numbers = number_column.values
    if (len(numbers)<942):

        a = np.zeros((1,942-len(numbers)))
        numbers = np.append(numbers,a)
    x[index,:]=numbers
    index= index+1
print (x)
```

```
1017209
[[   0. 5530. 4327. ... 4782. 5020. 5263.]
 [   0. 4422. 4159. ... 6402. 5567. 6064.]
 [   0. 6823. 5902. ... 7610. 8977. 8314.]
 ...
 [   0.    0.    0. ...    0.    0.    0.]
 [   0.    0.    0. ...    0.    0.    0.]
 [   0.    0.    0. ...    0.    0.    0.]]
```

In [151...
```
x_train = x[0:800,0:900]
y_train = x[0:800,900:943]
x_test = x[800:1000,0:900]
y_test = x[800:1000,900:943]
print(x_train.shape)
print(y_train.shape)
print(x_test.shape)
print(y_test.shape)
bias_column = np.ones(shape=(800,1))
A = np.append(bias_column,x_train,axis=1)
bias_column = np.ones(shape=(800,1))
B = np.zeros(shape=(42,901))
for i in range (0,42):
    aTranspose = np.transpose(A)
    aTran_a = np.matmul(aTranspose,A)
    aTran_a_inv = np.linalg.inv(aTran_a)

    aTran_y = np.matmul(aTranspose,y_train[:,i])

    b = np.matmul ((aTran_a_inv),(aTran_y))
    B[i,:]= b

print(B.shape)
```

```
(800, 900)
(800, 42)
(200, 900)
(200, 42)
(42, 901)
```

In [177...
```
bias_column = np.ones(shape=(200,1))
A_test= np.append(bias_column,x_test,axis=1)
print(A_test.shape)
y_hat_test = np.zeros(shape=(200, 42))
for i in range (0,42):
    y = np.matmul(A_test,np.transpose(B[i,:]))

    y_hat_test[:,i] = y

print(y_hat_test)
```

```
(200, 901)
[[ 68500.68969727  71262.44213867  43189.03271484 ...  59319.96826172
   83573.36230469 102244.1328125 ]
 [ 49287.37988281   9177.03100586  12270.60095215 ...  44640.62719727
   85267.05297852 112968.09106445]
 [ -2809.5612793   40208.50805664 -30184.32879639 ... -34250.36120605
   17273.62561035  -2710.7722168 ]
 ...
 [ 56438.08959961  27814.15600586  41082.89086914 ...  68104.33886719
   97599.09545898 118237.27648926]
 [ 13696.83300781  12844.22363281 -35911.95501709 ... -24306.86535645
   31095.93347168  58813.05285645]
 [150206.48754883  57331.34912109  81992.12310791 ... 134882.63391113
  128521.21032715 163513.37634277]]
```

In [179...
```
y_minus_y_hat = y_test- y_hat_test
RMSE = np.ones(shape=(42,1))
print(y_minus_y_hat.shape)
for i in range(42):
    y = y_minus_y_hat[:,i]
    rmse = 0
    for j in range (200):
        rmse = rmse + (y[j]*y[j])
    rmse = (rmse ** 0.5)/2
    RMSE[i]=rmse

print(RMSE)
```

```
(200, 42)
[[1.02792707e+18]
 [4.87243602e+17]
 [1.10221415e+18]
 [1.05057074e+18]
 [1.05315372e+18]
 [1.04307083e+18]
 [1.11332567e+18]
 [1.05966075e+18]
 [5.01515025e+17]
 [1.84166906e+18]
 [1.79723478e+18]
 [1.49952370e+18]
 [1.41663744e+18]
 [1.41978899e+18]
 [9.98477095e+17]
 [5.11525813e+17]
 [1.26474165e+18]
 [1.09124893e+18]
 [1.15968435e+18]
 [1.15740433e+18]
 [1.17879216e+18]
 [1.03493426e+18]
 [5.24919021e+17]
 [1.70021129e+18]
 [1.49972188e+18]
 [1.43502062e+18]
 [1.38114471e+18]
 [1.31536365e+18]
 [1.06342092e+18]
 [5.42996458e+17]
 [1.20883618e+18]
 [1.07184859e+18]
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In [ ]: