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Optimization of indoor thermal environment based on sensor networks and multimedia assisted physics teaching

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Abstract

This study aims to optimize the indoor thermal environment through sensor network technology to support the multimedia assisted physics teaching, improve the teaching effect and students' learning experience. The sensor network technology is used in the study to arrange a variety of sensors in the classroom to monitor the thermal environment parameters in real time. Through data analysis, the thermal environment optimization model is established, and the numerical simulation technology is used to adjust different environmental factors. Combined with multimedia teaching, this paper explores the influence of thermal environment optimization on students' learning effect. Studies have shown that reasonable adjustment of indoor temperature and air mobility can significantly improve students' attention and learning motivation. The optimized classroom environment showed higher effectiveness in both physics experiment and theoretical learning, and students' feedback satisfaction increased. Therefore, the indoor thermal environment optimization based on sensor network can effectively improve the quality of multimedia assisted physics teaching. By analyzing and processing the collected information, the cluster control end can reasonably arrange the playback content of multimedia courseware to meet the learning needs of students. This multimedia courseware assisted physics teaching application based on sensor networks and deep learning technology provides new help and support for physics teaching.

Keywords: Sensor network; Indoor thermal environment optimization; Multimedia assistance; Physics teaching

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1. Introduction

The application of multimedia technology plays an important role in the field of education. By using multimedia technology, teaching content can be visually presented to students in the form of images, sounds, videos, etc., making learning more vivid and interesting (Park et al. 2019). This intuitive presentation method can stimulate students' interest and curiosity, activate their thinking, and make learning more active and positive. In China's education reform, the application of multimedia technology has been widely promoted (Vaganova et al.

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2020). With the continuous progress and development of technology, the application of multimedia technology in the field of education will also continue to innovate and improve, providing students with better learning experiences and educational resources (Shu 2020). With the deepening of education reform and the development of modern teaching technology, the influence of classroom physical environment on students' learning effect has been paid more and more attention. Studies have shown that a good learning environment can not only increase students' motivation to learn, but also promote their cognitive development and physical and mental health. In this context, the optimization of indoor thermal environment has become an important research direction to improve teaching quality.

Indoor thermal environment includes many factors such as temperature, humidity, air flow rate, etc. These factors will directly affect students' attention, thinking ability and learning efficiency. For example, too high or too low a temperature can cause students to feel uncomfortable, thus reducing their interest and concentration in learning. On the contrary, appropriate temperature and humidity levels can help students participate in classroom activities better and realize active learning. In recent years, the rapid development of sensor network technology provides a new solution for indoor environment monitoring and control. By arranging a variety of sensors in the classroom, various data of thermal environment can be obtained in real time. Based on this data, teachers and administrators can quickly respond to environmental changes and make effective environmental adjustments, thus creating a more comfortable and efficient learning space for students. Therefore, the exploration of indoor thermal environment optimization based on sensor network not only conforms to the pursuit of teaching quality in the field of education, but also provides strong support for the implementation of multimedia assisted physics teaching.

This article proposes a multimedia courseware assisted physics teaching application based on sensor networks and deep learning technology. By combining multimedia technology with physics teaching, more rich, vivid, and intuitive teaching content can be provided, enabling students to better understand abstract physics concepts and principles (Liu and Zhuang 2022). The application of sensor networks can collect experimental data and student response data in real-time. Teachers can use sensor networks to obtain data on various physical quantities in experiments, and then combine these data with multimedia courseware to display to students. In this way, students can not only intuitively understand physical phenomena through experimental data, but also gain a deeper understanding of physical principles through data analysis and discussion. The application of deep learning technology can achieve personalized learning assistance (Weng and Chen 2020). By analyzing and mining students' learning data, we can understand each student's learning characteristics and difficulties, and provide personalized learning assistance accordingly. For example, based on students' learning situation, the system can automatically adjust the teaching content and difficulty, provide suitable learning materials and practice questions for students, and help them better master physics knowledge. The assistance of multimedia courseware can also increase students' participation and learning interest through interactive and gamified methods. By designing interactive links or turning the classroom into a game format, students' enthusiasm can be stimulated, enhancing the fun and attractiveness of learning (Yin 2015).

2. Related work

The research of indoor thermal environment optimization in the field of education has attracted more and more attention, especially in physics teaching. A good indoor environment directly affects students' learning effect and psychological state. Modern education has put forward higher requirements for classroom environment. The optimization of indoor thermal environment is not only related to students' comfort, but also closely related to learning efficiency, knowledge understanding and practical operation ability. In recent years, with the development of sensor network technology, relevant research has gradually focused on how to monitor and regulate the indoor thermal environment through intelligent means to create a more suitable atmosphere for learning. Indoor thermal environment mainly includes temperature, humidity, airflow speed and air quality and other factors. The suitable temperature range is generally considered to be between 20 ° C and 24 ° C. Studies have shown that in this range, students' attention and learning efficiency are higher, while too high or too low a temperature can cause fatigue, decreased concentration and reduced learning effectiveness. Humidity levels also affect the learning environment. Suitable humidity levels are usually between 40% and 60%. High humidity can lead to poor air circulation, mold breeding, affecting health; Too low humidity can cause dry skin and uncomfortable breathing. Good air mobility can improve indoor air quality and reduce the accumulation of harmful substances. It is found that the appropriate airflow speed can increase the comfort of students, and thus improve the learning effect. Indoor CO_2 concentration and harmful substance concentration directly affect students' thinking ability and physical health. High levels of CO_2 not only affect the oxygen content, but can also lead to poor learning efficiency.

In recent years, the application of sensor network technology in indoor environment monitoring has gradually become a research hotspot. By placing different types of sensors in the classroom, parameters such as temperature, humidity, airflow speed and air quality can be monitored in real time. These sensors can transmit data through a wireless network to a central processing unit to achieve real-time adjustment of the indoor environment through data analysis. The rapid development of wireless sensor networks makes it possible to realize real-time environmental monitoring in classrooms. By deploying sensor nodes, teachers and administrators can obtain detailed information about the indoor thermal environment to make timely adjustments. The introduction of various intelligent control systems makes it possible to automatically adjust when an unsuitable thermal environment is detected, such as adjusting the temperature setting of the air conditioner, or adjusting the air flow to meet real-time needs.

There have been many achievements in the research of indoor thermal environment optimization. Through sensor networks, researchers have proposed an environmental regulation strategy based on feedback control to ensure that indoor temperature and humidity are maintained within the optimal range. This kind of research mainly adopts experimental methods to verify the influence of environmental optimization on learning effect. Literature studies have shown that an optimized classroom environment can significantly improve students' attention and academic performance, with results showing that students' test scores improved by more than 10% in classrooms optimized for temperature and humidity. Literature research has found that the optimization of classroom environment not only affects students' learning efficiency, but also has a positive impact on their mental health. In classrooms optimized for thermal energy, students' anxiety levels were significantly reduced and satisfaction increased.

The combination of multimedia teaching and indoor thermal environment optimization further enhances the effectiveness of teaching. Multimedia teaching can not only enrich the classroom content, but also stimulate students' interest in learning, make physics knowledge more vivid, so as to achieve better teaching results. The research shows that the combination of good indoor environment and multimedia teaching can significantly enhance students' cognitive load management ability. The appropriate thermal environment allows students to concentrate better and helps to understand complex physical concepts. Through the application of multimedia technology, students can carry out interactive learning in a comfortable environment, enhancing the sense of participation and the spirit of exploration. This way of learning is in sharp contrast to traditional teaching, which greatly improves the activity and learning effect of the classroom.

The literature suggests that teachers need to receive training and guidance on multimedia teaching technology to enhance their teaching ability and technical level (Fang 2021). This can be achieved through specialized training courses, seminars, and teacher exchange platforms. The literature suggests that in the design and production process of multimedia textbooks, attention should be paid to the compatibility with teaching content and objectives, providing rich and diverse learning resources and interactive mechanisms (Bykonia et al. 2019). This requires teachers to work closely with educational technology experts and designers to jointly develop design guidelines and standards for teaching resources. The research of the literature is based on the QEMU/KVM platform, which is an open source virtualization platform with wide application and secondary development possibilities (Kratzke 2014). QEMU is a virtual machine monitor, while KVM is a module of the Linux kernel, allowing QEMU to run directly on hardware. This virtualization platform provides a lightweight virtualization solution that allows hardware resources to be shared between different operating systems and provides isolation, security, and manageability.

The literature mainly focuses on multimedia playback scenarios and proposes improvement methods to reduce system resource overhead, enhance cluster stability, and improve user experience (Volk et al. 2015). In this scenario, the user end refers to the user terminal device, such as a personal computer, smartphone, or tablet, while the cluster end refers to a cluster of multiple servers used to provide services and process user requests. In terms of user usage, literature has proposed some improvement methods to optimize the performance of multimedia playback (Colloton and Moomaw 2018). For example, by using hardware acceleration techniques such as GPU acceleration or dedicated hardware decoders, the CPU load can be reduced and the efficiency of decoding and rendering can be improved. The literature also proposes an adaptive rate control algorithm that automatically adjusts the video rate and quality based on network bandwidth and device performance to ensure a smooth playback experience (Kim et al. 2017). In terms of cluster side, literature focuses on the stability and resource utilization of clusters. In order to reduce system resource overhead, the literature proposes a dynamic resource allocation strategy that dynamically allocates server resources to different tasks based on current load conditions and demand changes. This can achieve better resource utilization and avoid resource waste or overload. The literature also proposes a fault-tolerant mechanism by introducing redundant nodes in a cluster, which can automatically migrate tasks to other normal nodes when a node fails, thereby improving the stability and reliability of the cluster (Mohapatra and Rath 2020).

The literature proposes a multimedia redirection technology based on user command redirection and develops corresponding user end programs (Deb 2011). This technology can achieve multimedia redirection playback, which means that multimedia content is transmitted from the server end to the user end for playback. On the user side, literature has developed a program to redirect multimedia playback through user command redirection. Users can control and operate multimedia through this program, while the actual playback is done on the server side. The user's actions will be redirected to the server, which will process the user's commands accordingly and transmit the results back to the user's end for display. This redirection technology can achieve multimedia playback without occupying user resources. On the cluster control side, the literature uses adaptive linear regression algorithms to fit the historical raw data provided by the user (Sharma et al. 2016). By continuously fitting user behavior data, the cluster control end can obtain the predicted playback weight values of the virtual machine. These predicted weight values can be used for cluster side selection and allocation to achieve reasonable allocation and scheduling of virtual machine resources.

3. Optimization Method for Sensor Networks Based on Deep Learning

3.1. Wireless Sensor Network Architecture

As shown in Figure 1, a typical wireless sensor network consists of four parts: wireless sensor nodes, gateways, servers, and end users.

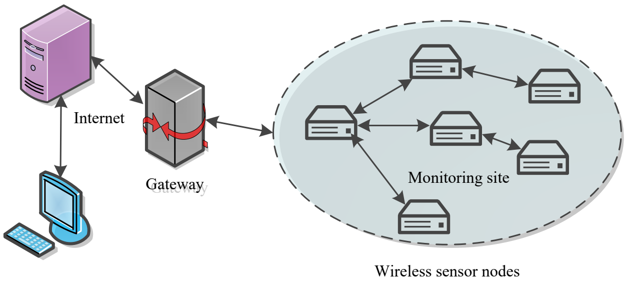

Figure 1. Wireless Sensor Network Architecture

Wireless sensor nodes are the basic units of wireless sensor networks, responsible for collecting and transmitting real-time data from monitoring sites. In the application scenario of this article, the structure of wireless sensor nodes is shown in Figure 2.

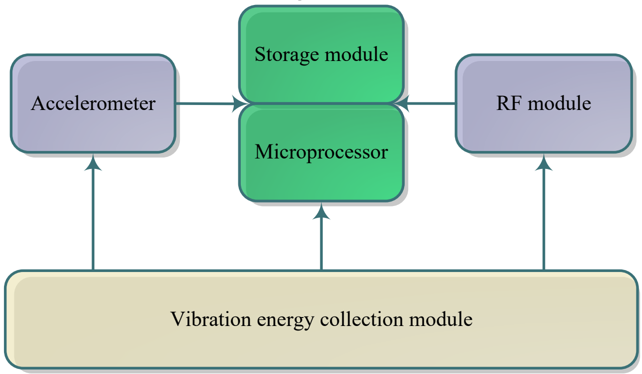

Figure 2. Wireless Sensor Node Structure

As shown in Figure 2, the vibration energy collection module is responsible for collecting vibration energy in the environment and converting it into a stable 3.3V DC power supply for use by other components. The microprocessor is responsible for controlling the various functions of the node and processing the collected data. It can exchange and transmit data with other nodes through specific communication protocols. The storage module is used to store the collected vibration acceleration data. Microprocessors can store data in storage modules through specific communication protocols for subsequent processing and transmission. Accelerometers are sensors used to collect vibration acceleration data of subway axles. It can convert vibration acceleration signals into digital signals and transmit them to microprocessors through specific communication protocols. The RF module is responsible for transmitting the collected vibration acceleration data to adjacent nodes through wireless signals. It uses specific communication protocols for data exchange and transmission with other nodes.

3.2. Basic Principles of Deep Learning

Time series data refers to a series of data arranged in chronological order. The LSTM network can effectively handle long-term dependency problems by introducing gating mechanisms, and has the characteristics of memory ability and long-term memory. This enables LSTM networks to better capture long-term dependencies and temporal patterns in temporal data processing.

The calculation formula for forgetting gate is as follows:

$$f_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f) \quad (1)$$

The step of updating cell status is achieved through input gates.

$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i) \quad (2)$$

Subsequently update the cell status:

$$\tilde{c}_t = \tanh\,(W_c \cdot [h_{t-1}, x_t] + b_c) \quad (3)$$

$$c_t = f_t * c_{t-1} + i_t * \tilde{c}_t \quad (4)$$

After updating the cell state, it is necessary to determine the output characteristics at the current time through the output gate.

3.3. Design of Optimization Algorithms Based on Deep Learning

Compared to the DDPG algorithm, the TD3 algorithm proposes a variant approach of clipping dual Q-Learning to solve the problem of overestimation of Q-values. In the original Q-Learning algorithm, there was a problem of overestimating the action values. Double Q-Learning solves this problem by using two estimators A and B to calculate the value function. These two estimators use different datasets for learning. When selecting to execute an action, randomly select one of these two functions to update the action. But when updating, choose the value of another function to update. However, in the Actor Critic architecture, due to the use of sliding average updates, the Online network and Target network are too similar to conduct independent estimation, resulting in poor performance of this scheme.

To solve this problem, the TD3 algorithm introduces two sets of critical networks with the same network architecture. When calculating the target value, the smaller Q value in these two sets of networks is used to estimate the value of the next state action on (s', a '). The specific updated formula is as follows:

$$y \leftarrow r + \gamma \min_{i=1,2} Q_{\theta_i}(s', a') \quad (5)$$

In deterministic strategy problems, there is a problem of overfitting to the peak of the value estimation function. When updating the Critical network, the target using deterministic strategies is easily affected by the inaccuracy of function approximation errors, resulting in excessive variance in value estimation and inaccurate estimation values. To solve this problem, the TD3 algorithm introduces a regularization strategy, which is target strategy smoothing.

$$y = r + \Upsilon Q_{\theta'}(s', \pi_{\Phi'}(s') + \vartheta) \quad (6)$$

$$\vartheta \sim \text{clip}\ (N(0, \sigma), -c, c) \quad (7)$$

The TD3 algorithm adds a small amount of noise to the target value when calculating it, and calculates the average value in a small batch to approximate the expected action, thereby reducing variance. This regularization strategy can help the algorithm better explore the action space and avoid overfitting to the peak of the value estimation function. At the same time, the TD3 algorithm also uses a delayed update strategy. At each time step, the Critical network and Actor network are only updated at regular intervals. This can avoid updating the network too frequently, reduce the variance of updates, and improve the stability and convergence of the algorithm.

$$s_t = \left[v_{1E_d}, v_{1E_\varepsilon}, v_{1T_d}; v_{2B_d}, v_{2E_\varepsilon}, v_{2T_d}; \ldots\ldots; v_{NB_d}, v_{NE_\varepsilon}, v_{NT_d}\right] \quad (8)$$

Action space refers to the set of all possible actions taken by the TD3 algorithm. In the TD3 algorithm, the action space can be represented as a vector, where each element represents different actions taken on different nodes. The action space can be represented as follows:

$$a = \left[a_{v_1}, a_{v2}, a_{v_3}, \ldots, a_{v_N}\right] \quad (9)$$

The action selection on each node is based on the current state and the output values of the policy network. The actions taken on node i can be expressed as:

$$a_{v_i} = \left\{a_{v_i - v_j} \mid i, j \in \{1,2,3, \ldots, N\}, i \neq j\right\} \quad (10)$$

In the TD3 algorithm, the reward function designed can be expressed as:

$$R = \begin{cases} r_e, & \text{The selected node is not an adjacent node} \\ \sum_{i=1}^{N} \left(\varpi_1 * Bd_i + \varpi_2 * Eg_i + \varpi_3 * \frac{1}{T_{d_i}}\right) & \text{Selected node is adjacent} \\ r_c, & \text{Reaching the target node} \end{cases} \quad (11)$$

By designing appropriate reward functions, the TD3 algorithm can select actions based on the remaining bandwidth, transmission delay, and energy consumption of nodes, thereby achieving effective scheduling and management of network resources.

3.4. Analysis of the Optimization Effect of Sensor Networks

In the experiment, the network load strength can be obtained by calculating the ratio of the actual traffic carried and the total network bandwidth. Each algorithm ran 500 rounds in the same experimental environment. This means that each algorithm has been evaluated and compared 500 times. By running multiple rounds of experiments, the performance of each algorithm under different network load intensities can be obtained and compared for analysis.

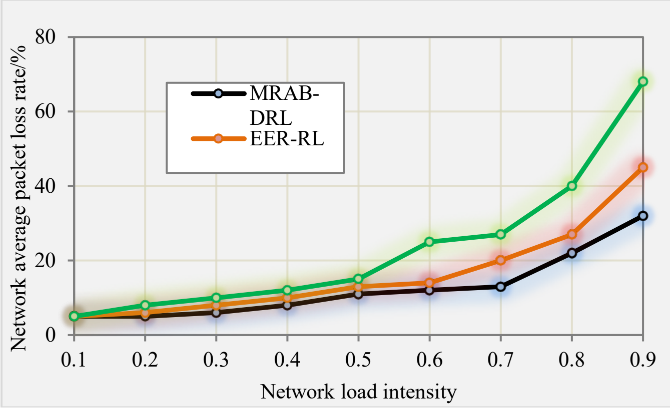

Figure 3. Comparison of packet delay of routing algorithms under different load intensities

Figure 3 shows the comparison of packet delay among three routing algorithms under different network load intensities. As the network load intensity increases, the packet delay also gradually increases. When the load intensity is low, the packet delay of the three algorithms is similar. This is because at the beginning of the network operation, the links are relatively idle and there is no obvious congestion, so all three algorithms can transmit packets quickly. When the load intensity reaches a certain level, the grouping delay of the three algorithms begins to increase. This is because as the load intensity increases, the load on the link also increases, leading to congestion in the link and increasing packet delay. This trend begins to manifest at a load intensity of 0.4. After the load intensity reaches a certain level, the grouping delay difference of the three algorithms further increases. Due to the lack of dynamic adjustment strategies for network congestion in the FA-SDN algorithm, its packet delay increases faster. In contrast, the EER-RL algorithm is based on the Q-Learning algorithm, which can select other links for forwarding when the link is congested, so its packet delay is relatively low. The MRAB-DRL algorithm is based on deep reinforcement learning, which comprehensively considers factors such as residual bandwidth, node residual energy, and transmission delay, and selects the optimal three paths for forwarding based on the global view. Therefore, it performs better in terms of packet delay.

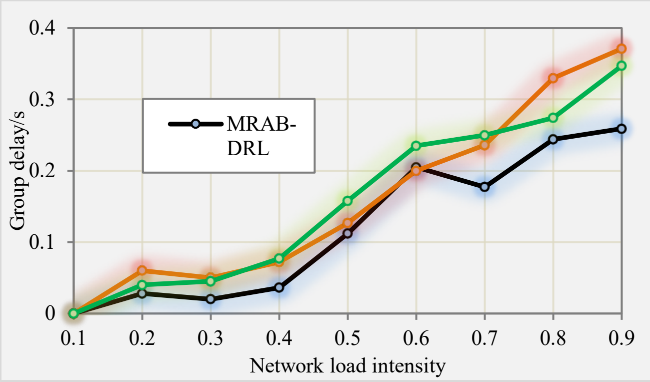

Figure 4. Comparison of Network Average Packet Loss Rates of Routing Algorithms under Different Load Intensities

According to the results in Figure 4, the average packet loss rate of the three algorithms is relatively low during the load intensity range of 0.1 to 0.3. This is because at this time, the network link is relatively idle and can transmit data packets well, with almost no packet loss. When the load intensity exceeds 0.5, the average packet loss rate of the three algorithms begins to significantly increase. This is because the network is approaching full load and the link capacity is insufficient, resulting in some data packets being unable to be transmitted in a timely manner, resulting in packet loss. Both MRAB-DRL algorithm and FA-SDN algorithm can dynamically adjust the transmission path based on the SDN controller, so their average packet loss rate is relatively low when the load intensity is high. In contrast, the EER-RL algorithm still adopts the traditional wireless sensor network architecture. Although the Q-Learning algorithm can choose different paths to forward data based on network conditions, due to the limited computing resources of wireless sensor nodes, the average packet loss rate is the highest when the load intensity reaches 0.8.

4. Design of Multimedia Teaching System Based on Sensor Networks

4.1. Principles of multimedia assisted application in physics teaching

In the development of the new education market, higher requirements have been put forward for college physics teaching, and certain principles need to be followed.

In practical teaching activities, the application of multimedia teaching needs to consider whether the teaching process is suitable for using this mode. If traditional teaching methods, such as using a blackboard or model for explanation, can clearly convey knowledge, then it can avoid wasting multimedia resources. Therefore, in the process of college physics teaching, teachers need to determine whether it is necessary to use multimedia teaching mode based on the situation. Multimedia teaching can vividly showcase physical phenomena and concepts through forms such as images, sounds, and animations, stimulate students' interest and curiosity, and enhance their learning initiative and participation.

When using multimedia teaching mode, physics teachers need to consider the principle of applicability. The computer-aided teaching model cannot completely replace the educational role of physics teachers, so using multimedia assistance in every teaching session may lead to physics teachers neglecting the important role of blackboard teaching. Therefore, physics teachers need to pay attention to the applicability of multimedia teaching mode, and make reasonable decisions on whether to use multimedia teaching based on specific teaching content and student needs. Under the principle of scenario, multimedia courseware can create real learning scenarios, help students actively explore problems, and solve problems through flexible application of physical knowledge, thereby enhancing students' learning effectiveness. Under the principle of assistance, multimedia devices mainly exist in physics classroom teaching in an auxiliary manner, and have the same teaching effect as traditional blackboards and chalk. It can provide teaching courseware to help physics teachers present teaching content more vividly and stimulate students' interest in learning. But physics teachers cannot completely rely on multimedia devices for teaching in actual teaching activities. Multimedia devices are just a tool, and physics teachers still the main body of teaching. Physics teachers need to use multimedia equipment reasonably according to the requirements of the teaching syllabus, assist students in handling key and difficult knowledge, and improve students' professional skills.

4.2. Structure Design of Multimedia Teaching System

The overall design concept of the system is shown in Figure 5.

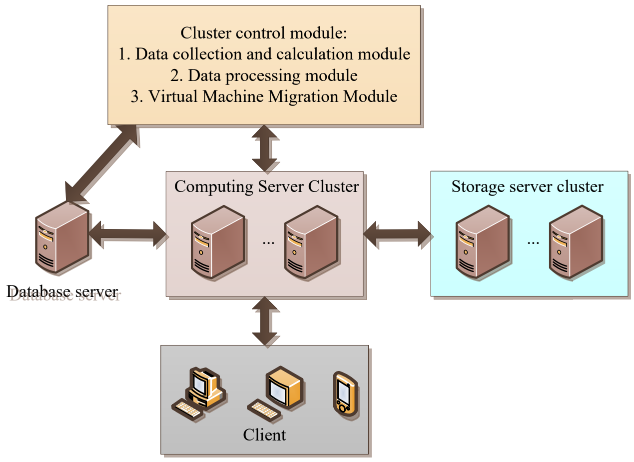

Figure 5. Overall Design Concept of the System

The system is divided into two functional modules: user user end and cluster control end. On the user side, the system obtains user commands through the virtual machine side and shares the original multimedia files using the CIFS protocol. The user's commands will be redirected to the user end, where corresponding commands will be executed to achieve the transmission and playback of multimedia files. At the same time, the system will also provide feedback and record of data, recording user behavior and system status. At the cluster control end, the system will process and analyze the collected information. Firstly, the system uses an adaptive linear regression algorithm to predict the reference values of the collected information. By predicting the reference values, the system can preliminarily arrange cluster virtual machines according to different needs and conditions. Then, the system uses a grouping based balancing algorithm to arrange virtual machines to achieve resource balance and optimization. Finally, the system will use the grouping reverse order combination algorithm to perform step-by-step fine-tuning on the layout of virtual machines, in order to further improve the performance and efficiency of the cluster and achieve a reasonable layout of virtual machines in the cluster.

In multimedia teaching, teachers can use multimedia devices to display experimental phenomena, simulate physical processes, guide students to observe and experiment, and understand and apply physics knowledge through discussion and thinking. Through this approach, students can better understand and master physics knowledge, cultivate problem-solving abilities and innovative thinking. At the same time, teachers can also provide learning resources and tools through multimedia devices to help students learn autonomously and manage their learning independently. This optimization can provide more learning resources and tools, allowing students to explore and learn more freely.

4.3. Virtual Machine Layout of Sensor Networks

In order to seek better performance of the cluster, it is hoped that the virtual machines in the cluster can achieve a more reasonable layout. For this purpose, consider optimizing an objective function to reduce the overlap of multimedia playback time generated by multiple virtual machines. On each server in the cluster, consider the playback weight as a representation of the playback probability. Therefore, set the objective function to the sum of the product of the virtual machine playback weights on each server.

This can be represented by the following mathematical expression:

$$S = W_{11}W_{12} \dots W_{1n} + W_{21}W_{22} \dots W_{2n} + \cdots + W_{m1}W_{m2} \dots W_{mn} \quad (2)$$

It is assumed that the sum of two groups of numbers combined in reverse order should be the smallest. This conjecture is expressed in the following mathematical expression:

$$S_1 = A_1A_{2n} + A_2A_{2n-1} + \cdots \dots + A_nA_{n+1} \quad (13)$$

In order to prove this conjecture, the proof by contradiction is adopted. Suppose there is a combination such that its sum is less than the value of the objective function, namely:

$$S_2 = A_1A_x + A_2A_{x+1} + \cdots \dots + A_nA_{x+n} \quad (14)$$

From this assumption, it can be inferred that the sum of the difference of S1 minus S2 must exist in some case so that its value is greater than zero, namely:

$$A_1(A_{2n} - A_x) + A_2(A_{2n-1} - A_{x+1}) + \cdots \dots + A_n(A_{n+1} - A_{x+n}) > 0 \quad (15)$$

When the number of values in each group is m, suppose that for any group A1, A2,... Am based combination, the above formula is not valid, that is:

$$S_3 = A_1(A_{2m} - A_x) + A_2(A_{2m-1} - A_{x+1}) + \cdots \dots + A_m(A_{m+1} - A_{x+m}) < 0 \quad (16)$$

For any combination with m+1 numbers per set, the desired objective function can be expressed as:

$$S_4 = A_l(A_{2m} - A_y) + A_2(A_{2m-1} - A_{y+1}) + \cdots \dots + A_m(A_{m+1} - A_{y+m}) + A_a(A_b - A_{min}) \quad (17)$$

Combine formula (17) and transform formula (18) into the following form:

$$S_5 = S_3 + A_a(A_b - A_{min1}) + A_{max1}(A_{min2} - A_b) - A_{max1}(A_{min2} - A_{min1}) \quad (18)$$

4.4 Reliability evaluation of sensor networks

According to the fault symptoms of WSN, the fault types are classified as follows:

The formula (19) for the drift deviation fault describes a deviation D(t) that varies continuously between the sensor output value Y(t) and the actual value X(t).

$$System_{out}(t) = System_{true}(t) \times \phi(t) \quad (19)$$

The formula (20) for the fault of reduced accuracy describes the error E(t) that exists between the sensor output value Y(t) and the actual value X(t), resulting in reduced accuracy of the output value.

$$System_{out}(t) = System_{true}(t) \pm \varepsilon \quad (20)$$

The formula (21) for the fixed deviation fault describes that there is a fixed deviation B between the sensor output value Y(t) and the actual value X(t).

$$System_{out}(t) = System_{true}(t) \pm \Delta \quad (21)$$

The formula (22) for a total failure fault describes that the sensor is unable to provide any valid output value, that is, the output value is 0.

$$System_{out}(t) = \Delta \quad (22)$$

5. Practice research of multimedia courseware assisted physics teaching

5.1. Design process of physics teaching

In the course of teaching, the use of multimedia courseware has become a common way of teaching. But before using multimedia courseware, teachers need to have a clear understanding of the practical educational significance of courseware in actual teaching activities. Teachers need to know the necessity of multimedia courseware. Multimedia courseware can display teaching content through image, sound, video and other forms, which makes teaching more vivid and intuitive, and can attract students' attention and improve learning effect. Teachers need to make clear the importance of the use of courseware for the realization of teaching objectives, as well as its role in transferring knowledge and cultivating students' ability. Teachers need to pay attention to the problems existing in the current physics teaching process. For example, traditional teaching methods may have problems such as unclear information transmission and low participation of students. Teachers need to recognize these problems and solve them through the use of multimedia courseware.

When using multimedia courseware in college physics class, physics teachers need to think about how to make full use of courseware content to optimize teaching, so as to strengthen students' comprehensive quality of physics and improve teaching effect. Physics teachers also need to consider the advantages of multimedia use, that is, how to present information through computer screens, transform textbook knowledge into visual learning processes, and build a relatively complete learning environment for students. Physics teachers need to think about how to optimize teaching through multimedia courseware. Multimedia elements such as images, animations and videos can be added to enrich classroom content, making abstract physical concepts more intuitive and easy to understand. At the same time, practical examples and application cases can be introduced to help students apply theoretical knowledge to practical problems and cultivate students' problem-solving ability and innovative thinking. Physics teachers need to think about the advantages of multimedia. Multimedia courseware can provide rich resources and interactivity, so that students can participate in the teaching process. Through the use of multimedia courseware, physics teachers can conduct real-time demonstrations and experimental displays in class, stimulate students' interest and curiosity, and promote students' active learning and inquiry spirit. Multimedia courseware can also provide personalized learning paths and independent learning opportunities, so that students can learn according to their own learning needs and interest points, improve the learning effect. The design of multimedia courseware system needs to consider the planning of knowledge frame and the design of multimedia screen. Physics teachers can organize and sort out the knowledge points according to the knowledge structure and teaching objectives of the subject, and build a relatively complete knowledge framework. The physics teacher can also design the layout and interface of the multimedia screen to suit the student's study habits and visual needs. At the same time, physics teachers can also use the interactive characteristics of computers to design some interactive learning activities, provide students with interaction and feedback with courseware content, and promote students' in-depth thinking and learning effect.

5.2. Status of physics multimedia teaching

As shown in Table 1, most students have a high degree of recognition for the multimedia equipment-assisted physics experiment teaching and believe that the multimedia teaching has good experimental effects. When the experiment is more complicated or they encounter problems they don't understand, students are more inclined to choose multimedia teaching to assist the experiment and ask the teacher to explain to help them understand and solve the problem. This shows that multimedia equipment has certain advantages and helpful role in physics experiment teaching.

Table 1. The situation of multimedia equipment assisting physics experiment teaching

Problem	Answer options	Agree rate (%)
The Relationship between Experiments and Multimedia Teaching	Practice in the field	22.74
	Multimedia assisted instruction	62.41
	Choose according to actual situation	14.84
Which method is preferred in complex experiments	Practice in the field	17.77
	Multimedia assisted instruction	69.80
	Nothing is unacceptable	12.42
What should I do if I don't understand the experiment once	Repeatedly watching experimental videos	17.08
	The teacher explained the experiment again.	51.03
	Group discussion learning	31.90

Table 2 shows that students believe that teachers should reduce their time for blackboard writing, especially for some definitions, illustrations, and summaries already included in the courseware. At the same time, teachers should not overly rely on multimedia teaching, but should increase blackboard teaching, such as deducing formulas. In addition, the design of multimedia courseware should be more humorous and interesting to attract students' attention. At the same time, teachers should slow down when using multimedia teaching to give students enough time to understand and digest the knowledge they have learned.

Table 2. Disadvantages and Improvements of Multimedia Assisted Physics Classroom Teaching

Problem options	Answer options	Agree rate (%)
What are the problems in multimedia assisted physics teaching	The teacher is slow to accept the new equipment	37.73
	Courseware boring, no interest	46.45
	Full attention shift	59.14
	Switching speed too fast	42.28
	The problem of "reading courseware" is serious	29.99
What are the improvement strategies for multimedia assisted physics teaching	Reduce unnecessary blackboard writing content	48.33
	Increase blackboard writing deduce	70.26
	Optimization of courseware design	37.42
	Moderate switching speed	48.43
	Other	10.12

5.3. The teaching effect of multimedia courseware assisted physics teaching

According to the data in Table 3, multimedia courseware assisted physics teaching has a positive impact on students' interest concepts, learning status, and thinking exploration abilities. These results indicate that multimedia courseware assisted physics teaching has the potential to improve students' learning outcomes and can be applied as an effective teaching method in physics teaching.

Table 3. Comparison of Teaching Effects of Multimedia Courseware Assisted Physics Teaching

Options	Mean value	Standard deviation
Interest concept	2.67	0.7927
Learning status	2.78	0.7261
Thinking Exploration	2.22	0.6791

According to the data in Table 4, multimedia courseware assisted physics teaching has the potential to improve students' academic performance and can be applied as an effective teaching method in physics teaching.

Table 4. Comparison of Unit Test Scores before and after

Time	Class	Number of people	Average score	Standard deviation
Before teaching	Experimental class	50	72.53	5.9480
	Comparison class	50	75.68	5.9444
After teaching	Experimental class	50	68.19	9.7477
	Comparison class	50	63.09	13.6496

5.4. Optimization Strategies for Multimedia Courseware Assisted Physics Teaching

Modern middle school teachers should have a correct understanding of the true significance of multimedia technology and make full use of this teaching method. The traditional methods of rote imitation and copying will only narrow the path of multimedia technology teaching, and may even be abandoned due to long-term failure to improve teaching effectiveness.

The emergence of multimedia technology is a way to narrow the teaching gap between urban and rural areas. In remote areas, due to resource scarcity, students often cannot enjoy the same teaching resources and conditions as urban students. The application of multimedia technology can transmit high-quality teaching resources to students in these remote areas through networks and electronic devices, providing them with the opportunity to access more comprehensive and high-quality educational content, thereby narrowing the education gap between urban and rural areas.

In order to ensure the teaching quality of school physics teachers, it is very important to regularly organize training. Rotational training can be used to train a group of physics teachers every six months to ensure that each teacher is proficient in the application of multimedia technology. In training, teachers should learn how to use multimedia technology to optimize physics teaching, so that students can have a better learning experience. The training content can include the production and use of multimedia courseware, the application of interactive teaching tools, and the mining and utilization of online resources. Teachers should learn how to create vivid and interesting multimedia courseware, combining elements such as animations, images, and videos to make abstract physics concepts more vivid and stimulate students' interest in learning. Teachers can also learn how to use interactive teaching tools, such as clickers and virtual experimental platforms, to actively engage students in classroom interaction and improve learning outcomes. At the same time, teachers should also learn to explore and utilize online resources, such as educational websites and open education resources, to enrich teaching content and broaden students' knowledge horizons. During the training period, teachers' learning outcomes can be evaluated through assessments. The assessment can be conducted through on-site production of multimedia courseware and explanation, in order to evaluate the teacher's multimedia technology application ability and teaching level. For teachers who fail the assessment, secondary training can be conducted to help them improve their skills and ensure that each teacher can apply multimedia technology for teaching. Teachers can adjust the presentation speed and content of courseware by observing students' reactions and interactions, ensuring that students can understand and accept the presented knowledge. Teachers need to have good discernment and proficient application skills to design the teaching content presented in multimedia courseware. Teachers should pay attention to students' learning burden and help them learn direct and simple knowledge points. Multimedia courseware can help teachers present knowledge points, but teachers need to arrange the depth and difficulty of content reasonably based on students' abilities and learning progress. Through carefully designed multimedia courseware, teachers can break down knowledge points into easier to understand parts, helping students gradually master and digest knowledge, and reducing the learning burden.

6. Conclusion

With the development of modern internet, people's ways of obtaining information have become diverse, which also puts higher demands on teachers' teaching methods. In the past, teachers could only rely on their own experience and teaching resources when changing their teaching methods. However, now, through the Internet, teachers can easily access various teaching resources, including multimedia courseware, teaching videos, case studies, etc., to obtain new teaching skills and methods. At the same time, teachers can also share teaching experience with teachers from other schools online, learn from each other, and learn from each other, which has a positive promoting effect on improving teachers' teaching level. In physics teaching, multimedia courseware assisted physics teaching application is a very effective way. The research shows that the real-time data acquisition and analysis of intelligent sensors can significantly improve the comfort of the classroom environment, and then promote the learning efficiency and enthusiasm of students. The optimization of thermal environment involves not only the adjustment of temperature, but also the comprehensive consideration of humidity, air flow and other factors. By establishing an intelligent environmental control system, teachers can dynamically adjust the classroom environment according to real-time data to ensure the best teaching conditions. This optimization can eliminate learning fatigue caused by too high or too low temperature, improve students' attention, and thus promote more effective knowledge transfer in the process of multimedia assisted teaching. The environment feedback mechanism based on sensor network enables teachers to know the internal situation of the classroom in time and take targeted measures. This data-driven teaching environment management method marks a new trend in the development of educational technology, and also provides a strong support for the future of smart classrooms. The application of sensor networks and deep learning technology can make multimedia courseware more vivid and interesting, helping students better understand and master physics knowledge. By using sensor networks, teachers can integrate real physics experimental data into courseware, allowing students to conduct experiments in a virtual environment and improving their experimental and observational abilities.

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