

Recommendations_with_IBM

November 3, 2019

1 Recommendations with IBM

In this notebook, you will be putting your recommendation skills to use on real data from the IBM Watson Studio platform.

You may either submit your notebook through the workspace here, or you may work from your local machine and submit through the next page. Either way assure that your code passes the project [RUBRIC](#). **Please save regularly.**

By following the table of contents, you will build out a number of different methods for making recommendations that can be used for different situations.

1.1 Table of Contents

I. Section ?? II. Section ?? III. Section ?? IV. Section ?? V. Section ?? VI. Section ??

At the end of the notebook, you will find directions for how to submit your work. Let's get started by importing the necessary libraries and reading in the data.

```
In [116]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import project_tests as t
import pickle

%matplotlib inline

df = pd.read_csv('data/user-item-interactions.csv')
df_content = pd.read_csv('data/articles_community.csv')
del df['Unnamed: 0']
del df_content['Unnamed: 0']

# Show df to get an idea of the data
df.head()
```

Out[116]:

| | article_id | title \ |
|---|------------|---|
| 0 | 1430.0 | using pixiedust for fast, flexible, and easier... |
| 1 | 1314.0 | healthcare python streaming application demo |
| 2 | 1429.0 | use deep learning for image classification |
| 3 | 1338.0 | ml optimization using cognitive assistant |
| 4 | 1276.0 | deploy your python model as a restful api |

```

                                email
0  ef5f11f77ba020cd36e1105a00ab868bbdbf7fe7
1  083cbdfa93c8444beaa4c5f5e0f5f9198e4f9e0b
2  b96a4f2e92d8572034b1e9b28f9ac673765cd074
3  06485706b34a5c9bf2a0ecdac41daf7e7654ceb7
4  f01220c46fc92c6e6b161b1849de11faacd7ccb2

```

```
In [117]: # Show df_content to get an idea of the data
df_content.head()
```

```
Out[117]:                                doc_body \
0  Skip navigation Sign in SearchLoading...\r\n\r...
1  No Free Hunch Navigation * kaggle.com\r\n\r\n ...
2  * Login\r\n * Sign Up\r\n\r\n * Learning Pat...
3  DATALAYER: HIGH THROUGHPUT, LOW LATENCY AT SCA...
4  Skip navigation Sign in SearchLoading...\r\n\r...
```

```
                                doc_description \
0  Detect bad readings in real time using Python ...
1  See the forest, see the trees. Here lies the c...
2  Heres this weeks news in Data Science and Bi...
3  Learn how distributed DBs solve the problem of...
4  This video demonstrates the power of IBM DataS...
```

```

                                doc_full_name doc_status  article_id
0  Detect Malfunctioning IoT Sensors with Streami...      Live          0
1  Communicating data science: A guide to present...      Live          1
2           This Week in Data Science (April 18, 2017)      Live          2
3  DataLayer Conference: Boost the performance of...      Live          3
4           Analyze NY Restaurant data using Spark in DSX      Live          4

```

1.1.1 Part I : Exploratory Data Analysis

Use the dictionary and cells below to provide some insight into the descriptive statistics of the data.

1. What is the distribution of how many articles a user interacts with in the dataset? Provide a visual and descriptive statistics to assist with giving a look at the number of times each user interacts with an article.

1.1.2 First we look at the data, we use the .describe() to look at article_id column in the df and df_content data

Ref: <https://www.geeksforgeeks.org/python-pandas-dataframe-describe-method/>

```
In [118]: # percentile list
perc = [.20, .25, .40, .50, .60, .75, .80]

# list of dtypes to include
```

```
include = ['object', 'float', 'int']
```

```
df.article_id.describe( percentiles = perc, include = include)
```

```
Out[118]: count      45993.000000
          mean        908.846477
          std         486.647866
          min           0.000000
          20%         310.000000
          25%         460.000000
          40%         910.000000
          50%        1151.000000
          60%        1185.000000
          75%        1336.000000
          80%        1362.000000
          max        1444.000000
          Name: article_id, dtype: float64
```

1.1.3 Similarly for df_content.article_id

```
In [119]: df_content.article_id.describe(percentiles = perc, include = include)
```

```
Out[119]: count      1056.000000
          mean        523.913826
          std         303.480641
          min           0.000000
          20%         210.000000
          25%         260.750000
          40%         418.000000
          50%         523.500000
          60%         628.000000
          75%         786.250000
          80%         839.000000
          max        1050.000000
          Name: article_id, dtype: float64
```

Analysis In the above cells, by looking at the results if describe, we can see that the article_ids of both data frames do not match with each other, df data frame has article id range from 0 to 1444, where as df_content range from 0 to 1050.

```
In [120]: ### we will use df data frame to look at the distribution of how many articles a user
          ### to interact with the article. We can use email to find out the count of interaction
```

```
user_interact = df.groupby('email')['article_id'].count()
user_interact.sort_values(ascending = False).head()
```

```
Out[120]: email
          2b6c0f514c2f2b04ad3c4583407dccd0810469ee      364
```

```

77959baaa9895a7e2bdc9297f8b27c1b6f2cb52a    363
2f5c7feae533ce046f2cb16fb3a29fe00528ed66    170
a37adec71b667b297ed2440a9ff7dad427c7ac85    169
8510a5010a5d4c89f5b07baac6de80cd12cfaf93    160
Name: article_id, dtype: int64

```

```
In [121]: user_interact.describe(percentiles = perc, include = include)
```

```

Out[121]: count      5148.000000
          mean         8.930847
          std        16.802267
          min         1.000000
          20%         1.000000
          25%         1.000000
          40%         2.000000
          50%         3.000000
          60%         5.000000
          75%         9.000000
          80%        11.000000
          max        364.000000
          Name: article_id, dtype: float64

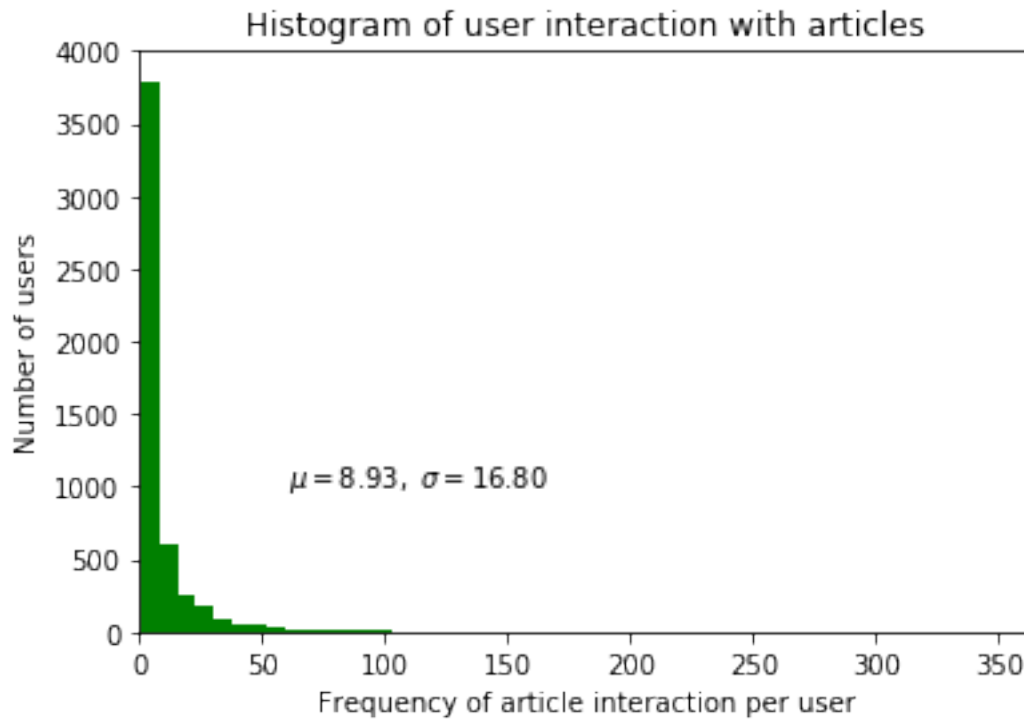
```

```

In [122]: ###Now we look at the visual representation
          ##Ref: https://matplotlib.org/3.1.1/gallery/pyplots/pyplot_text.html#sphx-glr-gallery-
          plt.hist(user_interact, bins = 50, color = 'g')
          plt.xlabel("Frequency of article interaction per user")
          plt.ylabel('Number of users')
          plt.title('Histogram of user interaction with articles')
          plt.text(60, 1000, r'$\mu=8.93, \sigma=16.80$')
          plt.xlim(0, 364)
          plt.ylim(0, 4000)

```

```
Out[122]: (0, 4000)
```



In []:

In [123]: *# Fill in the median and maximum number of user_article interactions below*

```
median_val = 3 # 50% of individuals interact with __3__ number of articles or fewer.
max_views_by_user = 364 # The maximum number of user-article interactions by any 1 user

print('50% of individuals interact with {} number of articles or fewer'.format(median_val))
print('The maximum number of user-article interactions by any 1 user is {}'.format(max_views_by_user))
```

50% of individuals interact with 3 number of articles or fewer

The maximum number of user-article interactions by any 1 user is 364

2. Explore and remove duplicate articles from the **df_content** dataframe.

In [124]: *# Find and explore duplicate articles*

```
df_content[df_content.duplicated(subset = 'article_id')]
```

```
Out[124]:
```

| | doc_body | \ |
|-----|---|---|
| 365 | Follow Sign in / Sign up Home About Insight Da... | |
| 692 | Homepage Follow Sign in / Sign up Homepage * H... | |
| 761 | Homepage Follow Sign in Get started Homepage *... | |

```

970 This video shows you how to construct queries ...
971 Homepage Follow Sign in Get started * Home\r\n...

```

```

                                doc_description \
365 During the seven-week Insight Data Engineering...
692 One of the earliest documented catalogs was co...
761 Todays world of data science leverages data f...
970 This video shows you how to construct queries ...
971 If you are like most data scientists, you are ...

```

| | doc_full_name | doc_status | article_id |
|-----|---|------------|------------|
| 365 | Graph-based machine learning | Live | 50 |
| 692 | How smart catalogs can turn the big data flood... | Live | 221 |
| 761 | Using Apache Spark as a parallel processing fr... | Live | 398 |
| 970 | Use the Primary Index | Live | 577 |
| 971 | Self-service data preparation with IBM Data Re... | Live | 232 |

```

In [125]: # Remove any rows that have the same article_id - only keep the first
df_content.drop_duplicates(subset = 'article_id', keep = 'first', inplace = True)

#check if there are any duplicates left.
df_content[df_content.duplicated(subset = 'article_id')]

```

```

Out[125]: Empty DataFrame
Columns: [doc_body, doc_description, doc_full_name, doc_status, article_id]
Index: []

```

1.1.4 Analysis:

As we can see there are no dupliates left

Ref: <https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.duplicated.html>

3. Use the cells below to find:

- The number of unique articles that have an interaction with a user.
- The number of unique articles in the dataset (whether they have any interactions or not).
- The number of unique users in the dataset. (excluding null values)
- The number of user-article interactions in the dataset.

a. The number of unique articles that have an interaction with a user.

c. The number of unique users in the dataset. (excluding null values)

Ref: <https://www.geeksforgeeks.org/python-pandas-dataframe-nunique/>

```

In [126]: a1 = df.nunique(axis = 0)
          a = a1['article_id']
          c = a1['email']
          print(a1)

```

```

        print(a)
        print(c)

article_id    714
title         714
email         5148
dtype: int64
714
5148

```

- b. The number of unique articles in the dataset (whether they have any interactions or not).
- d. The number of user-article interactions in the dataset.

Ref: <https://www.geeksforgeeks.org/python-pandas-dataframe-nunique/>

```

In [127]: b1 = df_content.nunique(axis = 0)
          b = b1['article_id']
          d= df.shape[0]
          print(b)
          print(d)

```

```

1051
45993

```

```

In [128]: unique_articles = a  # The number of unique articles that have at least one interaction
          total_articles = b# The number of unique articles on the IBM platform
          unique_users = c# The number of unique users
          user_article_interactions = d# The number of user-article interactions

          print('The number of unique articles that have at least one interaction are {}'.format(
          print('The number of unique articles on the IBM platform are {}'.format(b))
          print('The number of unique users are {}'.format(c))
          print('The number of user-article interactions are {}'.format(d))

```

```

The number of unique articles that have at least one interaction are 714
The number of unique articles on the IBM platform are 1051
The number of unique users are 5148
The number of user-article interactions are 45993

```

4. Use the cells below to find the most viewed **article_id**, as well as how often it was viewed. After talking to the company leaders, the `email_mapper` function was deemed a reasonable way to map users to ids. There were a small number of null values, and it was found that all of these null values likely belonged to a single user (which is how they are stored using the function below).

```
In [129]: ### Ref: https://stackoverflow.com/questions/48590268/pandas-get-the-most-frequent-val
```

```
df['article_id'].value_counts().idxmax()  
df['article_id'].value_counts().max()
```

```
Out[129]: 937
```

```
In [130]: most_viewed_article_id = df['article_id'].value_counts().idxmax().astype(str) # The m  
max_views = df['article_id'].value_counts().max() # The most viewed article in the da
```

```
print('The most viewed article in the dataset as a string with {}'.format(most_viewed_  
print('The most viewed article in the dataset was viewed {} times'.format(max_views))
```

The most viewed article in the dataset as a string with 1429.0

The most viewed article in the dataset was viewed 937 times

```
In [131]: ## No need to change the code here - this will be helpful for later parts of the noteb  
# Run this cell to map the user email to a user_id column and remove the email column
```

```
def email_mapper():  
    coded_dict = dict()  
    cter = 1  
    email_encoded = []  
  
    for val in df['email']:  
        if val not in coded_dict:  
            coded_dict[val] = cter  
            cter+=1  
  
        email_encoded.append(coded_dict[val])  
    return email_encoded
```

```
email_encoded = email_mapper()  
del df['email']  
df['user_id'] = email_encoded
```

```
# show header  
df.head()
```

```
Out[131]:
```

| | article_id | title | user_id |
|---|------------|---|---------|
| 0 | 1430.0 | using pixiedust for fast, flexible, and easier... | 1 |
| 1 | 1314.0 | healthcare python streaming application demo | 2 |
| 2 | 1429.0 | use deep learning for image classification | 3 |
| 3 | 1338.0 | ml optimization using cognitive assistant | 4 |
| 4 | 1276.0 | deploy your python model as a restful api | 5 |

```
In [132]: ## If you stored all your results in the variable names above,  
## you shouldn't need to change anything in this cell
```



```

sol_1_dict = {
    ``50% of individuals have _____ or fewer interactions.``: median_val,
    ``The total number of user-article interactions in the dataset is _____.``: user_
    ``The maximum number of user-article interactions by any 1 user is _____.``: max_
    ``The most viewed article in the dataset was viewed _____ times.``: max_views,
    ``The article_id of the most viewed article is _____.``: most_viewed_article_id,
    ``The number of unique articles that have at least 1 rating _____.``: unique_arti
    ``The number of unique users in the dataset is _____.``: unique_users,
    ``The number of unique articles on the IBM platform``: total_articles
}

# Test your dictionary against the solution
t.sol_1_test(sol_1_dict)

```

It looks like you have everything right here! Nice job!

1.1.5 Part II: Rank-Based Recommendations

Unlike in the earlier lessons, we don't actually have ratings for whether a user liked an article or not. We only know that a user has interacted with an article. In these cases, the popularity of an article can really only be based on how often an article was interacted with.

1. Fill in the function below to return the **n** top articles ordered with most interactions as the top. Test your function using the tests below.

```

In [133]: df['article_id'].value_counts().index[:5]

Out[133]: Float64Index([1429.0, 1330.0, 1431.0, 1427.0, 1364.0], dtype='float64')

In [134]: def get_top_articles(n, df=df):
    """
    INPUT:
    n - (int) the number of top articles to return
    df - (pandas dataframe) df as defined at the top of the notebook

    OUTPUT:
    top_articles - (list) A list of the top 'n' article titles

    """
    topn = df['article_id'].value_counts().index[:n]
    top_articles = list(df[df['article_id'].isin(topn)]['title'].unique())

    return top_articles # Return the top article titles from df (not df_content)

def get_top_article_ids(n, df=df):
    """
    INPUT:
    n - (int) the number of top articles to return

```

df - (pandas dataframe) df as defined at the top of the notebook

OUTPUT:

top_articles - (list) A list of the top 'n' article titles

'''

```
top_articles=list(df['article_id'].value_counts().index[:n])
```

```
return top_articles # Return the top article ids
```

```
In [135]: print(get_top_articles(10))
          print(get_top_article_ids(10))
```

```
['healthcare python streaming application demo', 'use deep learning for image classification', '
[1429.0, 1330.0, 1431.0, 1427.0, 1364.0, 1314.0, 1293.0, 1170.0, 1162.0, 1304.0]
```

```
In [136]: # Test your function by returning the top 5, 10, and 20 articles
```

```
top_5 = get_top_articles(5)
top_10 = get_top_articles(10)
top_20 = get_top_articles(20)
```

```
# Test each of your three lists from above
t.sol_2_test(get_top_articles)
```

Your top_5 looks like the solution list! Nice job.
Your top_10 looks like the solution list! Nice job.
Your top_20 looks like the solution list! Nice job.

1.1.6 Part III: User-User Based Collaborative Filtering

1. Use the function below to reformat the **df** dataframe to be shaped with users as the rows and articles as the columns.

- Each **user** should only appear in each **row** once.
- Each **article** should only show up in one **column**.
- If a user has interacted with an article, then place a 1 where the user-row meets for that **article-column**. It does not matter how many times a user has interacted with the article, all entries where a user has interacted with an article should be a 1.
- If a user has not interacted with an item, then place a zero where the user-row meets for that **article-column**.

Use the tests to make sure the basic structure of your matrix matches what is expected by the solution.

```
In [137]: ##test
          df2 = df.drop_duplicates(subset = ['user_id', 'article_id'])
          df2.head()
```

```
Out[137]:
```

| | article_id | title | user_id |
|---|------------|---|---------|
| 0 | 1430.0 | using pixiedust for fast, flexible, and easier... | 1 |
| 1 | 1314.0 | healthcare python streaming application demo | 2 |
| 2 | 1429.0 | use deep learning for image classification | 3 |
| 3 | 1338.0 | ml optimization using cognitive assistant | 4 |
| 4 | 1276.0 | deploy your python model as a restful api | 5 |

```
In [138]: ##test
```

```
user_item = df2.groupby(['user_id', 'article_id'])['title'].count().unstack()
user_item.head()
```

```
Out[138]:
```

| | article_id | 0.0 | 2.0 | 4.0 | 8.0 | 9.0 | 12.0 | 14.0 | 15.0 | \ |
|---------|------------|-----|-----|-----|-----|-----|------|------|------|---|
| user_id | | | | | | | | | | |
| 1 | | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | |
| 2 | | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | |
| 3 | | NaN | NaN | NaN | NaN | NaN | 1.0 | NaN | NaN | |
| 4 | | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | |
| 5 | | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | |

| | article_id | 16.0 | 18.0 | ... | 1434.0 | 1435.0 | 1436.0 | 1437.0 | 1439.0 | \ |
|---------|------------|------|------|-----|--------|--------|--------|--------|--------|---|
| user_id | | | | ... | | | | | | |
| 1 | | NaN | NaN | ... | NaN | NaN | 1.0 | NaN | 1.0 | |
| 2 | | NaN | NaN | ... | NaN | NaN | NaN | NaN | NaN | |
| 3 | | NaN | NaN | ... | NaN | NaN | 1.0 | NaN | NaN | |
| 4 | | NaN | NaN | ... | NaN | NaN | NaN | NaN | NaN | |
| 5 | | NaN | NaN | ... | NaN | NaN | NaN | NaN | NaN | |

| | article_id | 1440.0 | 1441.0 | 1442.0 | 1443.0 | 1444.0 |
|---------|------------|--------|--------|--------|--------|--------|
| user_id | | | | | | |
| 1 | | NaN | NaN | NaN | NaN | NaN |
| 2 | | NaN | NaN | NaN | NaN | NaN |
| 3 | | NaN | NaN | NaN | NaN | NaN |
| 4 | | NaN | NaN | NaN | NaN | NaN |
| 5 | | NaN | NaN | NaN | NaN | NaN |

[5 rows x 714 columns]

```
In [139]: ##test
```

```
user_item.fillna(0, inplace = True)

user_item.head()
```

```
Out[139]:
```

| | article_id | 0.0 | 2.0 | 4.0 | 8.0 | 9.0 | 12.0 | 14.0 | 15.0 | \ |
|---------|------------|-----|-----|-----|-----|-----|------|------|------|---|
| user_id | | | | | | | | | | |
| 1 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 2 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 3 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | |

| | | | | | | | | |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
| 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| | article_id | 16.0 | 18.0 | ... | 1434.0 | 1435.0 | 1436.0 | 1437.0 | 1439.0 | \ |
|---------|------------|------|------|-----|--------|--------|--------|--------|--------|---|
| user_id | | | | ... | | | | | | |
| 1 | | 0.0 | 0.0 | ... | 0.0 | 0.0 | 1.0 | 0.0 | 1.0 | |
| 2 | | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 3 | | 0.0 | 0.0 | ... | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | |
| 4 | | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 5 | | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |

| | article_id | 1440.0 | 1441.0 | 1442.0 | 1443.0 | 1444.0 |
|---------|------------|--------|--------|--------|--------|--------|
| user_id | | | | | | |
| 1 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[5 rows x 714 columns]

In [140]: # create the user-article matrix with 1's and 0's

```
def create_user_item_matrix(df):
    """
    INPUT:
    df - pandas dataframe with article_id, title, user_id columns

    OUTPUT:
    user_item - user item matrix

    Description:
    Return a matrix with user ids as rows and article ids on the columns with 1 values
    an article and a 0 otherwise
    """
    df2 = df.drop_duplicates(subset = ['user_id', 'article_id'])
    user_item = df2.groupby(['user_id', 'article_id'])['title'].count().unstack()
    user_item.fillna(0, inplace = True)

    return user_item # return the user_item matrix

user_item = create_user_item_matrix(df)
```

###Ref: <https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.unstack.html>

In [141]: ## Tests: You should just need to run this cell. Don't change the code.

```
assert user_item.shape[0] == 5149, "Oops! The number of users in the user-article mat"
```

31340441440451154026134042715404818404919405020405121214052224053234054244055254056264057274058284059294060304061314062

```
In [ ] :
In [ ] :
In [ ] :
In [ ] :
```

```
In [143]: def find_similar_users(user_id, user_item=user_item):
    '''
    INPUT:
    user_id - (int) a user_id
    user_item - (pandas dataframe) matrix of users by articles:
                1's when a user has interacted with an article, 0 otherwise

    OUTPUT:
    similar_users - (list) an ordered list where the closest users (largest dot product)
                    are listed first

    Description:
    Computes the similarity of every pair of users based on the dot product
    Returns an ordered

    '''
    ##First we get the list of ids, that is to be used for similarity
    ids = list(user_item.index)
    user_item_row = np.array(user_item[user_item.index == user_id])
    # compute similarity of each user to the provided user
```

```

dotx = np.dot(user_item_row, np.array(user_item).T)[0]
dotx = pd.Series(dotx, index = ids)
# sort by similarity
dotx_sorted = dotx.sort_values(ascending = False)

# remove the own user's id
dotx_sorted.drop(labels = [user_id], inplace = True)
# create list of just the ids
most_similar_users = list(dotx_sorted.index)

return most_similar_users # return a list of the users in order from most to least

```

```

In [144]: # Do a spot check of your function
print("The 10 most similar users to user 1 are: {}".format(find_similar_users(1)[:10]))
print("The 5 most similar users to user 3933 are: {}".format(find_similar_users(3933)[:5]))
print("The 3 most similar users to user 46 are: {}".format(find_similar_users(46)[:3]))

```

The 10 most similar users to user 1 are: [3933, 23, 3782, 203, 4459, 131, 3870, 46, 4201, 5041]

The 5 most similar users to user 3933 are: [1, 23, 3782, 4459, 203]

The 3 most similar users to user 46 are: [4201, 23, 3782]

3. Now that you have a function that provides the most similar users to each user, you will want to use these users to find articles you can recommend. Complete the functions below to return the articles you would recommend to each user.

```

In [145]: ##test

```

```

In [146]: def get_article_names(article_ids, df=df):
    '''
    INPUT:
    article_ids - (list) a list of article ids
    df - (pandas dataframe) df as defined at the top of the notebook

    OUTPUT:
    article_names - (list) a list of article names associated with the list of article_ids
    (this is identified by the title column)
    '''

    # First we start an empty list
    article_names = []
    ## we convert the article ids into float data type, just in case if they were a string
    article_ids = list(map(float, article_ids))

    #getting a dataframe with respect to article ids
    df_article = df.drop_duplicates(subset = 'article_id')[['article_id', 'title']].sort_values('article_id')
    article_name = list(df_article.loc[article_ids]['title'])

```

```

#Now for loop
for name in article_name:
    try:
        name = name.replace("\nName: title, dtype: object", "")
    except:
        continue
    article_names.append(name)

return article_names # Return the article names associated with list of article id

def get_user_articles(user_id, user_item=user_item):
    '''
    INPUT:
    user_id - (int) a user id
    user_item - (pandas dataframe) matrix of users by articles:
                1's when a user has interacted with an article, 0 otherwise

    OUTPUT:
    article_ids - (list) a list of the article ids seen by the user
    article_names - (list) a list of article names associated with the list of article
                    (this is identified by the doc_full_name column in df_content)

    Description:
    Provides a list of the article_ids and article titles that have been seen by a user
    '''
    # first get a row for user defined in the function
    user_row = user_item.loc[user_id]
    # Now we get the index where we have interactions
    user_ind = np.where(user_row == 1)
    #Now article ids
    article_ids = list(user_row.index[user_ind])
    ##Now we use the function above to get the article names
    article_names = get_article_names(article_ids)
    return article_ids, article_names # return the ids and names

def user_user_recs(user_id, m=10):
    '''
    INPUT:
    user_id - (int) a user id
    m - (int) the number of recommendations you want for the user

    OUTPUT:
    recs - (list) a list of recommendations for the user

    Description:

```

*Loops through the users based on closeness to the input user_id
 For each user - finds articles the user hasn't seen before and provides them as recommendations
 Does this until m recommendations are found*

Notes:

Users who are the same closeness are chosen arbitrarily as the 'next' user

*For the user where the number of recommended articles starts below m
 and ends exceeding m, the last items are chosen arbitrarily*

```
'''
#stat an empty list to store ids of recommended articles

recs = []

#finding similar users to current users and articles viewed by current user and similar users
sim_users = find_similar_users(user_id)
for i in sim_users:
    rec_ids, rec_names = get_user_articles(i)

    seen_ids, seen_names = get_user_articles(user_id)
    rec_articles = np.setdiff1d(np.array(rec_ids), np.array(seen_ids), assume_unique=True)
    recs.extend(list(rec_articles))

    # if we have enough articles
    if len(recs) >= m:
        break

recs = recs[:m]

return recs # return your recommendations for this user_id
```

##Ref: <https://docs.scipy.org/doc/numpy/reference/generated/numpy.setdiff1d.html>

In [147]: # Check Results

```
get_article_names(user_user_recs(1, 10)) # Return 10 recommendations for user 1
```

```
Out[147]: ['this week in data science (april 18, 2017)',
'timeseries data analysis of iot events by using jupyter notebook',
'got zip code data? prep it for analytics. ibm watson data lab medium',
'higher-order logistic regression for large datasets',
'using machine learning to predict parking difficulty',
'deep forest: towards an alternative to deep neural networks',
'experience iot with coursera',
'using brunel in ipython/jupyter notebooks',
'graph-based machine learning',
'the 3 kinds of context: machine learning and the art of the frame']
```



```
In [148]: # Test your functions here - No need to change this code - just run this cell
assert set(get_article_names(['1024.0', '1176.0', '1305.0', '1314.0', '1422.0', '1427.0'])) == set(['housing (2015): united states demography'])
assert set(get_article_names(['1320.0', '232.0', '844.0'])) == set(['housing (2015): united states demography'])
assert set(get_user_articles(20)[0]) == set([1320.0, 232.0, 844.0])
assert set(get_user_articles(20)[1]) == set(['housing (2015): united states demography'])
assert set(get_user_articles(2)[0]) == set([1024.0, 1176.0, 1305.0, 1314.0, 1422.0, 1427.0])
assert set(get_user_articles(2)[1]) == set(['using deep learning to reconstruct high-resolution face images'])
print("If this is all you see, you passed all of our tests! Nice job!")
```

If this is all you see, you passed all of our tests! Nice job!

4. Now we are going to improve the consistency of the `user_user_recs` function from above.

- Instead of arbitrarily choosing when we obtain users who are all the same closeness to a given user - choose the users that have the most total article interactions before choosing those with fewer article interactions.
- Instead of arbitrarily choosing articles from the user where the number of recommended articles starts below m and ends exceeding m , choose articles with the articles with the most total interactions before choosing those with fewer total interactions. This ranking should be what would be obtained from the **top_articles** function you wrote earlier.

```
In [151]: ##First we get the list of ids, that is to be used for similarity
ids = list(user_item.index)
ids
```

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Out[151]: [1,
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In [ ]:
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```
In [193]: def get_top_sorted_users(user_id, df=df, user_item=user_item):  
    '''  
    INPUT:  
    user_id - (int)  
    df - (pandas dataframe) df as defined at the top of the notebook  
    user_item - (pandas dataframe) matrix of users by articles:  
                1's when a user has interacted with an article, 0 otherwise  
  
    OUTPUT:  
    neighbors_df - (pandas dataframe) a dataframe with:  
                    neighbor_id - is a neighbor user_id  
                    similarity - measure of the similarity of each user to the provide  
                    num_interactions - the number of articles viewed by the user - if  
  
    Other Details - sort the neighbors_df by the similarity and then by number of inte  
                    highest of each is higher in the dataframe  
  
    '''  
    # Your code here  
    ##First we get the list of ids, that is to be used for similarity--we copy it from
```

```

ids = list(user_item.index)
user_item_row = np.array(user_item[user_item.index == user_id])
# compute similarity of each user to the provided user
dotx = np.dot(user_item_row, np.array(user_item).T)[0]
dotx = pd.Series(dotx, index = ids)

#Now we compute number of interactions which we have also computed above so we will
user_inter_art = df.groupby('user_id')['article_id'].count()
inter_count = user_inter_art.loc[ids]
neighbors_df = pd.DataFrame({'neighbour_id': ids, 'similarity' :dotx,\
                             'num_interactions':inter_count}).set_index('neighbour_id')

#Now we remove current user as we have done before
neighbors_df.drop([user_id], inplace = True)
neighbors_df.sort_values(['similarity', 'num_interactions'], ascending = [False, False],
                          inplace = True)

#Now we remove current user as we have done before

return neighbors_df # Return the dataframe specified in the doc_string

def user_user_recs_part2(user_id, m=10):
    '''
    INPUT:
    user_id - (int) a user id
    m - (int) the number of recommendations you want for the user

    OUTPUT:
    recs - (list) a list of recommendations for the user by article id
    rec_names - (list) a list of recommendations for the user by article title

    Description:
    Loops through the users based on closeness to the input user_id
    For each user - finds articles the user hasn't seen before and provides them as recommendations
    Does this until m recommendations are found

    Notes:
    * Choose the users that have the most total article interactions
    before choosing those with fewer article interactions.

    * Choose articles with the articles with the most total interactions
    before choosing those with fewer total interactions.

    '''
    #we have created a similar function above, following the same steps
    recs = []

```

```

#finding similar users to current users and articles viewed by current user and si
top_users = get_top_sorted_users(user_id)
topidx = top_users.index.values
art_inter = df.groupby(['article_id'])['user_id'].count()

## we created a similar for loop before(i.e. above)
for i in topidx:
    rec_ids, rec_names = get_user_articles(i)

    seen_ids, seen_names = get_user_articles(user_id)
    rec_articles = np.setdiff1d(np.array(rec_ids), np.array(seen_ids), assume_unique=True)
    sort_rec_articles = art_inter.loc[rec_articles].sort_values(ascending=False).i
    recs.extend(sort_rec_articles)

    # if we have enough articles
    if len(recs) >= m:
        break

# get only top m articles
recs = recs[:m]

rec_names = get_article_names(recs)

return recs, rec_names

```

In []:

```

In [194]: # Quick spot check - don't change this code - just use it to test your functions
rec_ids, rec_names = user_user_recs_part2(20, 10)
print("The top 10 recommendations for user 20 are the following article ids:")
print(rec_ids)
print()
print("The top 10 recommendations for user 20 are the following article names:")
print(rec_names)

```

The top 10 recommendations for user 20 are the following article ids:
[1330.0, 1427.0, 1364.0, 1170.0, 1162.0, 1304.0, 1351.0, 1160.0, 1354.0, 1368.0]

The top 10 recommendations for user 20 are the following article names:
['insights from new york car accident reports', 'use xgboost, scikit-learn & ibm watson machine

In [197]: get_top_sorted_users(1).head()

```

Out[197]:
          similarity  num_interactions
neighbour_id

```


| | | |
|------|------|-----|
| 3933 | 35.0 | 45 |
| 23 | 17.0 | 364 |
| 3782 | 17.0 | 363 |
| 203 | 15.0 | 160 |
| 4459 | 15.0 | 158 |

5. Use your functions from above to correctly fill in the solutions to the dictionary below. Then test your dictionary against the solution. Provide the code you need to answer each following the comments below.

```
In [198]: get_top_sorted_users(131).head(10)
```

```
Out[198]:
```

| | similarity | num_interactions |
|--------------|------------|------------------|
| neighbour_id | | |
| 3870 | 74.0 | 144 |
| 3782 | 39.0 | 363 |
| 23 | 38.0 | 364 |
| 203 | 33.0 | 160 |
| 4459 | 33.0 | 158 |
| 98 | 29.0 | 170 |
| 3764 | 29.0 | 169 |
| 49 | 29.0 | 147 |
| 3697 | 29.0 | 145 |
| 242 | 25.0 | 148 |

```
In [199]: ### Tests with a dictionary of results
```

```
user1_most_sim = 3933# Find the user that is most similar to user 1
user131_10th_sim = 242# Find the 10th most similar user to user 131
```

```
In [200]: ## Dictionary Test Here
```

```
sol_5_dict = {
    'The user that is most similar to user 1.': user1_most_sim,
    'The user that is the 10th most similar to user 131': user131_10th_sim,
}
```

```
t.sol_5_test(sol_5_dict)
```

This all looks good! Nice job!

6. If we were given a new user, which of the above functions would you be able to use to make recommendations? Explain. Can you think of a better way we might make recommendations? Use the cell below to explain a better method for new users.

Provide your response here:

Analysis: Since we have no information about the new user, so collaborative filtering will not be the best option, as we will not be able to compare and match with other users and provide recommendations, however we can use top rated recommendations, and just recommend top

7. Using your existing functions, provide the top 10 recommended articles you would provide for the a new user below. You can test your function against our thoughts to make sure we are all on the same page with how we might make a recommendation.

```
# What would your recommendations be for this new user '0.0'? As a new user, they have
# Provide a list of the top 10 article ids you would give to
new_user_recs = list(map(str, get_top_article_ids(10)))
# Your recommendations here
```

```
In [211]: assert set(new_user_recs) == set(['1314.0', '1429.0', '1293.0', '1427.0', '1162.0', '1364.0'])  
  
print("That's right! Nice job!")
```

1.1.7 Part IV: Content Based Recommendations (EXTRA - NOT REQUIRED)

1. Use the function body below to create a content based recommender. Since there isn't one right answer for this recommendation tactic, no test functions are provided. Feel free to change the function inputs if you decide you want to try a method that requires more input values. The input values are currently set with one idea in mind that you may use to make content based recommendations. One additional idea is that you might want to choose the most popular recommendations that meet your 'content criteria', but again, there is a lot of flexibility in how you might make these recommendations.

```
In [ ]: def make_content_recs():
```

INPUT:

OUTPUT:

'''

2. Now that you have put together your content-based recommendation system, use the cell below to write a summary explaining how your content based recommender works. Do you see any possible improvements that could be made to your function? Is there anything novel about your content based recommender?

1.1.9 This part is NOT REQUIRED to pass this project. However, you may choose to take this on as an extra way to show off your skills.

Write an explanation of your content based recommendation system here.

3. Use your content-recommendation system to make recommendations for the below scenarios based on the comments. Again no tests are provided here, because there isn't one right answer that could be used to find these content based recommendations.

1.1.10 This part is NOT REQUIRED to pass this project. However, you may choose to take this on as an extra way to show off your skills.

```
In [ ]: # make recommendations for a brand new user
```

```
# make a recommendations for a user who only has interacted with article id '1427.0'
```

1.1.11 Part V: Matrix Factorization

In this part of the notebook, you will build use matrix factorization to make article recommendations to the users on the IBM Watson Studio platform.

1. You should have already created a **user_item** matrix above in **question 1** of **Part III** above. This first question here will just require that you run the cells to get things set up for the rest of **Part V** of the notebook.

```
In [212]: # Load the matrix here
user_item_matrix = pd.read_pickle('user_item_matrix.p')
```

```
In [213]: # quick look at the matrix
user_item_matrix.head()
```

```
Out[213]: article_id  0.0  100.0  1000.0  1004.0  1006.0  1008.0  101.0  1014.0  1015.0  \
user_id
1          0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
2          0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
3          0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
4          0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
5          0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
```

| | article_id | 1016.0 | ... | 977.0 | 98.0 | 981.0 | 984.0 | 985.0 | 986.0 | 990.0 | \ |
|---------|------------|--------|-----|-------|------|-------|-------|-------|-------|-------|---|
| user_id | | ... | | | | | | | | | |
| 1 | | 0.0 | ... | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 2 | | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 3 | | 0.0 | ... | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 4 | | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 5 | | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |

| | article_id | 993.0 | 996.0 | 997.0 |
|---------|------------|-------|-------|-------|
| user_id | | | | |
| 1 | | 0.0 | 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 |
| 5 | | 0.0 | 0.0 | 0.0 |

[5 rows x 714 columns]

2. In this situation, you can use Singular Value Decomposition from [numpy](#) on the user-item matrix. Use the cell to perform SVD, and explain why this is different than in the lesson.

```
In [214]: # Perform SVD on the User-Item Matrix Here
          ## Ref: https://docs.scipy.org/doc/numpy/reference/routines.linalg.html
          u, s, vt = np.linalg.svd(user_item_matrix, full_matrices=False) # use the built in to g

In [215]: u.shape, s.shape, vt.shape

Out[215]: ((5149, 714), (714,), (714, 714))
```

Provide your response here.

Analysis: We can see that there are total of 5149 users, upto 714 latent features and 714 articles. Dimensions of all matrices are correct for dot product.

3. Now for the tricky part, how do we choose the number of latent features to use? Running the below cell, you can see that as the number of latent features increases, we obtain a lower error rate on making predictions for the 1 and 0 values in the user-item matrix. Run the cell below to get an idea of how the accuracy improves as we increase the number of latent features.

```
In [216]: num_latent_feats = np.arange(10,700+10,20)
          sum_errs = []

          for k in num_latent_feats:
              # restructure with k latent features
              s_new, u_new, vt_new = np.diag(s[:k]), u[:, :k], vt[:k, :]

              # take dot product
              user_item_est = np.around(np.dot(np.dot(u_new, s_new), vt_new))

              # compute error for each prediction to actual value
```

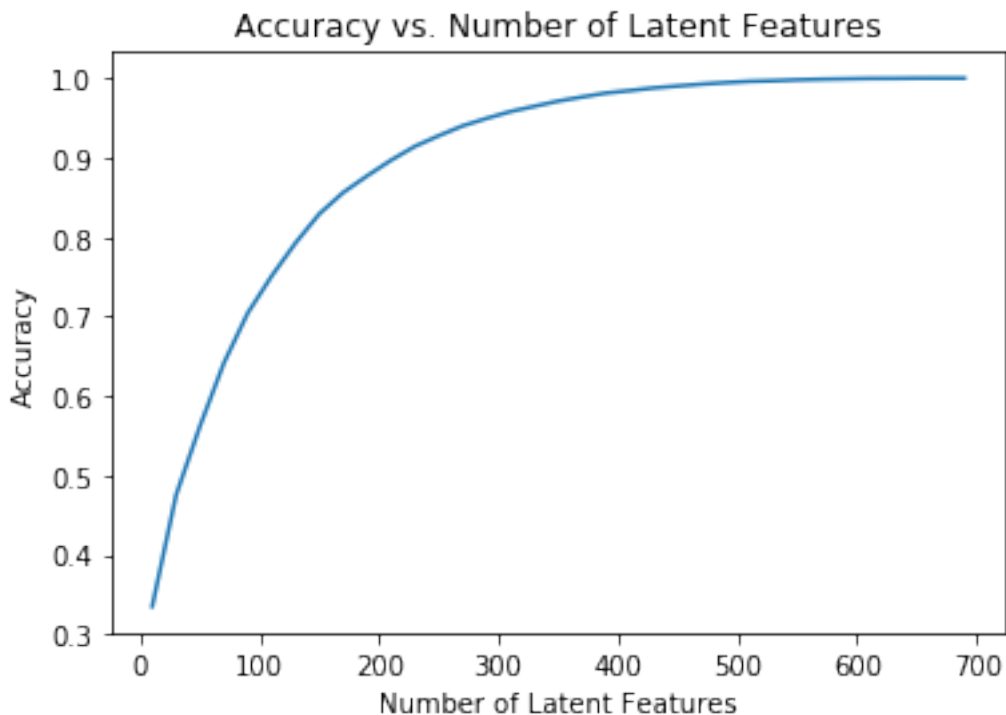
```

diffs = np.subtract(user_item_matrix, user_item_est)

# total errors and keep track of them
err = np.sum(np.sum(np.abs(diffs)))
sum_errs.append(err)

plt.plot(num_latent_feats, 1 - np.array(sum_errs)/df.shape[0]);
plt.xlabel('Number of Latent Features');
plt.ylabel('Accuracy');
plt.title('Accuracy vs. Number of Latent Features');

```



4. From the above, we can't really be sure how many features to use, because simply having a better way to predict the 1's and 0's of the matrix doesn't exactly give us an indication of if we are able to make good recommendations. Instead, we might split our dataset into a training and test set of data, as shown in the cell below.

Use the code from question 3 to understand the impact on accuracy of the training and test sets of data with different numbers of latent features. Using the split below:

- How many users can we make predictions for in the test set?
- How many users are we not able to make predictions for because of the cold start problem?
- How many articles can we make predictions for in the test set?
- How many articles are we not able to make predictions for because of the cold start problem?

```

In [221]: df_train = df.head(40000)
          df_test = df.tail(5993)

def create_test_and_train_user_item(df_train, df_test):
    '''
    INPUT:
    df_train - training dataframe
    df_test - test dataframe

    OUTPUT:
    user_item_train - a user-item matrix of the training dataframe
                     (unique users for each row and unique articles for each column)
    user_item_test - a user-item matrix of the testing dataframe
                     (unique users for each row and unique articles for each column)
    test_idx - all of the test user ids
    test_arts - all of the test article ids

    '''
    user_item_train = create_user_item_matrix(df_train)
    user_item_test = create_user_item_matrix(df_test)
    test_idx = user_item_test.index.values
    test_arts = user_item_test.columns.values

    return user_item_train, user_item_test, test_idx, test_arts

user_item_train, user_item_test, test_idx, test_arts = create_test_and_train_user_item

In [225]: train_idx = user_item_train.index.values
          numtest = len(np.intersect1d(test_idx, train_idx))
          numtest

Out[225]: 20

In [227]: numtest_null = len(test_idx) - numtest
          numtest_null

Out[227]: 662

In [228]: train_arts = user_item_train.columns.values
          numarts = len(np.intersect1d(test_arts, train_arts))
          numarts

Out[228]: 574

In [229]: numarts_null = len(test_arts) - numarts
          numarts_null

Out[229]: 0

```

```

In [231]: # Replace the values in the dictionary below
a = 662
b = 574
c = 20
d = 0

sol_4_dict = {
    'How many users can we make predictions for in the test set?': c,
    'How many users in the test set are we not able to make predictions for because of': b,
    'How many movies can we make predictions for in the test set?': b,
    'How many movies in the test set are we not able to make predictions for because of': c
}

t.sol_4_test(sol_4_dict)

```

Awesome job! That's right! All of the test movies are in the training data, but there are only

5. Now use the **user_item_train** dataset from above to find U, S, and V transpose using SVD. Then find the subset of rows in the **user_item_test** dataset that you can predict using this matrix decomposition with different numbers of latent features to see how many features makes sense to keep based on the accuracy on the test data. This will require combining what was done in questions 2 - 4.

Use the cells below to explore how well SVD works towards making predictions for recommendations on the test data.

```

In [232]: # fit SVD on the user_item_train matrix
u_train, s_train, vt_train = np.linalg.svd(user_item_train, full_matrices=False) # fit
u_train.shape, s_train.shape, vt_train.shape

Out[232]: ((4487, 714), (714,), (714, 714))

In [233]: # Now we find the subset of rows in user_item_Test

u_test = u_train[user_item_train.index.isin(test_idx), :]
u_test.shape

Out[233]: (20, 714)

In [236]: ## Now we find the subset of vtrain inside the test_arts

vt_test = vt_train[:, user_item_train.columns.isin(test_arts)]

vt_test.shape

Out[236]: (714, 574)

In [249]: pred = np.intersect1d(test_idx, train_idx)
user_test_sub = user_item_test[user_item_test.index.isin(pred)]
user_test_sub.shape

```

Out[249]: (20, 574)

```
In [253]: # Use these cells to see how well you can use the training  
# decomposition to predict on test data
```

```
from sklearn.metrics import accuracy_score
```

```
num_latent = np.arange(10,710,20)
```

```
train_acc = []
```

```
test_acc = []
```

```
### We emulated from the class room and created new matrices for different number of l
```

```
for i in num_latent:
```

```
    new_utrain, new_strain, new_vttrain = u_train[:, :i], np.diag(s_train[:i]), vt_train[:, :i]
```

```
    new_ustest, new_vttest = u_test[:, :i], vt_test[:, :i]
```

```
    ###Dot product of matrices
```

```
    user_item_train_pred = np.around(np.dot(np.dot(new_utrain, new_strain), new_vttrain))
```

```
    user_item_test_pred = np.around(np.dot(np.dot(new_ustest, new_strain), new_vttest))
```

```
    # clip predictions to 1 and 1 range
```

```
    # since we are only predicting whether user will interact with articles
```

```
    # which is a binary outcome
```

```
    user_item_train_pred = np.clip(user_item_train_pred, 0, 1)
```

```
    user_item_test_pred = np.clip(user_item_test_pred, 0, 1)
```

```
    # get accuracy score for this iteration
```

```
    acc_train = accuracy_score(np.array(user_item_train_pred).flatten(), user_item_train_pred)
```

```
    acc_test = accuracy_score(np.array(user_item_test_pred).flatten(), user_item_test_pred)
```

```
    train_acc.append(acc_train)
```

```
    test_acc.append(acc_test)
```

```
In [255]: fig, ax1 = plt.subplots();
```

```
    ax2 = ax1.twinx();
```

```
    ax1.plot(num_latent, train_acc, label="Train accuracy");
```

```
    ax2.plot(num_latent, test_acc, color='green', label="Test accuracy");
```

```
    handle1, label1 = ax1.get_legend_handles_labels();
```

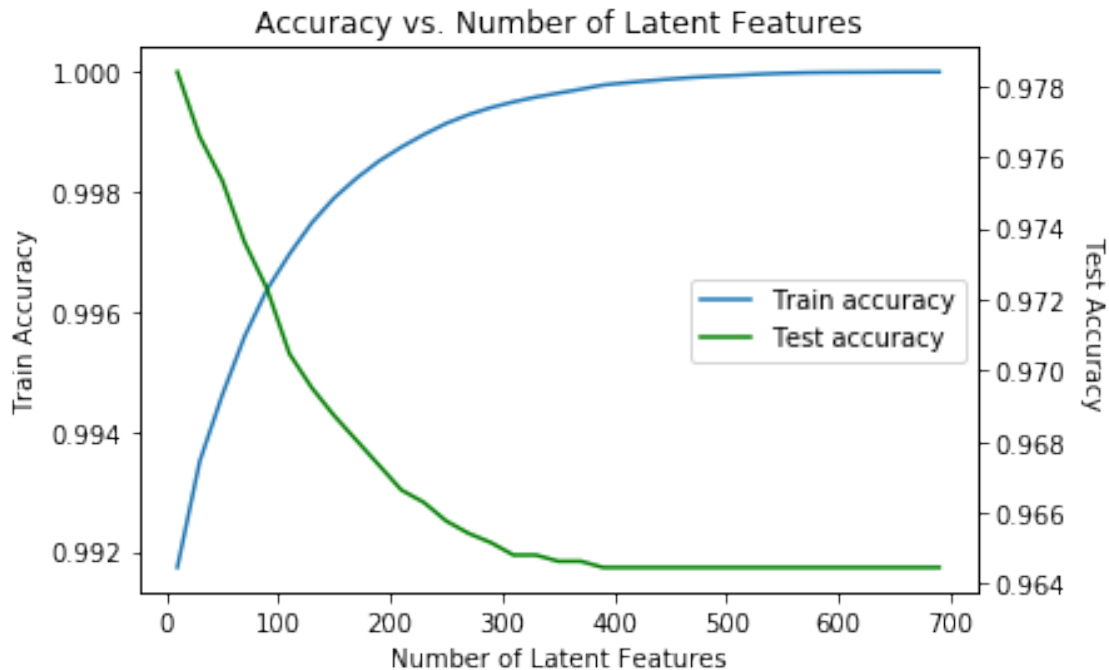
```
    handle2, label2 = ax2.get_legend_handles_labels();
```

```
    ax1.legend(handle1+handle2, label1+label2, loc='center right');
```

```
    ax1.set_title('Accuracy vs. Number of Latent Features');
```



```
ax1.set_xlabel('Number of Latent Features');
ax1.set_ylabel('Train Accuracy');
ax2.set_ylabel('Test Accuracy', rotation=270, labelpad=15);
```



In []:

In []:

In []:

6. Use the cell below to comment on the results you found in the previous question. Given the circumstances of your results, discuss what you might do to determine if the recommendations you make with any of the above recommendation systems are an improvement to how users currently find articles?

Your response here.

Analysis: As we have seen above that classes are highly imbalanced as there are lots of articles that user have no interacted with, as shown by the large proportion of class 0 as compared to class 1. There might be some overfitting, as we have used 740 latent features, which makes the model complex and takes into account even small changes, however we can rectify that by making the model simpler and using less latent features. We can see above that the best accuracy of test, train sets can be achieved when we use approximately 100 latent features. If we use above, it leads to over fitting.

Since we can only predict for 20 users, so above fitting might not be accurate representation for our prediction. A better metric will be the article recommendation and not article interaction.

It could be that user never interacted with the article because they don't like it, or maybe the user likes the article but has not yet interacted with it on the platform.

We can also use A/B testing to see how our predictions are working. We can assign half the users to the control group and half to the experimental group.

Extras Using your workbook, you could now save your recommendations for each user, develop a class to make new predictions and update your results, and make a flask app to deploy your results. These tasks are beyond what is required for this project. However, from what you learned in the lessons, you are certainly capable of taking these tasks on to improve upon your work here!

1.2 Conclusion

Congratulations! You have reached the end of the Recommendations with IBM project!

Tip: Once you are satisfied with your work here, check over your report to make sure that it satisfies all the areas of the [rubric](#). You should also probably remove all of the "Tips" like this one so that the presentation is as polished as possible.

1.3 Directions to Submit

Before you submit your project, you need to create a .html or .pdf version of this notebook in the workspace here. To do that, run the code cell below. If it worked correctly, you should get a return code of 0, and you should see the generated .html file in the workspace directory (click on the orange Jupyter icon in the upper left).

Alternatively, you can download this report as .html via the **File > Download as** sub-menu, and then manually upload it into the workspace directory by clicking on the orange Jupyter icon in the upper left, then using the Upload button.

Once you've done this, you can submit your project by clicking on the "Submit Project" button in the lower right here. This will create and submit a zip file with this .ipynb doc and the .html or .pdf version you created. Congratulations!

```
In [256]: from subprocess import call
          call(['python', '-m', 'nbconvert', 'Recommendations_with_IBM.ipynb'])
```

```
Out[256]: 0
```

```
In [ ]:
```