recommender_system

November 14, 2018

1 Recommender system

1.1 Data contains

1.1.1 943 Movie Users

1.1.2 1682 Movies

1.1.3 100000 ratings of movies

1.1.4 Given that each user has rated some item in the system, system will predict how the users would

1.1.5 rate items that they have not watched yet.

1.1.6 Used data from https://grouplens.org/datasets/movielens/

```
In [252]: import pandas as pd
          import matplotlib
          import matplotlib.pyplot as plt
          import numpy as np
          import math
          from scipy import stats
```

```
In [3]: #Reading Users data
        user_cols = ['user_id','age','sex','occupation','zip_code']
        users = pd.read_csv('u.user',sep = '|',names =user_cols,encoding='latin-1')
```

```
In [4]: users.shape
```

```
Out[4]: (943, 5)
```

```
In [5]: users.head()
```

```
Out[5]:    user_id  age sex  occupation zip_code
        0        1   24   M  technician    85711
        1        2   53   F       other    94043
        2        3   23   M      writer    32067
        3        4   24   M  technician    43537
        4        5   33   F       other    15213
```

```
In [6]: #Reading ratings data:
        rating_cols = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
        ratings = pd.read_csv('u.data', sep='\t', names=rating_cols,encoding='latin-1')

In [7]: ratings.shape

Out[7]: (100000, 4)

In [8]: ratings.head()

Out[8]:    user_id  movie_id  rating  unix_timestamp
        0      196       242       3       881250949
        1      186       302       3       891717742
        2       22       377       1       878887116
        3      244        51       2       880606923
        4      166       346       1       886397596

In [9]: #Reading movies file:
        movie_cols = ['movie id', 'movie title' ,'release date','video release date', 'IMDb URL
        'Animation', 'Children\'s', 'Comedy', 'Crime', 'Documentary', 'Drama', 'Fantasy',
        'Film-Noir', 'Horror', 'Musical', 'Mystery', 'Romance', 'Sci-Fi', 'Thriller', 'War', 'W
        movies = pd.read_csv('u.item', sep='|', names=movie_cols, encoding='latin-1')

In [10]: movies.shape

Out[10]: (1682, 24)

In [11]: movies.head()

Out[11]:    movie id        movie title release date  video release date  \
         0         1   Toy Story (1995)  01-Jan-1995                 NaN
         1         2   GoldenEye (1995)  01-Jan-1995                 NaN
         2         3  Four Rooms (1995)  01-Jan-1995                 NaN
         3         4  Get Shorty (1995)  01-Jan-1995                 NaN
         4         5     Copycat (1995)  01-Jan-1995                 NaN

                                                IMDb URL  unknown  Action  \
         0  http://us.imdb.com/M/title-exact?Toy%20Story%2...        0       0
         1  http://us.imdb.com/M/title-exact?GoldenEye%20(...        0       1
         2  http://us.imdb.com/M/title-exact?Four%20Rooms%...        0       0
         3  http://us.imdb.com/M/title-exact?Get%20Shorty%...        0       1
         4  http://us.imdb.com/M/title-exact?Copycat%20(1995)        0       0

            Adventure  Animation  Children's   ...     Fantasy  Film-Noir  Horror  \
         0          0          1           1   ...           0          0       0
         1          1          0           0   ...           0          0       0
         2          0          0           0   ...           0          0       0
         3          0          0           0   ...           0          0       0
         4          0          0           0   ...           0          0       0
```

```
   Musical  Mystery  Romance  Sci-Fi  Thriller  War  Western
0        0        0        0       0         0    0        0
1        0        0        0       0         1    0        0
2        0        0        0       0         1    0        0
3        0        0        0       0         0    0        0
4        0        0        0       0         1    0        0

[5 rows x 24 columns]
```

1.2 convert csv file into pandas Dataframe

```
In [1342]: r_cols = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           ratings_train = pd.read_csv('ua.base', sep='\t', names=r_cols, encoding='latin-1')
           ratings_test = pd.read_csv('ua.test', sep='\t', names=r_cols, encoding='latin-1')

In [1710]: ratings_test.shape

Out[1710]: (9430, 4)

In [1669]: r_cols1 = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           ratings_train1 = pd.read_csv('u1.base', sep='\t', names=r_cols1, encoding='latin-1')
           ratings_test1 = pd.read_csv('u1.test', sep='\t', names=r_cols1, encoding='latin-1')

In [1670]: r_cols2 = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           ratings_train2 = pd.read_csv('u2.base', sep='\t', names=r_cols2, encoding='latin-1')
           ratings_test2 = pd.read_csv('u2.test', sep='\t', names=r_cols2, encoding='latin-1')

In [1671]: r_cols3 = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           ratings_train3 = pd.read_csv('u3.base', sep='\t', names=r_cols3, encoding='latin-1')
           ratings_test3 = pd.read_csv('u3.test', sep='\t', names=r_cols3, encoding='latin-1')

In [1672]: r_cols4 = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           ratings_train4 = pd.read_csv('u4.base', sep='\t', names=r_cols4, encoding='latin-1')
           ratings_test4 = pd.read_csv('u4.test', sep='\t', names=r_cols4, encoding='latin-1')

In [1673]: #r_cols5 = ['user_id', 'movie_id', 'rating', 'unix_timestamp']
           #ratings_train5 = pd.read_csv('u5.base', sep='\t', names=r_cols, encoding='latin-1')
           #ratings_test5 = pd.read_csv('u5.test', sep='\t', names=r_cols, encoding='latin-1')
```

1.3 """Convert pandas dataframe trainging rating to numpy training matrix rating"""

```
In [1674]: R_train = np.array(ratings_train.pivot(index = 'user_id', columns = 'movie_id',value
           R_test = np.array(ratings_test.pivot(index = 'user_id', columns = 'movie_id',values

In [1675]: R_train1 = np.array(ratings_train1.pivot(index = 'user_id',columns = 'movie_id',valu
           R_test1 = np.array(ratings_test1.pivot(index = 'user_id', columns = 'movie_id',value

In [1676]: R_train2 = np.array(ratings_train2.pivot(index = 'user_id', columns = 'movie_id',val
           R_test2 = np.array(ratings_test2.pivot(index = 'user_id', columns = 'movie_id',value
```

```
In [1677]: R_train3 = np.array(ratings_train3.pivot(index = 'user_id', columns = 'movie_id',val
           R_test3 = np.array(ratings_test3.pivot(index = 'user_id', columns = 'movie_id',value

In [1678]: R_train4 = np.array(ratings_train4.pivot(index = 'user_id', columns = 'movie_id',val
           R_test4 = np.array(ratings_test4.pivot(index = 'user_id', columns = 'movie_id',value

In [1679]: #R_train5 = np.array(ratings_train5.pivot(index = 'user_id', columns = 'movie_id',v
           #R_test5 = np.array(ratings_test5.pivot(index = 'user_id', columns = 'movie_id',val

In [1681]: R_train2.shape

Out[1681]: (943, 1650)

In [ ]:

In [1356]: #ratings_train.ix[:10,:]

In [1357]: t_data = pd.DataFrame(R_train)
           t_data.to_csv("test3/R_data.csv")

In [1682]: class Recommender():
               def __init__(self,rating,test_rating,features,learning_rate,momentum):
                   self.rating= rating
                   self.test_rating = test_rating
                   self.num_users = len(rating)
                   self.num_movies = len(rating[1])
                   self.num_features = features
                   self.learning_rate = learning_rate
                   self.momentum = momentum
                   #self.iterations = iterations

                   #Take the rating of the movies given by user which are not zeros
                   self.training_samples = [(i,j,self.rating[i,j])
                                   for i in range(self.num_users)
                                   for j in range(self.num_movies)
                                     if self.rating[i,j]>0]
                   self.test_samples = [(i,j,self.test_rating[i,j])
                                   for i in range(len(self.test_rating))
                                   for j in range(len(self.test_rating[1]))
                                     if self.test_rating[i,j]>0]

               def data_for_initialization(self):
                   """Returns the mean and stadard deviation for the initialization of
                       features matrices"""
                   sum_of_data = 0
                   length = len(self.training_samples)
                   for i in range(length):
                       sum_of_data += self.training_samples[i][2]
                   data_mean = sum_of_data/length
```

```
        #init_mean is squart root of mean of the data divided by num of features in
        init_mean = math.sqrt((data_mean/self.num_features))
        init_sdev = math.sqrt((2/self.num_features))
        return init_mean,init_sdev

    def initialize_fetures_matrix(self):
        """Initialized features matrices with mean and variance"""
        i_mean, st_dev = self.data_for_initialization()
        self.user_features = np.random.normal(loc = i_mean,scale = st_dev,size =(sel
        self.movie_features = np.random.normal(loc = i_mean,scale = st_dev,size = (s
        #self.movie_features = np.random.randn(self.num_features,self.num_movies)*np


        #To Update the User features and Movie features with MOMENTUM
        self.previous_changed_user_features = np.zeros((self.num_features,self.num_m
        self.previous_changed_movie_features = np.zeros((self.num_users,self.num_fea

    def initialize_feat_from_pretrained_file(self,user_feature,movie_feature):
        """Initialized the movie features and user features from previous trained
            Model"""
        self.user_features = user_feature
        self.movie_features = movie_feature


    def predict_full_matrix(self):
        """Returns the predictated full matrix using user features and movie
            features"""
        predicted_rating = np.matmul(self.user_features,self.movie_features)
        return predicted_rating

    def predict_rating(self,user_row,movie_col):
        """Returns the predictated rating of the position referenced by user_row an
        rating = 0
        for i in range(self.num_features):
            rating += self.user_features[user_row][i]*self.movie_features[i][movie_c
        return rating

    def error(self,i,j):
        """Returns the difference between actual rating and predicted rating"""
        predicted_rating = self.predict_rating(i,j)
        #print("predicted rating",predicted_rating)
        actual_rating = self.rating[i][j]
        #print("actual rating",actual_rating)
        return (actual_rating-predicted_rating)

    def validation_error(self,i,j):
        """Returns difference between predicted rating and evaluation rating"""
        predicted_rating = self.predict_rating(i,j)
```

```
        evaluation_rating = self.test_rating[i,j]
        return (abs(evaluation_rating - predicted_rating))

    def stochastic_user_gradient(self,user_row,movie_col):
        """Calculate the gradient of the user features and Update the user features
        error = self.error(user_row,movie_col)
        #print("error",error)
        #print(type(error))
        for i in range(self.num_features):
            self.user_features[user_row][i] = (self.user_features[user_row][i] \
                                               + self.learning_rate*error*self.movie
                                               - self.momentum* self.previous_change
            self.previous_changed_user_features[i][movie_col] = self.learning_rate*e

    def stochastic_movie_gradient(self,user_row,movie_col):
        """Calculate the gradient of the movie features and Update the movie featur
        error = self.error(user_row,movie_col)
        for i in range(self.num_features):
            self.movie_features[i][movie_col] = (self.movie_features[i][movie_col] \
                                                 + self.learning_rate*error*self.use
                                               - self.momentum* self.previous_change
            self.previous_changed_movie_features[user_row][i] = self.learning_rate*e


    def train(self):
        """Train the model for given number of iteration """
        for itn in range(self.iterations):
            for row,col,r in self.training_samples:
                self.stochastic_user_gradient(row,col)
                self.stochastic_movie_gradient(row,col)

    def train_using_evaluation(self):
        """Train the Model until validation error starts to increase and training m
            reaches to certain thresold.
            Returns number of times validation error increases
                    number of iterations model has been trained
                    list of training mean errors
                    list of validation mean errors"""
        list_of_training_error = []
        list_of_validation_error = []

        count = 0
        num_of_iterations = 0
        validation_mean_error = 0
        training_mean_error = 0
        #list_of_training_error.append(training_mean_error)
        #list_of_validation_error.append(validation_mean_error)
        training_length = len(self.training_samples)
```

```
            test_length = len(self.test_samples)

            while(count<10):
                np.random.shuffle(self.training_samples)
                training_error = 0
                for row,col,r in self.training_samples:
                    self.stochastic_user_gradient(row,col)
                    self.stochastic_movie_gradient(row,col)
                    training_error += abs(r-self.predict_rating(row,col))
                training_mean_error = (training_error/training_length)
                list_of_training_error.append(training_mean_error)

                pre_validation_mean_error = validation_mean_error
                validation_error = 0
                for row,col,r in self.test_samples:
                    validation_error += abs(r - self.predict_rating(row,col))
                validation_mean_error = (validation_error/test_length)
                list_of_validation_error.append(validation_mean_error)
                if(pre_validation_mean_error < validation_mean_error):
                    count += 1
                num_of_iterations += 1
            return (count,num_of_iterations,list_of_training_error,list_of_validation_e

        def get_user_features(self):
            """Returns the User features matrix
                   It can be used later for the initialization purpose for the same Use
                   features matrix. It helps to save a lot of computation power """
            return (self.user_features)


        def get_movie_features(self):
            """Returns the movie features matrix
                   It can be used later for the initialization purpose for the same mov
                    features matrix. It helps to save a lot of computation power """
            return self.movie_features
        def get_test_samples(self):
            """Return list of tuples which contain rating and its coordinate
                corresponding to User Id and Movie Id"""
            return (self.test_samples)
```

In [1769]:
```
#Constructor for the Recommender system
#Rating,features,learning_rate,momentum,iterations
rm = Recommender(R_train,R_test,100,0.001,0)
```

In [ ]:
```
"""Load User features and Movie features"""
file_user_data = pd.read_csv("user_features_data.csv")
new_user_features = file_user_data.as_matrix()
```

In [1770]:
```
#Initilize the features matrices, User features and Movie features
```

```
            rm.initialize_fetures_matrix()
            print("Num of users ", rm.num_users)
            print("Num of movies", rm.num_movies)
            print("Num of latent features", rm.num_features)
            print("Learning rate",rm.learning_rate)
```

```
Num of users  943
Num of movies 1680
Num of latent features 100
Learning rate 0.001
```

2 Model initialization for ensemble

```
In [1683]: #Constructor for the Model1
           #Rating,features,learning_rate,momentum,iterations
           rm1 = Recommender(R_train1,R_test1,100,0.001,0.6)
           #Initilize the features matrices, User features and Movie features for Model 1
           rm1.initialize_fetures_matrix()
```

```
In [1684]: #Constructor for the Model2
           #Rating,features,learning_rate,momentum,iterations
           rm2 = Recommender(R_train2,R_test2,100,0.001,0.1)
           #Initilize the features matrices, User features and Movie features for Model 2
           rm2.initialize_fetures_matrix()
```

```
In [1756]: ### Constructor for the Model3
           #Rating,features,learning_rate,momentum,iterations
           rm3 = Recommender(R_train3,R_test3,100,0.001,0.4)
           #Initilize the features matrices, User features and Movie features for Model 3
           rm3.initialize_fetures_matrix()
```

```
In [1757]: #Constructor for the Model4
           #Rating,features,learning_rate,momentum,iterations
           rm4 = Recommender(R_train4,R_test4,100,0.001,0.4)
           #Initilize the features matrices, User features and Movie features for Model 4
           rm4.initialize_fetures_matrix()
```

```
In [1687]: #Constructor for the Model5
           #Rating,features,learning_rate,momentum,iterations
           ##rm5 = Recommender(R_train5,R_test5,100,0.001,0.6)
           #Initilize the features matrices, User features and Movie features for Model 5
           ##rm5.initialize_fetures_matrix()
```

3 Model training for ensemble

```
In [1771]: count,num_of_iterations,list_of_training_error,list_of_validation_error = rm.train_
```

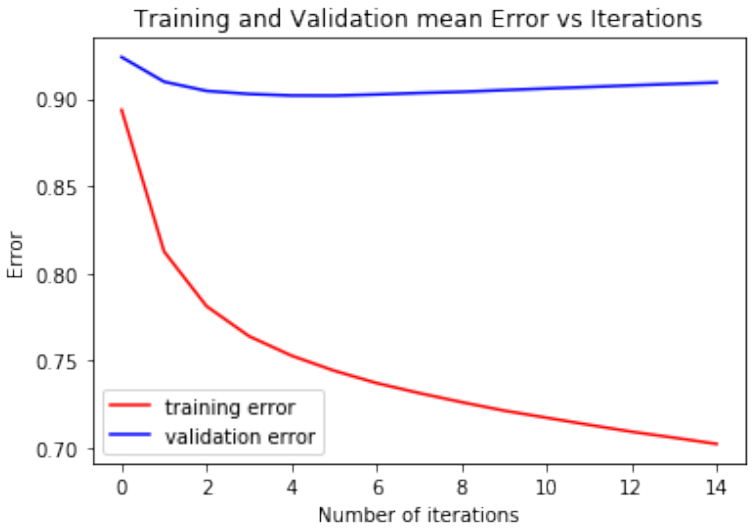
```
In [1688]: count1,num_of_iterations1,list_of_training_error1,list_of_validation_error1 = rm1.tr

In [1689]: count2,num_of_iterations2,list_of_training_error2,list_of_validation_error2 = rm2.tr

In [1758]: count3,num_of_iterations3,list_of_training_error3,list_of_validation_error3 = rm3.tr

In [1759]: count4,num_of_iterations4,list_of_training_error4,list_of_validation_error4 = rm4.tr

In [1749]: #count5,num_of_iterations5,list_of_training_error5,list_of_validation_error5 = rm5.

In [1750]: print(num_of_iterations)
           print(count)
           print(rm.learning_rate)

14
10
0.001
```

4 Display the evaluation and training error

```
In [1772]: list_of_iteration = []
           for i in range(num_of_iterations):
               list_of_iteration.append(i)

In [1761]: list_of_iteration1 = []
           for i in range(num_of_iterations1):
               list_of_iteration1.append(i)

           list_of_iteration2 = []
           for i in range(num_of_iterations2):
               list_of_iteration2.append(i)

           list_of_iteration3 = []
           for i in range(num_of_iterations3):
               list_of_iteration3.append(i)

           list_of_iteration4 = []
           for i in range(num_of_iterations4):
               list_of_iteration4.append(i)

In [1773]: total_ev_error = sum(list_of_validation_error)/len(list_of_validation_error)

           total_ev_error1 = sum(list_of_validation_error1)/len(list_of_validation_error1)
           total_ev_error2 = sum(list_of_validation_error2)/len(list_of_validation_error2)
           total_ev_error3 = sum(list_of_validation_error3)/len(list_of_validation_error3)
           total_ev_error4 = sum(list_of_validation_error4)/len(list_of_validation_error4)
```

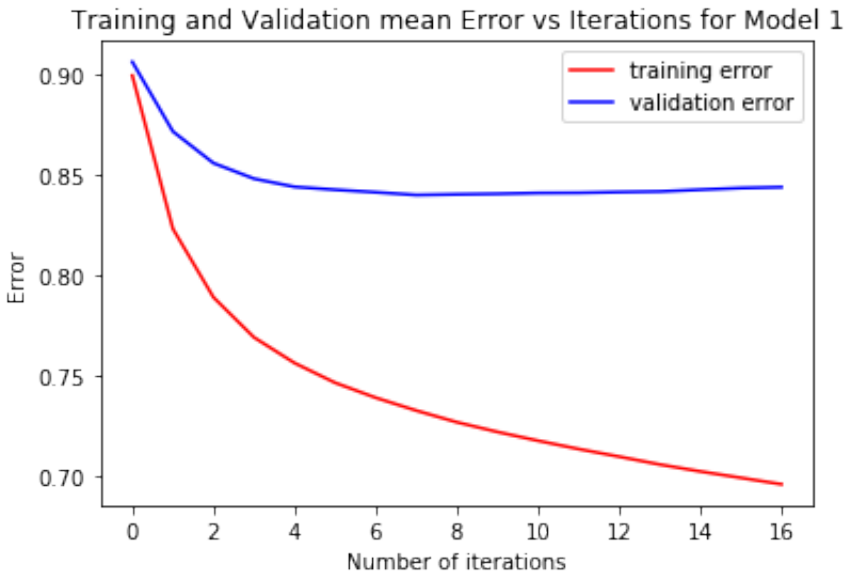
"""print(list_of_validation_error) total = sum(list_of_validation_error)/len(list_of_validation_error) print(total)"""

In [1774]:
```
plt.plot(list_of_iteration,list_of_training_error,'r',list_of_iteration,list_of_vali
plt.xlabel('Number of iterations')
plt.ylabel('Error')
plt.title('Training and Validation mean Error vs Iterations')
plt.gca().legend(('training error','validation error'))
plt.text(18,0.88,total_ev_error)
plt.show()
```



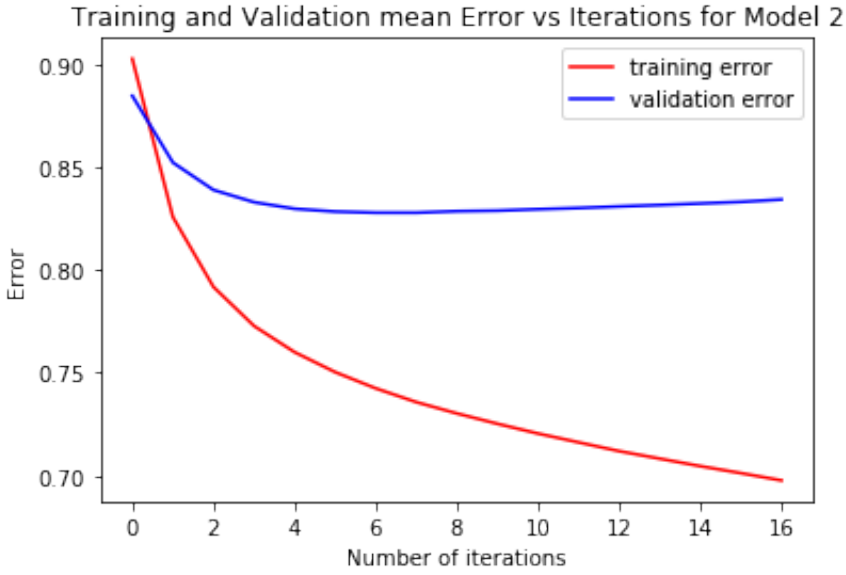
0.9065957888254474

In [1695]:
```
plt.plot(list_of_iteration1,list_of_training_error1,'r',list_of_iteration1,list_of_v
plt.xlabel('Number of iterations')
plt.ylabel('Error')
plt.title('Training and Validation mean Error vs Iterations for Model 1')
plt.gca().legend(('training error','validation error'))
plt.text(18,0.88,total_ev_error1)
plt.show()
```



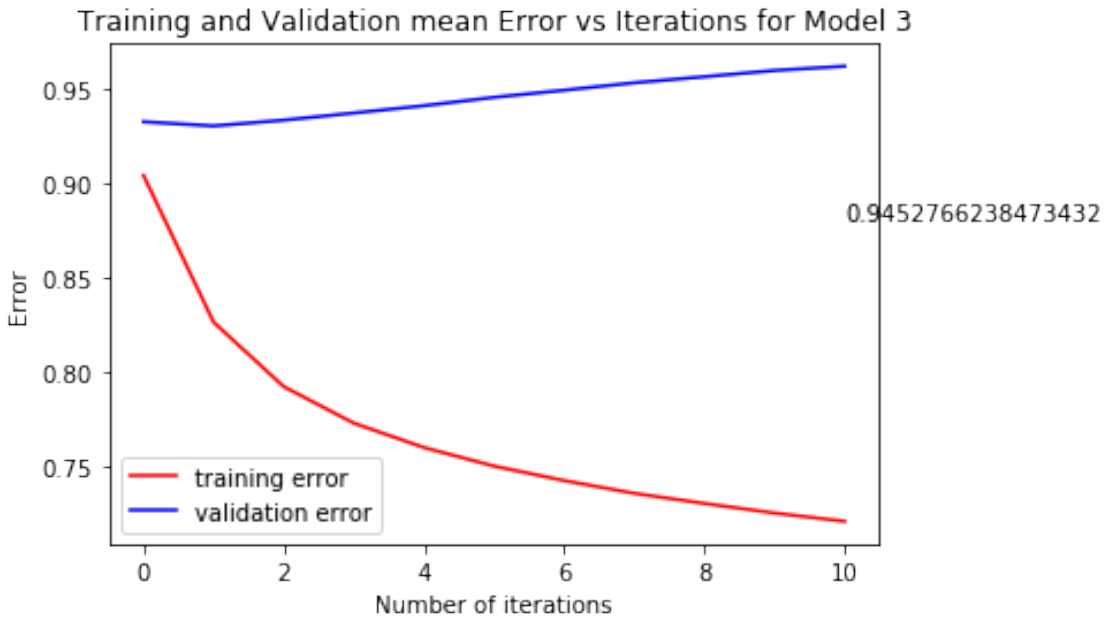
0.8486099248778879

In [1697]:
```
plt.plot(list_of_iteration2,list_of_training_error2,'r',list_of_iteration2,list_of_v
plt.xlabel('Number of iterations')
plt.ylabel('Error')
plt.title('Training and Validation mean Error vs Iterations for Model 2')
plt.gca().legend(('training error','validation error'))
plt.text(18,0.88,total_ev_error2)
plt.show()
```

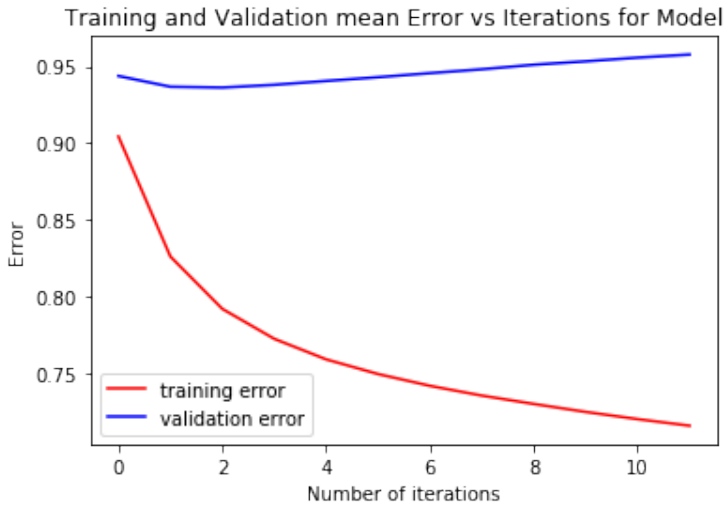


0.8352976397717123

In [1763]:
```
plt.plot(list_of_iteration3,list_of_training_error3,'r',list_of_iteration3,list_of_
plt.xlabel('Number of iterations')
plt.ylabel('Error')
plt.title('Training and Validation mean Error vs Iterations for Model 3')
plt.gca().legend(('training error','validation error'))
plt.text(10,0.88,total_ev_error3)
plt.show()
```



In [1764]:
```
plt.plot(list_of_iteration4,list_of_training_error4,'r',list_of_iteration4,list_of_
plt.xlabel('Number of iterations')
plt.ylabel('Error')
plt.title('Training and Validation mean Error vs Iterations for Model 4')
plt.gca().legend(('training error','validation error'))
plt.text(15,0.88,total_ev_error4)
plt.show()
```



0.9459272813283697

5 Get User features and Movie features for 4 Models

```
In [1700]: user_features1 = rm1.get_user_features()
           movie_features1 = rm1.get_movie_features()

           user_features2 = rm2.get_user_features()
           movie_features2 = rm2.get_movie_features()

           user_features3 = rm3.get_user_features()
           movie_features3 = rm3.get_movie_features()

           user_features4 = rm4.get_user_features()
           movie_features4 = rm4.get_movie_features()
```

6 Save User features and Movie features for 4 Models

```
In [1701]: user_feat_data1 = pd.DataFrame(user_features1)
           user_feat_data1.to_csv("trained_data/trained1/user_features_data.csv",header = None
           movie_feat_data1 = pd.DataFrame(movie_features1)
           movie_feat_data1.to_csv("trained_data/trained1/movie_features_data.csv",header=None

           user_feat_data2 = pd.DataFrame(user_features2)
           user_feat_data2.to_csv("trained_data/trained2/user_features_data.csv",header = None
           movie_feat_data2 = pd.DataFrame(movie_features2)
           movie_feat_data2.to_csv("trained_data/trained2/movie_features_data.csv",header=None

           user_feat_data3 = pd.DataFrame(user_features3)
           user_feat_data3.to_csv("trained_data/trained3/user_features_data.csv",header = None
```

```
movie_feat_data3 =pd.DataFrame(movie_features3)
movie_feat_data3.to_csv("trained_data/trained3/movie_features_data.csv",header=None

user_feat_data4 = pd.DataFrame(user_features4)
user_feat_data4.to_csv("trained_data/trained4/user_features_data.csv",header = None
movie_feat_data4 = pd.DataFrame(movie_features4)
movie_feat_data4.to_csv("trained_data/trained4/movie_features_data.csv",header=None
```

7 Load user features and movie features from the csv file

In [1702]:
```
"""Load User features and Movie features from csv and convert into numpy matrix"""

"""user_data1 = pd.read_csv("trained_data/trained1/user_features_data.csv")
new_user_features1 = user_data1.as_matrix()
movie_data1 = pd.read_csv("trained_data/trained1/movie_features_data.csv")
new_movie_features1 = movie_data1.as_matrix()

user_data2 = pd.read_csv("trained_data/trained2/user_features_data.csv")
new_user_features2 = user_data2.as_matrix()
movie_data2 = pd.read_csv("trained_data/trained2/movie_features_data.csv")
new_movie_features2 = movie_data2.as_matrix()

user_data3 = pd.read_csv("trained_data/trained3/user_features_data.csv")
new_user_features3 = user_data3.as_matrix()
movie_data3 = pd.read_csv("trained_data/trained3/movie_features_data.csv")
new_movie_features3 = movie_data3.as_matrix()

user_data4 = pd.read_csv("trained_data/trained4/user_features_data.csv")
new_user_features4 = user_data4.as_matrix()
movie_data4 = pd.read_csv("trained_data/trained4/movie_features_data.csv")
new_movie_features4 = movie_data4.as_matrix()

user_data5 = pd.read_csv("trained_data/trained5/user_features_data.csv")
new_user_features5 = user_data5.as_matrix()
movie_data5 = pd.read_csv("trained_data/trained5/movie_features_data.csv")
new_movie_features5 = movie_data5.as_matrix()"""
```

Out[1702]:
```
'user_data1 = pd.read_csv("trained_data/trained1/user_features_data.csv")\nnew_user_
```

8 Build One model from Four models

In [1703]:
```
"""Average of user features and movie features"""
final_user_features = (user_features1 + user_features2 + user_features3 + user_featu
final_movie_features = (movie_features1 + movie_features2 + movie_features3 + movie_
```

9 Predict final Rating

```
In [1704]: final_prediction = np.matmul(final_user_features,final_movie_features)

In [1705]: predicted_new

Out[1705]: array([[4.1712617 , 3.42230996, 3.46455652, ..., 3.31785628, 3.00893989,
                   3.67653794],
                  [4.05599722, 3.4828617 , 3.15430905, ..., 3.26848033, 3.29654828,
                   3.60031489],
                  [3.38916564, 2.98047259, 2.51129748, ..., 3.05891139, 2.59478471,
                   3.06422324],
                  ...,
                  [4.43797712, 3.64024225, 3.77981958, ..., 3.99244873, 3.73103081,
                   3.95037144],
                  [4.50454383, 3.87524603, 3.25799012, ..., 3.83214008, 3.98154132,
                   3.86783945],
                  [3.95507797, 3.38016644, 3.06990556, ..., 3.23456427, 3.03624816,
                   3.47524   ]])

In [1706]: final_prediction

Out[1706]: array([[4.05509619, 3.36577841, 3.15549775, ..., 3.57293928, 3.63302159,
                   3.34831009],
                  [4.05778652, 3.5155221 , 3.36608615, ..., 3.65153087, 3.64461442,
                   3.46588192],
                  [3.36051495, 2.9404846 , 2.76589047, ..., 3.00754895, 3.07428358,
                   2.862818  ],
                  ...,
                  [4.13477736, 3.47958878, 3.40234277, ..., 3.67709583, 3.768971  ,
                   3.5790974 ],
                  [4.40958017, 3.68757009, 3.5972183 , ..., 3.92127139, 4.00061187,
                   3.70003457],
                  [3.79013582, 3.35743678, 3.06242059, ..., 3.46528616, 3.4602782 ,
                   3.13222541]])

In [1707]: R_train

Out[1707]: array([[5., 3., 4., ..., 0., 0., 0.],
                  [4., 0., 0., ..., 0., 0., 0.],
                  [0., 0., 0., ..., 0., 0., 0.],
                  ...,
                  [5., 0., 0., ..., 0., 0., 0.],
                  [0., 0., 0., ..., 0., 0., 0.],
                  [0., 5., 0., ..., 0., 0., 0.]])
```

10 Final Absolute Mean Evaluation Error

```
In [1731]: final_prediction[0][4]
```

```
Out[1731]: 3.4458091566916895

In [1765]: new_test_samples = [(i,j,R_test[i,j])
                               for i in range(len(R_test))
                               for j in range(len(R_test))
                                 if R_test[i,j]>0]
           """With Ensemble"""
           test_error = 0
           test_mean_error = 0
           for row,col,r in new_test_samples:
               test_error += abs(r -final_prediction[row][col])
           test_mean_error = (test_error/len(new_test_samples))
           print("Test Mean Error Using Ensemble Model = ",test_mean_error)

           ##############################################################################
           """Without Ensemble"""
           test_error1 = 0
           test_mean_error1 = 0
           for row,col,r in new_test_samples:
               test_error1 += abs(r -predicted_new[row][col])
           test_mean_error1 = (test_error1/len(new_test_samples))
           print("Test Mean error with single Model = ",test_mean_error1)



Test Mean Error Using Ensemble Model =  0.8778874995757241
Test Mean error with single Model =  0.9067002149448486


In [1502]: i = 445
           r,c = test_samples[i][0],test_samples[i][1]
           print("Actual",test_samples[i][2])
           print("Ensemble Predicted",final_prediction[r][c])

           r,c = test_samples[i][0],test_samples[i][1]
           print("Actual",test_samples[i][2])
           print("Old Predicted",predicted_new[r][c])

Actual 3.0
Ensemble Predicted 3.9807339201017453
Actual 3.0
Old Predicted 4.067662122795133


In [1503]: test_samples = rm.get_test_samples()
```

11 Evaluation Using T-test

11.1 T-Test compare results obtained with two different methods A and B on the same sample, in order to confirm whether both methods provide similar analytical results or not.

```
In [1533]: class Evaluation:
               """Evaluate  Recommender using T-test
                   Real population is list of tupples in format(row,col,rating)
                   Predicted population is two dimensional array"""
               def __init__(self,real_population,predicted_population,num_samples,conf_interval
                   self.real_population = real_population
                   self.predicted_population = predicted_population
                   self.num_samples = num_samples
                   self.conf_interval = conf_interval

               def get_rating(self):
                   """Returns list of two samples for the t test from
                       given population
                       First sample is list of Actual rating
                       Second sample is list of Predicted rating"""
                   r_count = 0
                   list_real_samples = []
                   list_predicted_samples = []
                   np.random.shuffle(self.real_population)
                   for i in range(self.num_samples):
                       r_sample = self.real_population[i]
                       list_real_samples.append(r_sample[2])
                       row = r_sample[0]
                       col = r_sample[1]
                       list_predicted_samples.append(self.predicted_population[row][col])
                   return (list_real_samples,list_predicted_samples)

               def calculate_tvalue(self):
                   """Calculate t value from two samples
                       i.e. Actual rating and Predicted rating
                       Returns T-calculated value"""
                   real_value, predicted_value = self.get_rating()
                   mean1 = np.mean(real_value,dtype = np.float64)
                   mean2 = np.mean(predicted_value, dtype = np.float64)
                   std1 = np.std(real_value, dtype = np.float64)
                   std2 = np.std(predicted_value, dtype = np.float64)
                   n1 = len(real_value)
                   n2 = len(predicted_value)
                   t_value = (mean1 - mean2)/(math.sqrt(((std1**2)/n1 + (std2**2)/n2)))
                   return t_value

               def calculate_critical_tvalue(self):
```

```
            """Calculate critical t value from the t-distribution table
                for a given alpha,confidence interval and degree of freedom
                Returns T-theoritical value"""
            degree_freedom = 2*(self.num_samples -1)
            #self.conf_interval should be the lower tail probability
            t_critical = stats.t.ppf(self.conf_interval,degree_freedom)  #stats.t.cdf
            return t_critical

        def define_hypothesis(self):
            """Determine whether the null Hypothesis is accepted or not"""
            cal_value = self.calculate_tvalue()
            cri_value = self.calculate_critical_tvalue()
            if(abs(cal_value)<abs(cri_value)):
                print("Null Hypothesis is accepted,\
                i.e. both actual ratings and predicted ratings provide the same analyti
            else:
                print("Null Hypothesis is rejected,\
                i.e.actual ratings and predicted ratings provide different analytical re
```

```
In [1534]: ev = Evaluation(test_samples,final_prediction,60,0.05)
```

```
In [1535]: ev.define_hypothesis()
```

```
Null Hypothesis is accepted,           i.e. both actual ratings and predicted ratings provide
```

11.2 Get movies that has not been watched by user 'N' form pool of all movies

```
In [1536]: def get_movie_to_recommend(actual_matrix,trained_matrix,user_num):
               """Extract movies, that has not been watched by User yet,
               from Pool of all movies"""
               user_num = user_num-1
               list_rec_movies = {}
               length = len(actual_matrix[user_num])
               for i in range(length):
                   if actual_matrix[user_num][i] == 0:
                       list_rec_movies[i] = trained_matrix[user_num][i]
               return list_rec_movies
```

11.2.1 Last value of the constructor represent user number

```
In [1544]: movies_not_watched = get_movie_to_recommend(R_train,predicted_new,10)
```

11.2.2 Sort all movies that has not been watched by user N based on the rating predicted

11.2.3 by Recommender system

```
In [1545]: def sort_movie_rating(movies_list,num_ofmovies_torec):
               """Returns top N numbers of movies recommended to a particular User"""
```

```
    sorted_movies_rating = sorted(movies_list.items(),key = lambda movies_list: movi
    movies_torecommend = []
    for i in range(num_ofmovies_torec):
        movies_torecommend.append(sorted_movies_rating[i])
    return movies_torecommend
```

```
In [1546]: num_ofmovies_torec = 10
           top_movies_to_recommend = sort_movie_rating(movies_not_watched,num_ofmovies_torec)
```

```
In [1547]: movies.head()
```

Out[1547]:

	movie id	movie title	release date	video release date	\
0	1	Toy Story (1995)	01-Jan-1995	NaN	
1	2	GoldenEye (1995)	01-Jan-1995	NaN	
2	3	Four Rooms (1995)	01-Jan-1995	NaN	
3	4	Get Shorty (1995)	01-Jan-1995	NaN	
4	5	Copycat (1995)	01-Jan-1995	NaN	

	IMDb URL	unknown	Action	\
0	http://us.imdb.com/M/title-exact?Toy%20Story%2...	0	0	
1	http://us.imdb.com/M/title-exact?GoldenEye%20(...	0	1	
2	http://us.imdb.com/M/title-exact?Four%20Rooms%...	0	0	
3	http://us.imdb.com/M/title-exact?Get%20Shorty%...	0	1	
4	http://us.imdb.com/M/title-exact?Copycat%20(1995)	0	0	

	Adventure	Animation	Children's	...	Fantasy	Film-Noir	Horror	\
0	0	1	1	...	0	0	0	
1	1	0	0	...	0	0	0	
2	0	0	0	...	0	0	0	
3	0	0	0	...	0	0	0	
4	0	0	0	...	0	0	0	

	Musical	Mystery	Romance	Sci-Fi	Thriller	War	Western
0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0
2	0	0	0	0	1	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	1	0	0

[5 rows x 24 columns]

```
In [1548]: all_movies_name = movies['movie title']
```

12 Recommend Movies

```
In [1549]: def final_recomendation(all_movies_name,top_movies_to_recommend,num_ofmovies_torec)
               rec_movies_name = []
```

```
            for i in range(num_ofmovies_torec):
                m_index = top_movies_to_recommend[i][0]
                rec_movies_name.append(all_movies_name[m_index])

            return rec_movies_name
```

```
In [1550]: final_movie = final_recomendation(all_movies_name,top_movies_to_recommend,num_ofmovi
```

```
In [1551]: final_movie
```

```
Out[1551]: ['Wrong Trousers, The (1993)',
            "Schindler's List (1993)",
            'Boot, Das (1981)',
            'Close Shave, A (1995)',
            'Wallace & Gromit: The Best of Aardman Animation (1996)',
            'Sunset Blvd. (1950)',
            'Raise the Red Lantern (1991)',
            'Empire Strikes Back, The (1980)',
            'Titanic (1997)',
            'As Good As It Gets (1997)']
```

```
In [ ]:
```