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The Use of AI in E-Learning Recommender Systems: A Comprehensive Survey

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Abstract

Nowadays, Artificial Intelligence (AI) technology, especially, machine learning has received significant attention from many researchers and professionals in several domains. For instance, this technology has revolutionized industrials sectors, such as e-commerce, health, manufacturing, and entertainment, as well as, the educational sector. In this context, during the pandemic, educational institutions around the globe recognized the benefits of adopting remote learning and teaching based on many e-learning platforms. Hence, deploying virtual classrooms is not that easy, due to many constraints, such as time, technological cost, lack of interactivity of learners, and the unsuitability of the learner's cognitive abilities and learning style. To this end, understanding the learner's style and providing adapted and personalized content are the main concerns of today's e-learning systems. To this end, integrating efficient recommender systems into online learning environment is required in order to consider student's behaviors and preferences when recommending various learning materials. Thus, intelligent recommender systems are able to provide a personalized learning path in which the system adapts to the student's learning requirements and abilities. This review discusses the different applications, methods, and challenges of AI-based recommendation systems used to assist different stockholders in an online learning environment.

Keywords: Artificial intelligence; Deep learning; E-Learning; Education; Machine learning; Recommender systems.

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1. Introduction

E-learning has been considered as a “game-changer” of the education system around the world and debate about its value is no longer a trend [1] [2].

In the situation of COVID-19 pandemic crisis, the whole world is aware of the e-learning value. To this end, the use of online platforms provides the learners with various learning resources in several formats: video, audio, and text. In addition, the adoption of intelligent tutoring systems (ITS) in e-learning has changed the experience of both instructors and students; in other words, no face-to-face ex-change [3]. This enables students to gain remote access from any location and at any time by using a computer, smartphone, or mobile device. Accordingly, universities are increasingly incorporating e-Learning platforms into their university systems due their critical benefits. Of the top 25 universities, 22 of them—including Harvard, Stanford, and MIT—offer free online courses to students who are interested in learning [4]. Therefore, the increasing use and popularity of these platforms leads the learners to be confused with a massively increasing number of learning materials and courses, which makes the learning process more complex and time consuming. As a result, it is critical to implement software that filters all information and recommends the most appropriate options to the student. In this regard, recommender systems have emerged for the first time in mid-1990s and marked their presence as tools that rescues the users from the accumulated mountains of information available [5]. These systems typically solve the over-load problem by evaluating and predicting the student's behavior and preferences in order to suggest and promote appropriate items. Moreover, the integration of the recommender systems into ITS is the main objective behind using AI algorithms on learners' data in order to improve the outcomes of students [6] [7]. Thus, recommender systems help students to make suitable decisions, as well as, to provide practical recommendations to them, to teachers, and to administrators. As contrast to a traditional learning environment in which students adapt to the majority's abilities and preferences, an AI-based recommender system provides learners with a more personalized environment that suits their interests, learning requirements, learning abilities, and style. As a result, researchers in educational technology have been testing and presenting new approaches to include more AI techniques in e-learning recommendation systems throughout the past few years. The primary goal of this study is to provide an overview of the most commonly utilized AI algorithms for recommender system in online learning plat-forms.

In the rest of this paper, the traditional recommendation algorithms will be discussed briefly in the second section of this paper, along with two main of AI approaches: Machine Learning, and Deep Learning. The difficulties and potential directions of AI in e-learning recommender systems are covered in the third section. Finally, Section 4 concludes the study and offers some guidelines for future research.

2. Overview of AI based Recommender Systems for E-learning

Recommender systems can be defined as information filtering techniques that help users in the decision-making process. These systems typically operate by making suggestions and recommending products that correspond to user preferences and behaviors. Although many different methods for these systems have been proposed in the literature, Table 1 provides a brief comparison of the four most common ones: content-based filtering (CBF), collaborative filtering (CF), knowledge-based (KB), and hybrid recommendation (HR).

Table 1. Comparison of recommendation systems approaches

APPROACH	DEFINITION	PROS	CONS
CF	CF recommends items to users using the behavior, preferences and taste of similar users.	- CF does not need information about the item so it can perform in situations when there not enough item information.	- Cold start problem - The data sparsity problem - Scalability - Synonym problem [8].
CBF	CB recommender systems analyze the user’s past preferences to provide suggestions and recommendations. The items recommended in these systems are usually similar to the ones the user liked in the past.	- CB algorithms can recommend new items even without any rating provided by the users. - Rapidity in adjusting recommendation if the user changed its preferences. - Capacity to manage different users that does not share the same preferences.	- Limited content analysis - Over specialization - New user problem [9].

		-Ensures privacy due to providing recommendation without sharing the user's profile [8].	
KB	This system utilizes a knowledge base created by the user's past records to represent the user's taste and needs and provide items matching that taste and needs [10].	- No cold start problem - It is not based on user ratings. - Deterministic recommendations - Assured quality	- High Cost.
HR	The hybrid recommender system is a combination between two or more recommendation approaches in order to surpass some limitations.	- Provide better and more accurate recommendation due to the combination between the two approaches. - Overcame the cold start and the data sparsity.	- Increased complexity - Implementation expense increasing

Nonetheless, despite the effectiveness of these recommendation strategies, particularly CF, there are a number of issues that make it challenging to accurately predict the learner's preferences, including scalability, sparsity, and cold start difficulties. As a result, the academic community has been looking into how to use various AI domains to deal with the huge amount of data that is available and its complex nature in recent years. The use of the two main AI sub-domains for e-learning recommenders is discussed in this section. Table 2 compares these strategies briefly.

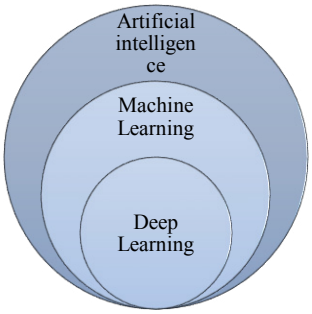

Fig.1. the main AI sub-domains

2.1 Machine learning

Machine Learning (ML) is when a computer program gets better at tasks in a class of tasks T as assessed by a performance measure P as a result of experience E [11]. Therefore, ML uses computers in order to mimic human learning and enables computers to recognize and gather knowledge from the real world. Then, based on this new knowledge, some activities can be improved. Many ML approaches can be used in a variety of ways to improve the quality of suggestions in e-learning. These techniques are divided into supervised and unsupervised methods. K-means is the most unsupervised machine learning methods that has been utilized, whereas K-Nearest Neighbor (KNN) is the most supervised algorithm that has been utilized in most research [12].

In [13], the authors suggested an ML course recommendation system for e-learning environments. In their study, python and the jupyter notebook were used in the implementation of these strategies, and the algorithms that were employed are Neural Collaborative Filtering (NCF), Singular Value Decomposition (SVD), and K-Nearest Neighbor (KNN). In a similar study [14], the authors employed the KNN classifier to forecast student performance in a big data setting.

2.2 Deep learning

Deep learning (DL) has emerged as a machine learning sub-discipline founded on artificial neural networks that train algorithms to imitate the human brain's functioning in acquiring knowledge [15]. DL algorithms have been widely used in studies to implement educational recommendation systems in recent years due to their popularity and

utility. To recommend educational content to users, deep learning recommender systems are efficient. In order to deliver precise and individualized recommendations, these systems can analyze vast volumes of data and discover trends from students' behavior. As they may offer pertinent and engaging content, deep learning recommender systems can be useful for students who want to study challenging ideas.

In their research work, Wei et al. [16] were primarily concerned with an intelligent tutoring system that analyzes students' prior preferences and predicts their future course selections using deep learning algorithms. In this work, the authors try to help overcome the complete cold start (CCS) and incomplete cold start (ICS) challenges. In [17], the DÉCOR technique has been presented to minimize the information overload issues and address the high-dimensional sparsity problem in the course recommender systems. In this article, the authors presented a deep learning-based course recommender system on an online educational website.

The beneficial aspect of deep learning approaches is the fact that they can offer an efficient way to get around the drawbacks of conventional methods. Because of this, the use of deep learning methods in recommender systems has become a hot study area. [18].

Table 2. Comparison of the AI sub-domains

	PURPOSE /BENIFITS	TECHNIQUES	ARTICLES
ML	ML approaches detect frequent patterns and correlations within various variables and generate mathematical models that represent them, allowing computers to learn based on user data and personalize recommendations much more.	unsupervised learning Supervised learning semi-supervised learning reinforcement learning	[13] [14] [19] [20] [21] [22] [23]
DL	DL facilitates the capture of complicated interactions between users and items. The power of these methods is that they're able to deliver efficient solutions for overcoming traditional approaches' limitations.	Graph neural network (GNN) Natural Language Processing (NLP) Auto encoder Recurrent Neural Network (RNN) Convolutional Neural Network (CNN)	[17] [16] [24] [25] [26] [27] [28]

3. AI recommenders' challenges and future directions

the inclusion of AI in education provides numerous advantages. These advantages include the automation of frequent and time-consuming activities like grading or supervising student attendance. As well as, aiding educators in their classwork, and collecting students' feedback using AI chatbots. In addition, it provides a better personalized education by utilizing its different methods in recommender systems [29]. AI research and applications have had a tremendous impact on today's educational system, where we see its rising use by learners, educators, and administrators, as well as the numerous algorithms and tools provided that have the potential to alter the education industry [30].

However, despite its benefits and promising results in personalizing learning, AI-based recommender systems in an online learning environment face certain obstacles. Including the information privacy problem, availability of data, as well as the significant costs associated with their implementation due to the heaviness of big data and AI systems.

Despite all these challenges, [31] noticed that there is an increasing tendency toward the leveraging of AI in e-learning, reflecting a future dependency on its technology and algorithms. Since the COVID-19 pandemic and the increasing popularity of e-learning platforms, AI has started to alter the manner in which today's universities operate. In addition, the number of AI technologies that may be utilized to assist students, teachers, and administration staff is increasing. These AI approaches appears to represent a large research opportunity for RS development which opens multiple future directions.

In addition, students become lost browsing through the massive amount of educational data available every second while keeping up with the latest trends due to the abundance of available educational information. In the internet age, new technologies might appear at any time, and the need for particular knowledge or technique can change rapidly or gradually. Furthermore, when students read and complete courses and learning materials, their requirements and interests change. Yet, recommender systems are incapable of adapting to such changes, necessitating the development of a high-performance system capable of providing real-time recommendations. [32].

The majority of e-learning recommender systems ignore giving users any explanations in favor of concentrating

on the precision and quality of the recommended content. However, despite recommender systems' excellent effectiveness, people still view them as mysterious black boxes. This makes people lose interest in and confidence in these systems, especially those that use sophisticated artificial intelligence algorithms [33]. Thus, explaining things through visualization aids helps students improve satisfaction by assisting them in comprehending the intricate process of recommendations [34]. So, creating a recommender system for online learning that offers visualization is a field that merits additional attention.

4. Conclusion

We've recently noticed a significant scientific effort to construct AI-based recommenders that fulfill a variety of educational objectives. By delivering a personalized education based on the student's requirements and skills and knowledge, recommender systems make an important contribution in strengthening every student's skill and competence. Nevertheless, the use of AI techniques and technologies alters the system in a way which makes it much more interactive, motivating, and engaging for the students, in addition to granting learners an even more personalized educational environment. Yet, even these systems have flaws that can limit their use, such as privacy and data security threats.

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