Virtual Reality-Enabled Online Education System Harnessing the Power of Internet of Things and Artificial Intelligence

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Abstract. With the rapid development of Internet technology, online education has become an important part of the education field. The traditional education model has problems such as poor interactivity and insufficient personalization. In order to solve these problems, this article proposes a study on the online education system model, aiming to optimize and improve the shortcomings of the existing online education model and improve its quality. This article first analyzes the application of Internet of Things technology and discusses its technology. This article studies the advantages of artificial intelligence and proposes an education system based on artificial intelligence. After that, this article investigates the development of online education using crawler technology and uses the method of algorithm comparison to analyze the system deeply. Experimental results show that the collaborative filtering + weighted combined recommendation algorithm has good performance in this system, and its completeness, reliability, and correctness exceed 90%.

Keywords: Internet of Things, Artificial Intelligence, Online Education, System Design, Virtual Reality.
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1 INTRODUCTION

The rapid development of Internet of Things technology has enabled people to have a higher level and more comprehensive understanding of the network environment, and it has also changed the way people live. The online education model is mainly aimed at the learning needs of students. Through the network platform, information exchange between teaching resources and students, between teachers and parents, etc., is realized. In the environment of the Internet of Things, intelligent education technologies such as online learning and distance education have gradually become a trend. The online education model has not yet formed a systematic model and is not mature enough, so it needs further analysis.

Hafsa Kabir Ahmad et al. said that personalized course recommendation systems in online learning platforms used students' individual preferences to offer courses tailored to their individual needs. Due to its excellent performance, collaborative filtering methods are widely used [7]. The rapid growth of diverse learners in online learning makes it critical for online instructors to integrate multicultural resources into courses and instructional activities. Alex Kumi-Yeboah et al. aimed to examine online teachers' perceptions of culturally relevant teaching methods in online education. They studied how teachers can integrate culturally appropriate teaching strategies into online learning environments and explored the challenges of promoting intercultural collaborative learning among students from different cultural backgrounds [2]. According to Margarida Lucas et al., a better understanding of the benefits and challenges of online teaching from the perspective of the faculty is crucial as it can inform the different levels of the university of the future. On the one hand, this will lead to a better understanding of how to support sustainable practices in teacher development. On the other hand, designing effective online/blended courses and high-quality practices can be helpful, especially when the instructor's perspective is aligned with that of the students [11].The innovative convergence of Virtual Reality, the Internet of Things, and Artificial Intelligence to create a dynamic and immersive online education system. As traditional online learning faces challenges in providing engaging and interactive experiences, this integration seeks to redefine the educational journey, offering students a holistic and personalized approach to learning.

This article describes the Internet of Things and artificial intelligence. Students obtain knowledge and information resources through mobile terminal devices such as smartphones. In this process, teachers can interact with students to learn knowledge through the Internet, mobile communications, etc., and can also use mobile phones or computer terminals to implement course teaching activities in distance education mode, as well as after-class interactive communication, online tutoring and Q&A services, etc., providing students with a good and convenient communication channel and tools to help students learn better on their own.

2 INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE TECHNOLOGY

2.1 Internet of Things

The Internet of Things connects various smart devices, sensors and other objects through the Internet, enabling them to communicate and interact with each other. Internet of Things technology can realize automatic identification, positioning, tracking and monitoring of objects, and realize the management and control of objects through cloud computing, big data analysis and other technologies. The development of the Internet of Things has brought many conveniences to our life and work. Through the smart home system, functions such as smart lighting, smart security monitoring, and remote control of home appliances are realized. This technology can realize intelligent traffic management, environmental monitoring and energy management, and improve the management efficiency and quality of life of the city. Internet of Things technology can realize remote monitoring and maintenance of equipment, and improve production efficiency and quality. The rapid development of IoT technology also brings problems. The first is the issue of network security. A large number of devices and sensors in the Internet of Things are connected to the Internet and have become potential attack targets, and the network security protection needs to be strengthened. Second is the issue of data privacy. Internet of Things technology collects and processes a large amount of personal and corporate data, and protecting users' data privacy has become an important task.

Cloud computing provides massive data storage and shared resources. Big data collects and analyzes student data to provide personalized learning suggestions. Machine learning predicts future learning effects by learning historical data. Deep learning handles complex problems such as natural language processing, image recognition, etc. Sensor technology plays a key role in artificial intelligence. By using various sensors, a large amount of data is collected and provided to the artificial intelligence system for analysis and reasoning. Virtual intelligent teaching assistant is a teaching aid that applies artificial intelligence technology and can simulate the role of a traditional teacher to interact and guide students. Through speech recognition, natural language processing and other technologies, virtual intelligent teaching assistants can understand students' questions and provide answers and explanations. At the same time, it can also recommend suitable learning resources and practice topics in a personalized manner based on students' knowledge reserves and learning progress. Interactive learning can realize personalized presentation of learning content and real-time feedback of learning process [17],[6]. By using tools such as virtual intelligent teaching assistants, students can interact with learning materials in a variety of ways, including asking questions, discussing, operating, etc. The online learning system will give real-time feedback and guidance based on students' behavior and performance, helping students to correct mistakes in time, deepen understanding, and improve learning effects [16],[9].

2.2 Artificial Intelligence

Artificial Intelligence (AI) is a discipline and technology that simulates, extends and expands human intelligent behavior. It realizes advanced intelligent functions such as perception, understanding, reasoning, learning and decision-making by researching and developing algorithms and systems similar to human intelligence. This technology has made significant progress in recent years and has produced a wide range of applications in many fields. Artificial intelligence technology can help doctors make disease diagnosis and treatment decisions, optimize self-driving cars and traffic dispatch, conduct risk assessment, fraud detection and intelligent investment, etc.

In the field of education, artificial intelligence can provide personalized educational assistance to students by collecting learning data such as students' learning behaviors and answering conditions [12],[19]. By analyzing these data and extracting valuable information, we can provide students with corresponding learning suggestions or targeted counseling. Using artificial intelligence technology to analyze and evaluate students' learning behavior and performance can help to better understand students' learning status and needs [15],[20]. Based on students' learning data and needs, we provide students with customized learning content and resource recommendations by analyzing the characteristics and suitability of learning materials and learning resources. This can increase students' interest and participation and improve learning effectiveness and efficiency. By tracking and monitoring students' learning progress, the system can accurately understand students' learning situations. According to students' learning speed and understanding level, artificial intelligence systems can give personalized learning suggestions and adjust difficulty, methods or time arrangements to meet students' different needs and learning rhythms [5],[3].

3 DESIGN AND IMPLEMENTATION OF ONLINE EDUCATION SYSTEM

3.1 Application of Online Education System

This paper explores the course and user data of the NetEase Cloud project and analyzes the application of the online education model, solves the requirements library, provides a metadata database for the course and user information used in the recommendation design, and analyzes the original data containing 9875 sample sets. The class data analyzed by crawlers includes two dimensions: users and courses. After standardizing learning resources, this paper received a set of data that met recommendation modeling standards, collected user rating information, and trained learners on preference models. In order to further understand the platform courses and user preferences, the following descriptive statistics were made:

Statistic	*Course score*	*The number of students*
Mean value	*4.5*	*410*
Standard deviation	*0.3*	*180*
Minimum value	*2.8*	*1*
Maximum value	*5*	*600*
Skewness	*-2.21*	*5.52*
Kurtosis	*-0.56*	*-0.55*

Table 1: Descriptive statistics.

The optional range of ratings for online courses is [0, 5]. As shown in Table 1, the lowest rating given by users is 2.8 points, the highest rating is 5 points, and the standard deviation of the ratings is 0.3 points. Additionally, the skewness of online courses is -2.21 and the kurtosis is -0.56. From the statistics of the number of students attending class, we can find that the average number of students online reaches 410, of which a maximum of 600 students are studying online. The skewness of students taking online classes is 5.52, and the kurtosis value is -0.55.

Type	*Proportion*	*Score*
AI/Data Science	*15*	*4.423*
Programming and development	*10*	*4.458*
Products and operations	*6*	*4.402*
E-commerce operations	*4*	*4.418*
Design creativity	*4*	*4.408*
Life interests	*25*	*4.413*
Language learning	*14*	*4.443*
Career advancement	*16*	*4.434*
Vocational Examination	*6*	*4.444*

Table 2: Analysis of the course types.

As shown in Table 2, the largest proportion of online course users is in the life interest category, accounting for 25% of all courses. This shows that the life interest category has the largest audience and the greatest demand for courses in online classes. Followed by workplace improvement and AI/data science, accounting for 16% and 15%, respectively. It can be seen that the total market demand for online education for workplace improvement is as high as 31%, and it also occupies a large market share. Language learning accounted for 14%, expressing people's strong demand for language improvement. Programming development, professional exams, products, and operations are courses that are used as tool learning courses, accounting for 4%-10%, respectively, reflecting the needs of a certain group of people. Overall, each course was rated over 4 points. Among them, programming and development courses have the highest score, reaching 4.458 points, and career examinations, workplace promotion, language learning, programming and development, and AI/data science all have score values above 4.42.

From the perspective of course price, various courses are divided into original price and discounted price. Course prices are shown in Table 3.

Type	Original cost	Discount price
AI/Data Science	284	175
Programming and development	418	241
Products and operations	508	261
E-commerce operations	340	365
Design creativity	580	285
Life interests	921	460
Language learning	495	615
Career advancement	348	96
Vocational Examination	252	370

Table 3: Course price change.

Life interest courses have the highest price, but they also have the most discounts, and the discount war is the main one. The "discounted price" of language learning, e-commerce operation and vocational examination is higher than the original price. The main reason is that the courses in this part are divided into upper and lower volumes or charged according to the number of courses, so the actual price after the discount is higher than the original price of a single course. Generally speaking, career improvement courses have the lowest discounted price, with an average price of less than 100 yuan, and the service duration is short, focusing on small lesson videos. It can be seen from the data in Table 3 that the price level of online education courses is medium, and the number of people targeted is large, so the overall economic benefits are good, and there is feasibility for continued development.

3.2 Intelligent Algorithm for Learning Resource Recommendation

Under artificial intelligence technology, recommendation algorithms can be classified into content-based, collaboration-based, association rule-based, utility-based, knowledge-based and combination-based algorithms. Among them, the combination recommendation algorithm usually introduces weighting, transformation, mixing, feature combination, cascading, feature expansion and meta-level. In the online education system, the performance data of different recommendation algorithms are counted by data capture technology, and the basic performance results are finally obtained.

As shown in Figure 1, the content-based recommendation algorithm takes the least time, and its accuracy is only 72%. The collaborative filtering algorithm took longer, requiring 5.5 seconds to react, and its accuracy was lower at 68%. The data intuitiveness and accuracy of the rule-based recommendation algorithm are between 70% and 75%. The utility-based recommendation algorithm is more accurate and intuitive. Its intuitiveness reaches 85%, and its accuracy is the highest among the five algorithms. The knowledge-based algorithm has an accuracy of 70% and takes more than twice as long as the content-based algorithm. Overall, the content-based approach takes the shortest time and is the most intuitive, but the rule-based method takes the longest and is the least intuitive. With the continuous maturity of technologies such as artificial intelligence and the Internet of Things, artificial intelligence technology and the Internet of Things technology are combined to create a more intelligent and humanized Internet of Things, so that it can meet the requirements of the majority of users, and people's increasingly high-quality needs can also be met.

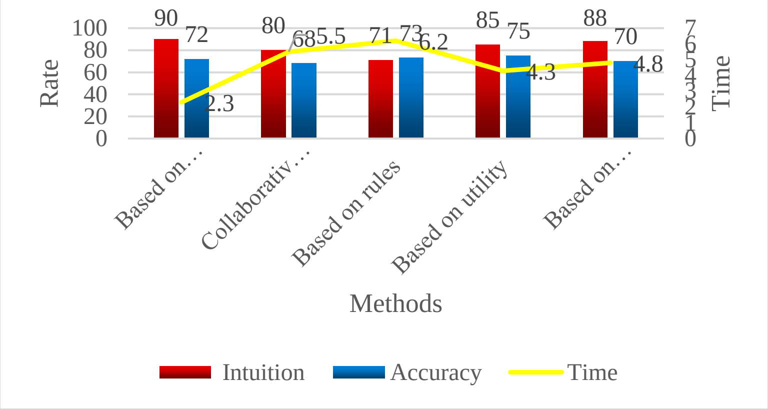

Figure 1: Performance of the different recommendation algorithms.

Artificial neural networks are widely used for accurate classification and pattern recognition, and applying neural networks to the Internet of Things is an interesting application. Whether the learning process of the BP (Back Propagation) neural network ends depends on the network output error and the number of learning times and ends when the output error or the number of learning times of the network meets the conditions. The calculation formula of forward propagation is as follows:

$$\text{net}_{ik} = \sum_{l=1}^{M_{i-1}} P_{(i-1)l} * V_{(i-1)lk} \tag{1}$$

$$P_{\text{ik}} = g_t(net_{\text{ik}}) = \frac{1}{1+exp[-(net_{\text{ik}}-\alpha_{\text{ik}})]} \tag{2}$$

Among them, the connection weight of the kth neuron in the i-th layer to the l-th neuron in the i+1th layer is expressed as $V_{(i-1)lk}$, and the output of the kth neuron in the i-th layer is P_{ik}. The algorithm can be used to predict the number of students and feasibility of online education systems and analyze the actual situation of courses. The course matrix is decomposed into two feature matrices Y and K, and the final objective function M is:

$$M = \sum_{i=1} \sum_{k=1} (S_{ik} - Y_i K_k) \tag{3}$$

In order to increase user engagement, professional software testers need to test the system and identify issues, then return bugs to developers for changes. After cleaning and processing, user course records were first obtained, and matrix decomposition still existed in the recommendation algorithm. Markov chain models represent important assumptions. The Word2Verc model is based on hierarchical normalization to build a Hafmann tree based on the vocabulary in the output layer. The exponentially decaying time series function is:

$$g(a) = exp(-x(Sri - Srk)) \tag{4}$$

x represents the coefficient of exponential decay, and SriandSrk are historical data at different times. People's learning of courses is often more time-sensitive, and their choice of courses is more variable. Whether it is due to work needs or life interests, the learning behavior of the same user is fragmented in time.

3.3 Online Education System Design

The online education system designed this time adopts the Browser/Server model. Users can access the system through a browser, and the server has the task of implementing system functions. A small part of the logic is also implemented on the front end. The server uses the Spring series programming framework in Java as the development language. The architecture of the online education system is shown in Figure 2.

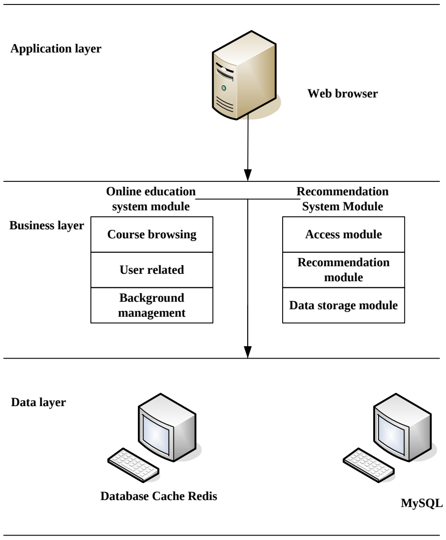

Figure 2: Online education system architecture.

The access module is a module for users to interact with the system, and its recommendation module is implemented through the Mahout framework and collaborative filtering recommendation algorithm. The data storage module is used to store data about the system and user behavior. This module stores course-related information data as well as course user evaluation and preference behavior data.

In the classroom, learners, classroom teachers, and remote learners connect to the system through clients, and the classroom camera device collects the teacher's classroom videos and uploads them to the streaming server [8],[4]. Remote learners receive course video notifications and watch live courses in real time through the client [18],[10]. Information flow can be divided into real-time comments and classroom interaction, both of which are two-way information flows. The information flow model of the online education system already has the characteristics of a network-based two-way information flow model [14]. The system information flow model mesh is shown in Figure 3.

In real-time online education systems used for the teaching process, the server mainly provides users with simulated online teaching, which is used in conjunction with offline teaching to enhance learning in real classrooms [1],[13]. Through the system, students can view their courses online, log in to the personal center, answer questions, view rankings, and communicate with classmates or teachers after entering a specific course. The system allows teachers to visualize the courses they are teaching, and to ask questions and communicate with classmates after entering a specific course. The hardware environment configuration of the online education system is shown in Table 4.

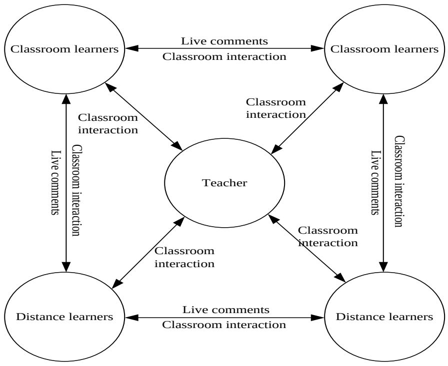

Figure 3: System information flow model network.

Name	*Internal storage*	*Space*	*Central processing unit*
Main database	*256*	*120*	*2.4G×16*
File database	*8*	*600*	*2.4G×8*
Front end server	*128*	*64*	*2.4G×16*
Background server	*64*	*64*	*2.4G×12*
Balanced server	*4*	*4*	*2.4G×8*

Table 4: Server configuration information.

Since the objects of the online education system are mobile and there are a lot of learning materials and data, the capacity of the database and server used by the system needs to be large enough, and the space and speed of operation also have high requirements. After the overall design of the system, it needs to implement the system by configuring the environment and writing code. System implementation is an important part of the software development process.

3.4 System Testing

Test object:itis online education system based on learning resource recommendation.

Testing purpose: After the system is developed, only a certain number of repeated system tests can identify system problems, then check for system errors and fill in the gaps in the system. When performing system testing, it is very important to find problems, especially after problems are discovered, analyze the cause of the problem and quickly fix existing errors.

Functional testing is not about how the system performs its functions, but only about whether the functions meet the design requirements of the system. This article provides functional tests of four main functional modules: course browsing, personal center, background management, and course material recommendation. If non-system users know the back-end management system, they can access the back-end management system by accessing the browser's address bar. This poses a significant threat to the data security of the back-end management module. This problem occurs because access to the page is in the foreground and there are no restrictions on who the background visitor can be. Therefore, this article must conduct a technical analysis of its security and propose a solution. Subsequently, functional modules such as system learning resource recommendation, resource evaluation, and learning support were tested, and the performance of the BP neural network algorithm, content-based + association rule-based and collaborative filtering + weighted improved recommendation algorithm was tested. The online education system uses these three algorithms to evaluate the accuracy, reliability, and completeness of resource recommendation and system content recognition, and to test the interaction and complementarity between the resource recommendation module functions and the existing functions of the learning platform.

4 SYSTEM TEST RESULT ANALYSIS

4.1 Functional Test Results

As shown in Figure 4, in the course browsing function, the pass rate applicable to the online education system is 75%, and there is still room for improvement of 25%. The functional qualification rate of the personal center is only 70%, and there is still a 30% improvement rate. The qualification rate of the background management function is the lowest because it needs to process a larger and more complex amount of data, so there is still 32% room for improvement. The pass rate for course material recommendation is the highest. Because the system designed in this article uses a variety of recommendation algorithms, it has a good performance rate in the system, but it still has 22% room for improvement. In short, the online education system designed in this article still has a lot of room for improvement, and the quality and capabilities of the system need to be further improved.

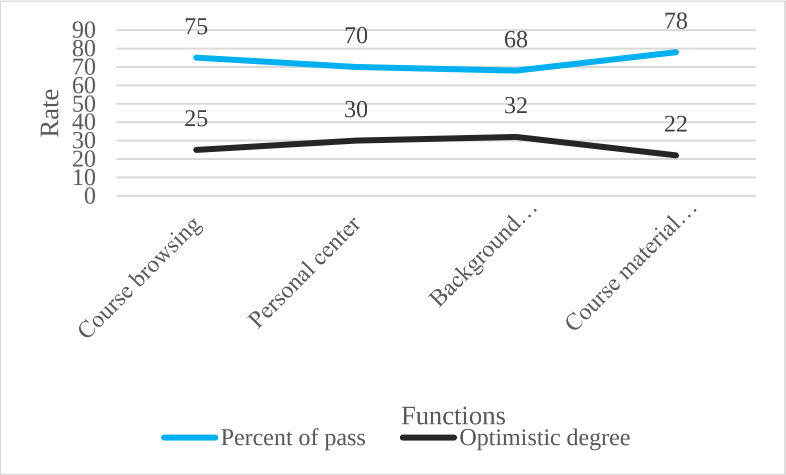

Figure 4: Results of the functional test.

4.2 Performance Test Results

As shown in Figure 5, the BP neural network algorithm performs well in the online education system. Its accuracy reaches 92%, reliability is 95%, and completeness and interactivity are slightly lower, only 88% and 85%. The recommendation algorithm based on content + association rules performed generally in this system, with the lowest correctness of only 88%, and its reliability and integrity were high, reaching 90% and 93% respectively. Therefore, in the online education system, collaborative filtering and weighting can be appropriately used to improve the recommendation function of learning resources, and the BP algorithm can also be used to enhance the reliability of the system.

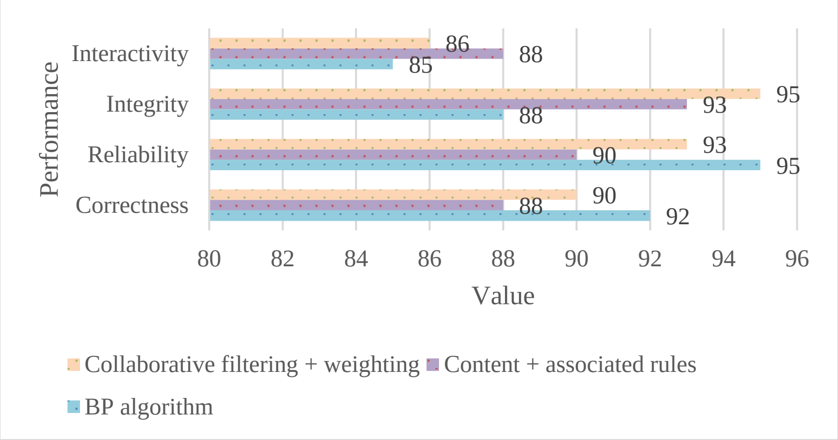

Figure 5: Performance test results.

5 CONCLUSION

The research object of this article is an online learning platform. After an in-depth analysis of the artificial intelligence of the Internet of Things, an online education system model based on the Internet of Things is designed. Under the traditional teaching model, students' learning results are poor and classroom efficiency is low. This article is based on the Internet of Things technology and uses advanced sensor sensing equipment to collect and process real-time interactive data for the online teaching system. Among them, this article uses BP algorithm, content-based and collaborative filtering and other improved algorithms to test the online education system. This article finds that the online education system that combines Internet of Things technology and artificial intelligence has good development prospects, and the system can be further adjusted and optimized from the perspective of intelligent algorithms.

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