homework_3

November 7, 2021

1 Homework 3

1.1 Baseline

[ ]:
```python
import gzip
from collections import defaultdict
from sklearn import linear_model
import csv

def readGz(path):
    for l in gzip.open(path, 'rt'):
        yield eval(l)

def readCSV(path):
    f = gzip.open(path, 'rt')
    c = csv.reader(f)
    header = next(c)
    for l in c:
        d = dict(zip(header,l))
        yield d['user_id'],d['recipe_id'],d
```

1.2 Cook/Make prediction

1.2.1 Task 1

[ ]:
```python
reviews = []

for _, _, review in readCSV("data/trainInteractions.csv.gz"):
  reviews.append(review)

train_reviews = reviews[:400000]
valid_reviews = reviews[400000:500000]
```

[ ]:
```python
## Making validation-set
import random

valid_recipes_per_user = defaultdict(set)
recipes = set()
```

```
for review in valid_reviews:
    valid_recipes_per_user[review['user_id']].add(review['recipe_id'])
    recipes.add(review['recipe_id'])
recipes = list(recipes)

valid_dict = defaultdict(int)
for valid_review in valid_reviews:
    user = valid_review['user_id']
    recipe = valid_review['recipe_id']
    valid_dict[(user, recipe)] =  1
    neg_sample = random.choice(recipes)
    while neg_sample in valid_recipes_per_user[user] or (user, neg_sample) in␣
 ↪valid_dict.keys():
        neg_sample = random.choice(recipes)
    valid_dict[(user, neg_sample)] =  0
```

[ ]:

```
recipe_count = defaultdict(int)
total_cooked = 0

for review in train_reviews:
  recipe_count[review['recipe_id']] += 1
  total_cooked += 1

def most_popular_recipes(treshold_percentile):
  most_popular = [(recipe_count[x], x) for x in recipe_count]
  most_popular.sort()
  most_popular.reverse()

  predict_true = set()
  count = 0
  for num, recipe_id in most_popular:
    count += num
    predict_true.add(recipe_id)
    if count > total_cooked*treshold_percentile: break

  return predict_true
```

[ ]:

```
##Predict the validation set
predict_true = most_popular_recipes(0.5)

pred_valid_dict = defaultdict(int)
for user, recipe in valid_dict.keys():
    pred_valid_dict[(user, recipe)] = (int(recipe in predict_true))
```

[ ]:

```
accuracy = sum((pred == valid) for pred, valid in zip(pred_valid_dict.values(),␣
 ↪valid_dict.values()))/len(pred_valid_dict)
print(f"Accuracy of baseline model: {accuracy}")
```

```
Accuracy of baseline model: 0.613615
```

1.2.2 Task 2

[ ]:

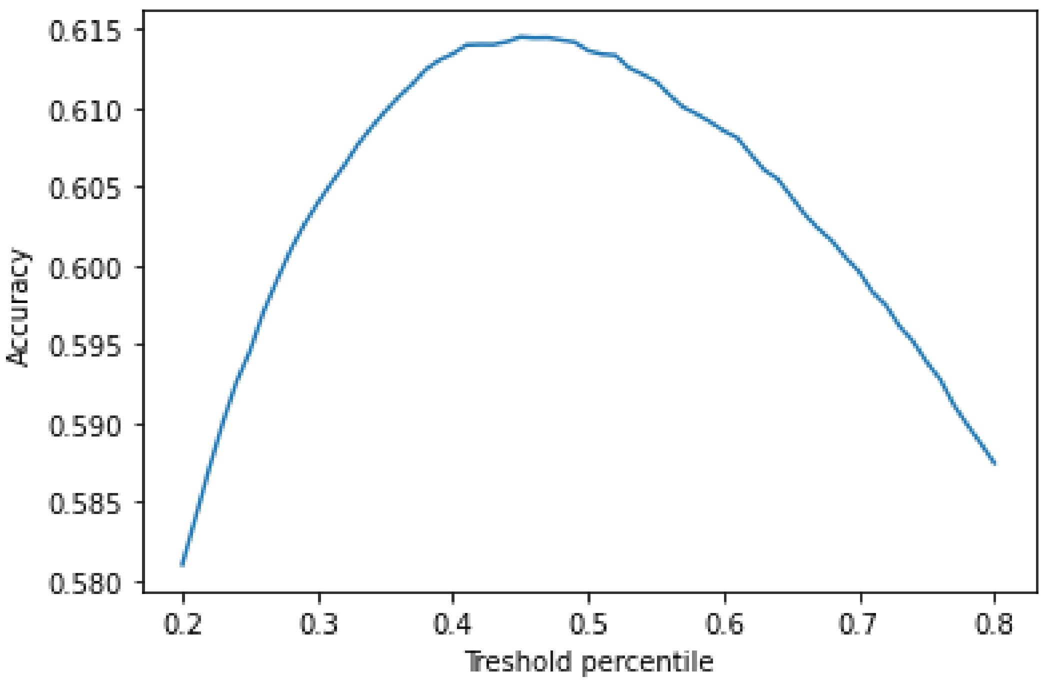
```
accuracies = {}

for i in range(20, 80 + 1):
    treshold_percentile = float(i)/100

    predict_true_2 = most_popular_recipes(treshold_percentile)

    pred_valid_dict_2 = defaultdict(int)
    for user, review in valid_dict.keys():
        pred_valid_dict_2[(user, review)] = review in predict_true_2

    accuracy = sum((pred == valid) for pred, valid in zip(pred_valid_dict_2.
 ↪values(), valid_dict.values()))/len(valid_dict)
    accuracies[treshold_percentile] = accuracy
```

[ ]:

```
import matplotlib.pyplot as plt

x_plot = [treshold_percentile for treshold_percentile in accuracies.keys()]
y_plot = [acc for acc in accuracies.values()]

plt.xlabel("Treshold percentile")
plt.ylabel("Accuracy")
plt.plot(x_plot, y_plot)
```

[ ]:

```
[<matplotlib.lines.Line2D at 0x7f453175c250>]
```



```
[ ]: predict_true_2 = most_popular_recipes(0.46)


     pred_valid_dict_2 = defaultdict(int)
     for user, review in valid_dict.keys():
         pred_valid_dict_2[(user, review)] = review in predict_true_2

     accuracy = sum((pred == valid) for pred, valid in zip(pred_valid_dict_2.
      ↪values(), valid_dict.values()))/len(valid_dict)
     print(f"Based on the graph and output you can see that the optimal treshold␣
      ↪\nlies at 0.46. You then get an accaruacy of {accuracy}, which \nis␣
      ↪marginally better than the baseline.")
```

```
Based on the graph and output you can see that the optimal treshold
lies at 0.46. You then get an accaruacy of 0.61442, which
is marginally better than the baseline.
```

1.2.3 Task 3

```
[ ]: def Jaccard(s1, s2):
         numerator = len(s1.intersection(s2))
         denominator = len(s1.union(s2))
         if(denominator == 0):
             return 0
         return numerator/denominator
```

[ ]:

```
train_recipes_per_user = defaultdict(set)
train_users_per_recipe = defaultdict(set)
for review in train_reviews:
    user = review['user_id']
    recipe = review['recipe_id']
    train_recipes_per_user[user].add(recipe)
    train_users_per_recipe[recipe].add(user)
```

[ ]:

```
def max_Jaccard(user, recipe):
    max_similarity = 0
    for other_recipe in train_recipes_per_user[user]:
        jac = Jaccard(train_users_per_recipe[recipe],␣
 ↪train_users_per_recipe[other_recipe])
        if jac > max_similarity:
            max_similarity = jac
    return max_similarity
```

[ ]:

```
maximum_jaccard = defaultdict(int)
for user, recipe in valid_dict.keys():
    maximum_jaccard[(user, recipe)] = max_Jaccard(user, recipe)
```

[ ]:

```
def predict_jaccard(treshold):
    pred_valid_dict_3 = defaultdict(int)
    for user, recipe in valid_dict.keys():
        max_jac = maximum_jaccard[(user, recipe)]
        pred_valid_dict_3[user, recipe] = max_jac > treshold
    return pred_valid_dict_3
```

[ ]:

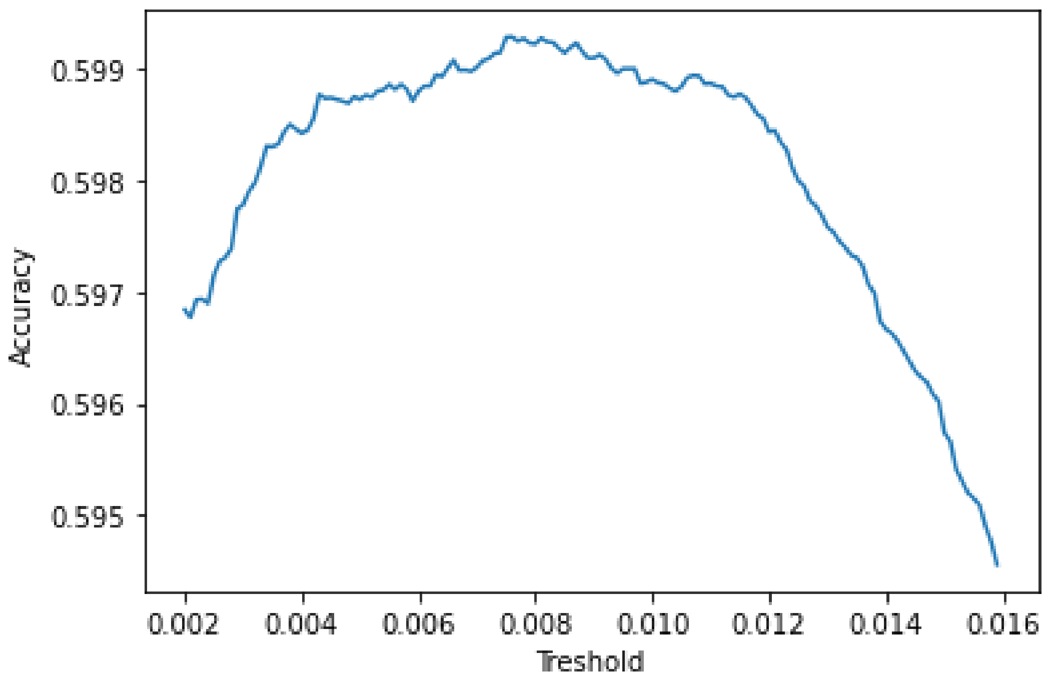
```
accuracies = {}
tresholds = [float(i)/10 for i in range(20,160)]
for treshold in tresholds:
    pred_dict = predict_jaccard(treshold/1000)
    accuracy = sum((pred == valid) for pred, valid in zip(pred_dict.values(),␣
 ↪valid_dict.values()))/len(valid_dict)
    accuracies[treshold/1000] = accuracy
```

[ ]:

```
x_plot = [treshold for treshold in accuracies.keys()]
y_plot = [acc for acc in accuracies.values()]

plt.xlabel("Treshold")
plt.ylabel("Accuracy")
plt.plot(x_plot, y_plot)
```

[ ]:

```
[<matplotlib.lines.Line2D at 0x7f452b39f040>]
```



[ ]:
```
pred_dict = predict_jaccard(0.008)
accuracy = sum((pred == valid) for pred, valid in zip(pred_dict.values(),␣
 ↪valid_dict.values()))/len(valid_dict)

print(f"The best accuracy with Jaccard similarity was {accuracy}, with a␣
 ↪treshold of {0.008}")
```

```
The best accuracy with Jaccard similarity was 0.59922, with a treshold of 0.008
```

1.2.4 Task 4

[ ]:
```
def pred_jac_pop(jac_treshold, pop_treshold, prediction_list):
    pred_dict = defaultdict(int)
    N_most_popular = most_popular_recipes(pop_treshold)
    for user, recipe in prediction_list:
        max_jac = maximum_jaccard[(user, recipe)]

        if max_jac > jac_treshold or recipe in N_most_popular:
            pred_dict[(user, recipe)] = 1
        else:
            pred_dict[(user, recipe)] = 0

    return pred_dict
```

[ ]:

```
jac_treshold = 0.008
pop_treshold = 0.46

pred_valid_dict_4 = pred_jac_pop(jac_treshold, pop_treshold, pred_dict.keys())

accuracy = sum((pred == valid) for pred, valid in zip(pred_valid_dict_4.
 ↪values(), valid_dict.values()))/len(valid_dict)
print(f"By combining the best tresholds from the two previous tasks, I managed␣
 ↪to improve the predictor from task 3.")
print(f"The performance on the validation set had an accuracy of {accuracy}")
```

```
By combining the best tresholds from the two previous tasks, I managed to
improve the predictor from task 3.
The performance on the validation set had an accuracy of 0.605275
```

1.2.5 Task 5

[ ]:

```
header = ""
test_list = []
for line in open("data/stub_Made.txt"):
    if line.startswith("user_id"):
        header = line
        continue
    user, recipe = line.strip().split('-')
    test_list.append((user, recipe))

jac_treshold = 0.008
pop_treshold = 0.46
pred_test_dict = pred_jac_pop(jac_treshold, pop_treshold, test_list)

predictions = open("data/predictions_Made.txt", 'w')
predictions.write(header)
for key, pred in pred_test_dict.items():
    user, recipe = key
    predictions.write(f"{user}-{recipe},{pred}\n")
```

Solution uploaded to Kaggle, with an impressive prediction of 67%(!!), quite an improvement from the validation set. My Kaggle user name is henriklarssonhestnes, with Henrik Larsson Hestnes as display name.

1.3 Rating prediction

1.3.1 Task 9

[ ]:

```
reviews = []

for _, _, review in readCSV("data/trainInteractions.csv.gz"):
  reviews.append(review)
```

```python

train_reviews = reviews[:400000]
valid_reviews = reviews[400000:500000]
```

[ ]:

```python
valid_dict = defaultdict(int)
for valid_review in valid_reviews:
    user = valid_review['user_id']
    recipe = valid_review['recipe_id']
    rating = valid_review['rating']
    valid_dict[(user, recipe)] =  int(rating)
```

[ ]:

```python
users_per_recipe = defaultdict(set)
recipes_per_user = defaultdict(set)
train_dict = defaultdict(int)
for train_review in train_reviews:
    user = train_review['user_id']
    recipe = train_review['recipe_id']
    rating = train_review['rating']
    train_dict[(user, recipe)] =  int(rating)
    recipes_per_user[user].add(recipe)
    users_per_recipe[recipe].add(user)
```

[ ]:

```python
N = len(train_dict)
```

[ ]:

```python
def calculate_alpha(data_dict, beta_user_dict, beta_item_dict, N):
    sum = 0
    for (user, item), rating in data_dict.items():
        sum += rating - (beta_user_dict[user] + beta_item_dict[item])
    return sum/N

def calculate_beta_user(data_dict, items_per_user, alpha, beta_item_dict, lamb):
    beta_user_dict = {}
    for user, items in items_per_user.items():
        sum = 0
        for item in items:
            rating = data_dict[(user, item)]
            beta_item = beta_item_dict[item]
            sum += rating - (alpha +beta_item)
        beta_user = sum / (lamb + len(items_per_user[user]))
        beta_user_dict[user] = beta_user
    return beta_user_dict

def calculate_beta_item(data_dict, users_per_item, alpha, beta_user_dict, lamb):
    beta_item_dict = {}
    for item, users in users_per_item.items():
        sum = 0
        for user in users:
            rating = data_dict[(user, item)]
            beta_user = beta_user_dict[user]
            sum += rating - (alpha + beta_user)
        beta_item = sum/(lamb + len(users_per_item[item]))
        beta_item_dict[item] = beta_item
    return beta_item_dict
```

[ ]:

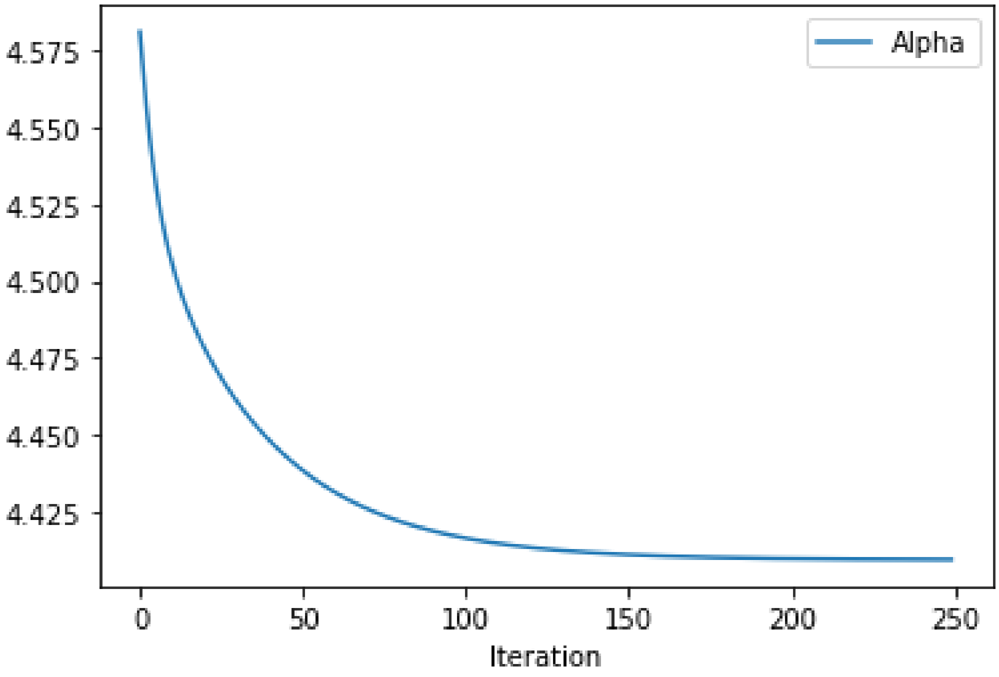
```
beta_user_dict = {user:0 for user in recipes_per_user.keys()}
beta_recipe_dict = {recipe:0 for recipe in users_per_recipe.keys()}
x=[]
y_alpha = []
y_bu = []
y_bi = []

lamb = 1
for i in range(250):
    alpha = calculate_alpha(train_dict, beta_user_dict, beta_recipe_dict, N)
    beta_user_dict = calculate_beta_user(train_dict, recipes_per_user, alpha,␣
 ↪beta_recipe_dict, lamb)
    beta_recipe_dict = calculate_beta_item(train_dict, users_per_recipe, alpha,␣
 ↪beta_user_dict, lamb)
    x.append(i)
    y_alpha.append(alpha)
    y_bu.append(beta_user_dict['88348277'])
    y_bi.append(beta_recipe_dict['03969194'])
```

[ ]:

```
plt.xlabel("Iteration")
plt.plot(x, y_alpha, label='Alpha')
plt.legend()
```

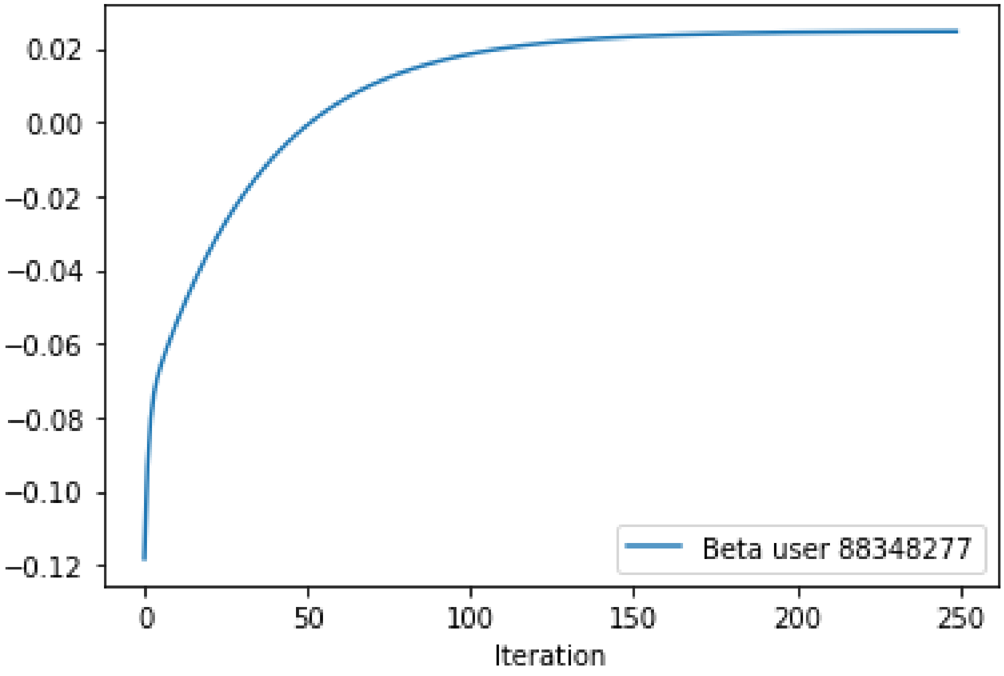
[ ]:

```
<matplotlib.legend.Legend at 0x7f44faa3f1f0>
```



```
[ ]: plt.xlabel("Iteration")
     plt.plot(x, y_bu, label='Beta user 88348277')
     plt.legend()
```

```
[ ]: <matplotlib.legend.Legend at 0x7f44fa9f3130>
```

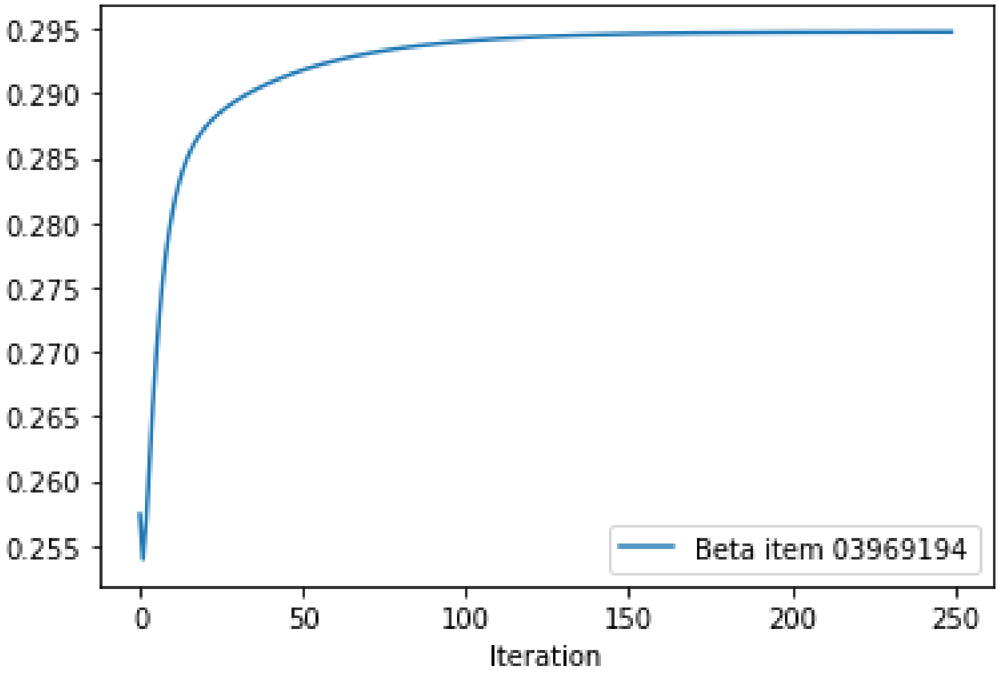


[ ]:

```
plt.xlabel("Iteration")
plt.plot(x, y_bi, label='Beta item 03969194')
plt.legend()
```

[ ]:

```
<matplotlib.legend.Legend at 0x7f44fb034670>
```



[ ]:

```
def MSE(predicted, validation):
    mse = 0
    for (user, recipe), review in predicted.items():
        mse += (review - validation[(user, recipe)])**2
    return mse/len(predicted)
```

[ ]:

```
pred_valid_dict_9 = defaultdict(int)
for user, recipe in valid_dict.keys():
    beta_user = beta_user_dict[user] if user in beta_user_dict else 0
    beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict else 0
    pred_valid_dict_9[(user, recipe)] = alpha + beta_user + beta_recipe
```

[ ]:

```
mse = MSE(pred_valid_dict_9, valid_dict)
print(f"MSE on the validation set: {mse}")
```

```
MSE on the validation set: 0.8803365761991694
```

1.3.2 Task 10

[ ]:

```
import math

user_lowest_value = math.inf
user_lowest_id = 0
user_highest_value = -math.inf
user_highest_id = 0

for user_id, beta_value in beta_user_dict.items():
    if beta_value > user_highest_value:
        user_highest_value = beta_value
        user_highest_id = user_id
    if beta_value < user_lowest_value:
        user_lowest_value = beta_value
        user_lowest_id = user_id

print(f"USER WITH SMALLEST BETA VALUE \nUser ID: {user_lowest_id}, Beta:␣
 ↪{user_lowest_value}")
print(f"\nUSER WITH LARGEST BETA VALUE \nUser ID: {user_highest_id}, Beta:␣
 ↪{user_highest_value}")


recipe_lowest_value = math.inf
recipe_lowest_id = 0
recipe_highest_value = -math.inf
recipe_highest_id = 0

for user_id, beta_value in beta_recipe_dict.items():
    if beta_value > recipe_highest_value:
        recipe_highest_value = beta_value
        recipe_highest_id = user_id
    if beta_value < recipe_lowest_value:
        recipe_lowest_value = beta_value
        recipe_lowest_id = user_id

print(f"\nRECIPE WITH SMALLEST BETA VALUE \nUser ID: {recipe_lowest_id}, Beta:␣
 ↪{recipe_lowest_value}")
print(f"\nRECIPE WITH LARGEST BETA VALUE \nUser ID: {recipe_highest_id}, Beta:␣
 ↪{recipe_highest_value}")
```

```
USER WITH SMALLEST BETA VALUE
User ID: 33431946, Beta: -4.380481082331884

USER WITH LARGEST BETA VALUE
User ID: 87153225, Beta: 1.1535736562941719

RECIPE WITH SMALLEST BETA VALUE
```

```
User ID: 33777570, Beta: -3.3635207273494365

RECIPE WITH LARGEST BETA VALUE
User ID: 14725150, Beta: 1.7529115477436843
```

1.3.3 Task 11

```
[ ]: ## Tuning the lambda parameter by coarse-tuning
     lamb = [0.01, 0.1, 1, 10]

     for l in lamb:
         beta_user_dict = {user:0 for user in recipes_per_user.keys()}
         beta_recipe_dict = {recipe:0 for recipe in users_per_recipe.keys()}
         for i in range(100):
             alpha = calculate_alpha(train_dict, beta_user_dict, beta_recipe_dict, N)
             beta_user_dict = calculate_beta_user(train_dict, recipes_per_user,␣
      ↪alpha, beta_recipe_dict, l)
             beta_recipe_dict = calculate_beta_item(train_dict, users_per_recipe,␣
      ↪alpha, beta_user_dict, l)

         pred_valid_dict_11 = defaultdict(int)
         for user, recipe in valid_dict.keys():
             beta_user = beta_user_dict[user] if user in beta_user_dict else 0
             beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict␣
      ↪else 0
             pred_valid_dict_11[(user, recipe)] = alpha + beta_user + beta_recipe

         mse = MSE(pred_valid_dict_11, valid_dict)

         print(f"MSE on the validation set with lambda={l}: {mse}")
```

```
MSE on the validation set with lambda=0.01: 1.024943027680394
MSE on the validation set with lambda=0.1: 0.9916221037025
MSE on the validation set with lambda=1: 0.8803862944245333
MSE on the validation set with lambda=10: 0.8198083327275589
```

```
[ ]: ## Tuning the lambda parameter by coarse-tuning
     lamb = [5, 10, 15, 20]

     for l in lamb:
         beta_user_dict = {user:0 for user in recipes_per_user.keys()}
         beta_recipe_dict = {recipe:0 for recipe in users_per_recipe.keys()}
         for i in range(100):
             alpha = calculate_alpha(train_dict, beta_user_dict, beta_recipe_dict, N)
             beta_user_dict = calculate_beta_user(train_dict, recipes_per_user,␣
      ↪alpha, beta_recipe_dict, l)
```

```
        beta_recipe_dict = calculate_beta_item(train_dict, users_per_recipe,␣
 ↪alpha, beta_user_dict, l)

    pred_valid_dict_11 = defaultdict(int)
    for user, recipe in valid_dict.keys():
        beta_user = beta_user_dict[user] if user in beta_user_dict else 0
        beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict␣
 ↪else 0
        pred_valid_dict_11[(user, recipe)] = alpha + beta_user + beta_recipe

    mse = MSE(pred_valid_dict_11, valid_dict)

    print(f"MSE on the validation set with lambda={l}: {mse}")
```

```
MSE on the validation set with lambda=5: 0.8251550501406563
MSE on the validation set with lambda=10: 0.8198083327275589
MSE on the validation set with lambda=15: 0.8206888107391213
MSE on the validation set with lambda=20: 0.8227300591931039
```

[ ]:

```
## Tuning the lambda parameter by coarse-tuning
lamb = [9, 9.5, 10, 10.5, 11]

for l in lamb:
    beta_user_dict = {user:0 for user in recipes_per_user.keys()}
    beta_recipe_dict = {recipe:0 for recipe in users_per_recipe.keys()}
    for i in range(100):
        alpha = calculate_alpha(train_dict, beta_user_dict, beta_recipe_dict, N)
        beta_user_dict = calculate_beta_user(train_dict, recipes_per_user,␣
 ↪alpha, beta_recipe_dict, l)
        beta_recipe_dict = calculate_beta_item(train_dict, users_per_recipe,␣
 ↪alpha, beta_user_dict, l)

    pred_valid_dict_11 = defaultdict(int)
    for user, recipe in valid_dict.keys():
        beta_user = beta_user_dict[user] if user in beta_user_dict else 0
        beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict␣
 ↪else 0
        pred_valid_dict_11[(user, recipe)] = alpha + beta_user + beta_recipe

    mse = MSE(pred_valid_dict_11, valid_dict)

    print(f"MSE on the validation set with lambda={l}: {mse}")
```

```
MSE on the validation set with lambda=9: 0.8200211338981331
MSE on the validation set with lambda=9.5: 0.8198874318795855
MSE on the validation set with lambda=10: 0.8198083327275589
MSE on the validation set with lambda=10.5: 0.8197752008430802
MSE on the validation set with lambda=11: 0.8197809489122868
```

[ ]:

```
print("After this trial and error procedure, I have found that the best MSE is␣
 ↪with lambda=10.5")

lamb = 11
for i in range(100):
    alpha = calculate_alpha(train_dict, beta_user_dict, beta_recipe_dict, N)
    beta_user_dict = calculate_beta_user(train_dict, recipes_per_user, alpha,␣
 ↪beta_recipe_dict, lamb)
    beta_recipe_dict = calculate_beta_item(train_dict, users_per_recipe, alpha,␣
 ↪beta_user_dict, lamb)

pred_valid_dict_11 = defaultdict(int)
for user, recipe in valid_dict.keys():
    beta_user = beta_user_dict[user] if user in beta_user_dict else 0
    beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict else 0
    pred_valid_dict_11[(user, recipe)] = alpha + beta_user + beta_recipe

mse = MSE(pred_valid_dict_11, valid_dict)

print(f"MSE on the validation set with lambda={10.5}: {mse}")
```

```
After this trial and error procedure, I have found that the best MSE is with
lambda=10.5
MSE on the validation set with lambda=10.5: 0.8197809488941853
```

[ ]:

```
header = ""
test_list = []
for line in open("data/stub_Rated.txt"):
    if line.startswith("user_id"):
        header = line
        continue
    user, recipe = line.strip().split('-')
    test_list.append((user, recipe))


pred_test_dict = defaultdict(int)

for (user, recipe) in test_list:
    beta_user = beta_user_dict[user] if user in beta_user_dict else 0
    beta_recipe = beta_recipe_dict[recipe] if recipe in beta_recipe_dict else 0
    pred_test_dict[(user, recipe)] = alpha + beta_user + beta_recipe

predictions = open("data/predictions_Rated.txt", 'w')
predictions.write(header)
for key, pred in pred_test_dict.items():
    user, recipe = key
    predictions.write(f"{user}-{recipe},{pred}\n")
```

Solution uploaded to Kaggle, and got an MSE of 0.8291. My Kaggle user name is henriklarsson-hestnes, with Henrik Larsson Hestnes as display name.