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Advancements and Application of Artificial Intelligence Technologies in Education

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Abstract:

In the field of education, information technology has been widely used in teaching and learning activities, bringing more efficient learning process for teachers as well as students. However, there are still some problems. The rapid development of Artificial Intelligence (AI) technology has brought a positive effect on the change of education technology. In this paper, the author did some investigation on the research of AI in education. The results of different researchers are divided into three parts in terms of application scenarios. The first part is student performance prediction. In this part, the author has categorized into machine learning and deep learning based on the kind of methods utilized. The second part is student data analysis, which can be functionally categorized into two directions, facial recognition and text analysis, based on the direction of the research. In the third part, the author summarizes some cases of AI-assisted teaching that are closer to actual teaching activities. These cases present solutions to the current deficiencies in the field of education, proving the efficiency of AI. Based on extensive research on many papers, the author suggests that AI currently faces difficult challenges in terms of interpretability, applicability, and safety. The application of AI in education can be improved in the future through technologies such as Open Learner Models (OLMs), expert system, and transfer learning. This paper provides an overview reference for research in this area.

Keywords: Artificial intelligence; machine learning; education; teaching activity.

1. Introduction

Information technology teaching method refers to the utilization of modern information technology in the teaching process to improve the quality of teaching and achieve teaching goals. Nowadays, information technology has deeply integrated into teaching activities, helping teachers accomplish their instructional tasks. However, there are still many issues within the current education system. Teachers are unable to fully focus on each student individually. Students lack personalized learning plans. Fewer and less accurate assessment tools for teaching and learning outcomes. With the advancement of Artificial Intelligence (AI) technology, AI has shown great potential in the field of education. Thanks to the great data mining and reasoning capabilities, it has enabled powerful educational technologies that have achieved significant changes to teaching activities.

Nowadays, artificial intelligence has been practically applied in multiple fields, with a considerable number of researchers exploring the applications in the education sector. For instance, Gomede et al. have focused on the feasibility of Deep Auto Encoder (DAE) in Adaptive E-learning Systems (AES). The DAE algorithm can process data generated from student behavior and make predictions, thereby being used to recommend learning content to students. They compared the recommendation quality and prediction accuracy of different DAEs. This study indicates that AI can assist educators in selecting suitable teaching topics for students and enable more targeted learning [1]. AI has played a significant positive role in promoting educational equity. Srinivasan points out the severe issue of educational inequality in the United States, where there is a vast gap between the educational resources enjoyed by different individuals. Moreover, providing adaptive teaching resources for learners is even more challenging. AI has transformed the role of teachers in instruction by diminishing their predominant position while strengthening student autonomy. Benefiting from the powerful integration capability and adaptability of AI, it implements applications on large-scale educational activities [2]. Chung et al. highlight the role emotions play in education. They investigated how AI can be used to objectively recognize and assess human emotions. They recruited subjects to provide movies expressing different emotions, recognized emotions by collecting Heart rate

variability (HRV) data and used the Partial Least Squares Discriminant Analysis (PLS-DA) model. This work assists educators more accurately determine changes in student mood as a way of adjusting the atmosphere and pace of the classroom [3]. Student grades assess their progress at various stages but as complex individuals, traditional grading may not provide comprehensive insights into their learning status entirely. Pallathadka et al constructed a model for predicting student grades by using the feature selection technology of AI. The model extracts more information from the student data and predicts the student performance in the future. Predicting student grades based on their behaviors enables educators to develop teaching programs as early as possible and intervene effectively in the teaching process. This promotes students to recognize the lack and accomplish a better grasp of what to work on [4]. Therefore, AI is playing an increasingly critical role in education. Various educational technologies based on AI are constantly appearing. This paper aims to provide a comprehensive review of papers on the application of AI in education in recent years, exploring the prospects and development direction of artificial intelligence used in education.

The rest of the paper will be presented in the following format. In the second section, this paper will reveal the methodologies used in various types of research on AI education. In the third section, it will discuss and analyze the shortcomings of the current AI education researches and the future challenges in the field of education, and explore the future direction of AI instructional technology. In the fourth part, this paper will be summarized, and the conclusions obtained from this review will be shown.

2. Method

2.1 Introduction of the Machine Learning Workflow

Machine learning is an important component of Artificial Intelligence that allows computers to learn patterns and methods from data [5]. In the domain of education, machine learning is widely applied to analyze and predict data according to its rigorous workflow.

The first step in machine learning is data collection, various schools and educational organizations can provide a large amount of data about students, teachers, and teaching activities. Data preprocessing is then performed to improve data quality. The third step, model building is built based on data preprocessing. The data is then divided into a training set and a test set, and the model is trained and tested until the accuracy is satisfactory. Ultimately, the model is deployed in the application based on actual usage.

2.2 Student Performance Prediction

2.2.1 Machine learning-based prediction

Yağcı selected some of the student records of a Turkish university as a dataset to calculate the degree of influence of students' midterm grades on their final performance utilizing Educational Data Mining (EDM). The author exploited Random Forest (RF), Neural Network (NN), Logistic Regression (LR), Support Vector Machine (SVM), Naive Bayes (NB) and k-Nearest Neighbors (KNN) to create predictive models. He used equal-width discretization model to classify the grades and evaluated the performance of the model [6].

Hussain and Khan employed the 30 best attributes from the preprocessed dataset to train the regression model and DT-classifier. For the selection of the best attributes, the researchers utilized Genetic Algorithm (GA), which ranks the attributes and then removes the lower ranked attributes. Finally, 30 attributes are left as GA optimized dataset. Grouping the optimized attributes, what generates a feature vector and a label vector. An Ķ-Fold Cross-validation method is applied for the evaluation of the performance of regression and classification models [7].

2.2.2 Deep learning-based prediction

Waheed et al. deployed a deep artificial neural network in Virtual Learning Environments (VLE) to help students predict negative learning trends. They chose publicly available datasets from OULA and tried several analysis methods. The risk of student failure was identified by a deep learning approach with three neuronal hidden layers. Intervening in student learning at an early stage can be effective in avoiding possible student difficulties [8].

Massive Open Online Courses (MOOCs) have been accompanied by the problem of high attrition rates since their emergence. Xing et al. investigated the way of personalized intervention for students through deep learning based on temporal dropout prediction models. They calculated the dropout probability of individual students through deep learning algorithms and predicted the actual dropout date of students. This research contributes to personalized interventions for students in MOOCs [9].

2.3 Student Data Analysis

2.3.1 Facial recognition

Bhardwaj et al. exploited deep learning algorithms to analyze emotions captured from faces and calculate scores based on weights to achieve improvements in teaching methods. They chose students in an e-classroom as their respondents. This study utilized Haar cascade classifier to categorize expressions and Convolutional Neural Network (CNN) to predict emotions. Finally, the Mean Engage-

ment Score (MES) was calculated, which was used to assess how active the students were in the classroom [10].

Student attention is an important indicator of the quality of instructional activities. Goldberg et al. had students fill out questionnaires about their personal information before the course. Students were videotaped during the course and a knowledge test was administered at the end of the course. They developed a continuous manual annotation to code the behavior of students per second through CARMA software. They used machine vision methods to extract features of faces, regressed the intensity of participation using linear support vector regression, and finally predicted the student's level of participation [11].

2.3.2 Text analysis

Onan aims to get useful teaching information from Student Evaluations of Teaching (SET) by deep learning-based sentiment analysis. He applied deep learning architectures such as Convolutional Neural Networks (CNN), recurrent neural network (RNN), Long Short-Term Memory Networks (LSTM), etc., and applied classification accuracy as well as F-measure as metrics [12].

Zhen et al. started with classroom conversation transcripts, which were categorized into cognition, meta-cognition, and off-topic according to the type of student interactions. The study manually categorized the data through data annotators, and then utilized the model of Bidirectional Encoder Representations from Transformers (BERT) for text processing of unlabeled data. The BERT model is divided into Pre-training part and Fine-Tuning parts for training the added data [13].

2.4 Artificial Intelligence Teaching Aids

Villegas-Ch et al. combining AI, data analytics, and Learning Management System (LMS) to create adaptive models for each student to help students improve their performance. They conducted their teaching activities through two modes, traditional teaching and online education respectively. Hadoop MapReduce can handle large amount of data. They applied naive Bayes data mining algorithm to analyze the data. Stratified cross-validation and Matrix of confusion were utilized as experimental results to compare the assessment scores. This study can improve the evaluation results [14].

Chen et al. investigated the effectiveness of using chatbots in teaching and the possible pitfalls. They created a chatbot as per their needs to enable online interviews. Through online interviews the research team got students' opinions about using chatbots in teaching. After that they improved the questions on the first chatbot and let the new chatbot carry out teaching activities to evaluate the effectiveness of the bot in teaching [15].

The feasibility of AI for educational application development was demonstrated by Sánchez-Morales et al. The application development tool EduMatic recognizes User Interface Design Pattern (UIDP) in pictures and generates source code. The author applied Multilayer Perceptron (MLP) as a basis for recognizing hand-drawn images that can recognize more complex elements. The author exploited Wiki-Comp which based on EduMatic with popular applications for qualitative evaluation. The results of the experiments demonstrated that software development based on AI is cheaper, more efficient and guarantees the quality [16].

3. Discussion

In the domain of education, many researchers are exploring the application of AI technology. An increasing number of research results have been created. But there are still many limitations and challenges before AI can be applied to teaching and learning activities on a large scale. Currently, most of AI research utilizes techniques of machine learning and deep learning to get predictions and personalized recommendations on student performance. However, the outputs of such AI models lack interpretability for the people they are intended to serve. Taking the prediction of student performance as an example, students can get the predicted values with high accuracy, but the process of generating these results cannot be observed. The internal model of AI has a complex structure, and the various features interact with each other, so it cannot make specific guidance for the student learning process. Students lack sufficient knowledge to understand the results of AI models, which cannot provide effective help to their learning and may even cause students to make wrong judgments about themselves.

In addition, AI technologies still need to evolve in terms of applicability. AI is a technology that relies on datasets and analyzes the data, which means that the performance and applicability of AI models are greatly influenced by the content of the dataset. Through data preprocessing, researchers can utilize methods such as data cleaning and data standardization to improve data quality. However, when acquiring datasets, reasons such as not being widely distributed and large enough often limit the applicability of AI models. When analyzing the role of AI technology in the domain of education, researchers often attain data from students in the same school or the same class to conduct experiments. Such datasets can only reflect the characteristics and distribution of a certain group but cannot represent all students in the entire educational domain. This leads to weak applicability of the relevant AI models, which cannot achieve the same performance and accuracy

on other datasets. From view of a researcher, obtaining data from educational institutions is not an easy task. On the other hand, the increase in data also leads to a rise in the difficulty of processing the data and an increase in the demand for computational resources. These reasons lead to the extremely high cost of training complex AI models. AI technology contributes to educational equity, but the problem of AI applicability restricts relatively backward areas from using the benefits of AI technology, which leads to the widening of the educational resource gap.

Along with the development of AI technology, another concern about AI security have risen. One of the biggest issues is privacy and ethics. The protection of personal information is a very important topic nowadays. And AI can get more and more detailed content from personal information with its powerful data analysis and feature extraction ability, which greatly deepens the harm caused by privacy leakage. Furthermore, students are mostly underage groups, and the society is more concerned about this area. In the future, AI technology will develop into a form closer to humans, gradually replacing functions that could only be realized by human in the past. The human relationship between teachers and students is an integral part of education. With the addition of AI, the content of this relationship will change dramatically, with unpredictable effects on education.

In the future, AI could solve the current problems through various techniques. Open Learner Models (OLMs) is a visualization method for eXplainable AI (XAI). OLMs can present students with a view of their learning progress and make it easy for them to manage their learning process [17]. The expert system consists of inference engine and knowledge base. The inference engine understands the logic of propositions and reasoning based on the information in the knowledge base. Expert systems can also help in problem solving for people who are not computer literate [18]. Transfer learning can utilize knowledge from one domain to solve problems in another domain. Through transfer learning, AI models can achieve higher performance while using less data and computational resources [19]. In transfer learning, Domain Adaptation [20] is a special form that can utilize the knowledge in the source domain to improve the learning in the target domain. Domain Adaptation is highly adaptive to different data distributions, and achieves to maintain a high level in the target threshold through feature alignment, subspace alignment, etc. Federated Learning is a distributed machine learning method that is particularly suitable for scenarios with high data privacy and security requirements. Federated Learning allows multiple participants to train a shared model, which is conducive to solving the problem of data silos. Federated Learning has the advantage of privacy in that it only needs to upload the parameters of the model trained based on local data without sharing the data.

4. Conclusion

This paper provides a comprehensive overview of the current applications of Artificial Intelligence technology in education. The paper examines the utilization of AI technology in student performance prediction, student data analysis, artificial intelligence teaching aids. This paper categorizes many AI research results according to the difference between machine learning and deep learning. It summarizes the status of AI development from the perspective of practical application of AI technology. This paper provides an in-depth understanding of the development results of AI in the domain of education through a literature review. On this basis, the author discussed the current limitations and challenges of AI technology in teaching and learning activities, pointing out the harm that these shortcomings may cause in the process of AI development. In addition, the paper proposes solutions to the limitations of AI. The limitation of this literature review is that it does not examine the integration of specific teaching methods with AI technology. In pedagogy, different educational targets and different teaching environments require the use of different teaching methods.

References

[1] Gomede E, Barros RM, Mendes LDS. Deep auto encoders to adaptive E-learning recommender system. Computers and Education: Artificial Intelligence, 2021, 2: 100009.

[2] Srinivasan V. AI & learning: A preferred future. Computers and Education: Artificial Intelligence, 2022, 3: 100062.

[3] Chung JWY, So HCF, Choi MMT, Yan VCM, Wong TKS. Artificial Intelligence in education: Using heart rate variability (HRV) as a biomarker to assess emotions objectively. Computers and Education: Artificial Intelligence, 2021, 2: 100011.

[4] Pallathadka H, Sonia B, Sanchez DT, De Vera JV, Godinez JAT, Pepito MT. Investigating the impact of artificial intelligence in education sector by predicting student performance. Materials Today: Proceedings, 2022, 51(8): 2264-2267.

[5] Helm JM, Swiergosz AM, Haeberle HS, et al. Machine Learning and Artificial Intelligence: Definitions, Applications, and Future Directions. Curr Rev Musculoskelet Med, 2020, 13: 69–76.

[6] Yağcı M. Educational data mining: prediction of students' academic performance using machine learning algorithms. Smart Learn. Environ., 2022, 9: 11.

[7] Hussain S, Khan MQ. Student-Performulator: Predicting Students' Academic Performance at Secondary and Intermediate Level Using Machine Learning. Ann. Data. Sci., 2023, 10: 637–655.
[8] Waheed H, Hassan S-U, Aljohani NR, Hardman J, Alelyani S, Nawaz R. Predicting academic performance of students from VLE big data using deep learning models. Computers in Human Behavior, 2020, 104: 106189.
[9] Xing W, Du D. Dropout Prediction in MOOCs: Using Deep Learning for Personalized Intervention. Journal of Educational Computing Research, 2019, 57(3): 547 - 570.
[10] Bhardwaj P, Gupta PK, Panwar H, Siddiqui MK, Menendez RM, Bhaik A. Application of Deep Learning on Student Engagement in e-learning environments. Computers & Electrical Engineering, 2021, 93: 107277.
[11] Goldberg P, Sümer Ö, Stürmer K, et al. Attentive or Not? Toward a Machine Learning Approach to Assessing Students' Visible Engagement in Classroom Instruction. Educ Psychol Rev, 2021, 33: 27–49.
[12] Onan A. Mining opinions from instructor evaluation reviews: A deep learning approach. Comput Appl Eng Educ., 2020, 28: 117–138.
[13] Zhen Y, Luo J-D, Chen H. Prediction of Academic Performance of Students in Online Live Classroom Interactions—An Analysis Using Natural Language Processing and Deep Learning Methods. Journal of Social Computing, 2023, 4(1): 12-29.
[14] Villegas-Ch W, Román-Cañizares M, Palacios-Pacheco X. Improvement of an Online Education Model with the Integration of Machine Learning and Data Analysis in an LMS. Appl. Sci., 2020, 10: 5371.
[15] Chen Y, Jensen S, Albert LJ, et al. Artificial Intelligence (AI) Student Assistants in the Classroom: Designing Chatbots to Support Student Success. Inf Syst Front, 2023, 25: 161–182.
[16] Sánchez-Morales LN, Alor-Hernández G, Rosales-Morales VY, Cortes-Camarillo CA, Sánchez-Cervantes JL. Generating educational mobile applications using UIDPs identified by artificial intelligence techniques. Computer Standards & Interfaces, 2020, 70: 103407.
[17] Khosravi H, Shum SB, Chen G, Conati C, Tsai Y-S, Kay J, Knight S, Martinez-Maldonado R, Sadiq S, Gašević D. Explainable Artificial Intelligence in education. Computers and Education: Artificial Intelligence, 2022, 3: 100074.
[18] Matsuzaka Y, Yashiro R. AI-Based Computer Vision Techniques and Expert Systems. AI, 2023, 4: 289-302.
[19] Zhuang F, et al. A Comprehensive Survey on Transfer Learning. Proceedings of the IEEE, 2021, 109(1): 43-76.
[20] Wang M, Deng W. Deep visual domain adaptation: A survey. Neurocomputing. 2018 Oct 27;312:135-53.