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PAPER

The Research on the Application of Deep Learning in Education

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ABSTRACT

With the in-depth reform of education, deep learning is gradually being applied to education, which can stimulate students' initiative in learning and improve their learning efficiency. This article explores some specific applications of deep learning in education, uses the deep learning model LSTM to predict students' learning abilities and outcomes, and obtains high accuracy. Through deep learning models, we have abstracted the characteristics of students' learning states and made relatively accurate predictions on their learning outcomes. This paper provides some useful explorations on the application of artificial intelligence and deep learning in education, which can provide valuable references for better research in the future.

KEYWORDS

deep learning, education, LSTM

1 INTRODUCTION

As information technology has advanced and spread rapidly, the field of artificial intelligence has also ushered in a golden age of flourishing development. Deep learning, as one of the core technologies of artificial intelligence, has quickly become a research hotspot and application focus in various industries due to its powerful data processing capabilities and intelligent algorithms. The education field, as an important cornerstone of social development, has also deeply felt the changes and opportunities being brought about by deep learning [1]. Deep learning includes principles, models, and technical applications. The application of deep learning technology in the education field has injected new vitality into teaching and learning, education evaluation, and management, and brought about unprecedented changes and opportunities [2].

Deep learning is a machine learning method based on artificial neural networks (ANN). It learns advanced abstract features from large-scale data by training multilayer neural networks, and uses these features to complete complex tasks such as image recognition, speech recognition, and natural language processing, and so on. Deep learning can be applied to algorithms for intelligent tutoring and personalized

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learning. It includes student error rate prediction, personalized recommendations, knowledge acquisition, intelligent tutoring, and adaptive testing [3, 4].

In teaching and learning, deep learning can realize personalized learning and adaptive education, provide customized learning plans and paths for each student, and help students to identify their strengths and weaknesses, and learn efficiently. Specifically, deep learning can construct personalized student models based on students' learning data, learning styles, learning characteristics, etc. On this basis, the personalized learning content can be generated, the appropriate learning resources can be recommended, and the targeted learning strategies to help students achieve personalized learning can be formulated [5, 6]. In addition, deep learning can also be used for the intelligent generation and recommendation of learning content, providing students with rich and high-quality learning resources to meet their personalized learning needs. For example, deep learning can automatically generate personalized learning materials, practice questions, explanation videos, etc., and recommend them based on students' learning progress and level to help students to master knowledge and skills efficiently.

In the monitoring and analysis of learning behavior, deep learning can monitor students' learning behavior in real time, analyze students' learning status and learning effects, provide teachers with timely and effective teaching feedback, help teachers improve teaching methods, and improve teaching quality. Specifically, deep learning can analyze data such as students' learning trajectories, learning time, learning efficiency, and learning errors, identify students' learning problems and learning difficulties, and provide teachers with corresponding teaching suggestions and strategies to help teachers carry out targeted teaching [7].

In education evaluation and management, deep learning can be used to construct intelligent education evaluation systems to objectively and fairly evaluate students' learning status, teachers' teaching effects, etc., and provide a scientific decision-making basis for education administrators. For example, deep learning can automatically grade students' homework and papers, analyze students' exam scores, and evaluate students' learning status based on exam scores. In addition, deep learning can also analyze teachers' classroom teaching data, evaluate teachers' teaching effects, and provide guidance for teachers' professional development [8].

Deep learning technology has brought unprecedented changes and opportunities to the field of education and has broad application prospects. With the continuous development and improvement of deep learning technology, its application in the field of education will be more in-depth and extensive, injecting new vitality into education development and promoting education reform and innovation.

2 BRIEF DESCRIPTION OF DEEP LEARNING TECHNOLOGIES

In recent years, deep learning technology has demonstrated its powerful ability to solve real-world problems, gaining widespread recognition from researchers in various fields. However, there exists a discrepancy between the definitions of deep learning in the artificial intelligence and education domains.

Deep learning is an emerging technique within the realm of machine learning, first introduced in 2006 by Professor Hinton of the University of Toronto. The advent of deep learning not only shattered the bottleneck in the development of traditional neural networks but also swiftly garnered significant attention from the academic community due to its robust feature extraction and nonlinear fitting capabilities [9, 10].

Deep learning neural networks are composed of input, hidden, and output layers. Through multi-layer neural networks, input data undergoes layered abstraction and representation learning, enabling the extraction of intricate patterns and regularities from vast amounts of data. Consequently, deep learning can model complex data structures and nonlinear relationships. In comparison to conventional machine learning methods, deep learning exhibits the following characteristics: (1) Deep structure: Deep learning models typically comprise multiple hidden layers. The greater the number of layers, the more complex features and regularities the model can learn. (2) Enhanced learning ability: Deep learning models can learn from massive datasets and automatically extract features without the need for human intervention. (3) Stronger representation capability: Deep learning models can acquire more abstract and high-level feature representations, which in turn enhance the model's generalization ability.

Deep learning possesses the ability to fit any complex function, extract features from diverse data types, and demonstrate strong recognition capabilities. Furthermore, deep learning can store long-term states within hidden layers, effectively preserving the connections between data points. Compared to other data mining techniques, deep learning offers greater flexibility and accuracy, effectively addressing the shortcomings of traditional methods. In recent years, deep learning has made significant strides in various fields, including speech recognition, image recognition, sentiment analysis, and natural language processing, which showcases its vast application potential.

Beyond the realm of artificial intelligence, the concept of deep learning also exists in the education domain. In 1956, Bloom proposed the notion of "cognitive levels" in learning, distinguishing between shallow learning and deep learning. Shallow learning emphasizes memorization and comprehension, while deep learning focuses on the application and innovation of knowledge. In 1976, American scholars Marton and Säljö introduced the concept of deep learning specifically for shallow learning. They defined deep learning as a profound understanding of knowledge that enables learners to broaden their thinking, cultivate their own thinking patterns, and ultimately apply their acquired knowledge to real-world situations [11, 12].

Deep learning in education has gained widespread recognition from educators. Through deep learning, each learner can effectively integrate and process information on a deeper level, apply their knowledge to practice, and ultimately expand their understanding to generate more creative ideas. Deep learning also presents new transformative opportunities for the education sector, holding the potential to address challenges in traditional education and enhance the quality of education. As deep learning technology continues to evolve, its applications in education will become increasingly extensive and profound.

3 THE APPLICATION OF DEEP LEARNING TECHNOLOGY IN EDUCATION

3.1 Personalized learning

Personalized learning is one of the most significant applications of deep learning in the education sector. Unlike traditional one-size-fits-all approaches, deep learning technology enables personalized learning paths and content recommendations by analyzing students' learning behaviors and characteristics, effectively catering to the diverse needs of individual learners. For instance, by analyzing data such as

students' learning history, interests, and learning abilities, deep learning algorithms can tailor learning plans and recommend appropriate learning resources to each student, optimizing their learning efficiency and motivation [13, 14].

3.2 Managing and optimizing of educational resources

Furthermore, deep learning plays a crucial role in managing and optimizing educational resources. With the advancement of information technology, educational resources have become increasingly diverse and abundant; however, effectively managing and utilizing these resources remains a challenge. Deep learning technology can achieve precise resource matching and optimized allocation through intelligent analysis and processing of teaching resources, enhancing teaching efficiency and quality. For example, by conducting deep learning analysis of teaching content, textbooks, and course designs, the inherent connections and values among different teaching resources can be uncovered, providing scientific evidence and support for organizing, updating, and optimizing teaching resources.

3.3 Assistance in evaluation and improvement in teaching quality

In addition, deep learning can assist educational institutions and teachers in evaluating and improving teaching quality. Traditional teaching evaluations often rely on students' exam scores and teachers' subjective assessments, which lack objectivity and comprehensiveness. Deep learning technology, on the other hand, can implement intelligent evaluation and precise improvement of teaching quality by analyzing data on students' learning behaviors and achievements, providing scientific evidence and support for education and teaching. For instance, by conducting deep learning analysis of students' learning status, progress, and performance, problems and areas for improvement in the teaching process can be identified, providing teachers with targeted teaching suggestions and improvement measures.

Deep learning has injected new vitality into education and provided a powerful driving force for educational transformation. As deep learning technology continues to evolve, education will become more intelligent, personalized, and high-quality, offering students a superior learning experience and a brighter future.

Deep learning has revolutionized the field of education by enabling personalized learning, optimizing resource management, and enhancing teaching evaluation. As deep learning technology matures, it will undoubtedly play an even more transformative role in shaping the future of education, empowering students to reach their full potential and fostering a more equitable and effective learning environment for all.

4 EXAMPLES OF DEEP LEARNING IN EDUCATION

In order to execute teaching tracking and effect prediction, we conducted an investigation and analyzed the obtained data based on deep learning. The survey focused on these university students from our school, with participants originating from Yunnan, Sichuan, Hunan, Jiangxi, Henan, Shaanxi, Xinjiang, and Chongqing. The study distributed questionnaires both online and offline, collecting 1,211 responses. After removing invalid ones, 1,165 valid questionnaires remained, resulting in an efficiency rate of about 93.6%. The primary research method was a questionnaire,

divided into two parts: basic information and learning ability/status. "Learning ability and status" encompassed three dimensions: cognition, ability, and emotion. As shown in Table 1, the emotional dimension of learning ability was higher than the cognitive, which was higher than the ability dimension.

Table 1. Statistics on dimensions of university students' learning ability

Dimension		Maximum	Minimum	Mean ± SD
Cognitive Dimension	Knowledge	5	1	3.19 ± 0.43
	Critical Thinking	5	1	3.21 ± 0.41
Ability Dimension	Ability Dimension	5	1	3.11 ± 0.46
	Metacognitive Ability	5	1	3.18 ± 0.83
	Collaboration Ability	5	1	3.12 ± 0.62
	Innovation Ability	5	1	3.03 ± 0.63
Emotional Dimension	Learning Motivation	5	1	3.32 ± 0.56
	Learning Engagement	5	1	3.21 ± 0.43
	Self-Efficacy	5	1	3.28 ± 0.63

The data shows significant differences in learning ability across grades (refer to Table 2). Overall, juniors exhibited higher learning abilities, followed by seniors, sophomores, and freshmen. Freshmen had the lowest learning ability levels, while seniors experienced a slight decline. This may be due to the transition from high school to university, where students initially struggle with self-directed learning. As they progress to sophomore year, self-discipline and learning abilities improve, peaking in junior year. By senior year, with major courses completed, motivation decreases slightly.

Table 2. Differences in learning ability by grade

Dimension		Freshman	Sophomore	Junior	Senior
Cognitive Dimension	Knowledge	2.76 ± 0.45	3.01 ± 0.67	3.39 ± 0.35	3.21 ± 0.57
	Critical Thinking	2.62 ± 0.31	3.08 ± 0.58	3.33 ± 0.41	3.19 ± 0.48
Ability Dimension	Problem-Solving Ability	2.81 ± 0.52	3.27 ± 0.62	3.36 ± 0.43	3.23 ± 0.42
	Metacognitive Ability	2.93 ± 0.73	3.13 ± 0.73	3.38 ± 0.83	3.20 ± 0.72
	Collaboration Ability	2.99 ± 0.62	3.21 ± 0.60	3.31 ± 0.62	3.35 ± 0.42
	Innovation Ability	2.58 ± 0.55	2.91 ± 0.54	3.23 ± 0.46	3.21 ± 0.48
Emotional Dimension	Learning Motivation	3.11 ± 0.47	3.25 ± 0.49	3.61 ± 0.56	3.61 ± 0.56
	Learning Engagement	3.18 ± 0.39	3.29 ± 0.51	3.56 ± 0.37	3.56 ± 0.37
	Self-Efficacy	3.13 ± 0.59	3.31 ± 0.53	3.58 ± 0.53	3.58 ± 0.53

Using deep learning with an LSTM neural network (see Figure 1), LSTM is a deep learning model that can process sequence and includes a put gate, forget gate, and output gate, we trained the model on students' learning ability data across grades to predict overall learning abilities. The results are shown in Table 3.

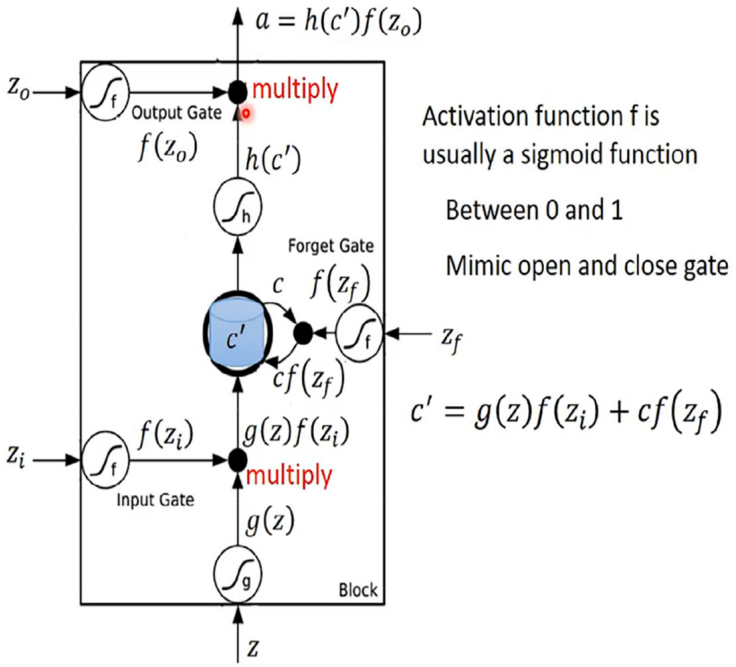

Fig. 1. LSTM schematic diagram

Table 3. The comparison of actual and predicted learning ability by grade of our university

	Freshman	Sophomore	Junior	Senior
Actual Value	2.93 ± 0.45	3.11 ± 0.55	3.34 ± 0.67	3.31 ± 0.48
Predicted Value	2.85 ± 0.61	3.00 ± 0.78	3.21 ± 0.72	3.19 ± 0.71
Accuracy	0.97	0.965	0.962	0.964

We also conducted a survey at the Forestry Vocational and Technical College (collecting 652 responses; 588 valid questionnaires remained) and applied the deep learning model trained based on our own school data to make predictions in this school's survey (refer Table 4). Similarly, the accuracy was also high.

Table 4. The comparison of actual and predicted learning ability by grade of the forestry vocational and technical college

	Freshman	Sophomore	Junior	Senior
Actual Value	2.72 ± 0.53	2.95 ± 0.47	3.13 ± 0.43	3.22 ± 0.56
Predicted Value	2.81 ± 0.59	3.03 ± 0.51	3.23 ± 0.46	3.16 ± 0.62
Accuracy	0.967	0.973	0.969	0.981

5 CONCLUSION

With the continuous development of artificial intelligence, deep learning and other artificial intelligence technologies are gradually penetrating into various fields of social life. Education, as one of the important fields, should also have specific applications in it. We explored the application of deep learning in education and made accurate predictions on students' learning abilities and teaching effectiveness

through experiments. Our experiments validated that the deep learning model can extract features of students' learning status and make predictions on their learning outcomes. This is a beneficial exploration of artificial intelligence in educational applications.

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