Homework1 Report

course: COMP9417

term: 2020T1

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full name: Zhaokun Su

zID: z5235878

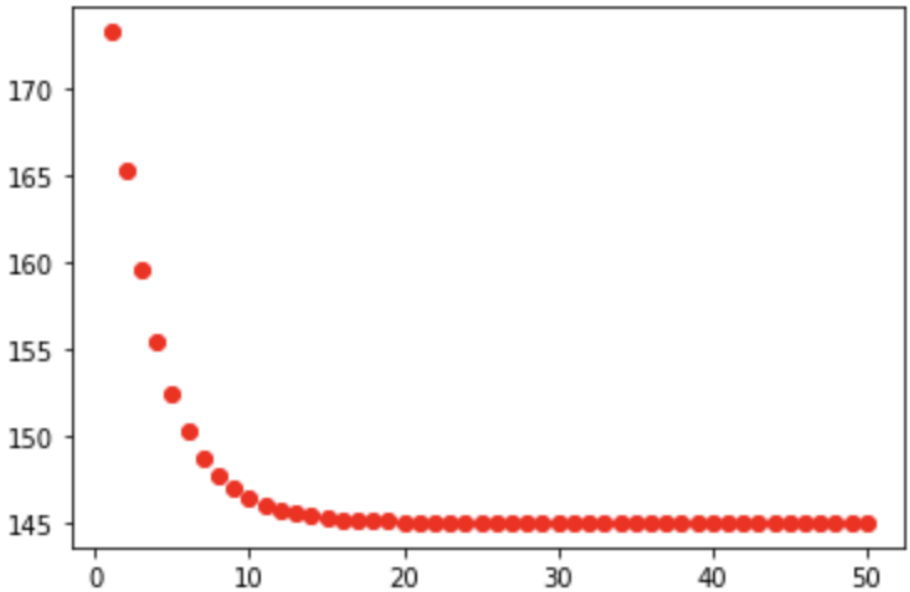
Report results:

1. The θ parameters (θ0, θ1) from step 3 when you are using house age feature. (2 marks) theta for house age is :

   theta[0] : 42.54078538346594

   theta[1] : -10.319399022339129

2. A plot, which visualises the change in cost function $J(\theta)$ at each iteration. (1 mark)



3. RMSE for your training set when you use house age feature. (0.5 mark)

   RMSE for house age training data set is : 12.045510305912353

4. RMSE for test set, when you use house age feature. (0.5 mark)

   RMSE for house age testing data set is : 16.58731450340051

5. RMSE for test set, when you use distance to the station feature. (0.25 mark)

   RMSE for distance to the nearest MRT station testing data set is : 12.652088009723935

6. RMSE for test set, when you use number of stores feature. (0.25 mark)

   RMSE for number of convenience stores testing data set is : 14.731993508206784

7. Compare the performance of your three models and rank them accordingly. (0.5 mark)

As we can see, this time we get all this three RMSE for our data sets;

this respectively is:

RMSE for house age training data set is : 12.045510305912353

RMSE for house age testing data set is : 16.58731450340051

RMSE for distance to the nearest MRT station training data set is : 9.165754538401488

RMSE for distance to the nearest MRT station testing data set is : 12.652088009723935

RMSE for number of convenience stores training data set is : 9.83487827563954

RMSE for number of convenience stores testing data set is : 14.731993508206784

and clearly:

9.165 < 9.834 < 12.045 (for training data)

12.652 < 14.731 < 16.587 (for testing data)

after this time training, we can rank all three models according to RMSE:

the performance of model_2 > model_3 > model_1;

So finally, we give code for comparation as following:

rank:

1.model_2(distance to the nearest MRT station model)

2.model_3(number of convenience stores model)

3.model_1(house age model)

In [20]:
```
import pandas as pd
import numpy as np
from sklearn import datasets, linear_model
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
import random
import math
```

In [21]:
```
# load data
data_frame = pd.read_csv('house_prices.csv')
feature_vectors = ['house age', 'distance to the nearest MRT station', 'number of convenience stores',
                   'house price of unit area']
data_frame
```

Out[21]:

	No	house age	distance to the nearest MRT station	number of convenience stores	house price of unit area
0	1	6.6	90.45606	9	58.1
1	2	20.5	2185.12800	3	25.6
2	3	30.0	1013.34100	5	22.8
3	4	12.9	250.63100	7	39.3
4	5	29.4	4510.35900	1	13.2
...	...	...	...	...	...
395	396	40.9	167.59890	5	41.0
396	397	31.7	5512.03800	1	18.8
397	398	8.0	132.54690	9	47.3
398	399	11.9	3171.32900	0	46.6
399	400	3.4	56.47425	7	54.4

400 rows × 5 columns

In [22]:
```
feature_vectors
```

Out[22]:
```
['house age',
 'distance to the nearest MRT station',
 'number of convenience stores',
 'house price of unit area']
```

after loading all data we need, go on the first step: pre-processing data

step 1: pre-processing data

In [23]:
```
# step 1: pre-processing data
# 3 features
data_house_age = data_frame[feature_vectors[0]]
data_distance_to_station = data_frame[feature_vectors[1]]
data_nb_of_stores = data_frame[feature_vectors[2]]

# 1 output
data_house_price = data_frame[feature_vectors[-1]]

# get normalized data
max_house_age = max(list(data_house_age))
min_house_age = min(list(data_house_age))
new_house_age = [((x - min_house_age) / (max_house_age - min_house_age))
                 for x in list(data_house_age)]

max_distance_to_station = max(list(data_distance_to_station))
min_distance_to_station = min(list(data_distance_to_station))
new_distance_to_station = [((x - min_distance_to_station) / (max_distance_to_station - min_distance_to_station))
                           for x in list(data_distance_to_station)]

max_nb_of_stores = max(list(data_nb_of_stores))
min_nb_of_stores = min(list(data_nb_of_stores))
new_nb_of_stores = [((x - min_nb_of_stores) / (max_nb_of_stores - min_nb_of_stores))
                    for x in list(data_nb_of_stores)]
```

step 2: Creating test and training set

In [24]:
```
# step 2: Creating test and training set
# total data y
data_house_price_y = np.array(data_house_price).reshape(-1, 1)
# total data x for three features
data_house_age_x = np.array(new_house_age).reshape(-1, 1)
data_distance_to_station_x = np.array(new_distance_to_station).reshape(-1, 1)
data_nb_of_stores_x = np.array(new_nb_of_stores).reshape(-1, 1)
# split data to training data and test data
# shuffle == false <==> not random
train_data_house_age_x, test_data_house_age_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_house_age_x, data_house_price_y, test_size=0.25, shuffle=False)
```

In order to compare with different features seperately, we create a function handling with step 3--step 5:

fuction:

Stochastic_gradient_decent

this function return:

1.theta[] after training

2.RMSE value we calculated

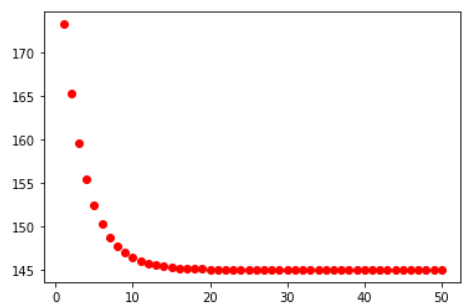
step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation

In [25]:
```
# step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation
def Stochastic_gradient_decent(train_data_feature_x, test_data_feature_x,
                               train_data_output_y, test_data_output_y):
    # step 3: Stochastic gradient descent
    loss_record = []  # record loss function value
    iter_record = []  # record iteration value
    training_len = len(train_data_feature_x)
    testing_len = len(test_data_feature_x)
    max_iteration = 50
    alpha = 0.01  # learning rate
    theta = [-1, -0.5]  # θ coefficients
    iter_count = 0

    # for every iteration
    while iter_count < max_iteration:
        loss = 0
        # algorithmn body
        for i in range(training_len):
            predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[i][0]
            theta[0] = theta[0] + alpha * (train_data_output_y[i][0] - predicted_fuc) * 1
            theta[1] = theta[1] + alpha * (train_data_output_y[i][0] - predicted_fuc) * train_data_feature_x[i][0]
        # calculate J(theta) cost fuction
        for j in range(training_len):
            predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[j][0]
            error = (train_data_output_y[j][0] - predicted_fuc) ** 2
            loss = loss + error
        loss = (1 / training_len) * loss
        iter_count += 1
        loss_record.append(loss)
        iter_record.append(iter_count)

    # step 4: Visualization
    iter_x = np.array(iter_record).reshape(-1, 1)
    loss_y = np.array(loss_record).reshape(-1, 1)
    # model = linear_model.LinearRegression()
    # model.fit(iter_x, loss_y)
    # predicted_y = model.predict(iter_x)
    plt.scatter(iter_x, loss_y, color="red")
    plt.show()

    # step 5: Evaluation
    # compute RMSE for training set
    total_sum_training_set = 0
    for i in range(training_len):
        predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[i][0]
        temp_sum = (train_data_output_y[i][0] - predicted_fuc) ** 2
        total_sum_training_set += temp_sum
    RMSE_training = math.sqrt(total_sum_training_set / training_len)

    # compute RMSE for training set
    total_sum_testing_set = 0
    for i in range(testing_len):
        predicted_fuc = theta[0] * 1 + theta[1] * test_data_feature_x[i][0]
        temp_sum = (test_data_output_y[i][0] - predicted_fuc) ** 2
        total_sum_testing_set += temp_sum
    RMSE_testing = math.sqrt(total_sum_testing_set / testing_len)

    return theta, RMSE_training, RMSE_testing
```

for the first feature: house_age

we get the theta[0] and theta[1], and also, RMSE for both training data set and testing data set;

In [26]:
```
 # step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation
feature = feature_vectors[0]
theta_house_age_model, RMSE_training_house_age, RMSE_testing_house_age = \
    Stochastic_gradient_decent(train_data_house_age_x, test_data_house_age_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_house_age)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_house_age)
print("theta for", feature, "is : ", "theta[0] : ", theta_house_age_model[0], "theta[1] : ",
      theta_house_age_model[1])
print()
```



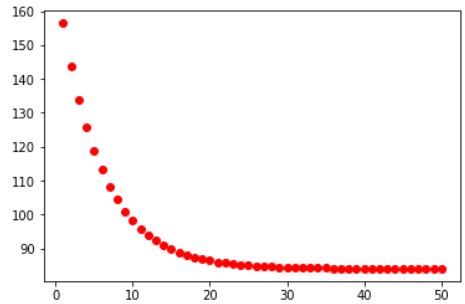

```
RMSE for house age training data set is :  12.045510305912353
RMSE for house age testing data set is :  16.58731450340051
theta for house age is :  theta[0] :  42.54078538346594 theta[1] :  -10.319399022339129
```

Then, we compute the other two features:

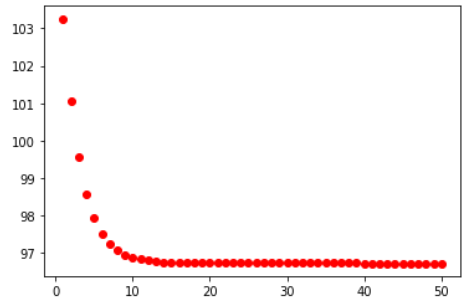
which are 'distance to the nearest MRT station' and 'number of convenience stores';

and compute corresponding theta[] and RMSE value;

In [27]:
```
# step 6: Repeating for the other two features
# for feature distance
feature = feature_vectors[1]
train_data_distance_x, test_data_distance_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_distance_to_station_x, data_house_price_y, test_size=0.25, shuffle=False)
theta_distance_model, RMSE_training_distance, RMSE_testing_distance = \
    Stochastic_gradient_decent(train_data_distance_x, test_data_distance_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_distance)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_distance)
print("theta for", feature, "is : ", "theta[0] : ", theta_distance_model[0], "theta[1] : ",
      theta_distance_model[1])
print()

 # for feature number of stores
feature = feature_vectors[2]
train_data_nb_store_x, test_data_nb_store_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_nb_of_stores_x, data_house_price_y, test_size=0.25, shuffle=False)
theta_nb_store_model, RMSE_training_nb_store, RMSE_testing_nb_store = \
    Stochastic_gradient_decent(train_data_nb_store_x, test_data_nb_store_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_nb_store)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_nb_store)
print("theta for", feature, "is : ", "theta[0] : ", theta_nb_store_model[0], "theta[1] : ",
      theta_nb_store_model[1])
print()
```




```
RMSE for distance to the nearest MRT station training data set is :  9.165754538401488
RMSE for distance to the nearest MRT station testing data set is :  12.652088009723935
theta for distance to the nearest MRT station is :  theta[0] :  44.766087037899375 theta[1] :  -46.500633970906314
```




```
RMSE for number of convenience stores training data set is :  9.83487827563954
RMSE for number of convenience stores testing data set is :  14.731993508206784
theta for number of convenience stores is :  theta[0] :  27.486676129636784 theta[1] :  25.642117651334722
```

In [28]:
```
# step 7: bonus compare
RMSE_training_dict = {feature_vectors[0]: RMSE_training_house_age,
                      feature_vectors[1]: RMSE_training_distance,
                      feature_vectors[2]: RMSE_training_nb_store, }
RMSE_testing_dict = {feature_vectors[0]: RMSE_testing_house_age,
                     feature_vectors[1]: RMSE_testing_distance,
                     feature_vectors[2]: RMSE_testing_nb_store, }
result_train = sorted(RMSE_training_dict.items(), key=lambda item: item[1])
result_test = sorted(RMSE_testing_dict.items(), key=lambda item: item[1])
print(result_train)
print(result_test)
```

```
[('distance to the nearest MRT station', 9.165754538401488), ('number of convenience stores', 9.83487827563954), ('house ag
e', 12.045510305912353)]
[('distance to the nearest MRT station', 12.652088009723935), ('number of convenience stores', 14.731993508206784), ('house
age', 16.58731450340051)]
```