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Exploration of Teaching Mode Combining Theory and Practice in Deep Learning Courses

Yujie Zhang, Xia Qiu *

Yibin Campus, Chengdu Technological University, Yibin, 644000, China
*** Corresponding author:** Xia Qiu

Abstract: "Deep Learning," as a key course in the Artificial Intelligence (AI) program, is grounded in advanced mathematics and computer technology, providing a solid foundation for applying AI across various industries. However, with the rapid development of AI technology, a purely theoretical approach to teaching "Deep Learning" can no longer meet the national demand for application-oriented AI professionals. To effectively cultivate AI talent, this paper explores a teaching model that combines theory and application within the context of higher education AI program development. By optimizing teaching content and experimental methods, the aim is to enhance the teaching effectiveness through project-based learning, ultimately fostering students' practical abilities and overall competence.

Keywords: Artificial Intelligence; Teaching Improvement; Combining Theory with Practice.

1. Introduction

With the development of societal intelligence, artificial intelligence (AI) is being rapidly and widely applied across various industries. Training application-oriented talent in AI has become a primary mission for universities[1]. By 2022, 345 universities in China[2] had established undergraduate AI programs. "Deep Learning," as a core course within the AI curriculum, is based on advanced mathematics and computer technology, providing a solid foundation for applying AI across industries. However, with the rapid advancement of AI technology, a focus solely on theoretical teaching in "Deep Learning" is no longer sufficient to meet the national demand for application-oriented AI professionals. To effectively build AI talent, this paper explores a teaching model that integrates theory with application in the context of AI program development in universities.

2. Current Status of Deep Learning Course Teaching Research

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2.1. The Course Content is too Theoretical

With the development of societal intelligence, artificial intelligence (AI) is being rapidly and widely applied across various industries. Training application-oriented talent in AI has become a primary mission for universities. By 2022, 345 universities in China had established undergraduate AI programs. "Deep Learning," as a core course within the AI curriculum, is based on advanced mathematics and computer technology, providing a solid foundation for applying AI across industries. However, with the rapid advancement of AI technology, a focus solely on theoretical teaching in "Deep Learning" is no longer sufficient to meet the national demand for application-oriented AI professionals. To effectively build AI talent, this paper explores a teaching model that integrates theory with application in the context of AI program development in universities

2.2. The Course Teaching Mode Needs to be Improved

Currently, the teaching model for "Deep Learning" predominantly follows the traditional "teacher lectures using blackboard and PowerPoint while students listen" approach, which no longer meets the needs of the new era for highly qualified, practice-oriented talent. (1) Students are in a passive state during class, lacking opportunities for active thinking and participation in discussions, making it difficult to develop deep understanding and autonomous learning abilities. (2) As a highly applied and practical discipline, deep learning cannot be effectively taught through a heavy reliance on theoretical lectures. Merely imparting theoretical knowledge is insufficient for helping students truly master and apply deep learning techniques. (3) The current teaching methods fail to foster students' innovation and practical skills. In a rapidly evolving technological environment, students need the ability to learn quickly and explore independently to remain competitive.

2.3. The Importance of Combining Practice with Theory in Teaching

Through practical learning, students can concretely apply abstract theoretical knowledge, thereby developing hands-on skills. This approach allows them to grasp and utilize the learned content more intuitively, not only reinforcing their

understanding of the material but also helping them build a systematic knowledge framework and enhance their overall competence. Especially in deep learning laboratory courses, students have the opportunity to engage with cutting-edge technologies and real-world programming tasks, keeping pace with industry developments. This practical experience enables them to quickly adapt to the work environment after graduation and effectively meet the technical demands of employers. Additionally, by deeply exploring theoretical knowledge, students can identify solutions to real-world challenges from a theoretical perspective and continuously validate and refine these theories in practice, making them more applicable to real-world situations. The combination of theory and practice not only strengthens their professional foundation but also provides robust support for their future innovation and problem-solving abilities in the workplace. By conducting in-depth research into theoretical knowledge, students can find solutions from a theoretical standpoint when facing challenges and refine those theories through practical application.[3]

3. Teaching Innovation Combining Course Theory with Practice

3.1. Optimize Teaching Content

"Deep Learning" extends into areas such as computer vision, natural language processing, and reinforcement learning, all of which demand strong practical skills from students. As a foundational course for these directions, deep learning requires innovative teaching content, with careful consideration given to the depth and breadth of the material to ensure differentiated instruction.[4] For example, when teaching neural networks, introducing cutting-edge research cases can be highly effective. This approach not only covers the theoretical knowledge of neural networks but also integrates these theories with corresponding computer code. For instance, when explaining how to build a neural network, one might use the example of a six-layer convolutional neural network, as illustrated in Figure 1, which recognizes classroom behavior. By analyzing the working principles and demonstrating how the layers of the neural network correspond to the relevant code, the lecture seamlessly integrates theory with practice. This method enhances students' interest in learning, increases their engagement, broadens their horizons, and provides them with a deeper understanding of industry knowledge, thereby laying a solid foundation for their future careers.

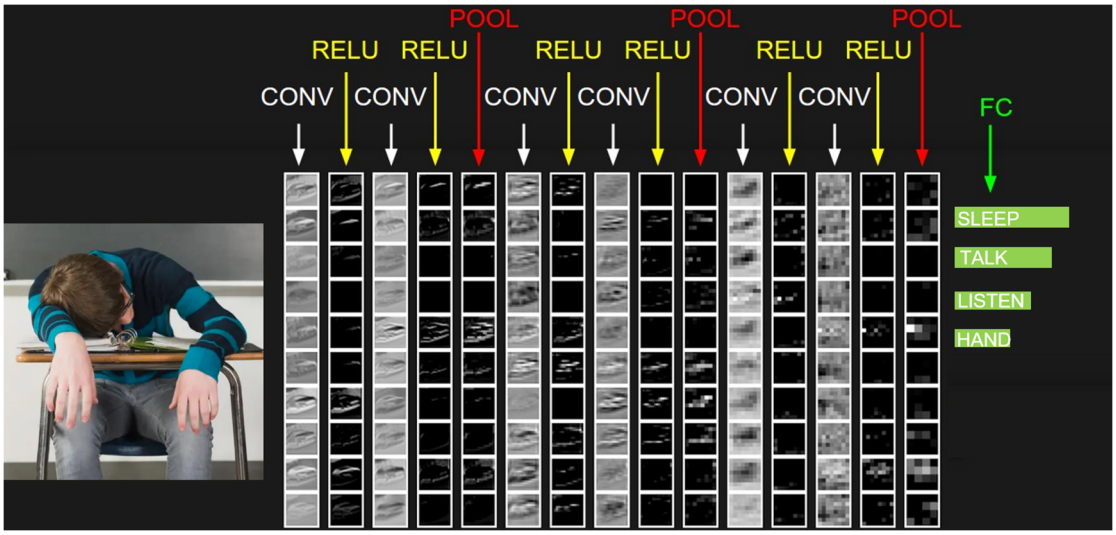


Figure 1. Six-layer convolutional neural network to identify students' classroom behavior

3.1.1. Neural Network Stacking Explained

As shown in Figure 1, the discretized input data of student behavior to be detected is first processed through the input layer, then passed through the first convolutional layer, where the linear mapping is transformed into a nonlinear mapping using the ReLU activation function. Next, it passes through the second convolutional layer, where another nonlinear transformation occurs using an activation function. The image is then compressed through a pooling layer, allowing the first level of feature extraction. The same process is repeated for the subsequent four layers. It can be observed that the features extracted at each layer differ in complexity, with deeper layers capturing more advanced features. The stacking of deep learning algorithms enables more accurate recognition of students' classroom behaviors by the computer.

3.1.2. Combining Experiment and Theory

```
model = Sequential()
model.add(Conv2D(32, kernel_size=(5,5), activation='relu', input_shape=(img_x, img_y, 1), strides=(1,1), padding="same"))
model.add(Conv2D(32, kernel_size=(5,5), activation='relu', input_shape=(img_x, img_y, 1), strides=(1,1), padding="same"))
model.add(MaxPool2D(pool_size=(2,2), strides=(2,2)))
model.add(Conv2D(64, kernel_size=(5,5), activation='relu'))
model.add(Conv2D(64, kernel_size=(5,5), activation='relu'))
model.add(MaxPool2D(pool_size=(2,2), strides=(2,2)))
model.add(Conv2D(128,(5,5),padding="same",activation="relu"))
model.add(Conv2D(128,(5,5),padding="same",activation="relu"))
model.add(MaxPooling2D(pool_size=(2,2)))
```

Figure 2. Six-layer convolutional neural network network stacking code

As shown in the deep learning code in Figure 2, a six-layer convolutional neural network is demonstrated. It begins with a stack command, followed by the sequential stacking of the model according to the program's execution. The first layer is a two-dimensional convolutional neural network with a kernel size of 5x5, corresponding to the same layer with the activation function in Figure 1. The experiment also explains the internal coding aspects that are not displayed in the theoretical part, such as the detailed usage of operations like strides and padding, which are merely parameters in the convolutional layers. After two convolutional layers, the data is passed to a max-pooling layer, forming a convolutional module. By stacking three such convolutional modules from top to bottom, a classroom behavior recognition system is built. Explaining each layer in conjunction with the code allows students to gain a clearer understanding of the theoretical concepts.

3.1.3. Course Content Arrangement

During the course, the instruction begins with a broad overview, integrating the curriculum with experiments to provide a solid theoretical foundation. A differentiated teaching approach is then adopted for different students, offering varying levels of difficulty and depth in learning materials based on their academic levels and interests. For students with a stronger foundation, advanced content, such as supplementary and exploratory experiments, can be introduced. For students with weaker foundations, the focus is on explaining basic concepts and principles, ensuring they grasp the core knowledge. The difficulty of the corresponding experiments is also reduced to align with the theoretical content, making it easier for these students to understand. This approach allows for tailored instruction, catering to the individual needs of each student.

3.2. Combining Traditional and Innovative Teaching Methods

The "Deep Learning" course should be based on traditional theoretical education, combined with innovative teaching methods that integrate theory and practice, and introduce a student-centered teaching philosophy. Understanding students' learning conditions and states, different teaching models should be applied in the classroom according to the needs of different students, enhancing interaction and engagement to stimulate students' interest and initiative in learning.

(1) Increase Interactive Teaching

Introducing more discussion, questioning, and Q&A sessions in the classroom is crucial for students' learning and comprehension. By encouraging students to actively participate in the class, share their insights, and raise questions, an open and dynamic learning atmosphere can be created, which effectively promotes interaction between teachers and students. This interactive teaching mode can spark students' interest in learning, helping them to deeply understand and master the course content.

(2) Incorporate Online Learning Platforms

Leveraging modern educational technology, an online learning platform can be established to provide rich learning resources and practical opportunities. Students can use the online platform for self-directed learning, completing online experiments and projects, and engaging with peers and instructors. The online platform can offer video tutorials, code examples, discussion forums, and more. Students can choose learning content and difficulty levels that suit their interests and abilities, leading to a more effective mastery of the knowledge. Through online experiments and projects, students can not only practice the theoretical knowledge but also develop problem-solving skills and innovative thinking in real-world applications, continuing their learning and exploration outside of class hours.

(3) Strengthen Practical Components

Increasing the number of lab courses and practical components is crucial for developing students' comprehensive application skills. By offering more hands-on and practical training opportunities, students can apply the theoretical knowledge they have learned to solve real-world problems. This practice-oriented teaching model not only reinforces students' understanding of knowledge but also enhances their practical skills in their professional fields. For example, students can be arranged to perform hands-on operations of deep learning frameworks, strengthening their practical skills through specific experimental projects. Lab courses can also simulate real industry environments, helping students better adapt to future career demands.

(4) Expand Extracurricular Knowledge

Due to the rapid development of the artificial intelligence field, teaching content not only needs to cover fundamental theories but must also keep up with the industry's cutting-edge advancements. As the AI industry continues to grow and national policies support its development, new AI models and functionalities are emerging. This means that course content design must consider the timeliness and updates of knowledge. Therefore, supplementing extracurricular knowledge is particularly important. Instructors can provide the latest research papers, industry reports, and real-world cases to help students stay informed about the latest trends in the field of artificial intelligence. This allows students to deepen the content learned in class and better adapt to the rapid changes in the industry.

(5) Implement Flipped Classroom

The flipped classroom, as a new teaching model, holds significant value in artificial intelligence education. Traditional classrooms usually focus on teacher-led lectures, with students passively receiving knowledge, whereas the flipped classroom reverses this model. In a flipped classroom, students independently study theoretical knowledge before class through videos, articles, or other resources, while classroom time is dedicated to discussion, practice, and problem-solving.

By integrating these measures, combining traditional and innovative teaching methods can greatly enhance the teaching effectiveness of the "Deep Learning" course, cultivating students' practical skills, innovative thinking, and teamwork spirit, laying a solid foundation for their future career development.

3.3. Experimental Teaching Through Project Application

In the current course design, most experiments are conventional and relatively singular, which limits the development of students' abilities to solve real-world problems. To address this, implementing project-based experimental teaching is an effective method. By using the instructor's projects as a guide, students can form teams, collaborate on project production, and solve issues encountered during the project.

Before the project begins, the instructor introduces the project's background, objectives, and requirements, clearly outlining the specific tasks and assessment criteria. Students are divided into several groups, each consisting of 3-5 members, encouraging collaboration and communication among them. Group members can divide tasks and work together to complete the project. The instructor guides the students to break down the project tasks into sub-tasks and develop detailed work plans and schedules. Each group member is responsible for one or more sub-tasks, ensuring the project progresses as planned. To foster independent thinking, the instructor may assign high-level English literature for students to read and discuss in group meetings, assessing their ability to independently analyze and understand the material. This not only enhances their independent thinking skills but also improves their English reading proficiency.

During the project implementation, the instructor should regularly check the progress of each group, providing necessary guidance and assistance, and addressing any issues that arise. After the project is completed, each group is required to write a project report, detailing the implementation process, results, and experiences. The project outcomes should be shared among groups through presentations, allowing for peer review and discussion. For example, a project could be designed around image classification, requiring students to complete a full deep learning application process, from data preprocessing to model construction, training optimization, and results evaluation. The specific steps are as follows:

(1) **Data Preprocessing**: Students need to collect and process datasets such as CIFAR-10 or MNIST, performing data augmentation and normalization.

(2) **Model Construction**: Using deep learning frameworks like TensorFlow or PyTorch, students build a convolutional neural network (CNN) model, selecting appropriate layers, kernel sizes, and pooling layers.

(3) **Training Optimization**: Students train the model using a cross-entropy loss function and optimization algorithms such as Adam or SGD, fine-tuning hyperparameters like learning rate and batch size to optimize model performance.

(4) **Results Evaluation**: Students assess the model's accuracy and other performance metrics using the test set, conducting error analysis to identify shortcomings in the model.

After the project experiment, the instructor should lead the students in evaluating and providing feedback on the project teaching. The evaluation should cover aspects such as project completion, teamwork, and innovation. Each group's project quality should be assessed based on project requirements and evaluation criteria, including code implementation, model performance, and result analysis. The collaboration within each group should also be evaluated, encouraging the development of teamwork and cooperative abilities. Students are encouraged to demonstrate innovative thinking and creative abilities within the project, and their unique insights and innovative applications in problem-solving should be assessed.

After the project concludes, the instructor should hold a meeting where students present their work, ensuring that all students have engaged in practical activities during the project. If it becomes apparent that students do not fully understand the work processes and thinking behind different modules, group-based peer learning activities should be conducted. Students responsible for different modules can explain their knowledge points and work processes, and others should be encouraged to think critically and offer improvement suggestions. In the next project cycle, modules should be reassigned to achieve comprehensive teaching goals.

By integrating project-based teaching with the instructor's guidance, students not only deepen their understanding of theoretical knowledge but also develop hands-on skills, problem-solving abilities, and teamwork spirit.

4. Conclusion

Through in-depth research into the teaching model of the "Deep Learning" course, analyzing the current situation, and reshaping educational methods, it is essential to focus on an innovative teaching model that integrates theory with practice. By leading student teams to complete projects based on real-world applications, educators can meet the national goal of cultivating high-tech talent while also enhancing the practical skills of students in the field of artificial intelligence. This approach not only aligns with the objective of developing industry-ready AI practitioners but also stimulates students' enthusiasm for participating in educational activities, thereby improving teaching efficiency and enhancing students' innovative and practical abilities.

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