MANIPAL UNIVERSITY JAIPUR

Faculty of Engineering | School of Computer Science Engineering

Department of Artificial Intelligence & Machine Learning
Course Hand-out

Recommender Systems | AI 4103 | 3 1 0 4

Session: Jul – Nov 24 | **Program:** B. Tech (AI & ML) | **Semester:** VII

Course Coordinator: Mr. Harshit Sharma

Instructor: Mr. Harshit Sharma & Ms. Rishika Singh

A.   Introduction:

This course provides a comprehensive introduction to Recommender Systems, essential in machine learning and data analytics for predicting user preferences from large datasets. Widely used in e-commerce, social media, and content streaming, these systems enhance user experience and engagement. The course covers fundamental concepts and techniques in designing and evaluating recommender systems, exploring collaborative filtering, content-based, knowledge-based, and hybrid approaches.

a) Core functions include understanding linear algebra foundations like matrix operations.
b) Apply user-based and item-based collaborative filtering and learn about their vulnerabilities.
c) Explore content-based systems' architecture, feature extraction, and classification algorithms.
d) Gain insights into knowledge-based systems, examining representation and reasoning techniques.
e) Investigate hybrid approaches, understanding design strategies and limitations.

B.   Course Outcomes: At the end of the course, students will be able to

CO	Statement	Cognitive Level
AI4103.1	Understand the core functions and applications of recommender systems, including related linear algebra concepts like matrix operations.	Understand
AI4103.2	Apply the techniques of user-based and item-based collaborative filtering.	Apply
AI4103.3	Apply principles of content-based recommendation, including system architecture and methods for item profile representation, feature extraction, and user profile learning.	Apply
AI4103.4	Analyze various techniques used in knowledge-based recommendation systems, focusing on knowledge representation and reasoning, and understand the difference between constraint-based and case-based recommenders.	Analyze
AI4103.5	Evaluate the opportunities and challenges in hybrid recommender systems, design strategies for implementing hybrid approaches, and analyze their potential to meet market needs and promote entrepreneurship	Evaluate

C.   PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PO 1:   Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization is to the solution of complex engineering problems.

PO 2:   Problem Analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3:   Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4:   Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5:   Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 6:   The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and   cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

PO 7:   Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8:   Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

PO 9:   Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO 1: Graduates will be able to examine the applications of Artificial Intelligence and Machine Learning in real-life problems.

PSO 2: Graduates will be able to design and implement intelligent systems for multidisciplinary problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Mid-Term Examination (Close Book)	30
	Class Work Sessional (CWS): 1 Quiz: 5 1 Assignment: 5 1 Technical Project: 20	30
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system. Collaborative Filtering: User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems. Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, obtaining item features from tags, representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. Knowledge based recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders. Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies. Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics.

References:
1. C.C. Aggarwal, Recommender Systems: The Textbook (1e), Springer, 2016.
2. N Manouselis, H. Drachsler, K. Verbert and E. Duval., Recommender Systems for Learning (1e), Springer 2013.
3. F. Ricci, L. Rokach, D. Shapira and B.P. Kantor, Recommender Systems Handbook (1e), Springer ,2011.

F.   Lecture Plan:

Lect.	Topics	Session Outcome	Correspon ding CO	Mode of delivery	Mode of Assessing CO
1	Introduction to Recommender System Functions	Understand system functions	AI4103.1	Slides / Blackboard	MTE, Quiz
2	Linear Algebra Notation: Matrix Addition and Multiplication	Analyze matrix operations	AI4103.1	Slides / Blackboard	
3	Linear Algebra Notation: Matrix Transposition and Inverses	Evaluate transposition and inversion	AI4103.1	Slides / Blackboard	
4	Linear Algebra Notation: Covariance Matrices	Examine covariance matrices	AI4103.1	Slides / Blackboard	
5	Revision	Review linear algebra	AI4103.1	Slides / Blackboard	
6	Understanding Ratings in Recommender Systems	Explore rating mechanisms	AI4103.1	Slides / Blackboard	
7	Applications of Recommender Systems	Identify system applications	AI4103.1	Slides / Blackboard	
8	Issues with Recommender Systems	Discuss system challenges	AI4103.1	Slides / Blackboard	
9	Collaborative Filtering: Overview and Concepts	Understand filtering concepts	AI4103.2	Slides / Blackboard	
10	Revision	Review filtering concepts	AI4103.2	Slides / Blackboard	
11	Collaborative Filtering: User-Based Nearest Neighbor Recommendation	Analyze user-based algorithms	AI4103.2	Slides / Blackboard	
12	Collaborative Filtering: Item-Based Nearest Neighbor Recommendation	Evaluate item-based algorithms	AI4103.2	Slides / Blackboard	
13	Collaborative Filtering: Model-Based Approaches	Examine model-based methods	AI4103.2	Slides / Blackboard	
14	Collaborative Filtering: Pre-Processing Based Approaches	Explore pre-processing methods	AI4103.2	Slides / Blackboard	Quiz MTE, Quiz & ETE
15	Revision	Review collaborative filtering	AI4103.2	Slides / Blackboard	
16	Attacks on Collaborative Recommender Systems	Identify security vulnerabilities	AI4103.2	Slides / Blackboard	
17	Content-Based Recommendation: Overview and Architecture	Understand system architecture	AI4103.3	Slides / Blackboard	

18	Content-Based Recommendation: Advantages and Drawbacks	Evaluate system pros and cons	AI4103.3	Slides / Blackboard	
19	Content-Based Recommendation: Item Profiles and Features	Analyze item profile methods	AI4103.3	Slides / Blackboard	
20	Content-Based Recommendation: Discovering Features from Documents	Explore feature extraction	AI4103.3	Slides / Blackboard	
21	Content-Based Recommendation: Obtaining Item Features from Tags	Examine tag-based features	AI4103.3	Slides / Blackboard	
22	Revision	Review content-based methods	AI4103.3	Slides / Blackboard	
23	Methods for Learning User Profiles	Explore user profile methods	AI4103.3	Slides / Blackboard	
24	Content-Based Recommendation: Similarity-Based Retrieval	Understand similarity retrieval	AI4103.3	Slides / Blackboard	
25	Content-Based Recommendation: Classification Algorithms	Analyze classification in systems	AI4103.3	Slides / Blackboard	
26	Knowledge-Based Recommendation: Overview and Concepts	Understand knowledge-based concepts	AI4103.4	Slides / Blackboard	
27	Knowledge Representation and Reasoning in Recommender Systems	Examine representation techniques	AI4103.4	Slides / Blackboard	
28	Knowledge-Based Recommendation: Constraint-Based Recommenders	Analyze constraint-based methods	AI4103.4	Slides / Blackboard	Technical Project & ETE
29	Knowledge-Based Recommendation: Case-Based Recommenders	Explore case-based methods	AI4103.4	Slides / Blackboard	
30	Technical Project	Review Practical Implementation	AI4103.4	Slides / Blackboard	
31	Hybrid Approaches: Overview and Opportunities	Explore hybrid system benefits	AI4103.5	Slides / Blackboard	
32	Monolithic Hybridization Design: Feature Combination	Understand feature combination	AI4103.5	Slides / Blackboard	
33	Monolithic Hybridization Design: Feature Augmentation	Explore feature augmentation	AI4103.5	Slides / Blackboard	
34	Revision	Review Hybridization Design	AI4103.5	Slides / Blackboard	
35	Parallelized Hybridization Design: Weighted Approach	Analyze weighted hybridization	AI4103.5	Slides / Blackboard	

36	Parallelized Hybridization Design: Switching Approach	Examine switching hybridization	AI4103.5	Slides / Blackboard	
37	Parallelized Hybridization Design: Mixed Approach	Understand mixed hybridization	AI4103.5	Slides / Blackboard	
38	Pipelined Hybridization Design: Cascade Approach	Explore cascade hybridization	AI4103.5	Slides / Blackboard	
39	Pipelined Hybridization Design: Meta-Level Approach	Analyze meta-level hybridization	AI4103.5	Slides / Blackboard	
40	Revision	Review hybridization strategies	AI4103.5	Slides / Blackboard	
41	Limitations of Hybridization Strategies	Discuss hybridization challenges	AI4103.5	Slides / Blackboard	
42	Evaluating Recommender Systems: Introduction and Importance	Understand evaluation importance	AI4103.5	Slides / Blackboard	
43	General Properties of Evaluation Research	Examine evaluation research	AI4103.5	Slides / Blackboard	
44	Evaluation Designs for Recommender Systems	Analyze evaluation designs	AI4103.5	Slides / Blackboard	Assignment & ETE
45	Evaluation on Historical Datasets	Explore evaluation on datasets	AI4103.5	Slides / Blackboard	
46	Revision	Review evaluation methodologies	AI4103.5	Slides / Blackboard	
47	Error Metrics in Recommender System Evaluation	Understand error metrics	AI4103.5	Slides / Blackboard	
48	Decision-Support and User-Centered Metrics	Analyze decision-support metrics	AI4103.5	Slides / Blackboard	
End Term Examination					

G.   Target attainment (%) for course outcomes:

CO	Target attainment (%)
1	80%
2	80%
3	80%
4	80%
5	80%

H. Course Articulation Matrix: (Mapping of COs with POs and PSOs)

CO	Statement	Correlation with Program Outcomes													
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
AI4103.1	Understand the core functions and applications of recommender systems, including related linear algebra concepts like matrix operations.	2									1		1		
AI4103.2	Apply the techniques of user-based and item-based collaborative filtering	2						1					2		
AI4103.3	Apply principles of content-based recommendation, including system architecture and methods for item profile representation, feature extraction, and user profile learning.		2												
AI4103.4	Analyze various techniques used in knowledge-based recommendation systems, focusing on knowledge representation and reasoning, and understand the difference between constraint-based and case-based recommenders.	2		3	1				2					2	2
AI4103.5	Evaluate the opportunities and challenges in hybrid recommender systems, design strategies for implementing hybrid approaches, and analyze their potential to meet market needs and promote entrepreneurship				2				2		2				2

Course Coordinator	Head of the Department	Student Representative
Name: Mr. Harshit Sharma	**Name:** Dr. Puneet Mittal	**Name:**
MUJ ID. MUJAD020	**MUJ ID.** MUJ1571	**Registration No.**