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Research and Application of Edge-Cloud Collaborative Intelligent Analysis System for Teaching Behaviors

Qianqian Ge*, Cuncun Wei

Zhejiang Business Technology Institute, Ningbo, 315012, Zhejiang, China

Abstract

With the integration of new generation information technologies such as cloud computing, big data, and learning analytics, smart education has become a trend in educational development. This paper addresses the challenges of heterogeneous multi-source data, system latency, and bandwidth costs in the smart education environment. Through edge-cloud collaboration, a solution is proposed to better achieve classroom teaching environment awareness, teaching behavior recognition, and intelligent analysis, thus realizing smarter teaching management. This study involves steps such as unified planning and management of heterogeneous data from multiple sources, construction of multidimensional teaching behavior intelligent evaluation methods, and design and implementation of edge-cloud collaborative system framework to comprehensively analyze the teaching behaviors of teachers and students in smart classroom environments, providing technical support for the development of smart education. This research not only addresses key issues in teaching behavior data analysis but also provides multidimensional and impartial support for teaching quality assessment, offering new insights for teaching management.

Keywords

Big Data; Teaching Behavior; Intelligent Analysis; Edge Computing.

1. Background

Cloud computing, big data, and learning analytic have been integrated into the entire process of education, making smart education the trend in educational development. The components of smart classrooms and smart teaching now go beyond traditional multimedia classrooms, including multimedia devices, smart IoT devices, interactive teaching software, and online course teaching. Smart classrooms collect and analyze data during teaching processes, track real-time behavioral data generated during classroom teaching, and comprehensively depict the teaching processes of teachers and students. Traditional qualitative analysis methods such as video analysis and classroom observation only provide surface information such as enhanced teacher-student interaction and active classrooms, lacking support for effective behavioral data at the underlying and application layers. Research introduces a solution through edge-cloud collaboration to address challenges in analyzing heterogeneous multi-source teaching behavior data in smart education environments, aiming to better identify the environment, feedback information, and intelligent analysis through classroom teaching environment awareness systems, achieving smarter teaching management. By utilizing appropriate data mining methods and visualization analysis techniques for the heterogeneous, multi-source, incomplete, and dynamically evolving data collected in smart teaching environments, this study comprehensively analyzes the value information of teaching and learning behaviors of teachers and students in smart classrooms, playing a role in the development of smart education in the era of big data.

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2. Design and Implementation of Intelligent Analysis and Control Platform for Teaching Behaviors

Addressing the collection of heterogeneous multi-source teaching behavior data, through intelligent control sub-device management, environment management, and full life cycle operation and maintenance management, data is unifiedly planned and managed. Various smart classroom devices and their data are integrated into the platform, providing efficient and convenient classroom management systems for schools.

2.1. Constructing a Multidimensional, Feature-Matching Intelligent Evaluation Method for Teaching Behaviors

Classroom teaching behavior analysis involves teacher behavior, student behavior, teacher-student interaction behavior, etc. At the same time, it is necessary to comprehensively consider classroom teaching content (knowledge points), intelligent teaching situations, and factors such as teacher-student emotional changes. The acquisition and collection of multi-source heterogeneous data in teaching behavior analysis is the foundation of behavior analysis. At present, most of the teaching behavior data collection technologies are mainly based on multimedia hardware integration. Although some classrooms have used AI recording systems to analyze the behavior of some teachers and students, the data is relatively single and has not been integrated with the entire teaching process.

Based on the mining and learning analysis of educational big data, constructing an ecological learning space based on smart classrooms, automatically adjusting learning content and process according to students' learning analysis, and forming a closed-loop feedback system is the ultimate goal of researching the perception system of smart classrooms, which will also have a great promoting effect on the evaluation research of smart learning environments. At the same time, the data services provided by the perception system will be an essential data foundation for situational awareness and personalized learning; In response to cognitive load issues in smart classrooms, the learning process records provided by the perception system will also be the basis for providing effective learning experiences for learners and valuable teaching data for educators.

The intelligent analysis system focuses on the influencing factors of precise interactive behavior of teaching subjects, attaches importance to interactive design, emphasizes subject interaction experience, and the depth of interaction. In addition to multimedia classrooms, intelligent teaching software, common synchronous interaction tools, and asynchronous interaction tools such as MOOCs, mobile teaching, and online open courses, there are also intelligent recognition devices such as facial expression recognition, gesture recognition, image recognition, and speech recognition in teaching scenarios. With the support of these tools and devices, interactive environments such as discussion, collaboration, emotional communication, and meaning construction can be built, integrating diverse information resources. Diversified, diversified, and three-dimensional interactions form massive amounts of data, which are then deeply mined and processed to analyze the hidden information behind the data, predict the learning behavior and needs of the interacting subjects, promote subsequent precise interaction behavior, and then affect subsequent precise teaching, ultimately achieving the goal of optimal teaching effectiveness.

This article evaluates the SMART model of smart classrooms from five dimensions: content presentation, environment management, resources and accessibility, real-time interaction, emotional perception, and four teaching evaluation elements: content, tools, interaction, and behavior. By using tone recognition, speech recognition, intonation analysis in speech systems, as well as facial recognition, emotion recognition, behavior recognition, and trajectory tracking in machine vision for sampling, combined with asynchronous interaction tools such as MOOCs,

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mobile teaching, online open courses, and equipment usage in multimedia classrooms, multiple heterogeneous data sources are obtained and collected to achieve precise data acquisition in teaching behavior analysis and standard governance of data, forming a unified multimodal symbol representation system..

2.2. Building an Edge-Cloud Collaborative System Framework

Using AI technologies such as speech recognition, speech to text conversion, and facial recognition tracking, integrated with teaching tool platforms, real-time online and imperceptible evaluation of teaching activities in smart classrooms is conducted comprehensively, comprehensively, and objectively from the dimensions of teacher's teaching organization, teaching expression, teaching content, teaching methods, teaching attitude, teaching effectiveness, and interactive data of students' pre class preview, in class learning, and post class review. Addressing the shortcomings of current teaching evaluation work, which relies on subjective feelings for scoring, lacks unified evaluation rules, has no basis for scoring, and lacks objective data. Enable the platform to play a guiding, decision-making, inspection, and evaluation role in the teaching work of the school.

(1) Sampling code: Divide a 45 minute class into 900 sampling points, and divide the teacher's speech into two types: indirect influence (creating motivation, praise, questioning) and direct influence (teaching, instruction, criticism). Sample code the student's speech (student response, student independent speech, silence or confusion).

Table 1 Code system for recording interactive teaching behaviors

Teacher behavior	1.Manufacturing motivation
	2.Praise
	3.Concept
	4.Ask questions
	5.Teaching
	6.Instructions
	7.Criticism
Student behavior	8.Student response
	9.Students speak spontaneously
	10.Silence or confusion

According to the FIAS Interactive Analysis Scale, classroom events are recorded in chronological order, presenting the structure, behavioral patterns, and styles of classroom teaching. Obtain 900 sampling values for a 45 minute lesson using 3 seconds as a sampling point:

6, 10, 5, 8, 2, 3, 5, 2, 5, 5, 5, 5, 5
5, 5, 5, 5, 5, 5, 10, 10, 10, 1, 1, 8, 2, 5, 5, 5, 5, 5, 5, 5,
5, 5, 10, 10, 10, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 6, 6, 8, 8, 8,
8, 8, 8, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 7, 10, 5, 5, 5, 5,
6, 10, 5, 8, 2, 310, 10, 5, 5, 5, 5, 5, 5, 6 , 5, 8, 2, 3, 5,
2, 5, 5,

For the recorded time series data, interactive analysis matrix method, ratio analysis method, and timeline labeling method are used for analysis. The data of each sampling point is organized using an interactive analysis transfer matrix.

(2) Data analysis

Using the data obtained from the aforementioned interactive analysis matrix method for further analysis, calculate the teacher discourse ratio, student discourse ratio, and quiet or chaotic ratio according to the following formula to analyze classroom structure; At the same

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time, the teaching style of teachers can also be analyzed by calculating the ratio of indirect to direct influence, and the ratio of positive to negative influence.

2.3. Development and Implementation of Intelligent Analysis and Control Platform for Teaching Behaviors

In the face of the dynamic contextual data collected in the smart classroom teaching environment, it is necessary to fully explore and apply it through interactive visualization analysis mechanisms, and construct a cloud edge end integrated data collection and analysis mining method. The implementation of this method includes on-site device terminals, transport layer, IaaS, PaaS, and SaaS services. The IaaS layer provides hardware, storage, servers, and data center space or network components. The teaching behavior data enters the preprocessing module through the interface module, and after preprocessing and standardization, it enters the analysis module, mainly using pattern mining and behavior recognition algorithms for analysis. The completed results are transmitted to the visualization module for interactive display through the service module.

The on-site terminal includes: recording system, sound system, multimedia central controller, interactive system, student behavior expression analysis system, and teacher behavior expression analysis system. The teaching behavior big data platform adopts B/S architecture and Java development. The server uses CentOS system, and the database uses MySQL database. The access terminal system includes mobile and PC terminals, and the mobile terminal includes Android and Apple system apps, as well as WeChat based mini programs. A data exchange tool based on ETL simplifies the exchange configuration by automatically comparing attributes through the selection of source and destination tables, and flexibly setting scheduled tasks to complete without any coding. A comprehensive strategy for capturing and extracting change data, the data exchange platform provides various mechanisms for capturing change data based on timestamps, full-text comparisons, and other methods. It offers various data extraction execution strategies such as batch extraction, real-time extraction, and timed extraction. The permission control adopts the Shiro permission control system to achieve unified authentication and use across the entire platform. The platform's information is standardized in the processes of collection, processing, exchange, user access, and transmission, achieving the sharing of teaching information resources and the coordinated development of information systems. At the same time, based on national standards, Ministry of Education standards, industry standards, etc., taking into account the compatibility, consistency, and scalability of various standards, a set of information management platforms that are in line with the actual management and evaluation mechanism of the school will be constructed to achieve visual analysis of teaching behavior data..

3. Conclusion

In summary, addressing the challenges of analyzing heterogeneous multi-source teaching behavior data in smart classrooms and key issues such as difficult data collection, closed architecture innovation, isolated application islands, challenging presentation of teaching effects, and difficulties in adapting to pure cloud architecture and industrial development, this paper introduces a solution through edge-cloud collaboration to address issues such as heterogeneous multi-source teaching behavior data analysis, system latency, and high bandwidth costs in smart education environments. The platform's design achieves effective integration of heterogeneous, multi-source, incomplete, and dynamically evolving data, completing multidimensional, three-dimensional, personalized teaching behavior analysis in teaching scenarios, addressing issues such as system latency and high bandwidth costs in smart education environments, providing technical support for the transformation of teaching

methods in the post-epidemic era, and playing a role in the development of teaching management.

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