In [1]:
```
import numpy as np
import scipy.stats as sc
import matplotlib.pyplot as plt
%matplotlib inline
import pandas as pd
from time import gmtime, strftime
import datetime
from numpy import nan
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as seabornInstance
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn import metrics
from datetime import datetime
from sklearn.model_selection import cross_val_score
from sklearn.metrics import make_scorer
%matplotlib inline
```

In [2]:
```
data_full = pd.read_csv("MoveInSyncData-final.csv")
print(data_full.head())
np.shape(data_full)
#data = data_full.head(500)
data = data_full
print(data.columns.values)
data_rows = data.shape[0]
data_col = data.shape[1]
data_transformed = pd.DataFrame()
data.reset_index(drop = True, inplace = True)
data.head()
print(data.shape)
```

```
  employee_id  trip_id trip_type  gender  cab_type trip_state_text  \
0    ATT-0001   461353    LOGOUT    MALE  4 Seater       COMPLETED
1    ATT-0002   461528     LOGIN    MALE  4 Seater       COMPLETED
2    ATT-0003   461849    LOGOUT    MALE  4 Seater       COMPLETED
3    ATT-0004   461431    LOGOUT    MALE  4 Seater       COMPLETED
4    ATT-0005   461915     LOGIN  FEMALE  4 Seater       COMPLETED

  planned_pickup_time  pickup_geoX  pickup_geoY  drop_geoX  ...  \
0      5/16/2019 6:45    12.923583    77.671061  12.988366  ...
1      5/16/2019 6:26    12.955146    77.738991  12.934748  ...
2     5/16/2019 15:45    12.924626    77.671098  12.968512  ...
3      5/16/2019 1:45    12.924514    77.671051  13.043238  ...
4      5/16/2019 6:09    12.921150    77.646636  12.923322  ...

   total_distance  costoftrip  perpersoncost hour_shift  minute_shift
```

```
hour  \
0       30.629322  155.066034      77.047147          6             30
6.0
1        7.177641   53.012574      46.083283          6             45
6.0
2       46.928047  165.427313      56.728831         15             30
15.0
3       59.086995  458.732089     128.031994          1             30
1.0
4        5.193483   51.934835      25.967417          6             15
6.0

  minute  month  date_of_month  day
0   45.0      5             16    5
1   26.0      5             16    5
2   45.0      5             16    5
3   45.0      5             16    5
4    9.0      5             16    5

[5 rows x 30 columns]
['employee_id' 'trip_id' 'trip_type' 'gender' 'cab_type' 'trip_state_t
ext'
 'planned_pickup_time' 'pickup_geoX' 'pickup_geoY' 'drop_geoX' 'drop_g
eoY'
 'distance' 'Company' 'dayofweek' 'employee_count_x' 'required_escort_
x'
 'trip_state_text_y' 'employee_count_y' 'required_escort_y' 'max_dista
nce'
 'total_distance' 'costoftrip' 'perpersoncost' 'hour_shift' 'minute_sh
ift'
 'hour' 'minute' 'month' 'date_of_month' 'day']
(510778, 30)
```

In [3]:
```
Defining set of functions required for feature transformation

Generic functions
def one_hot(x):
num_rows = x.shape[0]
unique_list = []

for i in range(0,num_rows):
    if(x[i] not in unique_list):
        unique_list.append(x[i])
print("column key is:", unique_list)
unique_list_length = np.size(unique_list)
one_hot_vector = np.zeros((num_rows,unique_list_length))

for i in range(0,num_rows):
    for j in range(0,unique_list_length):
        if x[i]==unique list[j]:
```

```
            one_hot_vector[i][j] = 1

    return(one_hot_vector)

def freq(lst):
    d = {}
    for i in lst:
        if d.get(i):
            d[i] += 1
        else:
            d[i] = 1
    return d


def ordinal_many_hot(z,ordered_list):
    num_rows = np.size(z)
    num_col = np.size(ordered_list)-1
    ordinal_vector = np.zeros((num_rows,num_col))

    for i in range(0,num_rows):
        j=ordered_list.index(z[i])
        if j > 0:
            for k in range(0, j):
                ordinal_vector[i,k]=1

    return(ordinal_vector)



eature transformation 1 - One hot vector for Hour of the request.
def hour(x):
    y = x.find(':')
    z = int(x[0:y])
    return(z)

eature transformation 2 - One hot vector for quardant of Hour of the reque
def minute(z):
    if z <=15:
        return(1)  #1st quardant
    elif 15<z<=30:
        return(2)  #2nd quardant
    elif 30<z<=45:
        return(3)  #3rd quardant
    else:
        return(4)  #4th quardant

eature transformation 4 - One hot vector for day of the week
= sunday, 1= monday, 2 = tuesday and so on
def day_of_week(x):
    y_1 = x.find('/')
```

```
    #print(y_1)
    y_2 = x.find('/', y_1+1)
    #print(y_2)

    date = x[y_1+1:y_2]
    #print(date)
    if(len(date) == 1):
        date = "0"+date

    month = x[0:y_1]
    #print(month)
    if(len(month) == 1):
        month = "0"+month

    year = "20"+x[y_2+1:len(x)]
    #print(year)

    date = month+","+date+","+year
    print(date)

    day_of_week = datetime.datetime.strptime(date, '%m,%d,%Y').strftime('%w'

    return(int(day_of_week))


'eature # 10: calculates customer location density at 2 decimal points
 cx_loc_density(cx_lat_long_X,cx_lat_long_Y, z):
      print("x =", x)
    num_rows = cx_lat_long_X.shape[0]
    lat_long = np.zeros((num_rows,2))
    lat_long_concat = [None]*num_rows
    x_final_cat = [None]*num_rows


    for i in range(0,num_rows):
        lat = cx_lat_long_X[i]
        long = cx_lat_long_Y[i]
          print(lat)
          print(long)
        lat_shortened = str(round(lat,z)) #12.42 (2 digits post decimal)
        long_shortened = str(round(lat,z))
        lat_long_concat[i] = lat_shortened+"-"+long_shortened

    #print(lat_long_concat)

    unique_list = []

    for i in range(0,num_rows):
        if(lat_long_concat[i] not in unique_list):
            unique_list.append(lat_long_concat[i])
```

```
  print("unique_list =", unique_list)
L = len(unique_list)
  print(np.size(unique_list))

# counting occurance of unique items

unique_list_freq = []

for i in range(0,L):
    y = lat_long_concat.count(unique_list[i])
    a = [unique_list[i], y]
    unique_list_freq.append(a)
  print("unique_list_freq =", unique_list_freq)

unique_list_freq.sort(key=lambda x: x[1])
  print(unique_list_freq)

# Assigning cateogries = {1,2,3,4,5} to the unique list. 5 being with hi
# Ideally we woudl want to do it for geohash-hour level densities, but c
# further cuts for day of week etc can be make to get this density funct
# if current transformation do not work, we can explore some of these er

unique_list_freq_sum = np.zeros(L)
for i in range(0,L):
    b = 0
    for j in range(0,i):
        b = b+unique_list_freq[j][1]
    unique_list_freq_sum[i] = b

category = [None]*L

  print("L=", L)
for i in range(0,L):
    if unique_list_freq_sum[i] <= num_rows*0.2:
        category[i] = '1'
    elif ((num_rows*0.2) < unique_list_freq_sum[i] <= (num_rows*0.4)):
        category[i] = '2'
    elif ((num_rows*0.4) < unique_list_freq_sum[i] <= (num_rows*0.6)):
        category[i] = '3'
    elif ((num_rows*0.6) < unique_list_freq_sum[i] <= (num_rows*0.8)):
        category[i] = '4'
    else:
        category[i] = '5'


### Assignging categories for input data points

x_final_cat = ['5']*num_rows
for i in range(0,num_rows):
    for j in range(0,L-1):
```

```
            if lat_long_concat[i] == unique_list_freq[j][0]:
                x_final_cat[i] = category[j]

    print(unique_list_freq)
    print(category)
    print(x_final_cat)

  return(x_final_cat)

eature transformation 11 - traffic points on the way

 is array containing lat longs.
 is digits after decimal.

 geo_hash_trim(x,z):
  num_rows = x.shape[0]
  lat_long = np.zeros((num_rows,1))

  for i in range(0,num_rows):
      y = x[i]
      lat_long[i] = round(y,z)
  return(lat_long)

eturns distance in meters.
sumes all inputs in 2 decimal digit significance, hence multiplier of 110
eal distance
 line_point_distance(x1,y1,x2,y2,xp,yp):
  p1=np.array([x1,y1])
  p2=np.array([x2,y2])
  p3=np.array([xp,yp])
  d=abs(np.cross(p2-p1,p3-p1)/np.linalg.norm(p2-p1))*110
  #print ("distance from line=", d)
  return(d)

=4 column array (x1,y1,x2,y2),
=2 column array with points xp,yp in each row,
reshhold in meters.
 num_points_nearby(from_to,point,threshold):
  #print(point)
  num_row = np.shape(from_to)[0]
  #print(num_row)
  num_points = np.shape(point)[0]
  #print(num_points)
  points_on_the_way = np.zeros(num_row)

  for i in range(0,num_row):
        print(from_to[i,0])
        print(from_to[i,1])
        print(from_to[i,2])
        print(from_to[i,3])
        print(point[0])
```

```
        print(point[0])
        print(point[1])
    distance = line_point_distance(from_to[i,0],from_to[i,1],from_to[i,2
    if(distance <= threshold):
        #print(j, "lies near connecting line")
        points_on_the_way[i] = 1

return(points_on_the_way)
```

In [4]:

```
#feature transformation 1 - One hot vector for Hour of the request.

X_hour = np.zeros((data_rows,24))
for i in range(0,(data_rows)):
    y = int(data["hour"][i])
    X_hour[i,y-1] = 1    ##X[i,j] indices i nd j starts from 0.
X_hour.shape

#feature transformation 2 - One hot vector for quardant of Hour of the r

X_min = np.zeros((data_rows,4))
for i in range(0,(data_rows)):
    y = minute(data["minute"][i])
    X_min[i,y-1] = 1
X_min.shape

#feature transformation 3 - One hot vector for month.
X_month = np.zeros((data_rows,12))
for i in range(0,(data_rows)):
    y = data["month"][i]
    X_month[i,y-1] = 1
X_month.shape

#feature transformation 4 - One hot vector for day of the week

X_dow = np.zeros((data_rows,8))
for i in range(0,(data_rows)):
    y = data["day"][i]
    X_dow[i,y] = 1
print(X_dow.shape)
sum(sum(X_dow))

#feature transformation 5 - One hot vector for office location

X_office = one_hot(data["Company"])
print(X_office.shape)

#feature transformation 6 - trip_type

X_trip_type = one_hot(data["trip_type"])
X_trip_type.shape
```

```
X_trip_type.shape

#feature transformation 7 - gender

X_gender = one_hot(data["gender"])
X_gender.shape

#feature transformation 8 - distance

X_distance = data["distance"].as_matrix().reshape(len(data["distance"]),
#print(X_distance.shape)

import numpy as np
from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(2)
X_distance_poly = poly.fit_transform(X_distance)
np.shape(X_distance_poly)


#feature transformation 9 - cab_type

X_cab_type = one_hot(data["cab_type"])
X_cab_type.shape

#feature transformation 10 - user_location_density one hot

data.loc[data["trip_type"] == "LOGOUT", "cx_lat_long_X"] = data["drop_ge
data.loc[data["trip_type"] == "LOGOUT", "cx_lat_long_Y"] = data["drop_ge

data.loc[data["trip_type"] == "LOGOUT", "office_lat_long_X"] = data["pic
data.loc[data["trip_type"] == "LOGOUT", "office_lat_long_Y"] = data["pic

data.loc[data["trip_type"] == "LOGIN", "cx_lat_long_X"] = data["pickup_g
data.loc[data["trip_type"] == "LOGIN", "cx_lat_long_Y"] = data["pickup_g

data.loc[data["trip_type"] == "LOGIN", "office_lat_long_X"] = data["drop
data.loc[data["trip_type"] == "LOGIN", "office_lat_long_Y"] = data["drop


      # 2 significant digit is showing large number of uniques points (2
z = cx_loc_density(data["cx_lat_long_X"],data["cx_lat_long_Y"],2)

freq(z)

ordered_list = ['1', '2', '3', '4', '5']
X_cx_density = ordinal_many_hot(z,ordered_list)
# print(X_cx_density)
# print(X_cx_density.shape)
# (sum(X_cx_density))

#feature transformation 11 - traffic points on the way
```

```
traffic_points = [[12.9, 77.6],[12.95, 77.70],[13.01, 77.58],[13.00, 77.
#silk board: 12.91, 77.62
#marathalli bridge: 12.95, 77.70
#mekhari circle: 13.01, 77.58
#KR puram junction: 13.00, 77.67
# Sarjapur junciton: 12.92, 77.66

cx_trimmed_lat_long_X = geo_hash_trim(data["cx_lat_long_X"],3)
cx_trimmed_lat_long_Y = geo_hash_trim(data["cx_lat_long_Y"],3)
office_trimmed_lat_long_X = geo_hash_trim(data["office_lat_long_X"],3)
office_trimmed_lat_long_Y = geo_hash_trim(data["office_lat_long_Y"],3)

from_to_lat_long = np.concatenate((cx_trimmed_lat_long_X, cx_trimmed_lat
X_traffic_points = pd.Series()
#print(type(X_traffic_points))
for i in range(0, len(traffic_points)):
    A = num_points_nearby(from_to_lat_long,traffic_points[i], 3)
    A = pd.Series(A)
    X_traffic_points = pd.concat([X_traffic_points, A], axis=1)
#print(type(X_traffic_points))

X_traffic_points = X_traffic_points.iloc[:,1:]
print(X_traffic_points.shape)
print((X_traffic_points))
#X_traffic_points

#feature transformation 12 - speed categorization of office_cx geo hash

### speed data does not look accurate


#feature transformation 13 - escort prediction (using SVM classifier)
#seperate file
X_escort = one_hot(data["required_escort_y"])
X_escort = X_escort[:,:-1]

print(np.shape(X_escort))
print(type(X_escort))
```

```
(488472, 8)
column key is: [1, 3, 4, 2, 7, 5, 6, 9, 8, 10]
(488472, 10)
column key is: ['LOGOUT', 'LOGIN']
column key is: ['MALE', 'FEMALE']

/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:50: FutureWarning: Method .as_matrix will be removed in a futu
re version. Use .values instead.

column key is: ['4 Seater', '6 Seater', 'Xylo', '4Seater', '4 SEATER',
```

```
'Sumo', 'Indica', 'TT', 'SEDAN', 'INOVO', 'Sedan', nan]

/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:199: RuntimeWarning: invalid value encountered in true_divide

(488472, 5)
```

	1	0	0	0	0
0	0.0	0.0	0.0	0.0	1.0
1	1.0	1.0	0.0	0.0	1.0
2	0.0	0.0	0.0	0.0	1.0
3	0.0	1.0	0.0	1.0	1.0
4	1.0	1.0	0.0	0.0	1.0
5	1.0	1.0	0.0	0.0	1.0
6	1.0	1.0	0.0	0.0	1.0
7	0.0	1.0	0.0	0.0	0.0
8	1.0	1.0	0.0	0.0	1.0
9	0.0	1.0	0.0	1.0	1.0
10	1.0	1.0	0.0	0.0	1.0
11	0.0	0.0	1.0	1.0	0.0
12	1.0	1.0	0.0	0.0	1.0
13	0.0	0.0	0.0	0.0	1.0
14	0.0	0.0	0.0	1.0	1.0
15	0.0	0.0	0.0	0.0	1.0
16	1.0	1.0	0.0	0.0	1.0
17	1.0	1.0	0.0	0.0	1.0
18	0.0	0.0	0.0	0.0	1.0
19	0.0	0.0	0.0	0.0	1.0
20	0.0	0.0	0.0	0.0	1.0
21	0.0	0.0	1.0	1.0	0.0
22	0.0	1.0	0.0	1.0	1.0
23	1.0	1.0	0.0	0.0	1.0
24	0.0	0.0	0.0	1.0	1.0
25	0.0	0.0	0.0	1.0	1.0
26	0.0	0.0	0.0	1.0	1.0
27	0.0	0.0	0.0	0.0	1.0
28	0.0	0.0	0.0	0.0	1.0
29	0.0	1.0	0.0	0.0	1.0
...	...	...	...	...	...
488442	0.0	1.0	0.0	0.0	1.0
488443	1.0	1.0	0.0	0.0	1.0
488444	1.0	1.0	0.0	0.0	1.0
488445	1.0	1.0	0.0	0.0	1.0
488446	0.0	1.0	0.0	0.0	1.0
488447	1.0	1.0	0.0	0.0	1.0
488448	0.0	1.0	0.0	0.0	0.0
488449	0.0	1.0	0.0	0.0	0.0
488450	1.0	1.0	0.0	0.0	1.0
488451	0.0	1.0	0.0	0.0	1.0
488452	1.0	1.0	0.0	0.0	1.0
488453	1.0	1.0	0.0	0.0	1.0

```
488454  0.0  1.0  0.0  0.0  1.0
488455  0.0  1.0  0.0  0.0  1.0
488456  0.0  1.0  0.0  0.0  0.0
488457  1.0  1.0  0.0  0.0  1.0
488458  0.0  1.0  0.0  1.0  0.0
488459  0.0  1.0  0.0  1.0  0.0
488460  0.0  1.0  0.0  0.0  1.0
488461  0.0  1.0  0.0  1.0  0.0
488462  0.0  1.0  0.0  0.0  1.0
488463  0.0  1.0  0.0  1.0  0.0
488464  0.0  1.0  0.0  0.0  1.0
488465  0.0  1.0  0.0  0.0  0.0
488466  0.0  1.0  1.0  0.0  0.0
488467  1.0  1.0  0.0  0.0  1.0
488468  1.0  1.0  0.0  0.0  1.0
488469  0.0  1.0  0.0  0.0  1.0
488470  0.0  1.0  0.0  1.0  0.0
488471  1.0  1.0  0.0  0.0  1.0

[488472 rows x 5 columns]
column key is: [0.0, 1.0]
(488472, 1)
<class 'numpy.ndarray'>
```

In [5]:
```
### Printing shape of mini features

print("Shape of X_hour is:", np.shape(X_hour))
print("Shape of X_dow is:", np.shape(X_dow))
print("Shape of X_gender is:", np.shape(X_gender))
print("Shape of X_distance_poly is:", np.shape(X_distance_poly))
print("Shape of X_trip_type is:", np.shape(X_trip_type))
print("Shape of X_cab_type is:", np.shape(X_cab_type))
print("Shape of X_month is:", np.shape(X_month))
print("Shape of X_min is:", np.shape(X_min))
print("Shape of X_cx_density is:", np.shape(X_cx_density))
print("Shape of X_traffic_points is:", np.shape(X_traffic_points))
print("Shape of X_escort is:", np.shape(X_escort))

### Concating and dropping columns with all 0s or all 1s.
X_final = np.concatenate((X_hour, X_dow, X_gender,X_distance_poly, X_tri
print(np.shape(X_final))
X_final = np.transpose(X_final)
X_final = X_final[~np.all(X_final == 0, axis=1)]  # removing all 1 colum
X_final = X_final[~np.all(X_final == 1, axis=1)]  # removing all zero co
X_final = np.transpose(X_final)
X_final = np.hstack((X_final,np.ones((len(X_distance),1))))
print(np.shape(X_final))
```

```
Shape of X_hour is: (488472, 24)
Shape of X_dow is: (488472, 8)
Shape of X_gender is: (488472, 2)
Shape of X_distance_poly is: (488472, 3)
Shape of X_trip_type is: (488472, 2)
Shape of X_cab_type is: (488472, 12)
Shape of X_month is: (488472, 12)
Shape of X_min is: (488472, 4)
Shape of X_cx_density is: (488472, 4)
Shape of X_traffic_points is: (488472, 5)
Shape of X_escort is: (488472, 1)
(488472, 77)
(488472, 66)
```

In [6]:
```
## Calculating Ys
per_person_cost = data["perpersoncost"].fillna(0)
per_person_cost = per_person_cost.values.reshape(len( data["perpersoncos
## writting X and Y to csv files
pd.DataFrame(X_final).to_csv('processed_features.csv')
pd.DataFrame(per_person_cost).to_csv('perpersoncost.csv')
```

In [214]:
```
#-----Linear Regression -----#
```

In [215]:
```
t1 = datetime.now()
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
regressor = LinearRegression()
regressor.fit(X_train, y_train) #training the algorithm
#print(regressor.intercept_)
#print(regressor.coef_)
t1_response = datetime.now()
y_pred_test = regressor.predict(X_test)
t2_response = datetime.now()
y_pred_train = regressor.predict(X_train)
print ("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(regressor, X_train, y_train, scoring=my_scorer,
print("Cross validation MAE are:", scores)
```

```
y_mean =  57.53583772081395
Absolute Mean Error for training data: 19.754264584868395
Absolute Mean Squared Error for test data: 19.72270242309356
time take for algorithm to run: 0:00:02.516143
response time is : 0:00:00
Cross validation MAE are: [19.58604755 19.66997132 19.72871429 19.7175
2019 19.85366736 19.81208971
 19.79516181 19.94359442 19.77512191 19.69536323]
```

In [216]:
```
#-----Huber Regression -----#
```

In [217]:
```
t1 = datetime.now()
import numpy as np
from sklearn.linear_model import HuberRegressor
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
huber = HuberRegressor().fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = huber.predict(X_test)
t2_response = datetime.now()
y_pred_train = huber.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
```

```
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(huber, X_train, y_train, scoring=my_scorer, cv=
print("Cross validation MAE are:", scores)
```

```
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)

y_mean =  57.53583772081395
Absolute Mean Error for training data: 18.777862774214775
Absolute Mean Squared Error for test data: 18.71337373406781
time take for algorithm to run: 0:00:28.566592
response time is : 0:00:00

/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
```

```
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)

Cross validation MAE are: [18.5467868  18.25208407 18.94107835 18.7892
5494 18.97093669 18.68032384
 18.6694181  18.80986609 18.43378673 18.75658018]
```

In [218]:
```
#-----Ridge Regression -----#
```

In [219]:
```
t1 = datetime.now()
import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = linear_model.Ridge(alpha=0.1)
reg.fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
y_pred_train = reg.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=10
print("Cross validation MAE are:", scores)
```

```
y_mean =  57.53583772081395
Absolute Mean Error for training data: 19.75426388518387
Absolute Mean Squared Error for test data: 19.722696339307074
time take for algorithm to run: 0:00:01.597042
response time is : 0:00:00
Cross validation MAE are: [19.58604051 19.66996443 19.72870796 19.7175
1339 19.85366087 19.81208299
 19.79515432 19.94358845 19.77511608 19.69535714]
```

In [220]:
```
#-----LASSO Regression-------#
```

In [221]:
```
t1 = datetime.now()
import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = linear_model.Lasso(alpha=0.1)
reg.fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
y_pred_train = reg.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=10
print("Cross validation MAE are:", scores)
```

```
y_mean =  57.53583772081395
Absolute Mean Error for training data: 19.781693233889765
Absolute Mean Squared Error for test data: 19.73686926018247
time take for algorithm to run: 0:00:05.943550
response time is : 0:00:00
Cross validation MAE are: [19.59917334 19.6856162  19.77275868 19.7470
5787 19.88585167 19.86766035
 19.80691969 19.96973729 19.78645436 19.71557522]
```

In [222]:
```
#-----LARS Lasso Regression-------#
```

In [223]:
```
t1 = datetime.now()
import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = linear_model.LassoLars(alpha=.1)
reg.fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
y_pred_train = reg.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=10
print("Cross validation MAE are:", scores)
```

```
y_mean =  57.53583772081395
Absolute Mean Error for training data: 32.54908378501242
Absolute Mean Squared Error for test data: 32.36544821587066
time take for algorithm to run: 0:00:01.383515
response time is : 0:00:00
Cross validation MAE are: [32.16017936 32.26667786 32.5924324  32.6620
7618 32.64247068 32.71003794
 32.56647449 32.89792214 32.52634732 32.46709666]
```

In [224]:
```
#-----Bayesian Regression-------#
```

In [225]:
```
t1 = datetime.now()
import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = linear_model.BayesianRidge()
reg.fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
y_pred_train = reg.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
```

```
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=10
print("Cross validation MAE are:", scores)
```

```
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)

y_mean =  57.53583772081395
Absolute Mean Error for training data: 19.75374940363546
Absolute Mean Squared Error for test data: 19.722156150114955
time take for algorithm to run: 0:00:03.791611
response time is : 0:00:00

/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
```

```
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/utils/
validation.py:724: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to (n_sampl
es, ), for example using ravel().
  y = column_or_1d(y, warn=True)

Cross validation MAE are: [19.58541026 19.66936315 19.72821758 19.7169
2054 19.85307506 19.81151622
 19.79450885 19.94302636 19.77457701 19.69480598]
```

In [226]:

```
#--------DT regressor ---------#
```

In [7]:
```
t1 = datetime.now()
import numpy as np
from sklearn.tree import DecisionTreeRegressor
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = DecisionTreeRegressor(random_state = 0, max_depth = 40)
reg.fit(X_train, y_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
y_pred_train = reg.predict(X_train)
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=10
print("Cross validation MAE are:", scores)
```

```
y_mean =  57.53583772081395
Absolute Mean Error for training data: 0.45415394731384173
Absolute Mean Squared Error for test data: 14.365150836539632
time take for algorithm to run: 0:00:13.084408
response time is : 0:00:00.000002
Cross validation MAE are: [14.45029298 14.39049444 14.54024613 14.4430
0384 14.54452154 14.3410605
 14.41218566 14.67437989 14.64150811 14.39175579]
```

In [228]:
```
#--------Random Forest ---------#
```

In [230]:
```
t1 = datetime.now()
import numpy as np
from sklearn.ensemble import RandomForestRegressor
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
reg = RandomForestRegressor(n_estimators=1000, min_samples_split=10, min
# Best Performing Hyperparameters: {'n_estimators': 1000, 'min_samples_s
reg.fit(X_train, y_train)
y_pred_train = reg.predict(X_train)
t1_response = datetime.now()
y_pred_test = reg.predict(X_test)
t2_response = datetime.now()
print("y_mean = ", np.mean(y))
print('Absolute Mean Error for training data:', metrics.mean_absolute_er
print('Absolute Mean Error for test data:', metrics.mean_absolute_error(
```

```
t2 = datetime.now()
print("time take for algorithm to run:", t2-t1)
print("response time is :", (t2_response-t1_response)/np.shape(X_test)[0
my_scorer = make_scorer(metrics.mean_absolute_error)
scores = cross_val_score(reg, X_train, y_train, scoring=my_scorer, cv=5)
print("Cross validation MAE are:", scores)
```

```
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:9: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  if __name__ == '__main__':

y_mean =  57.53583772081395
Absolute Mean Error for training data: 8.342956401189689
Absolute Mean Error for test data: 12.302081114852568
time take for algorithm to run: 1:51:56.127918
response time is : 0:00:00.001156

/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_validation.py:514: DataConversionWarning: A column-vector y
was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  estimator.fit(X_train, y_train, **fit_params)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_validation.py:514: DataConversionWarning: A column-vector y
was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  estimator.fit(X_train, y_train, **fit_params)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_validation.py:514: DataConversionWarning: A column-vector y
was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  estimator.fit(X_train, y_train, **fit_params)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_validation.py:514: DataConversionWarning: A column-vector y
was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  estimator.fit(X_train, y_train, **fit_params)
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_validation.py:514: DataConversionWarning: A column-vector y
was passed when a 1d array was expected. Please change the shape of y
to (n_samples,), for example using ravel().
  estimator.fit(X_train, y_train, **fit_params)

Cross validation MAE are: [12.50235504 12.56188471 12.64982907 12.6822
331  12.56353074]
```

In [ ]:

```
### Fairness
```

In [241]:
```
X_train[:,31] #Column no. 31 is Male, 32 is female, 33 is distance.
```

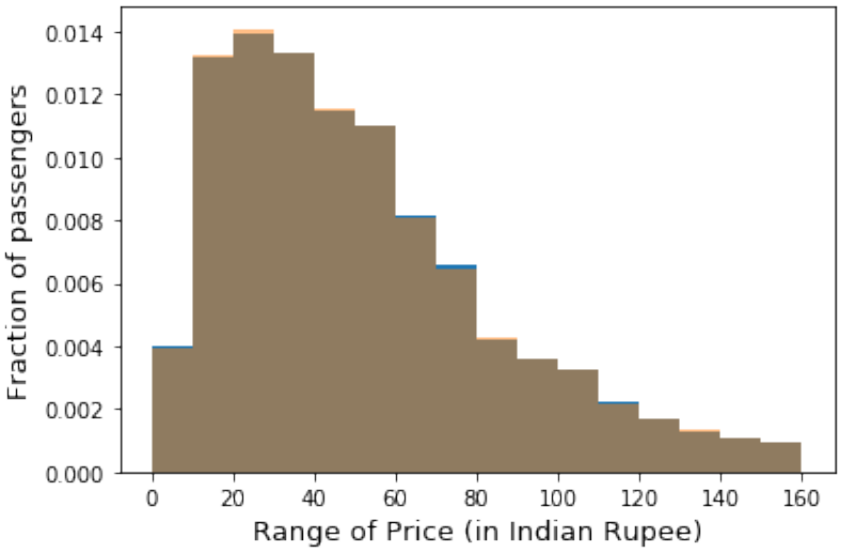
Out[241]:
```
array([1., 1., 1., ..., 1., 0., 0.])
```

In [256]:
```
a = X_test[:,31]==0
print(np.shape(X_test[a,33]))
print("Average distance =", np.mean(X_test[a,33]))
print("Average price =", np.mean(y_test[a]))
```

```
(39676,)
Average distance = 11.436200836728904
Average price = 50.30143903672411
```

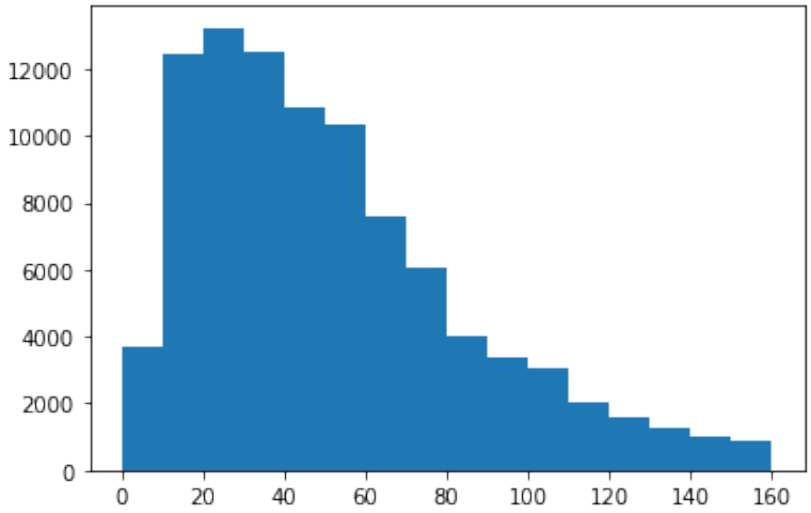
In [280]:
```
plt.hist(y_train, bins=[0,10,20,30,40,50,60,70,80,90,100,110,120,130,140
plt.hist(y_test, bins=[0,10,20,30,40,50,60,70,80,90,100,110,120,130,140,
plt.xlabel('Range of Price (in Indian Rupee)',fontsize=13)
plt.ylabel('Fraction of passengers',fontsize=13)
```

Out[280]:
```
Text(0, 0.5, 'Fraction of passengers')
```



In [272]:
```
plt.hist(y_test, bins=[0,10,20,30,40,50,60,70,80,90,100,110,120,130,140,
```

Out[272]:
```
(array([ 3680., 12455., 13230., 12486., 10866., 10329.,  7589.,  6086.
,
         4006.,  3361.,  3035.,  2029.,  1610.,  1271.,  1040.,   865.
]),
 array([  0,  10,  20,  30,  40,  50,  60,  70,  80,  90, 100, 110, 12
0,
        130, 140, 150, 160]),
 <a list of 16 Patch objects>)
```



In [ ]:
```
residual = y_test-y_pred_test
```

In [ ]:
```
plt.hist(residual, bins=[-50,-40,-30,-20,-10, 0, 10, 20, 30, 40,50])
```

In [ ]:
```

```

In [ ]:
```

```

In [ ]:
```
##---HyperParameter Training---DO NOT REFRESH THIS PART ------
```

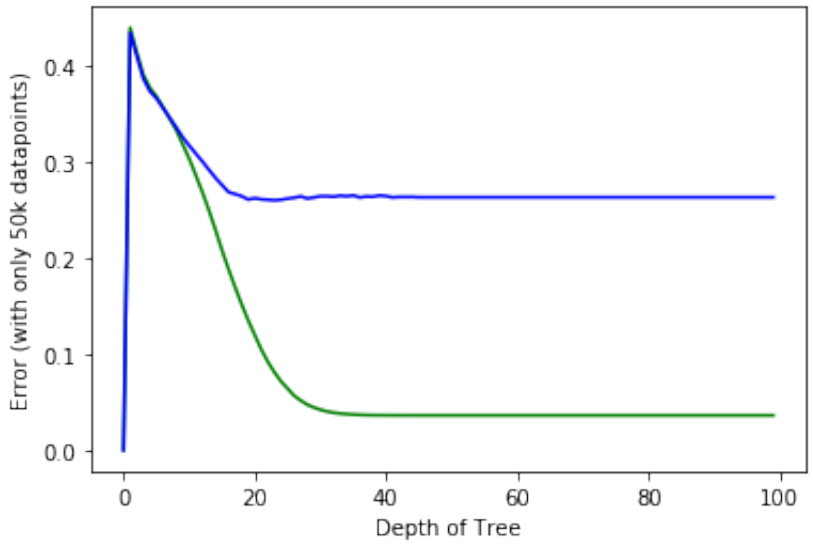
In [ ]:
```
##---HyperParameter Training---
```

In [447]:
```
training_error = np.zeros(100)
testing_error = np.zeros(100)
import numpy as np
from sklearn.tree import DecisionTreeRegressor
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,

for i in range(1,100):
    reg = DecisionTreeRegressor(random_state = 0, max_depth = i)
    reg.fit(X_train, y_train)
    t1_response = datetime.now()
    y_pred_test = reg.predict(X_test)
    t2_response = datetime.now()
    y_pred_train = reg.predict(X_train)
    training_error[i] = metrics.mean_absolute_error(y_train, y_pred_trai
    testing_error[i] = metrics.mean_absolute_error(y_test, y_pred_test)/
```

In [454]:
```
plt.plot(training_error, "-g" , label = "Training error")
plt.plot(testing_error, "-b", label="Testing error")
plt.ylabel('Error (with only 50k datapoints)')
plt.xlabel('Depth of Tree')
```

Out[454]: Text(0.5, 0, 'Depth of Tree')



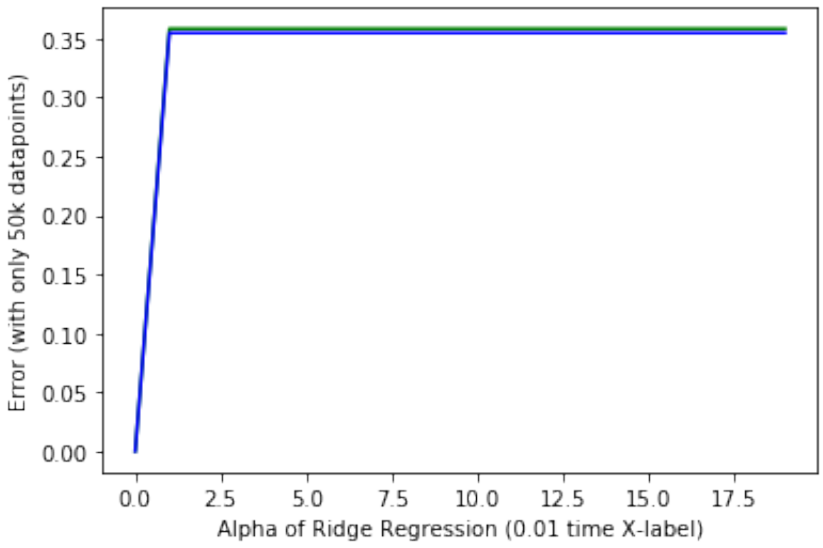
In [455]:
```
##---HyperParameter testing for Ridge regression---
```

In [461]:
```
num_iter = 20
training_error = np.zeros(num_iter)
testing_error = np.zeros(num_iter)

import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
for i in range(1,num_iter):
    reg = linear_model.Ridge(alpha=0.01*i)
    reg.fit(X_train, y_train)
    t1_response = datetime.now()
    y_pred_test = reg.predict(X_test)
    t2_response = datetime.now()
    y_pred_train = reg.predict(X_train)
    training_error[i] = metrics.mean_absolute_error(y_train, y_pred_trai
    testing_error[i] = metrics.mean_absolute_error(y_test, y_pred_test)/

fig = plt.figure()
plt.plot(training_error, "-g" , label = "Training error")
plt.plot(testing_error, "-b", label="Testing error")
plt.ylabel('Error (with only 50k datapoints)')
plt.xlabel('Alpha of Ridge Regression (0.01 time X-label)')
```

Out[461]: Text(0.5, 0, 'Alpha of Ridge Regression (0.01 time X-label)')



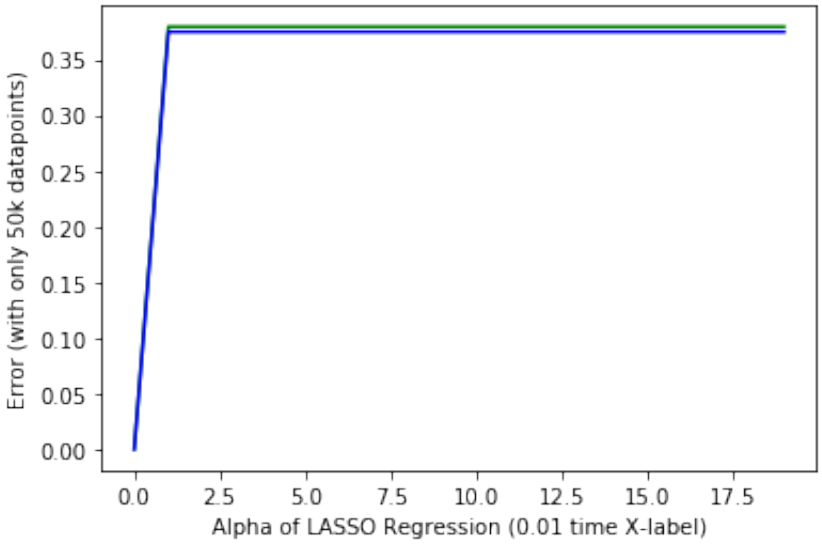
In [ ]:
```
##---HyperParameter testing for LASSO--
```

In [462]:
```
num_iter = 20
training_error = np.zeros(num_iter)
testing_error = np.zeros(num_iter)

import numpy as np
from sklearn import linear_model
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
for i in range(1, num_iter):
    reg = linear_model.Lasso(alpha=0.1)
    reg.fit(X_train, y_train)
    t1_response = datetime.now()
    y_pred_test = reg.predict(X_test)
    t2_response = datetime.now()
    y_pred_train = reg.predict(X_train)
    training_error[i] = metrics.mean_absolute_error(y_train, y_pred_trai
    testing_error[i] = metrics.mean_absolute_error(y_test, y_pred_test)/

fig = plt.figure()
plt.plot(training_error, "-g" , label = "Training error")
plt.plot(testing_error, "-b", label="Testing error")
plt.ylabel('Error (with only 50k datapoints)')
plt.xlabel('Alpha of LASSO Regression (0.01 time X-label)')
```

Out[462]:
```
Text(0.5, 0, 'Alpha of LASSO Regression (0.01 time X-label)')
```



In [ ]:
```
##---HyperParameter testing for Random forest regressor--
```

In [464]:
```
num_iter = 15
training_error = np.zeros(num_iter)
testing_error = np.zeros(num_iter)
```

```
import numpy as np
from sklearn.ensemble import RandomForestRegressor
X = X_final
y = per_person_cost
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
for i in range(1,num_iter):
    reg = RandomForestRegressor(n_estimators = i*100, random_state = i)
    reg.fit(X_train, y_train)
    y_pred_train = reg.predict(X_train)
    t1_response = datetime.now()
    y_pred_test = reg.predict(X_test)
    t2_response = datetime.now()
    training_error[i] = metrics.mean_absolute_error(y_train, y_pred_trai
    testing_error[i] = metrics.mean_absolute_error(y_test, y_pred_test)/

fig = plt.figure()
plt.plot(training_error, "-g" , label = "Training error")
plt.plot(testing_error, "-b", label="Testing error")
plt.ylabel('Error (with only 50k datapoints)')
plt.xlabel('number of estimators for RandomForestRegressor(100 time X-la
```

```
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
```

```
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
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/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
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1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/ipykernel_laun
cher.py:11: DataConversionWarning: A column-vector y was passed when a
1d array was expected. Please change the shape of y to (n_samples,), f
or example using ravel().
  # This is added back by InteractiveShellApp.init_path()
```
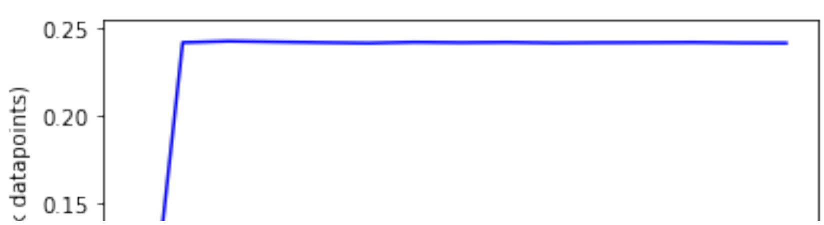
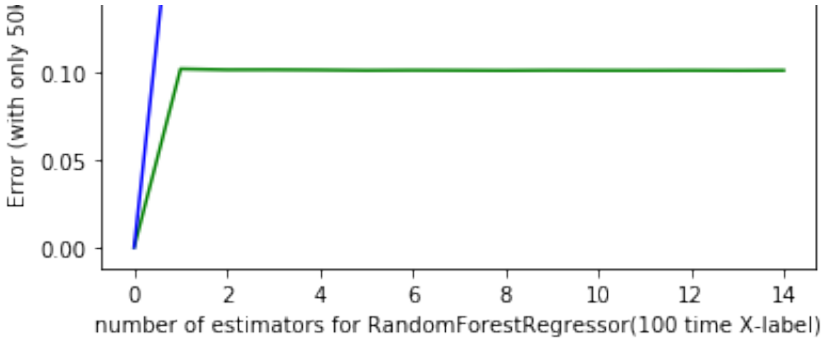

Out[464]:
```
Text(0.5, 0, 'number of estimators for RandomForestRegressor(100 time
X-label)')
```





In [480]:
```
## Grid search on Random Forest
# Number of trees in random forest
n_estimators = [int(x) for x in np.linspace(start = 500, stop = 1500, nu
max_features = ['auto', 'sqrt']
max_depth = [int(x) for x in np.linspace(5, 40, num = 8)]
max_depth.append(None)
min_samples_split = [2, 5, 10]
min_samples_leaf = [1, 2, 4]
bootstrap = [True, False]
# Create the random grid
random_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
               'min_samples_split': min_samples_split,
               'min_samples_leaf': min_samples_leaf,
               'bootstrap': bootstrap}
print(random_grid)
```

```
{'n_estimators': [500, 750, 1000, 1250, 1500], 'max_features': ['auto'
, 'sqrt'], 'max_depth': [5, 10, 15, 20, 25, 30, 35, 40, None], 'min_sa
mples_split': [2, 5, 10], 'min_samples_leaf': [1, 2, 4], 'bootstrap':
[True, False]}
```

In [481]:
```
from sklearn.model_selection import RandomizedSearchCV
# Use the random grid to search for best hyperparameters
# First create the base model to tune
rf = RandomForestRegressor()
# Random search of parameters, using 3 fold cross validation,
# search across 100 different combinations, and use all available cores
rf_random = RandomizedSearchCV(estimator = rf, param_distributions = ran
# Fit the random search model
rf_random.fit(X_train, y_train);
print(rf_random.best_params_)
best_random = rf_random.best_estimator_
Y_pred = best_random.predict(X_test)

print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent wor
kers.
[Parallel(n_jobs=-1)]: Done  33 tasks      | elapsed: 34.4min
[Parallel(n_jobs=-1)]: Done 154 tasks      | elapsed: 154.8min
[Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed: 370.4min finishe
d
/Users/ankitajain/anaconda3/lib/python3.7/site-packages/sklearn/model_
selection/_search.py:714: DataConversionWarning: A column-vector y was
passed when a 1d array was expected. Please change the shape of y to (
n_samples,), for example using ravel().
  self.best_estimator_.fit(X, y, **fit_params)

{'n_estimators': 1000, 'min_samples_split': 10, 'min_samples_leaf': 1,
'max_features': 'auto', 'max_depth': 35, 'bootstrap': True}
Absolute Mean Squared Error for test data: 1.4848173772307298
```

In [475]:
```
print('Absolute Mean Squared Error for test data:', metrics.mean_absolut
```

```
Absolute Mean Squared Error for test data: 1.4871448150821998
```

In [234]:
```

```

Out[234]:
```
array([31.03575011, 14.21493936, 12.76303624,  5.63103019])
```

In [ ]:
```

```