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Methods and applications of artificial intelligence in education

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Abstract. Artificial Intelligence (AI) has undergone significant development over the past few decades. This review paper gives an introduction of the study of AI and some of its applications in the realm of education. Specifically, this paper discusses three methods used by AI education. The first is learning decomposition which is a way to evaluate learning efficiency., The second is Randomized Controlled Trials (RCT) analysis which is a general idea for conducting experiments, we also introduce a method to analyze data produced by RCT. The third is iNotitium, an online platform using AI algorithms to provide useful educational information and prevent people from misleading by incorrect messages. Besides, the paper also introduces three specific fields in that AI is applied in education, including navigating visually impaired people, tutoring English learning, and helping with early childhood education (ECE). Finally, the paper discusses the prospect of AI and its application in education field, along with the difficulties that we may face in the future when developing AI method in this field.

Keywords: artificial intelligence, deep learning, artificial intelligence in education (AIED).

1. Introduction

Artificial intelligence (AI) has made significant developments in recent years by teaching machines to perceive, learn, and react. AI has a lot of applications in education, including navigation for visually impaired people [1], English learning, and early childhood education. Many educational institutions have begun to use this technology to improve the learning experience and efficiency of students. Deep learning has evolved as an essential concept in the field of machine learning, where artificial neural networks are used for modeling and problem-solving. The use of AI in the field of education has been further developed with the advancement of these technologies.

AI has advanced in many different fields and has been triggering multiple revolutions in these areas. With the theoretical development of AI, such as deep learning, the innovative application of AI came out frequently. Recently in Natural Language Process (NLP) field, a multimodal model named GPT-4, which is an upgraded version of GPT-3.5 and can use the input of image and text to generate text output [2], has gained wide popularity. And as methods to improve neural networks were presented [3], the study of computer vision has made breakthrough progress.

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AI has also resulted in significant breakthroughs in the education sector [4]. According to Chen et al., there was a steady increase in the amount of research published on Web of Science and Google Scholar on the topics of "Education" and "AI" from 2010 to 2019, demonstrating the rising interest in the field. With the maturation of AI, there has been a commensurate increase in research interest in Artificial Intelligence in Education (AIED). There are several AI uses in education. According to Holmes et al., these applications may be roughly categorized into three categories: student-focused AIED, teacher-focused AIED, and institution-focused AIED [5].

Intelligent teaching system (ITS) is the most prevalent use of AI in student focused AIED. By collecting test scores, learning feedback, etc., ITS can model learners, teaching styles, and knowledge. According to Beck et al., a complete description of knowledge tracing is available by modeling students using dynamic Bayesian networks [6]. This type of modeling allows for more accurate and efficient student evaluation, prediction of student and knowledge models, and adaptation of educational approaches using machine learning and data mining to deliver tailored learning programs for diverse students. AI also plays an essential part in education and administration. In terms of teacher focused AIED, AI is widely used as an assistive technology for the academic assessment of students and the detection of academic plagiarism. On the administrative side, AI is applied to the management of teaching resources and the scheduling of semester course plans. This automated approach to assessment and management has effectively improved the efficiency of educational institutions. However, there is still tremendous untapped potential for AI in these two areas. Given the substantial amount of research on the application of artificial intelligence in education, it is imperative to give a comprehensive overview of this field for current and future scholars entering this area.

The remainder of this paper is structured as follows: The second section of this study enumerates some representative methods in this field, and the third section describes the application scenarios as well as provides the corresponding discussion. Lastly, the summarization of the entire study is given in the last section.

2. Methods

2.1. Learning decomposition

Measuring the effectiveness of student learning is vital to the application of AI. By measuring and assessing student learning effectiveness, AI can better understand students' knowledge levels and provide them with personalized learning experiences to improve learning outcomes. At the same time, as students learn, their learning profiles are constantly changing. Effective assessment methods can help AI adjust delivery methods to suit students' needs better. According to Beck et al., by analyzing data such as student performance on different subtasks and answer records, Learning Decomposition can assess the effectiveness of different learning methods, thus providing stage-by-stage feedback on student learning outcomes [7].

$$performance = A * e^{-b(B*t1+t2)} \quad (1)$$

As a generalization of the learning curve analysis, the learning decomposition can use nonlinear regression to determine how to evaluate various types of practice possibilities in relation to one another. In the learning decomposition, the evaluation of the effectiveness of the learning method is mainly based on the exponential curve. The free parameter A indicates the student's performance when undertaking the practical exercise for the first time. Parameter e is a mathematical constant (2.718). The free parameter b represents the rate at which learners acquire skills. The variable t1 represents the number of learning opportunities when the learner practiced the ability for the first time that day. t2 shows the number of practice opportunities accomplished as a consequence of practicing on the same day. Parameter B reflects the relative weight of the day's initial learning opportunity.

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2.2. Randomized controlled trials analysis

Another method to evaluate the efficiency of the teaching tutor is Randomized controlled trials analysis (RCT). RCTs are a type of scientific experiment that aims to reduce bias when testing new treatments or interventions. In an RCT, participants are randomly assigned to either an experimental group receiving the treatment or intervention being tested or a control group not given the treatment or intervention.[8]

RCT is more like an idea rather than a specific algorithm, which means in different scenarios of AI education, specific experiments should be designed. For example, in project Listen, the students who participated in it were randomly given help from the tutor [9]. And then they measured how the students read the word, which helped in assessing the efficiency of the reading tutor.

There are multiple ways to analyze the data generated by RCT, including analysis of variance (ANOVA) or t-test. For example, in an intelligent tutoring system for the accounting cycle [10], the researchers intended to see if the tutor had a greater influence on students with lower foundations than on students with stronger foundations. Students were placed into two groups depending on their pretest results. Following that, an ANOVA was performed with the pre-test and post-test scores as independent factors. Eventually, the ANOVA reveals that the students with weaker bases do have a more significant improvement than students with higher pretest scores.

2.3. Educational program-iNotitium

Although the internet includes a combination of information from different sources, some of it is not guaranteed to be correct or up to date. Therefore, there is a study to develop an educational program that complements the teaching process by filtering the information for teachers and students —iNotitium [11]. iNotitium receives and processes the information that the lecturer provided (key concepts and URLs) that will be used by the crawler and eNLP system and displays relevant articles. The lecturer can manipulate the setting to limit the sources from which the displayed articles are.

3. Applications

3.1. Navigation support for visually impaired people

In daily navigation, visually impaired people face challenges like identifying stairs, pits on the path, roadblocks, or wet floors. Thus, various systems have been developed to capture and analyze the surroundings of visually impaired people to facilitate safe navigation.

Visual Imagery Systems, for example, identify impediments using visual features and then present guidance to the user for safe navigation. Stereo cameras, Internet Protocol (IP) camera networks, or Red Green Blue-Depth (RGB-D) cameras are utilized in these systems. Microsoft Kinect is an RGB-D camera [12]. It uses an algorithm to detect the depth of an obstacle and give the user voice feedback through headphones.

3.2. ITS in English learning

The integration of Artificial Intelligence (AI) has also significantly impacted the field of English learning. The Intelligent Tutoring System (ITS) is a crucial component, which can provide personalized content and learning guidance to different students by leveraging mathematical modeling and big data analysis. Specifically, ITS is predominantly applied for vocabulary learning and speaking practice.

With respect to vocabulary learning, ITS can assess the user's learning ability and generate predictions for the errors they may make by modeling the student and the knowledge they have learned. These models reflect students' abilities, learning preferences, and knowledge acquisition in English learning. They help ITS track students' learning progress and predict their future performance, thus providing personalized learning content and more targeted help for students' vocabulary learning. In terms of speaking practice, ITS also plays an important role in continuous learning and learning assessment for users. For continuous learning, users can use ITS to practice pronunciation and conversation, and ITS provides learners with immediate feedback on the accuracy of their pronunciation

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and suggestions for improvement. In terms of learning assessment, ITS creates student models for English learners, which are subsequently used to assess students' English proficiency and learning performance.

3.3. Application in early childhood education (ECE)

AI has contributed significantly to the field of early childhood education, and many studies have concluded that it has enhanced the efficiency of ECE [13]. An interesting subset of ECE is utilizing AI to teach AI, which refers to imparting elementary AI and computer science knowledge to children since many future job opportunities will be closely related to AI [14]. Research conducted by Vartiainen, H. [15] explores how six children aged 3-9 taught and explored Google's Teachable Machine in non-school settings and analyzes the process and content of children's interaction with machine learning systems based on sociocultural theory. It poses the research question about how young children participate, interact, think, express, and understand when they teach and explore machine learning. Finally, the study concludes that young children are capable of actively participating in machine learning systems, demonstrating curiosity, interest, and creativity in exploring the functioning of machine learning, including the generation of datasets and the underlying mechanics of the process.

4. Conclusion

The development and implementation of artificial intelligence in education is the topic of this study. This paper reviews three techniques commonly used in the AIED field. In the application scenarios section, we introduce the applications of AI in the fields of disability education, English language learning, and early childhood education. These examples prove that AI is playing an increasingly important role in education. It has significant implications for improving school efficiency and reducing inequities in education. At the same time, AIED also faces some problems, such as the fact that AI is still underdeveloped in teacher work. In the future, in addition to the field of learning, AI will also make a greater contribution in the daily work of teachers, school administration and other areas.

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