ISSN 2522-6398 Vol. 5, Issue 12: 87-91, DOI: 10.25236/FER.2022.051216

A Practical Study on Building a Distributed Artificial Intelligence Experimental Teaching Platform Based on Traditional Laboratories

Chunlin Chen

Economic Management Experimental Teaching Center, Southwest University of Finance and Economics, Chengdu, 611130, China

Abstract: *In the process of integration of AI teaching into various disciplines, theoretical teaching and practical teaching are given equal importance, while the experimental teaching of AI has specific and complex requirements for the experimental environment. This paper introduces the practice and reflection on the method of microservice cluster transformation into AI experimental teaching platform based on the traditional laboratory, which makes full use of the existing laboratory hardware resources, fully introduces K8s, Docker and other open source technology solutions, creates a full process experimental environment for AI teaching that can fully improve the efficiency of teaching and research without affecting the daily teaching activities, optimizes the operation mechanism and service mode, realize the on-demand customization of teaching resources, improve teaching governance, and provide useful ideas and methods for the construction of experimental teaching environment of artificial intelligence.*

Keywords: *artificial intelligence, experimental teaching, teaching platform, microservices, K8s, Jupyter, vGPU*

1. Introduction

Artificial intelligence technology, which has both technical and social characteristics and is highly integrated, has not only put forward a new discipline construction approach on computer science and technology-related majors but also put forward the discipline required of “artificial intelligence + X” in all disciplines [1] because of its significant demand change of the whole socio-economic life production model. Taking Southwest University of Finance and Economics as an example, the mandatory courses in machine learning (including deep learning and reinforcement learning) of artificial intelligence account for nearly one-third of the total number of undergraduate majors in the class of 2021.

In the process of AI penetration into various disciplines of education, practice is bound to become an important part of teaching. Teaching requires both theory and practice to be closely integrated: at the theoretical level, the logic and solution models developed from the basic theoretical frontier research in cross-disciplinary fields propose an optimization method model for solving a certain type of problem, the type of algorithm chosen to be used, the tuning settings of hyperparameters in the algorithm, etc. needing theoretical teaching to bring awareness; at the practical level, it is the process of applying the involved and selected algorithms to practical problems. Hands-on, verification and exploration of the condition limits, accuracy and performance requirements in various types of theoretical algorithms.

The teaching of AI in convergent disciplines relies on professional and easy-to-use programming environments, efficient and stable computing resources, secure and convenient data resources, and reliable and flexible teaching models. The traditional computer room can provide an effective but relatively fixed teaching environment based on pre-installed operating systems and hardware, for example, 50 computers with NVIDIA GPUs are provided in the lab to serve for the daily teaching curriculum. However, the number of the traditional computer room, the daily working hours of the site, the number of seats, course intervals, class segregation, equipment maintenanceare limited, the traditional computer room is difficult to achieve an all-weather open mode without teacher’s supervision. So the potential efficiency of laboratory use still has room for improvement.

To build an educational service supply capacity to meet the ubiquitous learning in the context of the new era, this paper will introduce an effective method to transform the infrastructure without changing

ISSN 2522-6398 Vol. 5, Issue 12: 87-91, DOI: 10.25236/FER.2022.051216

the use mode and teaching experience of the original computer laboratory, virtualize the computing power of the traditional computer room, establish a computing environment with effective scheduling of computing power and ready-to-use, and provide ubiquitous AI experimental teaching platform services through the Web, so that both teaching parties can use mobile terminals: either tablet or laptop or PC or even cell phone browser to use the platform equipped with a perfect environment for relevant algorithm development research and application practice.

2. Framework Design of Artificial Intelligence Experimental Teaching Platform

According to the existing hardware resource conditions, by decomposing the teaching requirements of data science and artificial intelligence, it is necessary to realize the virtualization and scheduling transformation of the computing and storage capacity of the infrastructure, and also the virtualization of the experimental teaching environment, i.e., to provide Web-based access to the experimental teaching environment and management platform.

2.1 Infrastructure service capabilities

It should encompass not only the capabilities of computing and storage services, but also the ability to schedule and manage these services.

2.1.1 Scheduling of computing capacity

To realize virtualized scheduling of CPU, GPU, and memory computing power distributed among 50 terminals in the lab, a virtualizated model with containerization as the base unit is adopted, container services by building a Linux system on terminals is established in the traditional lab, and container services is centralized with Kubernetes (hereafter referred to as K8s) for orchestration services [2], as Docker containers The granularity of control system resources is greatly reduced through the use of cgroups technology, thus significantly increasing the utilization of system resources[3], with negligible computational performance loss [4], but at the same time satisfying the normal use of terminals in daily teaching lab courses. Containers are virtualized at the kernel level to achieve higher performance and efficiency than building virtual machines on the terminal to obtain GPU computing power. To enable the container to split the exclusive GPU into multiple (two in this practice) vGPUs to provide more GPU instances[5], after comparing various solutions (Table 1), the TKE solution was chosen as the basis for image generation and K8s orchestration integration, which enables the original 50 GPU cards with 8G of video memory to be split into 100 vGPUs with 4GB of video memory as the minimum unit. vGPU, capable of doubling the number of users.

Table 1: Comparison of vGPU partitioning solutions

Solution Type	K8s Support	Segmentation Granularity	Licensing Mode	Virtualization Method
Nvidia vCS	Yes	Minimum 4GB video memory	Subscription Fees	Driver
TKE GPU-manager	Yes	0.1 card, 100M video memory	Open Source	vCUDA
Aliyun cGPU	Yes	Number of physical cards/specified card number	Open Source	vCUDA
4paradigm vGPU	Yes	Number of physical cards/specified card number, support virtual video memory	Open Source	vCUDA

2.1.2 Scheduling of storage capacity

Concerning of storage services, to control cost, the existing centralized storage arrays would be employed. Since the centralized storage array uses SAN storage, while K8S uses file storage, a new

ISSN 2522-6398 Vol. 5, Issue 12: 87-91, DOI: 10.25236/FER.2022.051216

virtual machine is used in the storage pool that has been connected to SAN storage, and the centralized storage array LUN is mounted to this host, through which the host is docked to K8s.

The storage service provides three parts for usage: the storage required for the operation of the master node in the K8s; the data storage required by the users of the AI experimental teaching platform when using the platform for data annotation, data and algorithm training; and the repository storage for saving the docker images required by the platform and the users. To facilitate the users of the platform to obtain data from the platform in the local system, this part of the data storage is separately opened to the users using the NFS mode[6] , and the users can obtain data from the platform and share data to the platform users only by the corresponding set account password.

2.1.3 Scheduling Management Services

In designing the overall structure, considering that the terminals located in the traditional labs are switched on and off more frequently and the environment does not meet the condition of turning on the service for a long time, the master host of K8s cluster is realized by establishing virtual machines in the resource pool of the existing data center and 50 terminals in the traditional labs join as computing nodes. VLAN link, and the physical link is gigabit fiber.

The resource scheduling layer contains two parts. First, K8S schedules the computing nodes distributed in the lab realizes lightweight virtualization of computing resources through containers, and quickly completes the encapsulation and isolation of resources required for computing; K8S completes the scheduling, dispatching, and container lifecycle management of the container cluster. Second, resource scheduling, combined with teaching and research needs, can provide the computing resources distributed in 50 computing node terminals according to the demand for the integration of CPU, memory and vGPU, which can complete the user in the application of distributed training can achieve multi-node multi-card, single-node single multi-card training [7].

2.2 Micro-servitization of experimental teaching environment

To meet the need of the teaching and research on machine learning and deep learning, the experimental teaching platform model of artificial intelligence learning is abstracted from the experimental process of data processing, algorithm development, training, and model generalization. Combining with the features of machine learning, it packages the optimized machine/deep learning framework and distributed training framework such as TensorFlow, PyTorch [8], MXnet and distributed machine learning framework Horovod, etc. into the containers. It make the above experimental process available by web mode through Jupyter service[9], and containerized transformation for some common data processing and analysis software such as MATLAB, which is available through VNC interface[10]. Meanwhile, with the advantage of cluster management, the container service capabilities within the cluster can be mapped out utilizing network address translation (NAT) [11] to keep the platform system open to support SSH and Tensorboard [12]. In terms of user authorization, the existing authentication system on campus would be employed for user screening. The corresponding resource access is given according to the identities of students or faculty in the platform.

3. Advantages and further improvement of artificial intelligence experimental teaching platform

3.1 Advantages

Based on the transformation of the existing traditional laboratory computing terminal, it could play two roles: one is for daily on-site experiments; the other is to be switched into an on-line AI experiment platform to provide arithmetic support by starting container services in ten minutes. Through on-demand allocation, multi-task isolation and parallelism, further enhancement of resource utilization could be realized.

The platform realizes second-level pre-set environment creation, and also provides data preparation, algorithm model construction, training tuning, model management and deployment application to realize machine learning life cycle process management, thus achieving improvement on teaching and research efficiency improvement

This platform constructs a comprehensive machine learning technology toolchain to serve the whole life cycle of AI teaching. Integrate common software such as MATLAB into it, thus realizing a ready-to-use, on-demand service model. Open the reserved standard API extension interface through

ISSN 2522-6398 Vol. 5, Issue 12: 87-91, DOI: 10.25236/FER.2022.051216

K8s' network discovery service[13], thus enhancing the usability of the platform. The platform integrates many mainstream machine learning frameworks such as TensorFlow, PyTorch, MXnet, etc. It also integrates container repository frameworks such as Harbor, which enables container image extension at a later stage.

3.2 Further improvement

In terms of platform construction, there are some room to be improved. First to be noted is to enhance the intelligence of experimental teaching. For example, the current mode of using Jupyter services to realize the whole process of artificial intelligence to develop experimental teaching can be embedded in the relevant teaching management plug-ins of Jupyter, such as Auto Grade, to further enhance the intelligence of experimental teaching.

Another point to be mentioned is to expand the teaching applicability of the platform. Based on the characteristics of containerized services, multiple kinds of experimental teaching software will be containerized and tested, and the experimental teaching software can be realized on this platform for Web-based access when the resource stock allows, which further improves the efficiency of using experimental teaching software and hardware and facilitates the teaching and research use of the majority of teachers and students.

Concerning the last point, more paid-out work is needed to the application of open source software. This artificial intelligence experimental teaching platform from the cluster orchestration using the K8s software, computing terminal using the Linux operating system, container image service harbor and computing framework horovod, GPU virtualization partition vGPU TKE program, teaching framework Jupyter, etc., are provided by the open source community, which needs to pay more attention to paid on security and log code review, timely vulnerability updating, adding on staff number to form a virtuous circle.

4. Conclusion

The design and practice of this platform is a practical attempt on the aspects of promoting the intelligent development of experimental teaching, motivating the change of experimental teaching, building up a new technology-enabled teaching environment, exploring a new teaching model based on artificial intelligence, and reconstructing the teaching process. Further more, it optimizes the operation mechanism and service mode; realizes the on-demand customization of teaching resources and teaching governance; promotes online learning; develops learner-centered learning platform; provide on-demand customization of learning resources; innovates the service supply mode and realizes the intelligence of experimental teaching at the end.

Acknowledgments

This work was financially supported by the research project of Fintech Innovation Center of Southwest University of Finance and Economics(FIC, SWUFE): “Hybrid Cloud Data Analysis Open Sharing Platform”.

References

[1] N. Zeng, Y. Zhang. (2022). Ensuring AI serves the common good and promotes education system change-"Artificial intelligence and education: a guide for policymakers" interpreted. China's E-learning, no.427, p.1-8.

[2] J. X. Wang, L. Guo. (2018). Enterprise container cloud platform solution based on Kubernetes and Docker technology. Journal of Shanghai Institute of Shipping and Transportation Science, no.41(3), p. 51-57.

[3] Z. X. Wu. (2017). Development and trends of cloud computing virtualization technology. Computer Applications, no. 37(4), p. 915-923.

[4] J.W. Miao, Z. Wang, J. Yu et al. (2019). Performance analysis of high-performance vGPU computing in desktop cloud environment. Computer Technology and Development, no. 29(11) p. 184-189.

[5] W. N. Li. (2018). Applying differential update techniques to achieve performance optimization of

ISSN 2522-6398 Vol. 5, Issue 12: 87-91, DOI: 10.25236/FER.2022.051216

GPU virtualization scenarios. Shanghai Jiao Tong University.
[6] X. Ying. (2013). How to build and configure NFS (Network File System) under Linux. Computers and Networks, no. 39(21) p.44-45.
[7] Y.X. Lu. (2021). Machine learning platform improvements for distributed training and high-performance inference with Tensorflow. Beijing Jiaotong University.
[8] Y.P. Huang, W.X. Liang, Z.H. Xiao. (2020). A comparative analysis of deep learning frameworks based on TensorFlow and PyTorch. Modern Information Technology, no. 4(4). p. 80-82,87.
[9] Z. P. He, X. D. Zhang, Y. Liu. (2019). Microservice architecture based on Jupyter interactive analysis platform. Computer System Applications. no. 28(8) p.63-70.
[10] Y. Q. Zhu, X. Tang. (2016). Analysis and research on VNC-based remote desktop transfer protocol. Computer System Applications, no. 25(11). p. 284-287.
[11] F.H. Liu,H.L. Ding, Y.P. Zhang. (2006). Research and application on NAT technology. Computer Engineering and Design, no.10. p.1814-1817.
[12] N. Fei, H.R. Zhang. (2019). A study of TensorFlow architecture and implementation mechanism. Computer Technology and Development, no.29(9). p. 31-34.
[13] L. Ma, J. D. Song, M. N. Song. (2012). Open platform:A review of operation model and technical architecture research. Telecommunications Science, no.28(6), p.125-140.