MANIPAL UNIVERSITY JAIPUR

Faculty of Engineering | School of Computer Science Engineering

Department of Artificial Intelligence & Machine Learning

Assignment

Recommender Systems | AI 4103 | 3 1 0 4

Session: Jul – Nov 25 | Program: B. Tech (AI & ML) | Semester: VII

Course Coordinator: Dr. Shivendra Dubey

Instructor: Dr. Shivendra Dubey, Ms. Akanksha Mrinali

Part A – Conceptual Questions (Short Answer)

1. **Explain the core functions of a recommender system with real-world applications in e-commerce and streaming platforms.**
2. **Differentiate between user-based and item-based collaborative filtering with suitable examples.**
3. **What is the role of matrix factorization in recommendation systems? Illustrate with Singular Value Decomposition (SVD).**
4. **Define and compare content-based and knowledge-based recommenders.**
5. **Explain any two recent trends in recommender systems: *Context-aware, Cross-domain, Multimodal, or Graph Neural Network based.***

Part B – Problem-Solving (Numerical/Analytical)

6. **Consider the following user–item interaction matrix (ratings on a 1–5 scale, blank = missing):**

	Item A	Item B	Item C	Item D
User 1	5	3		1
User 2	4		2	1
User 3		4	5	
User 4	1	1	2	4

(a) Use cosine similarity to compute similarity between User 1 and User 2.
(b) Based on neighborhood methods, predict User 1's rating for Item C.
(c) Discuss the limitations of this approach.

7. **Perform SVD decomposition on a 2×2 matrix of your choice and explain how latent factors can reveal hidden patterns in user preferences.**

Part C – Case Study & Application

8. **Imagine you are designing a content-based recommender system for a clothing e-commerce website.**
9. **What item features would you extract (visual + textual)?**
10. **How would you build user profiles?**
11. **Which similarity metric would you use to recommend clothing items?**
12. **A hospital wants to design a knowledge-based recommender system for personalized treatment.**
13. **Suggest how constraint-based and case-based reasoning can be applied.**
14. **What challenges might arise in implementing such a system?**
15. **Explain with an example how hybrid recommender systems overcome the limitations of pure collaborative and pure content-based methods.**

Part D – Evaluation & Tools

11. **Define the following metrics with formulas and significance: RMSE, Precision, Recall, F1-score, NDCG, Coverage.**

12. **What is the role of A/B testing in evaluating recommended systems? Give a real-world example.**

13. **Write a short note on two libraries/frameworks for recommender systems: Surprise, LightFM, TensorFlow Recommenders, or RecBole.**

Numerical Assignment (10 Marks Each)

Q1. Matrix Addition & Multiplication (10 Marks)

Given the matrices:

$$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}, \quad B = \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$$

(a) Compute $A + B$.

(b) Compute $A \times B$.

(c) Verify whether matrix multiplication is commutative by checking $B \times A$.

Q2. Matrix Transpose & Inverse (10 Marks)

Let

$$C = \begin{bmatrix} 2 & 4 \\ 1 & 3 \end{bmatrix}$$

(a) Find the transpose C^T.

(b) Compute the determinant of C.

(c) Find the inverse of C using the formula for a 2×2 matrix.

Q3. Eigenvalues & Eigenvectors (10 Marks)

For the matrix

$$D = \begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$$

(a) Find the eigenvalues by solving the characteristic equation.

(b) Compute the corresponding eigenvectors.

(c) Verify the eigenvalue–eigenvector relation $Dv = \lambda v$.

Q: (10 Marks)

The following dataset contains two variables X and Y:

X	Y
2	3
4	7
6	5
8	9

(a) Compute the mean of X and Y.

(b) Using the formula, calculate the **covariance between X and Y**.

(c) Interpret the result in terms of the relationship between the two variables.

Q5. Singular Value Decomposition (SVD) (10 Marks)

Given the matrix

$$E = \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}$$

(a) Perform Singular Value Decomposition (SVD) of E.

(b) Write down matrices U, Σ, and V^T.

(c) Verify that $E = U\Sigma V^T$.

Q6. K-Means Clustering (10 Marks)

You are given 1-D data points: $\{2, 4, 10, 12, 3, 20, 25, 30\}$.

(a) Apply **K-Means clustering** with $K = 2$.

(b) Initialize cluster centroids as $c_1 = 2, c_2 = 20$.

(c) Perform two iterations and show cluster assignments after each iteration.

Q7. Confusion Matrix (10 Marks)

A binary classifier produced the following results on 20 samples:

- Predicted Positive: 8 (6 correct, 2 wrong)
- Predicted Negative: 12 (10 correct, 2 wrong)

(a) Construct the confusion matrix.

(b) Compute **Accuracy, Precision, Recall, and F1-score**.

(c) Interpret the results.

Case Study-Based Questions (10 Marks Each)

Q1. Netflix Case Study

Netflix uses a recommendation engine that analyzes viewing history, ratings, search behavior, genres, actors, and directors to suggest personalized movies and TV shows.

- **Explain how matrix factorization (SVD) plays a role in improving Netflix recommendations.**
- **Discuss one advantage and one limitation of Netflix's recommendation approach.**

Q2. Amazon Case Study

Amazon's engine suggests products based on a user's purchase history, browsing data, and items in the cart.

- **Explain how content-based filtering supports Amazon's recommendations.**
- **Identify one major challenge Amazon might face when recommending products.**

Q3. YouTube Case Study

YouTube recommends videos by analyzing watch history, liked videos, and search activity, also considering session duration and channel preferences.

- **Describe how context-aware recommender systems improve YouTube's video suggestions.**
- **Suggest one improvement YouTube could adopt to reduce filter bubble effects.**

Q4. Spotify Case Study

Spotify applies collaborative filtering to recommend music based on listening habits and playlists.

- **Explain the role of user-based and item-based collaborative filtering in Spotify's system.**
- **Discuss how cold-start problems could impact new songs or new users.**

Q5. Social Media Case Study

Platforms like Facebook and LinkedIn use collaborative filtering for friend suggestions, group recommendations, and targeted ads.

- **Explain how graph-based recommender systems could enhance these recommendations.**
- **Discuss one ethical concern related to recommender systems on social media.**

Q6. E-Commerce Case Study

E-commerce websites recommend products that similar users purchased or viewed.

- **Using item-based collaborative filtering, explain how the system decides "Customers who bought this also bought…".**
- **Give an example of how cross-domain recommendation could benefit e-commerce platforms.**

Q7. News Recommendation (Extended)

Google News and Flipboard recommend articles based on reading history and trending topics.

- **Explain how content-based filtering is applied.**
- **Discuss one risk of bias in news recommendation**

Q8. Online Learning Case Study (Extended)

Coursera/edX recommend courses using learner profiles, skills, and past enrollments.

- **Explain how knowledge-based recommenders help here.**
- **Suggest one way to personalize recommendations for lifelong learning.**

Q9. Healthcare Recommendation (Extended)

AI-driven systems recommend treatment plans and health monitoring for patients.

- **Describe how hybrid recommendation (content + collaborative) improves outcomes.**
- **Mention one challenge of privacy/security in healthcare recommenders.**

Q10. Hybrid Systems in Entertainment (Extended)

Modern platforms like Disney+ use hybrid recommenders (content + collaborative + knowledge-based).

- **Explain why hybrid approaches perform better than single-method systems.**
- **Give an example of serendipity in recommendations.**