

mra

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```
[1]: import numpy as np
import pandas as pd
import sklearn
import matplotlib as mpl
import matplotlib.pyplot as plt
import os

print(f"    numpy version: {np.__version__}")
print(f"    pandas version: {pd.__version__}")
print(f"    sklearn version: {sklearn.__version__}")
print(f"matplotlib version: {mpl.__version__}")
```

```
    numpy version: 1.26.4
    pandas version: 2.2.1
    sklearn version: 1.4.1.post1
matplotlib version: 3.8.3
```

```
[3]: df = pd.read_csv('./movies.csv')

# Display the first few rows of the DataFrame
print(df.head())
```

	movieId	title \
0	1	Toy Story (1995)
1	2	Jumanji (1995)
2	3	Grumpier Old Men (1995)
3	4	Waiting to Exhale (1995)
4	5	Father of the Bride Part II (1995)

	genres
0	Adventure Animation Children Comedy Fantasy
1	Adventure Children Fantasy
2	Comedy Romance
3	Comedy Drama Romance
4	Comedy

```
[4]: df = pd.read_csv('./ratings.csv')
print(df.head())
```

	userId	movieId	rating	timestamp
0	1	1	4.0	964982703
1	1	3	4.0	964981247
2	1	6	4.0	964982224
3	1	47	5.0	964983815
4	1	50	5.0	964982931

```
[5]: df = pd.read_csv('./links.csv')
      print(df.head())
```

	movieId	imdbId	tmdbId
0	1	114709	862.0
1	2	113497	8844.0
2	3	113228	15602.0
3	4	114885	31357.0
4	5	113041	11862.0

```
[6]: df = pd.read_csv('./tags.csv')
      print(df.head())
```

	userId	movieId	tag	timestamp
0	2	60756	funny	1445714994
1	2	60756	Highly quotable	1445714996
2	2	60756	will ferrell	1445714992
3	2	89774	Boxing story	1445715207
4	2	89774	MMA	1445715200

```
[2]: movies_df = pd.read_csv('./movies.csv')
      ratings_df = pd.read_csv('./ratings.csv')
      links_df = pd.read_csv('./links.csv')
      tags_df = pd.read_csv('./tags.csv')
```

```
[3]: # Display the first few rows of each DataFrame
      print("Movies DataFrame:")
      print(movies_df.head())

      print("\nRatings DataFrame:")
      print(ratings_df.head())

      print("\nLinks DataFrame:")
      print(links_df.head())

      print("\nTags DataFrame:")
      print(tags_df.head())
```

Movies DataFrame:

	movieId	title \
0	1	Toy Story (1995)
1	2	Jumanji (1995)

2	3	Grumpier Old Men (1995)
3	4	Waiting to Exhale (1995)
4	5	Father of the Bride Part II (1995)

	genres
0	Adventure Animation Children Comedy Fantasy
1	Adventure Children Fantasy
2	Comedy Romance
3	Comedy Drama Romance
4	Comedy

Ratings DataFrame:

	userId	movieId	rating	timestamp
0	1	1	4.0	964982703
1	1	3	4.0	964981247
2	1	6	4.0	964982224
3	1	47	5.0	964983815
4	1	50	5.0	964982931

Links DataFrame:

	movieId	imdbId	tmdbId
0	1	114709	862.0
1	2	113497	8844.0
2	3	113228	15602.0
3	4	114885	31357.0
4	5	113041	11862.0

Tags DataFrame:

	userId	movieId	tag	timestamp
0	2	60756	funny	1445714994
1	2	60756	Highly quotable	1445714996
2	2	60756	will ferrell	1445714992
3	2	89774	Boxing story	1445715207
4	2	89774	MMA	1445715200

```
[4]: # Compute summary statistics
ratings_summary = ratings_df.describe()
print("Summary Statistics for Ratings:")
print(ratings_summary)

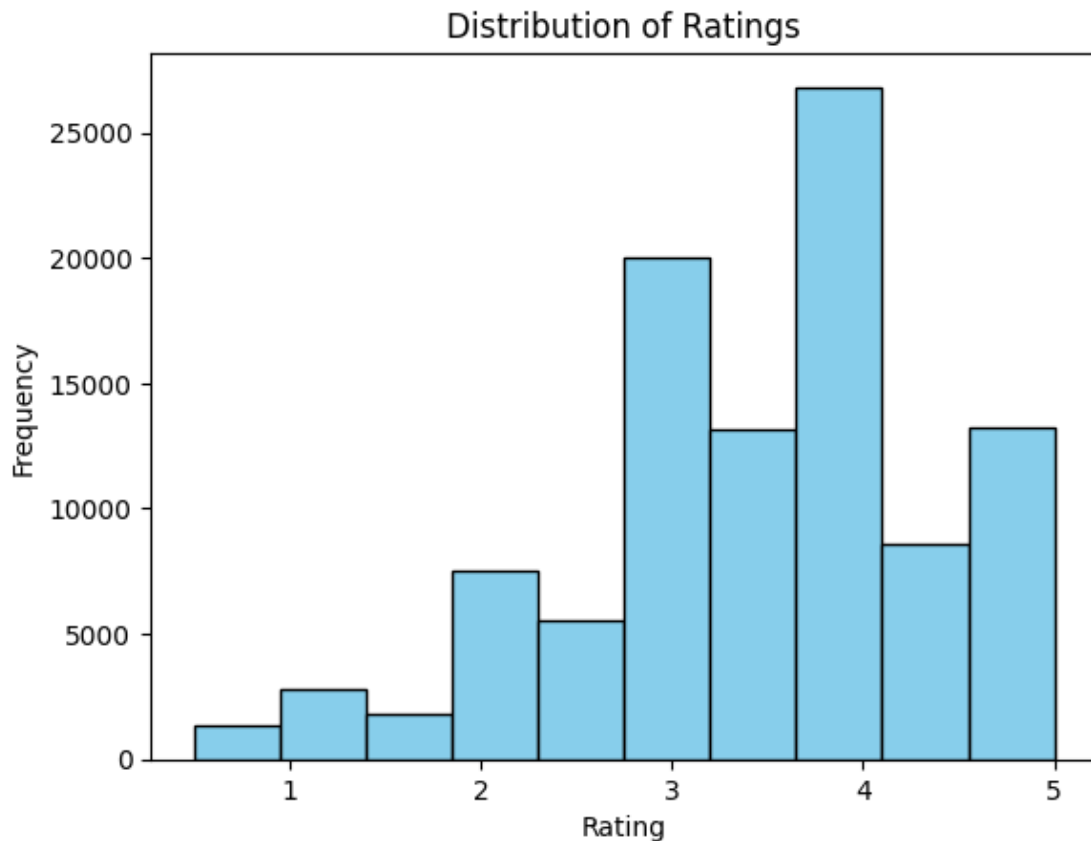
# Visualize the distribution of ratings
import matplotlib.pyplot as plt

plt.hist(ratings_df['rating'], bins=10, color='skyblue', edgecolor='black')
plt.xlabel('Rating')
plt.ylabel('Frequency')
plt.title('Distribution of Ratings')
```

```
plt.show()
```

Summary Statistics for Ratings:

	userId	movieId	rating	timestamp
count	100836.000000	100836.000000	100836.000000	1.008360e+05
mean	326.127564	19435.295718	3.501557	1.205946e+09
std	182.618491	35530.987199	1.042529	2.162610e+08
min	1.000000	1.000000	0.500000	8.281246e+08
25%	177.000000	1199.000000	3.000000	1.019124e+09
50%	325.000000	2991.000000	3.500000	1.186087e+09
75%	477.000000	8122.000000	4.000000	1.435994e+09
max	610.000000	193609.000000	5.000000	1.537799e+09



```
[5]: # Merge ratings and movies DataFrames on movieId
ratings_movies_df = pd.merge(ratings_df, movies_df, on='movieId', how='inner')
print(ratings_movies_df.head())
```

	userId	movieId	rating	timestamp	title \
0	1	1	4.0	964982703	Toy Story (1995)
1	1	3	4.0	964981247	Grumpier Old Men (1995)
2	1	6	4.0	964982224	Heat (1995)

3	1	47	5.0	964983815	Seven (a.k.a. Se7en) (1995)
4	1	50	5.0	964982931	Usual Suspects, The (1995)

	genres
0	Adventure Animation Children Comedy Fantasy
1	Comedy Romance
2	Action Crime Thriller
3	Mystery Thriller
4	Crime Mystery Thriller

```
[6]: import networkx as nx

# Assuming you have loaded the ratings data into a DataFrame ratings_df

# Create a directed graph
G = nx.DiGraph()

# Add edges for each user-item interaction
for _, row in ratings_df.iterrows():
    user_id = row['userId']
    movie_id = row['movieId']
    G.add_edge(user_id, movie_id) # Assuming user ID and movie ID are unique
    ↪ identifiers

# Print the number of nodes and edges in the graph
print("Number of nodes in the graph:", G.number_of_nodes())
print("Number of edges in the graph:", G.number_of_edges())
```

Number of nodes in the graph: 9811
 Number of edges in the graph: 100836

```
[7]: from community import community_louvain

# Assuming you have already created a user-item interaction network graph, G
G_undirected = G.to_undirected()

# Detect communities using the Louvain algorithm
partition = community_louvain.best_partition(G_undirected)

# Print the number of communities detected
num_communities = max(partition.values()) + 1
print("Number of communities detected:", num_communities)

# Assign community labels to nodes in the graph
nx.set_node_attributes(G, partition, 'community')

# Access community labels for individual nodes
community_labels = nx.get_node_attributes(G, 'community')
```

```
# Print the community labels of the first few nodes
for node, community_label in list(community_labels.items())[:5]:
    print("Node:", node, "- Community:", community_label)
```

Number of communities detected: 6

Node: 1.0 - Community: 0

Node: 3.0 - Community: 1

Node: 6.0 - Community: 1

Node: 47.0 - Community: 1

Node: 50.0 - Community: 2

```
[8]: import pandas as pd

# Create an empty list to store the rows
rows = []

# Iterate over the nodes in the graph
for node, community_label in partition.items():
    # Append the node and its community label to the list
    rows.append({'Node': node, 'Community': community_label})

# Create a DataFrame from the list of rows
community_df = pd.DataFrame(rows)

# Convert node IDs to integer type
community_df['Node'] = community_df['Node'].astype(int)

# Print the first few rows of the DataFrame
print(community_df.head())
```

	Node	Community
0	1	0
1	3	1
2	6	1
3	47	1
4	50	2

```
[9]: # Assuming you have the DataFrame 'community_df' containing community labels
# You can replace 'community_df' with the actual DataFrame name if it's
↳different

# Calculate the size of each community
community_size = community_df['Community'].value_counts().sort_index()

# Print the size of each community
print("Size of each community:")
print(community_size)
```

```

# Calculate the distribution of nodes across communities
community_distribution = community_size.value_counts().sort_index()

# Print the distribution of nodes across communities
print("\nDistribution of nodes across communities:")
print(community_distribution)

# Calculate the number of unique communities
num_communities = community_df['Community'].nunique()
print("\nNumber of unique communities:", num_communities)

# Calculate the interactions within and between communities (if applicable)
# You may need additional data (e.g., ratings, interactions) to analyze
    ↪ interactions

# Example: If 'ratings_df' contains user-item interactions, you can calculate
# the average rating within each community
# Assuming 'ratings_df' has columns 'userId', 'movieId', and 'rating'
# and 'community_df' has columns 'Node' and 'Community'

# Merge 'community_df' with 'ratings_df' on the common column (e.g., userId)
community_ratings_df = pd.merge(community_df, ratings_df, left_on='Node',
    ↪ right_on='userId', how='inner')

# Calculate average rating within each community
avg_rating_per_community = community_ratings_df.groupby('Community')['rating'].
    ↪ mean()

# Print average rating within each community
print("\nAverage rating within each community:")
print(avg_rating_per_community)

```

Size of each community:

Community

0	2015
1	610
2	3037
3	812
4	789
5	2548

Name: count, dtype: int64

Distribution of nodes across communities:

count

610	1
789	1

```

812      1
2015     1
2548     1
3037     1
Name: count, dtype: int64

```

Number of unique communities: 6

Average rating within each community:

```

Community
0      3.534961
1      3.621345
2      3.598736
3      3.460557
4      2.993375
5      3.274992
Name: rating, dtype: float64

```

```

[10]: # Assuming you have the necessary DataFrames: ratings_df, tags_df, movies_df,
      ↪and community_df

      # Merge ratings_df with community_df to associate community labels with ratings
ratings_community_df = pd.merge(ratings_df, community_df, left_on='userId',
      ↪right_on='Node', how='inner')

      # Merge movies_df with ratings_community_df to associate movie information with
      ↪ratings and community labels
ratings_community_movies_df = pd.merge(ratings_community_df, movies_df,
      ↪on='movieId', how='inner')

      # Calculate average ratings for each movie within each community
avg_ratings_per_community_movie = ratings_community_movies_df.
      ↪groupby(['Community', 'title'])['rating'].mean().reset_index()

      # Print average ratings for each movie within each community
print("Average ratings for each movie within each community:")
print(avg_ratings_per_community_movie.head(10)) # Displaying first 10 rows as
      ↪an example

      # Similarly, you can perform analysis on tags or other metadata associated with
      ↪the nodes (e.g., movies or users)

      # Merge tags_df with ratings_community_movies_df to associate tags with movies
      ↪and community labels
tags_community_movies_df = pd.merge(tags_df, ratings_community_movies_df,
      ↪on='movieId', how='inner')

      # Analyze tags within each community (e.g., most frequent tags)

```



```

top_tags_per_community = tags_community_movies_df.groupby(['Community',
↳ 'tag'])['tag'].count().reset_index(name='tag_count')
top_tags_per_community = top_tags_per_community.sort_values(by=['Community',
↳ 'tag_count'], ascending=[True, False])

# Print top tags within each community
print("\nTop tags within each community:")
print(top_tags_per_community.head(10)) # Displaying first 10 rows as an example

```

Average ratings for each movie within each community:

	Community	title	rating
0	0	'Hellboy': The Seeds of Creation (2004)	4.000000
1	0	'Round Midnight (1986)	3.500000
2	0	'Salem's Lot (2004)	5.000000
3	0	'Til There Was You (1997)	4.000000
4	0	'burbs, The (1989)	2.833333
5	0	(500) Days of Summer (2009)	4.000000
6	0	*batteries not included (1987)	3.500000
7	0	...And Justice for All (1979)	3.500000
8	0	10 (1979)	3.333333
9	0	10 Items or Less (2006)	2.500000

Top tags within each community:

	Community	tag	tag_count
1078	0	sci-fi	755
1213	0	twist ending	624
487	0	atmospheric	529
638	0	dark comedy	528
1124	0	space	515
584	0	classic	508
808	0	imdb top 250	502
1193	0	time travel	482
1191	0	thought-provoking	462
454	0	aliens	457

```

[11]: from community import community_louvain
import networkx as nx
G = nx.Graph()

# Iterate over the rows of the ratings DataFrame
for index, row in ratings_df.iterrows():
    user_id = row['userId']
    movie_id = row['movieId']
    rating = row['rating']

    # Add edges for each user-item interaction
    G.add_edge(user_id, movie_id, weight=rating)

```

```

# Assuming you have already created a user-item interaction network graph, G
# Convert the graph to an undirected graph
G_undirected = G.to_undirected()

partition = community_louvain.best_partition(G_undirected)

# Evaluate modularity
modularity = community_louvain.modularity(partition, G_undirected)

# Evaluate community structure quality (e.g., average community size)
community_sizes = {c: sum(1 for node, comm in partition.items() if comm == c)}
    ↪ for c in set(partition.values())}
avg_community_size = sum(community_sizes.values()) / len(community_sizes)

# Print evaluation metrics
print("Modularity:", modularity)
print("Average community size:", avg_community_size)

```

Modularity: 0.25383615928161896

Average community size: 1401.5714285714287

Drawback: The Louvain algorithm requires tuning of resolution parameter, which affects the granularity of the detected communities. Inappropriate parameter settings can lead to suboptimal community detection.

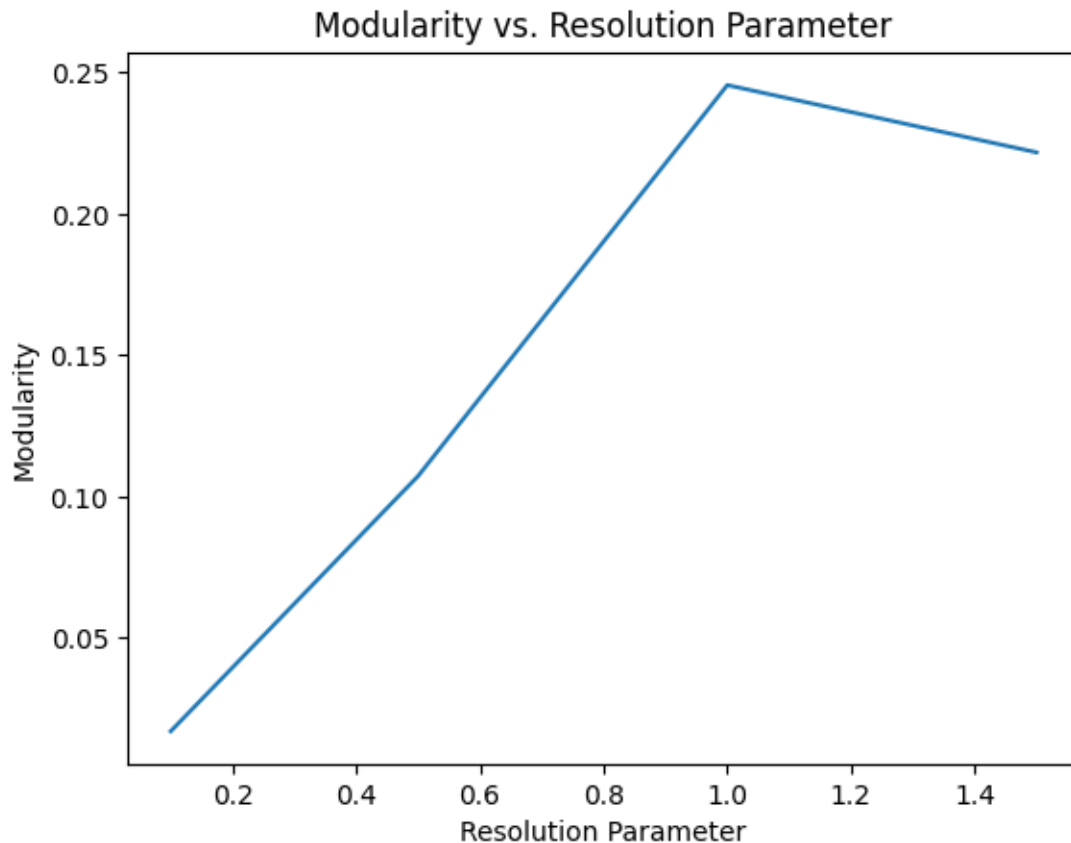
```

[13]: # Sensitivity to resolution parameter
resolution_values = [0.1, 0.5, 1.0, 1.5]
modularity_values = []

for resolution in resolution_values:
    partition = community_louvain.best_partition(G_undirected,
    ↪ resolution=resolution)
    modularity = community_louvain.modularity(partition, G_undirected)
    modularity_values.append(modularity)

# Plot modularity values for different resolution parameters
plt.plot(resolution_values, modularity_values)
plt.xlabel('Resolution Parameter')
plt.ylabel('Modularity')
plt.title('Modularity vs. Resolution Parameter')
plt.show()

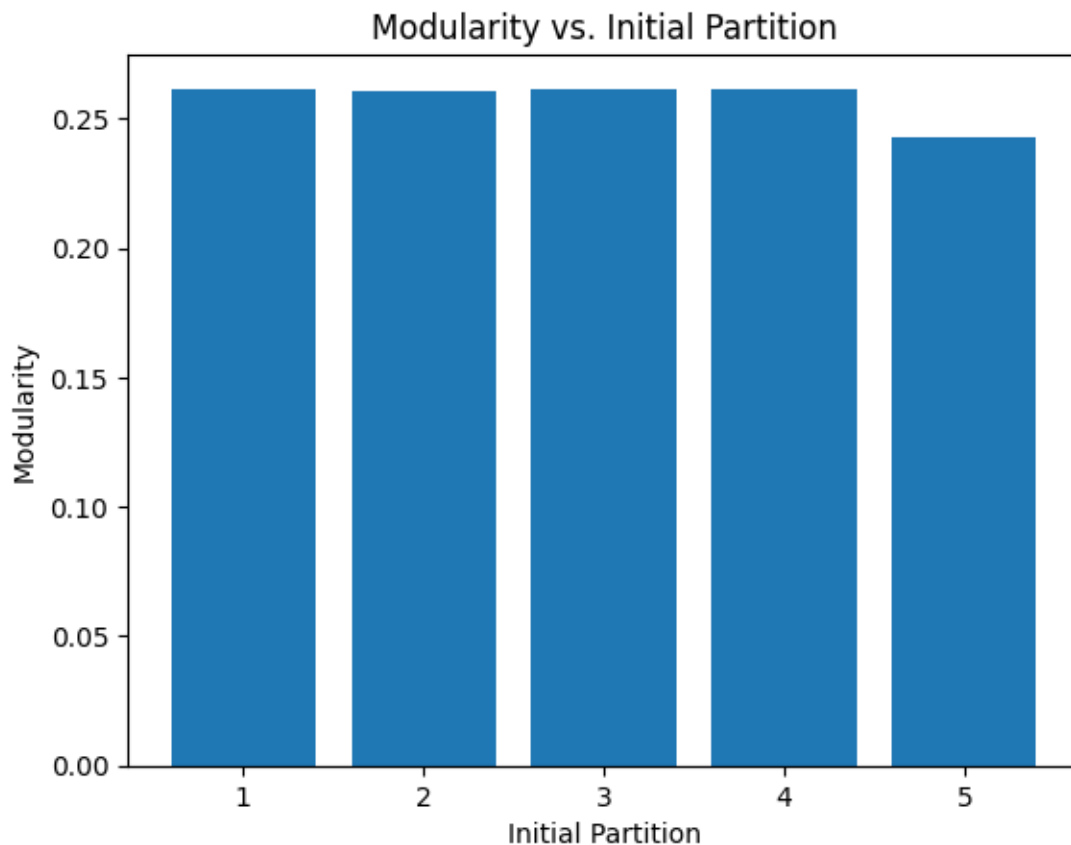
```



The Louvain algorithm's performance can be influenced by the initial partitioning of the network. Different initial conditions may lead to different final community structures.

```
[14]: # Dependency on initial conditions
initial_partitions = [community_louvain.best_partition(G_undirected) for _ in
    ↪range(5)]
modularity_values = [community_louvain.modularity(partition, G_undirected) for
    ↪partition in initial_partitions]

# Plot modularity values for different initial partitions
plt.bar(range(1, 6), modularity_values)
plt.xlabel('Initial Partition')
plt.ylabel('Modularity')
plt.title('Modularity vs. Initial Partition')
plt.show()
```



```
[15]: print(ratings_community_movies_df.head(10))
```

	userId	movieId	rating	timestamp	Node	Community	\
0	1	1	4.0	964982703	1	0	
1	1	3	4.0	964981247	1	0	
2	1	6	4.0	964982224	1	0	
3	1	47	5.0	964983815	1	0	
4	1	50	5.0	964982931	1	0	
5	1	70	3.0	964982400	1	0	
6	1	101	5.0	964980868	1	0	
7	1	110	4.0	964982176	1	0	
8	1	151	5.0	964984041	1	0	
9	1	157	5.0	964984100	1	0	

	title	genres
0	Toy Story (1995)	Adventure Animation Children Comedy Fantasy
1	Grumpier Old Men (1995)	Comedy Romance
2	Heat (1995)	Action Crime Thriller
3	Seven (a.k.a. Se7en) (1995)	Mystery Thriller
4	Usual Suspects, The (1995)	Crime Mystery Thriller

5	From Dusk Till Dawn (1996)	Action Comedy Horror Thriller
6	Bottle Rocket (1996)	Adventure Comedy Crime Romance
7	Braveheart (1995)	Action Drama War
8	Rob Roy (1995)	Action Drama Romance War
9	Canadian Bacon (1995)	Comedy War

```
[16]: # Assuming you have applied the Louvain algorithm and obtained community_
↳assignments
# Also assuming you have a DataFrame `community_df` containing user-community_
↳mapping
# And a DataFrame `ratings_df` containing user-item interactions

# Step 1: Generate Recommendations
# Example: Recommend the most popular items within each community
louvain_recommendations = {}

for community_id, group in ratings_community_movies_df.groupby('Community'):
    # Get the users in the current community
    users_in_community = group['userId'].tolist()

    # Filter ratings for users in the current community
    ratings_in_community = ratings_df[ratings_df['userId'].
↳isin(users_in_community)]

    # Group by item and calculate the count of ratings for each item
    item_counts = ratings_in_community.groupby('movieId').size().
↳reset_index(name='count')

    # Sort items by count in descending order to get the most popular items
    popular_items = item_counts.sort_values(by='count', ascending=False)

    # Store the recommended items for the current community
    louvain_recommendations[community_id] = popular_items['movieId'].tolist()
```

```
[17]: # Iterate over the louvain_recommendations dictionary and print each_
↳community's recommendations
for community_id, recommendations in louvain_recommendations.items():
    print(f"Community {community_id} recommendations: {recommendations}")
```

```
Community 0 recommendations: [260, 1196, 593, 2571, 2858, 356, 296, 1198, 1210,
318, 480, 2028, 858, 1580, 589, 2762, 608, 527, 1214, 1270, 1197, 1200, 50, 110,
457, 780, 2628, 1265, 1213, 1240, 1097, 1291, 1, 541, 2716, 1036, 1136, 2959,
150, 924, 1259, 32, 912, 1617, 3578, 1610, 2987, 592, 1208, 1089, 2918, 2916,
1193, 1968, 648, 377, 2115, 2396, 1221, 2174, 1387, 2683, 2797, 380, 1258, 2000,
47, 590, 2997, 919, 1923, 1127, 3175, 1356, 111, 1219, 1391, 750, 2791, 1220,
1721, 1206, 904, 1222, 1079, 3793, 1527, 1304, 1584, 1573, 1374, 1704, 1288,
1307, 2706, 903, 1101, 1225, 1784, 2985, 1517, 1653, 733, 1961, 2640, 4993,
4226, 1080, 2406, 34, 3996, 587, 1073, 2617, 597, 1917, 1393, 588, 1682, 316,
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Community 1 recommendations: [296, 318, 356, 110, 150, 592, 380, 480, 593, 590, 457, 344, 589, 588, 165, 153, 780, 47, 349, 1, 316, 377, 32, 161, 364, 367, 454, 527, 231, 434, 292, 208, 253, 648, 595, 50, 329, 500, 185, 10, 736, 339, 34, 300, 597, 587, 95, 539, 39, 410, 141, 2571, 260, 62, 733, 288, 357, 266, 21, 608, 225, 25, 586, 36, 440, 1073, 6, 2, 19, 317, 474, 17, 350, 1210, 293, 509, 786, 168, 337, 2858, 11, 553, 7, 420, 858, 160, 442, 5, 368, 432, 788, 236, 104, 508, 1356, 315, 1196, 1198, 2959, 48, 2028, 435, 252, 282, 223, 163, 2762, 552, 173, 551, 112, 158, 5952, 376, 151, 653, 494, 186, 111, 1704, 520, 16, 1270, 594, 708, 224, 3, 661, 802, 7153, 353, 261, 172, 196, 333, 235, 7361, 3578, 1393, 485, 4973, 58559, 1580, 265, 204, 4993, 277, 555, 1721, 1265, 1197, 778, 193, 4226, 805, 2329, 1036, 256, 1214, 628, 272, 852, 2628, 22, 4306, 145, 355, 273, 596, 637, 370, 31, 497, 1240, 237, 44, 3793, 1193, 783, 466, 784, 79132, 762, 1089, 48516, 6539, 60, 362, 1291, 2396, 2502, 135, 719, 276, 585, 5445, 52, 1221, 1527, 216, 227, 5989, 44191, 6377, 4878, 529, 4995, 471, 327, 616, 371, 2706, 6874, 230, 1206, 1208, 6016, 342, 1136, 2683, 5418, 610, 743, 431, 541, 540, 68954, 475, 524, 3147, 832, 8961, 3949, 5349, 4886, 1367, 1246, 1923, 14, 1097, 9, 1784, 8360, 203, 8636, 2716, 246, 51662, 1682, 1258, 1259, 6365, 849, 1917, 79, 1391, 58, 33794, 3623, 1407, 455, 543, 2572, 45, 4011, 1485, 4963, 4022, 198, 1732, 5618, 383, 6934, 673, 1200, 1213, 60069, 140, 65, 3996, 7438, 515, 248, 3948, 3897, 1968, 348, 924, 218, 1584, 1225, 107, 761, 1653, 1307, 2080, 4896, 1222, 477, 2324, 280, 281, 2692, 2617, 35836, 2355, 2353, 303, 1517, 745, 105, 109487, 3114, 72998, 707, 234, 837, 1101, 912, 1617, 63082, 207, 170, 32587, 2115, 46578, 3363, 5378, 2085, 1961, 1387, 2987, 33493, 880, 8368, 374, 4979, 48385, 1625, 1234, 419, 6711, 724, 647, 345, 413, 54286, 4034, 12, 222,

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Community 2 recommendations: [79132, 2571, 356, 318, 7153, 58559, 2959, 4993, 5952, 68954, 260, 6539, 296, 60069, 72998, 4306, 593, 59315, 8961, 1198, 6377, 33794, 6874, 91529, 109487, 4226, 3578, 89745, 1196, 68157, 99114, 2028, 858, 4886, 69122, 5989, 74458, 5816, 527, 112852, 48516, 8368, 4896, 5418, 4963, 48780, 7438, 1210, 1, 50, 54286, 122904, 7361, 2762, 4995, 44191, 2858, 47, 1704, 70286, 76093, 91500, 69844, 50872, 589, 1270, 49272, 109374, 116797, 2329, 88125, 1036, 96079, 1291, 73017, 63082, 293, 1682, 40815, 5349, 106782, 80463, 81845, 48394, 110, 364, 1732, 1721, 122882, 3793, 5218, 3147, 608, 51662, 134130, 45722, 4878, 59784, 78499, 4973, 5445, 68358, 6365, 77561, 1221, 1265, 111759, 54001, 71535, 3949, 5618, 1193, 35836, 56367, 8360, 1580, 1136, 46578, 134853, 81834, 480, 1197, 6934, 1213, 1089, 87232, 3948, 56174, 33493, 122886, 32587, 1214, 51255, 4022, 4011, 6373, 8665, 588, 115617, 48774, 53125, 79702, 64614, 6016, 98809, 54503, 52973, 79091, 3114, 55820, 119145, 49530, 8644, 30793, 91542, 780, 6942, 57669, 8636, 34162, 31685, 1206, 1200, 2324, 91658, 60684, 367, 76251, 59369, 152081, 8641, 85414, 1527, 8361, 2628, 541, 3751, 41566, 5378, 7293, 81591, 1258, 4027, 1240, 112552, 64957, 88140, 778, 92259, 58998, 2918, 96610, 3996, 88129, 5459, 6863, 69757, 150, 47099, 102125, 112556, 48385, 110102, 33679, 8874, 2706, 55247, 108932, 52722, 4246, 7147, 37729, 2, 4262, 97938, 64969, 2716, 63113, 54272, 4816, 4025, 139385, 86332, 2115, 115149, 7143, 595, 32, 45447, 106487, 106696, 750, 104841, 500, 61323, 111362, 5956, 88163, 8529, 924, 95167, 106489, 33615, 45499, 34405, 4447, 69481, 1222, 95510, 97304, 47610, 97921, 27773, 122892, 94864, 61024, 122918, 7254, 6333, 4720, 84152, 59615, 30707, 3535, 1968, 6378, 586, 93510, 8533, 6711, 44199, 102445, 344, 55765, 4018, 1961, 377, 457, 74789, 122900, 45517, 72641, 7451, 7458, 166528, 2011, 2291, 34048, 8984, 53996, 648, 6502, 912, 72011, 2012, 68237, 116823, 94959, 1923, 164179, 3717, 2997, 2355, 53322, 2502, 1097, 60040, 31696, 3081, 231, 66097, 81847, 168252, 1247, 551, 104, 87869, 45720, 117529, 2791,

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2565, 2570, 2575, 2491, 2482, 2585, 2390, 2366, 2377, 2380, 2381, 2382, 2383,
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2463, 2465, 2476, 2582, 2586, 2835, 2772, 2731, 2732, 2741, 2743, 2748, 2751,
2752, 2757, 2765, 2766, 2775, 2713, 2782, 2784, 2786, 2793, 2801, 2802, 2805,
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2696, 2697, 2698, 3420, 3422, 3436, 4197, 4153, 4157, 4166, 4168, 4171, 4178,
4181, 4184, 4189, 4195, 4200, 4130, 4204, 4207, 4217, 4218, 4219, 4236, 4240,
4242, 4243, 4251, 4139, 4129, 4255, 4061, 3988, 4006, 4023, 4030, 4031, 4032,
4042, 4043, 4046, 4055, 4064, 4123, 4065, 4066, 4077, 4080, 4082, 4086, 4089,
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3898, 3899, 3900, 3901, 3918, 3744, 3919, 3920, 3928, 3929, 3932, 3937, 3951,
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3790, 3794, 3795, 3801, 3802, 3808, 3810, 3813, 3816, 3821, 3823, 3837, 3838, 3839, 3840, 2358, 2357, 2349, 861, 725, 731, 760, 764, 795, 804, 806, 835, 839, 841, 867, 691, 881, 885, 893, 897, 907, 917, 918, 921, 929, 932, 718, 688, 937, 638, 580, 583, 600, 609, 611, 619, 631, 632, 634, 637, 639, 680, 640, 645, 650, 661, 665, 667, 668, 670, 674, 678, 935, 938, 1324, 1184, 1099, 1114, 1117, 1121, 1131, 1132, 1156, 1161, 1176, 1177, 1191, 1082, 1194, 1202, 1236, 1238, 1279, 1280, 1286, 1305, 1306, 1321, 1096, 1078, 941, 990, 944, 945, 947, 955, 956, 959, 961, 970, 976, 982, 993, 1068, 1005, 1009, 1012, 1014, 1017, 1018, 1024, 1034, 1040, 1051, 579, 577, 574, 240, 181, 187, 199, 202, 205, 211, 212, 217, 228, 234, 242, 177, 248, 250, 251, 259, 263, 265, 270, 281, 291, 305, 179, 174, 573, 68, 8, 9, 12, 20, 38, 48, 54, 60, 61, 63, 74, 146, 78, 79, 80, 87, 93, 96, 116, 118, 119, 135, 315, 321, 328, 513, 460, 461, 468, 472, 478, 479, 488, 504, 506, 511, 514, 334, 518, 528, 537, 540, 547, 548, 550, 558, 563, 564, 456, 450, 448, 437, 340, 343, 346, 352, 354, 358, 363, 365, 366, 381, 386, 393, 405, 407, 408, 409, 417, 422, 424, 425, 433, 1322, 1325, 2346, 2034, 1999, 2004, 2007, 2014, 2015, 2016, 2017, 2026, 2027, 2033, 2035, 1996, 2044, 2048, 2050, 2053, 2059, 2066, 2068, 2069, 2073, 2091, 1998, 1987, 2111, 1940, 1928, 1929, 1931, 1932, 1933, 1934, 1936, 1937, 1938, 1939, 1942, 1984, 1946, 1948, 1949, 1966, 1970, 1971, 1973, 1975, 1976, 1983, 2108, 2112, 1326, 2282, 2244, 2260, 2263, 2264, 2266, 2267, 2271, 2272, 2279, 2281, 2283, 2240, 2290, 2292, 2303, 2306, 2323, 2332, 2333, 2338, 2339, 2342, 2241, 2239, 2131, 2163, 2132, 2135, 2138, 2142, 2147, 2148, 2150, 2153, 2155, 2156, 2172, 2227, 2178, 2179, 2180, 2184, 2190, 2202, 2204, 2207, 2210, 2211, 1927, 1926, 1924, 1545, 1453, 1454, 1461, 1468, 1493, 1496, 1503, 1507, 1518, 1537, 1546, 1442, 1554, 1556, 1566, 1571, 1581, 1588, 1594, 1599, 1600, 1602, 1446, 1439, 1922, 1361, 1328, 1329, 1330, 1332, 1340, 1346, 1351, 1352, 1353, 1355, 1363, 1437, 1367, 1385, 1388, 1389, 1395, 1398, 1413, 1417, 1423, 1426, 1612, 1620, 1623, 1844, 1791, 1794, 1797, 1798, 1804, 1812, 1816, 1829, 1836, 1837, 1855, 1624, 1857, 1862, 1863, 1870, 1875, 1885, 1887, 1893, 1902, 1904, 1772, 1767, 1762, 1757, 1629, 1633, 1642, 1643, 1646, 1648, 1649, 1656, 1661, 1662, 1665, 1681, 1683, 1684, 1688, 1695, 1707, 1713, 1734, 1752, 1755, 4483, 4488, 4490, 7080, 7062, 7063, 7067, 7070, 7072, 7073, 7074, 7075, 7078, 7079, 7083, 7059, 7086, 7088, 7089, 7091, 7104, 7107, 7108, 7109, 7118, 7124, 7061, 7058, 7131, 7037, 6994, 6998, 7000, 7005, 7012, 7016, 7017, 7024, 7025, 7028, 7038, 7057, 7041, 7045, 7047, 7049, 7050, 7051, 7052, 7053, 7054, 7055, 7125, 7134, 7344, 7297, 7248, 7251, 7256, 7257, 7258, 7261, 7264, 7282, 7292, 7294, 7303, 7225, 7305, 7307, 7310, 7311, 7315, 7316, 7321, 7326, 7328, 7333, 7236, 7223, 7141, 7178, 7155, 7163, 7164, 7165, 7167, 7171, 7173, 7175, 7176, 7177, 7179, 7219, 7181, 7190, 7191, 7192, 7205, 7206, 7209, 7211, 7216, 7217, 6992, 6990, 6987, 6671, 6619, 6628, 6639, 6643, 6644, 6650, 6660, 6663, 6664, 6667, 6679, 6612, 6684, 6687, 6688, 6689, 6691, 6695, 6696, 6699, 6702, 6705, 6616, 6611, 6984, 6574, 6553, 6554, 6557, 6560, 6563, 6566, 6567, 6568, 6571, 6573, 6577, 6609, 6578, 6579, 6584, 6586, 6587, 6588, 6592, 6595, 6598, 6603, 6718, 6722, 6723, 6948, 6837, 6856, 6860, 6882, 6883, 6887, 6902, 6911, 6912, 6935, 6950, 6732, 6952, 6961, 6962, 6963, 6965, 6969, 6971, 6973, 6975, 6982, 6817, 6816, 6812, 6809, 6734, 6748, 6750, 6760, 6765, 6768, 6770, 6772, 6775, 6776, 6780, 6782, 6783, 6786, 6788, 6789, 6794, 6797, 6798, 6803, 6804, 7336, 7352, 6550, 8495, 8458, 8459, 8461, 8462, 8463, 8465, 8477, 8481, 8482, 8492, 8500, 8454, 8502, 8512, 8518, 8521, 8530, 8531,

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4626, 4632, 4635, 4649, 4661, 4603, 4663, 4666, 4670, 4671, 4675, 4683, 4687,
4689, 4690, 4701, 4605, 4599, 4965, 4541, 4502, 4504, 4511, 4516, 4518, 4521,
4524, 4526, 4529, 4531, 4544, 4597, 4565, 4568, 4573, 4574, 4580, 4583, 4584,
4589, 4594, 4595, 4703, 4704, 4709, 4900, 4840, 4850, 4860, 4863, 4871, 4879,
4883, 4885, 4893, 4899, 4909, 4714, 4917, 4925, 4926, 4939, 4945, 4946, 4956,
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4765, 4769, 4770, 4772, 4777, 4780, 4782, 4785, 4794, 4798, 4801, 4804, 4809,
4811, 4814, 5478, 5485, 6545, 6232, 6193, 6201, 6202, 6203, 6204, 6219, 6222,
6223, 6225, 6228, 6234, 6182, 6237, 6245, 6246, 6250, 6254, 6265, 6266, 6267,
6273, 6279, 6192, 6181, 6285, 6122, 6055, 6060, 6064, 6067, 6070, 6090, 6101,
6104, 6107, 6111, 6123, 6178, 6124, 6140, 6141, 6148, 6155, 6156, 6158, 6163,
6166, 6169, 6280, 6289, 5489, 6482, 6422, 6425, 6428, 6434, 6442, 6448, 6449,
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6533, 6542, 6415, 6408, 6291, 6332, 6295, 6298, 6306, 6310, 6313, 6314, 6316,
6319, 6324, 6327, 6336, 6407, 6344, 6345, 6347, 6357, 6382, 6386, 6387, 6390,
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5733, 5736, 5612, 5604, 6042, 5538, 5497, 5498, 5499, 5503, 5504, 5515, 5522,
5525, 5527, 5529, 5539, 5603, 5550, 5562, 5581, 5585, 5590, 5591, 5596, 5597,
5601, 5602, 5741, 5742, 5755, 5968, 5922, 5927, 5929, 5932, 5947, 5949, 5957,
5961, 5962, 5963, 5974, 5768, 5975, 5980, 5986, 5990, 6005, 6014, 6020, 6033,
6036, 6040, 5915, 5896, 5883, 5880, 5771, 5772, 5780, 5784, 5788, 5799, 5801,
5802, 5803, 5817, 5818, 5826, 5829, 5836, 5849, 5853, 5856, 5863, 5874, 5875,
5879, 189713]

```
[18]: # Assuming we have a DataFrame containing user-item interactions or ratings
# Let's call this DataFrame 'ratings_df'

# Split the ratings DataFrame into training and test sets
from sklearn.model_selection import train_test_split

train_df, test_df = train_test_split(ratings_community_movies_df, test_size=0.
    ↪2, random_state=42)

# Group the test data by user ID and collect the item IDs as sets
ground_truth = test_df.groupby('userId')['movieId'].apply(set).to_dict()

# Now 'ground_truth' is a dictionary where keys are user IDs and values are ↪
    ↪sets of item IDs
# representing the ground truth preferences for each user
```

```
[19]: # Assuming we have ground truth data stored in a dictionary named 'ground_truth'
# where keys are user IDs and values are sets of ground truth item IDs

precision_sum = 0
recall_sum = 0
num_users = len(ground_truth)

for user_id, ground_truth_items in ground_truth.items():
    if user_id in louvain_recommendations:
        recommendations = louvain_recommendations[user_id]
        true_positives = len(set(recommendations) & ground_truth_items)
        precision = true_positives / len(recommendations) if recommendations ↪
    ↪else 0
        recall = true_positives / len(ground_truth_items)
        precision_sum += precision
        recall_sum += recall

# Calculate average precision and recall
average_precision = precision_sum / num_users
average_recall = recall_sum / num_users

print("Average Precision:", average_precision)
print("Average Recall:", average_recall)
```

Average Precision: 4.16129197384105e-05
 Average Recall: 0.006800217482683627

```
[20]: # Check if the columns exist in the DataFrame
print(ratings_community_movies_df.columns)
```

```
# Ensure that the column names are correct and match the actual column names in
↳ your DataFrame
```

```
Index(['userId', 'movieId', 'rating', 'timestamp', 'Node', 'Community',
      'title', 'genres'],
      dtype='object')
```

```
[21]: # Pivot the average ratings DataFrame to get average ratings for each movie
↳ within each community as features
movie_features_df = avg_ratings_per_community_movie.pivot(index='title',
↳ columns='Community', values='rating').fillna(0)

# Print the first few rows of the feature DataFrame as an example
print("Feature vectors for each movie:")
print(movie_features_df.head())

# Now you can proceed to calculate cosine similarity and make recommendations
↳ as described earlier.
```

Feature vectors for each movie:

Community	0	1	2	3	4	5
title						
'71 (2014)	0.0	0.0	4.0	0.0	0.0	0.0
'Hellboy': The Seeds of Creation (2004)	4.0	0.0	0.0	0.0	0.0	0.0
'Round Midnight (1986)	3.5	3.5	0.0	0.0	0.0	0.0
'Salem's Lot (2004)	5.0	0.0	0.0	0.0	0.0	0.0
'Til There Was You (1997)	4.0	0.0	0.0	0.0	0.0	0.0

```
[22]: from sklearn.metrics.pairwise import cosine_similarity

# Calculate cosine similarity matrix
cosine_sim_matrix = cosine_similarity(movie_features_df)

# Convert cosine similarity matrix to DataFrame for better visualization
cosine_sim_df = pd.DataFrame(cosine_sim_matrix, index=movie_features_df.index,
↳ columns=movie_features_df.index)

# Print the first few rows and columns of the cosine similarity DataFrame as an
↳ example
print("Cosine similarity matrix:")
print(cosine_sim_df.head())
```

Cosine similarity matrix:

title	'71 (2014) \
title	
'71 (2014)	1.0
'Hellboy': The Seeds of Creation (2004)	0.0
'Round Midnight (1986)	0.0

'Salem's Lot (2004)	0.0
'Til There Was You (1997)	0.0
title 'Hellboy': The Seeds of Creation (2004)	
\	
title	
'71 (2014)	0.000000
'Hellboy': The Seeds of Creation (2004)	1.000000
'Round Midnight (1986)	0.707107
'Salem's Lot (2004)	1.000000
'Til There Was You (1997)	1.000000
title 'Round Midnight (1986) \	
title	
'71 (2014)	0.000000
'Hellboy': The Seeds of Creation (2004)	0.707107
'Round Midnight (1986)	1.000000
'Salem's Lot (2004)	0.707107
'Til There Was You (1997)	0.707107
title 'Salem's Lot (2004) \	
title	
'71 (2014)	0.000000
'Hellboy': The Seeds of Creation (2004)	1.000000
'Round Midnight (1986)	0.707107
'Salem's Lot (2004)	1.000000
'Til There Was You (1997)	1.000000
title 'Til There Was You (1997) \	
title	
'71 (2014)	0.000000
'Hellboy': The Seeds of Creation (2004)	1.000000
'Round Midnight (1986)	0.707107
'Salem's Lot (2004)	1.000000
'Til There Was You (1997)	1.000000
title 'Tis the Season for Love (2015) \	
title	
'71 (2014)	1.0
'Hellboy': The Seeds of Creation (2004)	0.0
'Round Midnight (1986)	0.0
'Salem's Lot (2004)	0.0
'Til There Was You (1997)	0.0
title 'burbs, The (1989) \	
title	
'71 (2014)	0.566962
'Hellboy': The Seeds of Creation (2004)	0.356976

'Round Midnight (1986)	0.597642
'Salem's Lot (2004)	0.356976
'Til There Was You (1997)	0.356976

title	'night Mother (1986) \
title	
'71 (2014)	0.0
'Hellboy': The Seeds of Creation (2004)	0.0
'Round Midnight (1986)	0.0
'Salem's Lot (2004)	0.0
'Til There Was You (1997)	0.0

title	(500) Days of Summer (2009) \
title	
'71 (2014)	0.461858
'Hellboy': The Seeds of Creation (2004)	0.476757
'Round Midnight (1986)	0.632097
'Salem's Lot (2004)	0.476757
'Til There Was You (1997)	0.476757

title	*batteries not included (1987) ... \
title	...
'71 (2014)	0.000000 ...
'Hellboy': The Seeds of Creation (2004)	0.521387 ...
'Round Midnight (1986)	0.368676 ...
'Salem's Lot (2004)	0.521387 ...
'Til There Was You (1997)	0.521387 ...

title	Zulu (2013) [REC] (2007) \
title	
'71 (2014)	0.0 0.409564
'Hellboy': The Seeds of Creation (2004)	0.0 0.369929
'Round Midnight (1986)	0.0 0.635264
'Salem's Lot (2004)	0.0 0.369929
'Til There Was You (1997)	0.0 0.369929

title	[REC] ² (2009) \
title	
'71 (2014)	0.585491
'Hellboy': The Seeds of Creation (2004)	0.000000
'Round Midnight (1986)	0.000000
'Salem's Lot (2004)	0.000000
'Til There Was You (1997)	0.000000

title	[REC] ³ 3 Génesis (2012) \
title	
'71 (2014)	1.0
'Hellboy': The Seeds of Creation (2004)	0.0

'Round Midnight (1986)	0.0
'Salem's Lot (2004)	0.0
'Til There Was You (1997)	0.0

title anohana: The Flower We Saw That Day -

The Movie (2013) \

title

'71 (2014)

1.0

'Hellboy': The Seeds of Creation (2004)

0.0

'Round Midnight (1986)

0.0

'Salem's Lot (2004)

0.0

'Til There Was You (1997)

0.0

title eXistenZ (1999) xXx (2002) \

title

'71 (2014)

0.512292

0.478635

'Hellboy': The Seeds of Creation (2004)

0.480274

0.538465

'Round Midnight (1986)

0.569492

0.625521

'Salem's Lot (2004)

0.480274

0.538465

'Til There Was You (1997)

0.480274

0.538465

title xXx: State of the Union (2005) \

title

'71 (2014)

0.654931

'Hellboy': The Seeds of Creation (2004)

0.000000

'Round Midnight (1986)

0.320612

'Salem's Lot (2004)

0.000000

'Til There Was You (1997)

0.000000

title ¡Three Amigos! (1986) \

title

'71 (2014)

0.476358

'Hellboy': The Seeds of Creation (2004)

0.372802

'Round Midnight (1986)

0.571157

'Salem's Lot (2004)

0.372802

'Til There Was You (1997)

0.372802

title À nous la liberté (Freedom for Us)

(1931)

title

'71 (2014)

0.000000

'Hellboy': The Seeds of Creation (2004)

```

1.000000
'Round Midnight (1986)
0.707107
'Salem's Lot (2004)
1.000000
'Til There Was You (1997)
1.000000

```

[5 rows x 9719 columns]

```

[25]: def get_cosine_recommendations(movie_title, top_n=5):
        # Get the row corresponding to the given movie title
        movie_row = cosine_sim_df.loc[movie_title]

        # Sort movies based on their cosine similarity scores
        similar_movies = movie_row.sort_values(ascending=False)[1:top_n+1] #
        ↪ Exclude the movie itself

        return similar_movies

# Example usage:
example_movie_title = "'71 (2014)"
cosine_recommendations = get_cosine_recommendations(example_movie_title)
print("Cosine similarity-based recommendations for movie", example_movie_title,
      ↪ ":")
print(cosine_recommendations)

```

Cosine similarity-based recommendations for movie '71 (2014) :

title

```

If I Were a Rich Man (2002)          1.0
If These Walls Could Talk 2 (2000)   1.0
Illusionist, The (L'illusionniste) (2010) 1.0
Imagine Me & You (2005)              1.0
Immature, The (Immaturo) (2011)       1.0
Name: '71 (2014)', dtype: float64

```

```

[26]: print(ratings_community_movies_df.head(10))

```

	userId	movieId	rating	timestamp	Node	Community	\
0	1	1	4.0	964982703	1	0	
1	1	3	4.0	964981247	1	0	
2	1	6	4.0	964982224	1	0	
3	1	47	5.0	964983815	1	0	
4	1	50	5.0	964982931	1	0	
5	1	70	3.0	964982400	1	0	
6	1	101	5.0	964980868	1	0	
7	1	110	4.0	964982176	1	0	
8	1	151	5.0	964984041	1	0	

9	1	157	5.0	964984100	1	0
---	---	-----	-----	-----------	---	---

	title	genres
0	Toy Story (1995)	Adventure Animation Children Comedy Fantasy
1	Grumpier Old Men (1995)	Comedy Romance
2	Heat (1995)	Action Crime Thriller
3	Seven (a.k.a. Se7en) (1995)	Mystery Thriller
4	Usual Suspects, The (1995)	Crime Mystery Thriller
5	From Dusk Till Dawn (1996)	Action Comedy Horror Thriller
6	Bottle Rocket (1996)	Adventure Comedy Crime Romance
7	Braveheart (1995)	Action Drama War
8	Rob Roy (1995)	Action Drama Romance War
9	Canadian Bacon (1995)	Comedy War

```
[33]: ground_truth = {
    '1': ['If I Were a Rich Man (2002)', 'Toy Story', 'Rob Roy'],
    '2': ['71 (2014)', 'From Dusk Till Dawn'],
    # Add more users and their rated movies as needed
}

# Function to calculate precision and recall
def calculate_precision_recall(cosine_recommendations, ground_truth):
    # Initialize variables to store precision and recall values
    precision_total = 0
    recall_total = 0

    # Iterate over each user in the ground truth data
    for user, actual_movies in ground_truth.items():
        # Get the recommended movies for the current user
        recommended_movies = cosine_recommendations[user] if user in cosine_recommendations else []

        # Calculate intersection and union of recommended movies and actual movies
        intersection = len(set(recommended_movies) & set(actual_movies))
        union = len(set(recommended_movies) | set(actual_movies))

        # Calculate precision and recall for the current user
        precision = intersection / len(recommended_movies) if recommended_movies else 0
        recall = intersection / len(actual_movies)

        # Accumulate precision and recall values
        precision_total += precision
        recall_total += recall

    # Calculate average precision and recall across all users
```

```

avg_precision = precision_total / len(ground_truth)
avg_recall = recall_total / len(ground_truth)
print("Avg_Precision:", avg_precision)
print("Avg_recall:", avg_recall)
return avg_precision, avg_recall

# Calculate precision and recall for cosine similarity-based recommendations
precision, recall = calculate_precision_recall(cosine_recommendations,
↪ground_truth)

# Print the results
print("Precision:", precision)
print("Recall:", recall)

```

```

Avg_Precision: 0.0
Avg_recall: 0.0
Precision: 0.0
Recall: 0.0

```